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Research Report (by Fellow) (Cover Page)

I hereby submit the research report of my fellowship.

1. Name (Print) : JIAYIN GAO
2. Nationality : CHINESE
3. Host Institution : SOPHIA UNIVERSITY
4. Host Researcher : TAKAYUKI ARAI
5. Title of Research in Japan : Laryngeal mechanisms in speech production and perception:
A cross-language study on F0 perturbation
6. Fellowship Tenure : From 2017 / 08 / 09 To 2019 / 08 / 02
(YYYY) (MM) (DD) (YYYY) (MM) (DD)

*Notes for writing the Research Report

*Type this form except the date and the signature.

Please prepare your Research Report in English or Japanese within three to ten pages including this page. The contents should include:

7. Background of Research

This research project, in collaboration with members from Arai Laboratory of Sophia University, bears on the crosslinguistic comparisons of laryngeal articulations of the obstruent consonants.

Languages with a two-way laryngeal contrast can be broadly divided into two categories, “true voicing” and “aspirating” (Beckman, Jessen, & Ringen, 2013). In “true voicing” languages, such as many Romance and Slavic languages, the difference between the “b, d, g” sounds and the “p, t, k” sounds lies in the presence or absence of glottal vibration during closure. In “aspirating” languages, such as many Germanic languages, the difference between these sounds lies in the presence or absence of aspiration. While Japanese is commonly described as a “true voicing” language (e.g., Nasukawa, 2005), recent data suggest that Japanese is undergoing some devoicing, that is, the “b, d, g” sounds are not frequently produced with glottal vibration during closure (Takada, 2011; Takada, Kong, Yoneyama, & Beckman, 2015). We may thus suspect that the theses sounds are more easily confused with the “p, t, k” sounds. One interesting question thus arises: how do Japanese speakers/listeners distinguish the two plosive series?

Among the numerous phonetic properties, one important property is the fundamental frequency (F0) of the

vowel following the plosive consonant. It has been found that in both “true voicing” and “aspirating” languages, F0 is higher after “p, t, k” than after “b, d, g” (Hombert, Ohala, & Ewan, 1979). This F0 pattern may eventually lead to a tonal development, in which a tonal contrast replaces the plosive contrast.

According to historical reconstructions, such tonal developments have taken place in many Asian languages such as Chinese, Vietnamese, and Thai (Haudricourt, 1961). More convincingly, in recent years, we may observe ongoing tonal developments in several languages including Seoul Korean (Silva, 2006), Afrikaans (Coetzee, Beddor, Shedden, & Styler, 2018), and Dutch (Pinget, 2015).

In our project, we aimed to investigate the interaction between laryngeal articulations for plosives and fricatives, especially voicing, aspiration, and F0. Japanese provides an ideal testing ground because (1) the presence of glottal vibration is not a reliable cue anymore, and (2) no proposal of any tonal development has been made. We asked the following questions: What are the cause and the consequence of devoicing in Japanese? How does (de-)voicing interact with F0 in production and perception? Will this eventually lead to a tonal development?

In addition, we intended to compare Japanese data with several other languages. The project also included (1) French, in which the presence vs. absence of glottal vibration during closure is a reliable cue to distinguish “b, d, g” from “p, t, k”; and (2) Korean, in which an ongoing tonal development has been widely described. We also compared Japanese data with previously collected data from two languages: Tamang, a Tibeto-Burman language spoken in Nepal, where the tonal development has reached the final stage, and Shanghaiese, in which the tone system is well established. In these two tonal languages, previous phonetic properties have not completely disappeared.

The purpose of this project was thus two-fold: (1) for the understanding of the diversity of laryngeal articulations in the languages of the world, in both production and perception; and (2) for gaining insights into the diachronic evolution from a consonantal contrast to a tonal contrast observed in different languages.

Our hypothesis is as follows: in a stage prior to any tonal development, the effect of consonant on F0 is originally automatic, but reproduced intentionally by listeners-speakers to enhance the voicing contrast only when the primary voicing cue is threatened.

8. Research methodology

An acoustic measurement, Voice Onset Time (VOT), is often used to assess the phonetic realizations of the laryngeal contrast. In “true voicing” languages, the VOT boundary between the two plosive series is reported to be around zero, while in “aspirating” languages, this boundary is reported to be around 30 ms. For Tokyo Japanese, we conducted several experiments: (a) an acoustic study on plosives and fricatives with a wide panel of acoustic measurements (VOT, voicing ratio, F0, closure duration, frication duration, etc.), taking into account the variations of place of articulation, following vowel, pitch-accent context, and position in the word and the sentence; (b) a perception study using synthesized nonce syllables created by a Klatt synthesizer, in order to study the VOT boundary between the two plosives series perceived by Japanese listeners; and (c) a perception study using modified stimuli based on naturally produced real words, varied in VOT and F0, in order to study the relative importance of VOT and F0 in the identification of plosive consonants.

