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The World of Language and Speech

from Keio's Faculty of
Science and Technology

How do we humans understand each other?

Yukiko Sugiyama

Associate Professor
Department of Foreign Languages
and Liberal Arts



I'd like to unravel the mechanisms of our speech and hearing

Investigating what characterizes word recognition

We utter words when speaking, but it's impossible to physically utter the same words twice even if the words are the same. If so, how do we recognize the words spoken to us, understand their meaning and communicate with one another? Or is it possible to distinguish words such as “*hashi* (bridge)” and “*hashi* (edge)” that are pronounced likewise but have different meanings in Japanese? Associate Professor Yukiko Sugiyama approaches the process and mechanism of speech production and perception from both aspects: words uttered by the speaker and their perception on the part of the listener.

What is “phonetics”?

Dr. Sugiyama's specialty is a field of study known as “phonetics.” Phonetics is largely classified into three academic areas (Fig. 1): “acoustic phonetics” examines physical properties of spoken words; “articulatory phonetics” analyzes how speech sounds are produced in the oral cavity when humans speak; and “perceptual phonetics” investigates the process by which humans perceive speech.

“Phonetics is often regarded as a branch of linguistics. However, in order to examine speech, we need to identify its physical characteristics such as duration, frequency and intensity. Also, articulation deals with the workings of the oral cavity and vocal folds while speech perception concerns the human sensory mechanism. These factors require knowledge from a wide range of disciplines including physics, engineering, medicine and cognitive psychology, among others. It is

indeed a multidisciplinary field involving both humanities and sciences,” explains Dr. Sugiyama.

With phonetics as the base, Dr. Sugiyama takes a two-way approach in proceeding with her research. One way is to analyze the physical characteristics of speech, and the other is to examine how a person perceives speech. By using this two-way approach she'd like to unravel characteristics of the Japanese language.

Looking for characteristics that distinguish words

“The target I use for this purpose is Tokyo Japanese, or so-called the Standard Japanese. I collect and record samples of speech from Tokyo Japanese speakers. To begin with, I examine the physical characteristics of speech such as the frequencies and durations of speech segments. In the case of the Tokyo Japanese, for example, the word ‘*ame*’ (rain) is pronounced with a higher pitch for ‘*a*’ and a lower pitch for ‘*me*.’ On the

other hand, the word ‘*ame*’ (candy) is pronounced with a lower pitch for ‘*a*’ and a higher pitch for ‘*me*.’ In other words, the pitch levels of high and low determine the meaning of words.”

But what if it comes to “*hashi*” (meaning “bridge” and “edge”) and “*tori*” (meaning “bird” and “last performer”)?

“Both words are pronounced with the same pitch pattern of low-high, making it difficult to distinguish them. However, when you say ‘*hashi o aruku*’ (the former meaning ‘walk over a bridge’ and the latter ‘walk along the edge’), the postpositional article ‘*o*’ that follows ‘*hashi*’ is pronounced with a low pitch for the former and with a high pitch for the latter. By putting words of interest in an environment where they minimally differ, we find out the characteristics that people use to identify words,” she continues.

As a matter of fact, if we analyze the frequency components in one's speech and look at their spectrogram – the so-called “voiceprint” – we see rises and falls of the fundamental frequency (the rate at which the vocal folds vibrate per second, which we perceive as pitch) which serve to distinguish words (Fig. 2). Thus, in Japanese, we use pitch accent to distinguish one word from another.

“In terms of distinguishing words by the movement of fundamental frequency, Japanese is similar to Mandarin Chinese, which is classified as a tone language. Meanwhile, the function of pitch in Japanese is similar to that of stress in English.”

Some propose that Japanese pitch accent is characterized not only by fundamental frequency but also by intensity and duration of segments as is typically observed in English and other stress accent languages.

“I don't think that fundamental frequency alone is sufficient to distinguish between words in robust communication. In fact, English stress accent includes multiple elements such as intensity, duration and pitch. However, the meanings of Japanese words change if segment durations change. Then what elements can be used as acoustic correlates of pitch accent in Japanese?”

Fig.1 Phonetics

Phonetics is largely classified into three areas as shown below:

