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An Electroglottograph study of voiced plosives in two Japanese dialects

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1. Introduction

Voiced obstruents in northeastern Japanese are described as fully voiced compared to other varieties of Japanese (高田 2011). In this paper, we report the findings of a preliminary Electroglottograph (EGG) study that analyzes recordings of 4 speakers of two Japanese dialects: Kanto and Hokkaido. Acoustic studies of these dialects exist, but as far as we know there are no EGG studies that investigate the difference in voicing between these two dialects. Figure 1 shows EGG results of the token /higo/ 'sticks' produced by a Kanto speaker and a Hokkaido speaker. The vibration in the production of /g/ by the Kanto speaker shows that the vibration almost stops, whereas the vibration fully continues in the Hokkaido speaker's production of /g/.

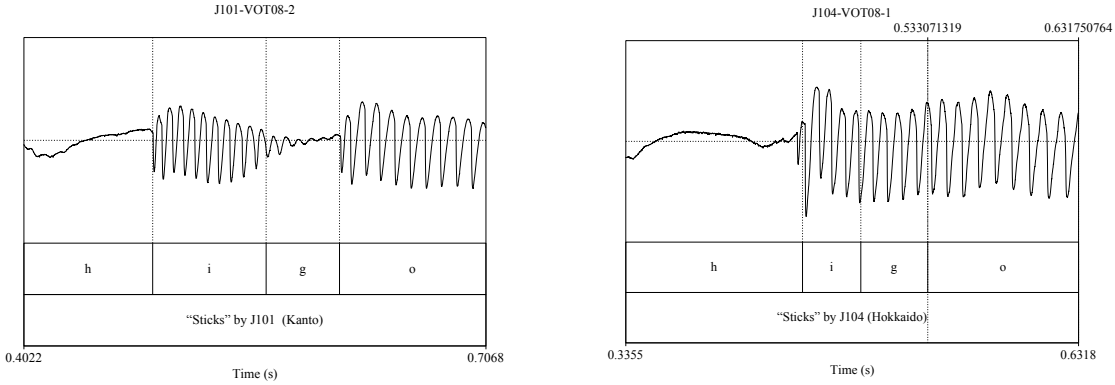

Figure 1: An EGG signal of /higo/ produced by a Kanto speaker (left) and a Hokkaido speaker (right).

Overall EGG results show that voiced plosives produced by Hokkaido speakers tend to have fuller voicing than those produced by Kanto speakers. While voiced plosives are fully voiced in Hokkaido speakers' speech, Kanto speakers show more variation: from no voicing to fully voiced. Examining the place of articulation, tone of a following vowel, and closure duration did not suggest any interaction with the voicing patterns.

2. Method

Two speakers from Hokkaido and two speakers from Kanto read 40 words that include three voiced

plosives [b], [d], [g] and three voiceless plosives [p], [t], [k]. All recordings were read three times in a frame sentence /kore-wa X desɯ/ 'This is X', where X is the target word. Stimuli written in Hiragana were presented in a slide show using power point, which was advanced by an experimenter. For the EGG recording, participants wore a two-headed electrode after applying electrogel on it. The electrode was connected to the EG2-PCX2 Electroglottograph machine, which was connected to an NEC Windows laptop computer and an ECM 8000 Microphone. Recording was done using Praat (Boersma 2001) on a laptop computer while the microphone was held by another experimenter. The analysis comes from a data set of 200 voiced plosives and 71 voiceless plosives. The voicing patterns of the plosives were analyzed using the EGG signal. Based on the voicing patterns, a number was assigned: from 1 for full continuous vibration to 0 for no vibration. Further categorical vibration patterns were analyzed as 0.2, 0.5 and 0.8 depending on the duration of the vibration within the closure of the plosives.

3. Results

3.1. Voicing

We first investigated the degree of voicing in Hokkaido speech versus Kanto speech. A cumulative link mixed model was used for analyzing the voicing pattern, with speaker as a random factor. Hokkaido speakers produced more tokens with full voicing than Kanto speakers ($p < 0.001$). This result holds regardless of whether all consonants are considered or whether only the voiced plosives [b], [d], [g] are considered. Table 1 shows the distribution of vibration pattern based on each plosive, only tokens with full vibration (1) and no vibration (0) are listed. Voiceless plosives show no vibration of the vocal cords in both dialects. In the Hokkaido dialect, almost all voiced plosives show full vibration in the EGG signal. In Kanto, [b] is always fully vibrating, whereas EGG data of [d] and [g] indicate that non-labial voiced plosives may not always be accompanied with vibration of the vocal folds. Figure 2 shows this diribution in a histogram format.

Table 1: Tokens of voiced and voiceless plosives.

	Hokkaido		Kanto	
	full vibration	no vibration	full vibration	no vibration
[b]	60	2	54	0
[d]	47	0	33	3
[g]	82	0	57	13
[p]	0	4	0	5
[t]	2	3	0	6
[k]	0	60	0	59

3.2. Voicing and place of articulation

We then looked into the effect of place of articulation on vibration. In the Kanto dialect, the distribution in table 1 shows that the voiced velar plosive has more tokens with no vibration, compared to the voiced bilabial plosive where there is no tokens with no vibration. In the Hokkaido dialect, nearly all voiced plosives show full vibration, but two instances of no vibration were observed in the bilabial [b]. The cumulative link mixed model shows that there is no overall effect of place of articulation, nor is there an interaction between voicing and place of articulation in both dialects.