For French, we conducted a perception study using the same stimuli as used in Experiment (c) for Tokyo Japanese, in order to tease apart universal and language-specific patterns concerning the perception of VOT and F0.

For Seoul Korean, we collected both acoustic data and physiological data. The physiological data were

recorded with electroglottography (EGG), which gives precise indications not only about the presence and absence of glottal vibration, but also about how the vocal folds vibrate. Seoul Korean has three plosive series: “ph, th, kh” are aspirated, that is, with a long VOT, and followed by higher F0, “b, d, g” are called “lenis”, and produced with a similar VOT pattern as aspirated but followed by lower F0, “p’, t’, k’” are called “fortis”, produced with a short VOT, and followed by higher F0. Another characteristics is that the glottal vibration during and after “lenis” plosives is more lax than the other two series, resulting in a breathier voice. The main goal of this study was to examine the time course of this voice quality difference on the vowel following the two series.

9. Results/impacts

We here summarize the most important results and focus on the Japanese data.

The production data of Tokyo Japanese shed lights on the phonetic properties related to the plosive series. Concerning voicing and aspiration, our data confirm the devoicing trend in young speakers’ production for voiced plosives “b, d, g” and fricative “z” in word-initial position, but not in word-medial position.

Meanwhile, “p, t, k” plosives are slightly aspirated in word-initial position but not in word-medial position. This pattern contradicts the traditional “true voicing” description for Japanese, but is also different from a typical “aspirating” pattern. We conclude that some languages belong to an intermediate category between “true voicing” and “aspirating”. Furthermore, we also found that voiced fricatives were frequently realized as affricates in word-initial position, but not in word-medial position. Concerning F0, our study was the first to show the variations of F0 pattern according to the position and the pitch-accent in Japanese. The F0 pattern differs essentially according to the position in the word: in word-initial position, F0 is higher after “p, t, k, s” than “b, d, g, z”, whether “b, d, g, z” are devoiced or not (see Figure 1 for plosives), while in word-medial position, the F0 difference after these consonants is negligible. This positional variation suggests that the F0 distinction is large only when the two obstruents series are difficult to distinguish based on glottal vibration. These results have been published in the proceedings of the 2018 Spring Meeting of the Acoustical Society of Japan and several international conferences (e.g., LabPhon 16, 6th International Symposium on Tonal Aspects of Languages), and a revised paper has been submitted to *Journal of Phonetics*.

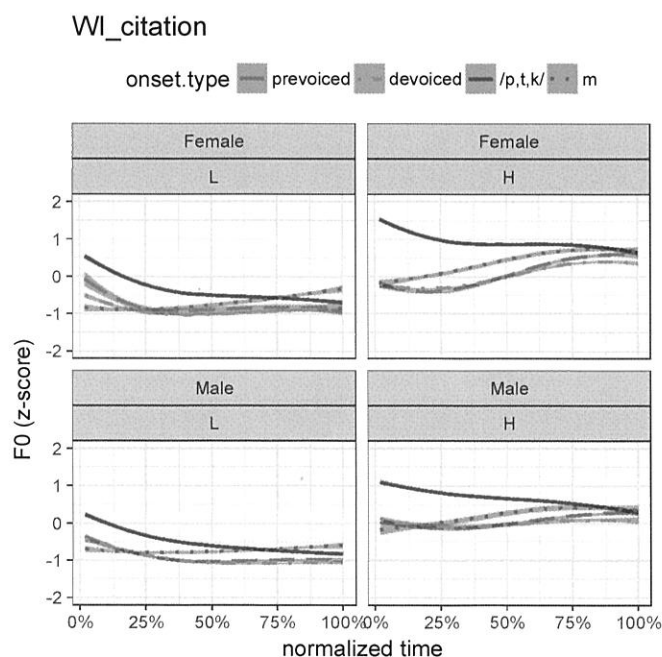


Figure 1. F0 curves after /p, t, k/, /b, d, g/ (prevoiced, and devoiced), and /m/ in word-initial position.

The perception data of Tokyo Japanese showed for the first time the relation between VOT and F0 in the perception of plosive consonants in Japanese. In the first experiment with synthesized stimuli, our results suggested that the VOT boundary is around 0 or 10 ms with a higher F0, and around 10 or 20 ms with a lower F0. This boundary is different from that for a “true voicing” language in which the boundary is 0 ms on average, suggesting again that Japanese is not a “true voicing” language. Furthermore, around half of the listeners were affected by F0 and the other half of the listeners were not, while all of the listeners relied on VOT in identifying a “ta” or a “da” syllable. In the second experiments with modified natural stimuli, we constructed orthogonally a VOT continuum and an F0 continuum. Our results suggested again that listeners relied primarily on VOT, and only secondarily on F0. Comparing Japanese data with French data, French listeners relied less on F0, and their VOT boundary was closer to 0 ms than Japanese listeners. Another important finding is that, both Japanese and French listeners were more sensitive to high F0 than to low F0. This is in line with the production pattern reported by Hanson (2009) for English, and by Kirby and Ladd (2016) for French and Italian. Our results on the perception data have been published in the proceedings of the 2019 Spring Meeting of the Acoustical Society of Japan and the 19th International Congress of Phonetic Sciences. A journal paper is currently in preparation.

