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PRESS RELEASE

Source: Toyohashi University of Technology, Japan, Committee for Public Relations

Release Title: How Japanese speakers confuse the pronunciations of /hi/ and /si/

Release Subtitle: Real-time MRI and supercomputer simulations reveal the production mechanisms of these sounds in a Japanese dialect

Overview

According to a linguistic survey report, people often confuse the pronunciation of /hi/ ([çi] in the IPA phonetic alphabet) with that of /si/ ([çi] in the dialect of Tokyo and the Tohoku region of Japan. A team of researchers at Toyohashi University of Technology and the National Institute for Japanese Language and Linguistics (NINJAL) found that the confusion is resulted from the articulation of the tongue varying in the transverse direction while the tongue tip is positioned at the same place of articulation.

Details

According to a linguistic survey report, people often confuse the pronunciation of /hi/ ([çi] in the IPA phonetic alphabet) with that of /si/ ([çi] in the dialect of Tokyo and the Tohoku region of Japan. A team of researchers at Toyohashi University of Technology and the National Institute for Japanese Language and Linguistics (NINJAL) found that the confusion is resulted from the articulation of the tongue varying in the transverse direction while the tongue tip is positioned at the same place of articulation. The study was published online in the *Journal of the Acoustical Society of America* on April 7, 2021.

In the Japanese language, the consonant /s/ followed by vowel /i/ is pronounced [çi], distinct from /s/ followed by other vowels [sa], [su], [se], and [so], because of the palatalized tongue articulation. Similarly, /h/ followed by /i/ is pronounced [çi], distinct from /h/ followed by the other vowels [ha], [hu], [he], and [ho]. In both cases, the articulation is palatalized and often confused. For example, the initial syllables of Japanese words /higasi/ “east” and /hige/ “mustache” are often pronounced /sigasi/ and /sige/, respectively, in Tokyo and a wide area of the Tohoku region of Japan. In addition, the initial syllable of /sicigatsu/ “July” is variably pronounced as /hicigatsu/ throughout Japan. This phenomenon has already been known by researchers in linguistics. However, it was still unclear how the acoustic contrast between the two sounds /hi/ and /si/ was reflected from their articulation.

In this study, the researchers observed the tongue movement during the articulation of a Japanese sentence “korega hisi gata” (“This is a rhomboid shape.”) by 10 Japanese subjects using real-time MRI and found that 3 subjects pronounced /hi/ and /si/ with almost identical places of articulation, while the



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acoustic contrast between /hi/ and /si/ was audible.

To examine how the acoustic contrast was formed with an apparently identical place of articulation, the research team conducted numerical flow simulations on oral models using a supercomputer. The results demonstrated that the acoustic contrast between /hi/ and /si/ can be produced by the difference in tongue shape in the transverse direction without changing the place of articulation.

In the classification of the International Phonetic Alphabet (IPA), the place of articulation is mainly defined by the position of the narrowing of the oral passage in the anterior-posterior direction. However, the current findings show the possibility of changing the sounds of /hi/ and /si/ with different tongue shapes in the transverse direction, suggesting the necessity of including a new parameter for the IPA.

“The pronunciations of /hi/ and /si/ are often used in Japanese and articulated unintentionally in a daily conversation,” says the lead author Tsukasa Yoshinaga, assistant professor at Toyohashi University of Technology. “However, to simulate the production of these sounds in our mouths, we need to precisely calculate the generation of many small vortices in turbulent airflow and the sound propagation from these vortices. To simulate these vortices, approximately 80 million computational grid points were set, and the formulas were solved on the grids using a supercomputer. We were excited when we found small vortices causing the acoustic contrast between /hi/ and /si/ in the simulation results.”

For future research, the research team believes that understanding the cause of the acoustic contrast between /hi/ and /si/ will provide useful information for obtaining fluency in Japanese articulation. In addition, knowledge of tongue articulations in the transverse direction can be useful for the rehabilitation of articulation disorders with speech therapists. Currently, coauthor Kikuo Maekawa, professor at NINJAL, is developing a database of articulatory movies of real-time MRI. Additional analysis for the other syllables will provide us useful information for speech therapists as well as learners of Japanese as a second language.

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Reference

Tsukasa Yoshinaga, Kikuo Maekawa, and Akiyoshi Iida (2021). Aeroacoustic differences between the Japanese fricatives [ç] and [ç̥]. *The Journal of the Acoustical Society of America*, DOI: 10.1121/10.0003936.



Further information

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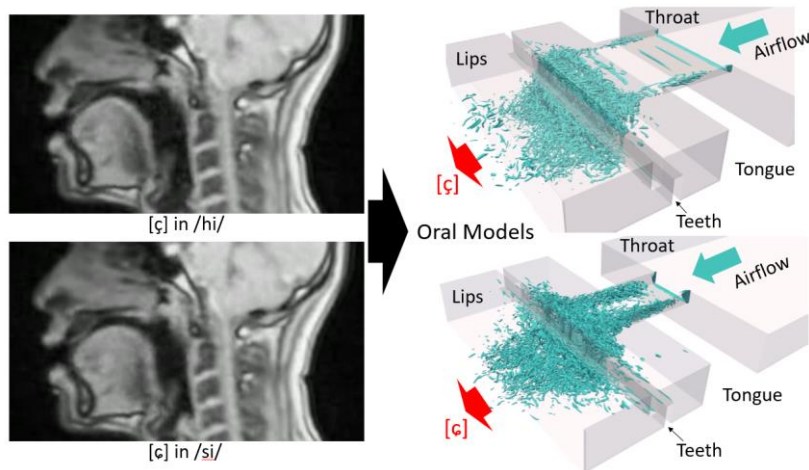
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Figure1:



Title: Numerical simulations of the speech productions of /hi/ and /si/.

Caption: Observation on the real-time MRI and flow vortices in the oral models.

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