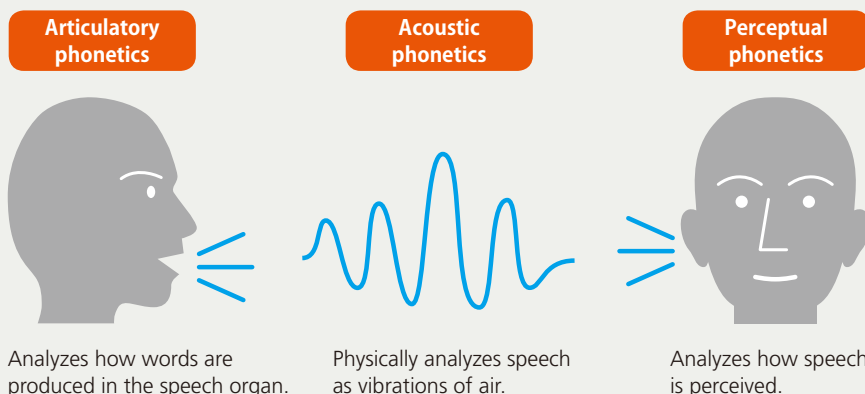
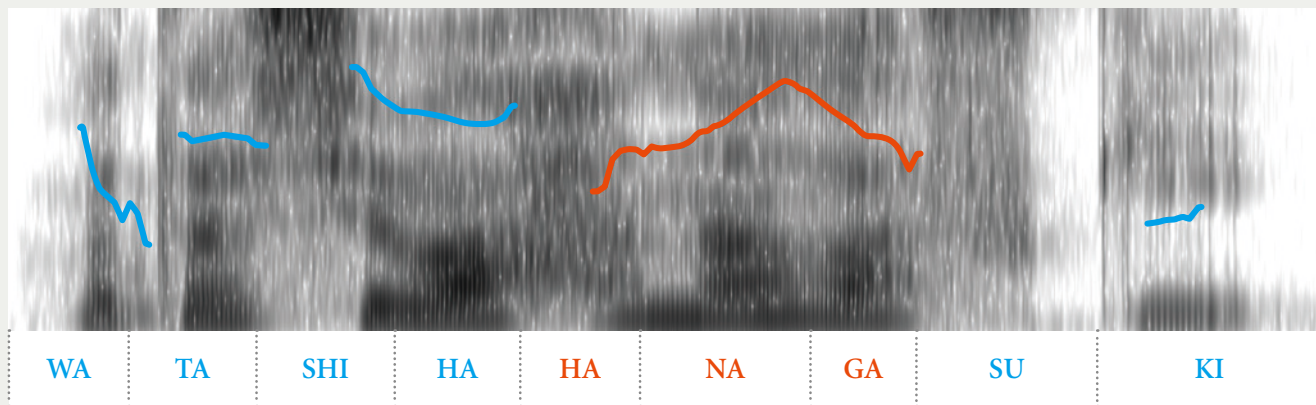
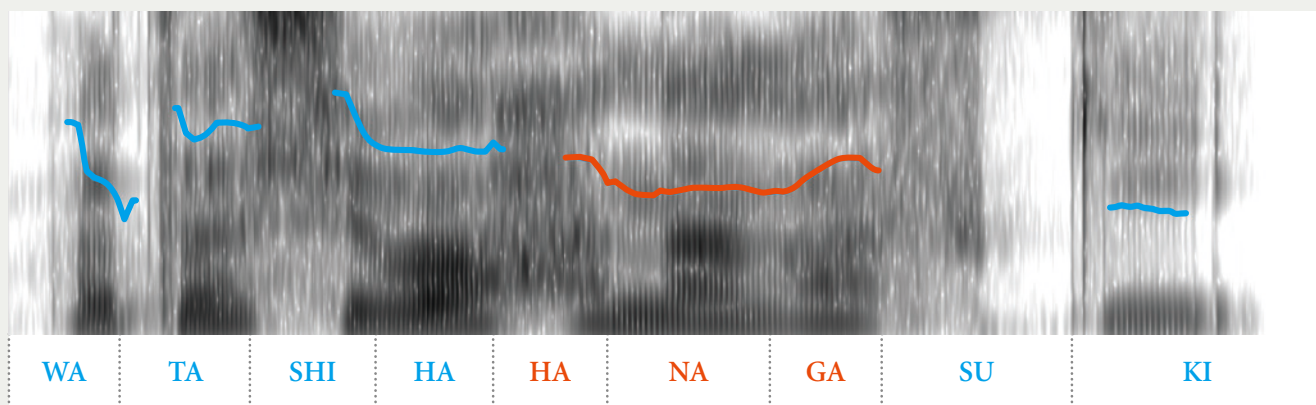


Fig.2 Voice pitches and difference in meanings

The dark areas with vertical striations are spectrograms (the so-called voiceprint). The vertical axes indicate frequencies (Hz). In the spectrograms, the darker an area, the greater the amount of energy. The blue and red lines lying on top of the spectrograms show pitch contours (Hz).



"Watashi wa hana ga suki" The fundamental frequency (red line) rises at "na" and falls at "ga."
("I like flowers.")



"Watashi wa hana ga suki" The fundamental frequency (red line) remains relatively flat (strictly speaking, slightly rises at "ga") in the area from "na" to "ga".
("I like a nose.")

This weighs on my mind," Dr. Sugiyama remarks.

To address this problem, Dr. Sugiyama conducts perception experiments using edited speech from which the fundamental frequency has been artificially removed. If listeners can successfully distinguish words such as "hashi" (bridge) and "hashi" (edge), even when there is no fundamental frequency, it would suggest that acoustic cues other than the fundamental frequency are present in the speech, enabling the listeners to use them to identify the words they heard.

Dr. Sugiyama says, "The results found that the listeners were over 95% correct in word identification when they heard natural speech. For the edited speech which contained no pitch information, the accuracy dropped to roughly 65%, but it was above chance level. This leads to a conclusion that Japanese pitch accent is realized by certain other acoustic characteristics in addition to the fundamental frequency."