Based on all these results, we propose a timeline for the VOT-F0 relation in Tokyo Japanese. The devoicing, that is, loss of glottal vibration during closure, has taken place because glottal vibration is difficult to initiate and maintain in word-initial position. The devoiced realizations thus create possible confusion at the perceptual level. Consequently, speakers enhance their F0 distinction only in word-initial position to compensate for the perceptual confusion.

Altogether, the outcomes of our project provide empirical data for the modelling of the relation between consonants and F0. They also contribute to the theoretical understanding. Our hypothesis has been confirmed: in a stage prior to any tonal development, the effect of consonant on F0 is originally automatic, but reproduced intentionally by listeners-speakers to enhance the voicing contrast only when the primary voicing cue is threatened. Last but not least, our findings about the sensitivity to high F0 will lead to further investigations which will involve future collaborative research with Japanese colleagues.

Note: As much as possible, describe the contents and results of your research in a manner that is easily understandable to a non-specialist in your field. Provide a concrete description if (1) papers related to your work have been published in major academic journals, (2) particularly outstanding research results were achieved, or (3) patent applications have been made or other tangible outcomes achieved through the research.

10. Research Presentations during the period of the fellowship (Name of the conference, title, place, date)

- Gao, J., & Arai, T. (2019). Is French more “true voicing” than Japanese? Perception of plosive voicing in French vs. Japanese. New Sounds 2019. September 2019. Tokyo, Japan.
- Mazaudon, M., & Gao, J. (2018). A perception study of the cues to tone differentiation in Risiangku Tamang. 39th Annual Conference of Linguistic Society of Nepal. November 2018, Kathmandu, Nepal.
- Gao, J., & Arai, T. (2018). Revisiting laryngeal features with a dynamic approach. 16èmes Rencontres du Réseau Français de Phonologie. June 2018, Paris, France.
- Gao, J., & Arai, T. (2018). Is Japanese a true voicing language? So much we know, yet so much to learn about [voice]. The 16th Conference on Laboratory Phonology. June 2018, Lisbon, Portugal.
- Mazaudon, M., & Gao, J. (2018). Cue weighting after a tone-split in Tamang. A perception study of stop initial words. The 16th Conference on Laboratory Phonology. June 2018, Lisbon, Portugal.
- Gao, J. (2018). Laryngeal features in Tokyo Japanese as illustrated by its F0 perturbation patterns. Invited conference, Séminaire de Recherche en Phonétique et Phonologie. June 2018, Université Paris 3, France.

- ✓ 11. A list of paper published during or after the period of the fellowship, and the names of the journals in which they appeared (Please fill in the format below). Attach a copy of each article if available.

Author(s)	Title	Name of Journal	Volume	Page	Date	Note
Gao, J., & Arai, T.	Plosive (de-)voicing and f0 perturbations in Tokyo Japanese: positional variation, cue enhancement, and contrast recovery	Journal of Phonetics				Revision submitted
Gao, J., Hallé, P., & Draxler, C.	Breathy voice and low-register: A case of trading relation in Shanghai Chinese tone perception?	Language and Speech			in press	
Gao, J., Yun, J., & Arai, T.	VOT-F0 coarticulation in Japanese: production-biased or misparsing?	Proceedings of the 19th International Congress of Phonetic Sciences		Paper number 619, 1-5	2019	
Gao, J., Yun, J., & Arai, T.	VOT and F0 cues in the perception of synthesized plosives by Japanese listeners	Proceedings of the 2019 Spring Meeting of the Acoustical Society of Japan		785-786	2019	
Gao, J., & Arai, T.	F0 perturbation in a "pitch-accent" language	Proceedings of the 6th International Symposium on Tonal Aspects of Languages		Paper number 13, 1-5	2018	
Gao, J., & Arai, T.	Acoustic cues of the stop voicing contrast in modern Tokyo Japanese.	Proceedings of the 2018 Spring Meeting of the Acoustical Society of Japan		1273-1274	2018	
Gao, J., & Mazaudon, M.	Relative use of de-phonologized cues in perception of tones in Tamang (Nepal)	Proceedings of 2017 Seoul International Conference on Speech Sciences		86-87	2017	

- ✓ 12. Awards during the period of the fellowship (Name of the award, Institution, date etc.)

Travel bursary for ICPhS 2019, awarded by the International Phonetic Association (IPA) in 2019