3.3. Voicing and lexical tone

Both the Hokkaido dialect and the Kanto dialect have a lexical pitch accent. We examined whether there is an effect of lexical tone in the following vowel in the degree of vibration in the Kanto dialect. The model shows that there is no overall effect of tone in predicting the vibration in either dialect. However, there was an interaction found between dialect and lexical tone. The difference in the vibration of voiced plosive before low versus high tone in the Kanto dialect is larger than that in the Hokkaido dialect. This effect, nonetheless, is marginal ($p = 0.04$)

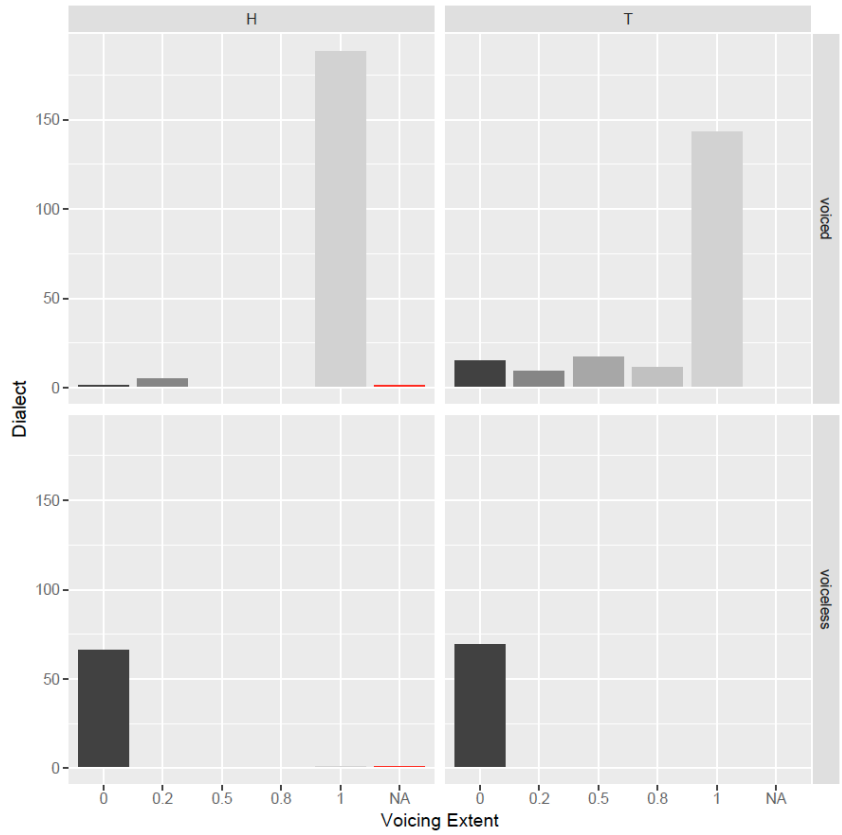

Figure 2: Histogram of the distribution of vibration in voiced versus voiceless plosives in Hokkaido. The y-axis shows the number of tokens belong to a category: 1 for full vibration and 0 for no vibration.

3.4. Voicing and closure duration

Voiceless plosives and voiced plosives have different closure durations. An analysis of the three voiced plosives [b], [d], [g] and three voiceless plosives [p], [t], [k] shows that the closure duration is significantly longer by about 45 ms across both dialects for voiceless stops ($p < 0.001$). We hypothesized that the closure duration may compensate for some neutralized vibration in the Kanto dialect. We tested whether there is an interaction between the degree of vibration and closure duration in both dialects using a standard linear mixed model with speaker as a random factor. The model suggests that an interaction exists for vibration and dialects, but in an unexpected direction: the closure duration difference for voiced versus voiceless plosives is slightly larger in the Hokkaido dialect than in the Kanto dialect, but only by 7 ms ($p = 0.02$). This means that the difference in the closure duration does not compensate for some neutralized vibration in the Kanto dialect.

4. Conclusion

This paper has shown the voiced plosives in the Kanto dialect show more variation when the vibration of the vocal cords is concerned. About 11% of the voiced plosives show no vibration, and most of them are velar plosives. In the Hokkaido dialect, however, no velar plosive shows no vibration, and only two labial plosives show no vibration. The results of a mixed model analysis show that there are no effects of place of articulation, a marginal effect of lexical tone, and a weak effect of closure duration.

Appendix. List of stimuli

HL (n = 21)			LH (n = 19)		
だれ	ぶな	まど	むだ	まご	かべ
ひご	ばね	がす	びら	げぷ	ぼく
しが	げき	かじ	ごみ	だめ	ひげ
べる	ぐみ	もず	かぎ	みず	どく
じが	ふぐ	ねじ	にじ	ばら	かび
はだ	そば	まだ	がき	さが	
へび	とび	どき	じく	ぐち	

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