For future research, she would like to identify exactly what acoustic characteristics listeners use to identify words when there is no fundamental

frequency.

Would like to contribute to machine-based speech recognition and synthesis

In what way do these studies benefit us socially and academically?

"Academically, I think my research would contribute to a better understanding of the possible prosodic types that human language can have by revealing the acoustic details of Japanese pitch accent."

"I think it would also contribute to improving speech recognition systems and speech synthesis by indicating what acoustic correlates accompany pitch. In order to raise the accuracy of these systems, are there any other acoustic elements that need to be taken into consideration? If we can find an answer to this question, it will also help to synthesize more human-like speech," remarks Dr. Sugiyama.

While hearing aids and cochlear implants are very helpful to those who need them, their performance is still far from that of an actual human ear, causing difficulty in sensing pitch, having a narrower dynamic range, and introducing

noise into what we actually want to hear. This is why hearing performance closer to the human ear is sought after.

"Also, the ability to recognize speech is known to vary largely from one person to another and much remains unsolved. For example, you can hear your name mentioned somewhere all of a sudden even when you are talking to someone in a noisy environment, a phenomenon known as the 'cocktail party effect.' Individual differences in perception mean that there is much more to be understood about the physiological details of pitch perception. To address these questions, it is necessary to collaborate with researchers from the engineering field, which will greatly help to formally characterize the acoustic details of speech."

In order to learn the methods used in signal processing, Dr. Sugiyama has sat in on an applied mathematics class together with second year students and gets help from a student whenever she has questions from the class. Dr. Sugiyama's challenge continues.

(Reporter & text writer : Madoka Tainaka)



I changed my specialization to phonetics while studying in the U.S. Encounters with people from diverse fields helped to deepen my academic pursuit.

As a junior high school student, Dr. Sugiyama was first exposed to English and became interested in differences among languages, which paved the way for going into linguistics. She went on to graduate school in the United States to study semantics, but her interest soon shifted to phonetics. She was attracted to phonetics because, unlike other areas in linguistics, the target of analysis, waveforms, has a physical reality, which can be objectively separated from the analyzer. Upon returning to Japan, she joined her alma mater Keio University, where she currently serves as an English language teacher while also conducting research in an interdisciplinary environment.

How did you spend your childhood?

Born in Aichi Prefecture, I was raised in a family of four: parents, a younger brother and myself. When I was young, I was a going-my-way type of precocious girl who would say, "I'm attending kindergarten just to kill time," which surprised adults around me (*Laughter*). I was bad at group activities such as collective playing/dancing and practicing for an athletic event. Speaking of my personality, while I am similar to my mother in some aspects, I have much more in common with my father. With an engineering background, my father worked for an electrical manufacturer. I guess I can say I overlap with him to some extent career-wise as well.

Did you have difficulties because you were bad at group activities?

I attended private school offering combined junior and senior high school education, where I was comfortable thanks to its liberal school culture.

I became interested in English when I first learned it in junior high school. This is the origin of my interest in language. I must also mention the book titled "*kotoba to bunka* (English title: Words in Context)" authored by Takao Suzuki, some of which was cited in a textbook I used in high school. I was inspired by cultural differences found in different languages.

For example, Japanese vocabulary is relatively limited regarding manners of motion such as "walk" and "run." By contrast, English vocabulary is very rich. In addition to "run," it has words such as "scurry," "scuttle" and "trot," which express minute differences in terms of how these motions are carried out. On the other hand,

Japanese vocabulary is quite rich in mimetics. The world may look different due to differences in the ways different languages express things. This aroused my interest in languages.

I entered Keio University wishing to learn about languages from a scientific point of view. Although Keio had no independent linguistics department, it offered linguistics studies within general education. In fact, a variety of linguistics-related classes were available. Another advantage was that I was able to take classes of professors from the Institute of Cultural and Linguistic Studies on the Mita Campus.

Did you take part in any club activities?

I first joined the Keio English Speaking Society club, but I quit after only one year because it was a little too time-consuming. Practices and stage-making work for the inter-college English theatrical performance contest took so much time. Then I joined an inter-college international exchange organization. At the organization, we organized camps and invited students from foreign countries to discuss various international issues. Through the organization's exchange programs, I visited the Philippines and Norway myself. These activities were valuable opportunities for me to directly learn about foreign cultures and how people with different backgrounds communicate with others.

Was it your initial intention to choose a researcher's career?

Not at all. I had been thinking that I would find employment at a corporate company upon graduation. But near the end of the third year, when students in Japan start job hunting, I just didn't feel that way. At the same time, I did not know if I could do anything to contribute to the society as a researcher. When I talked to my academic advisor, he said, "At the beginning, I myself was not confident that I could become a respectable researcher but dared to advance to graduate school. So, if you are interested in an academic career, why not pursue it?" With this advice, I made a decision to go to graduate school. Although my mother was originally against my going on to graduate school and going abroad to study, I finally convinced her (or I had her give up, you might say). In the summer of the year I finished college, I flew to the United States to study at the University at Buffalo, the State University of New York (SUNY at Buffalo).

There were three reasons for why I went to the U.S. to study linguistics. First, there were practically no universities in Japan where I could learn linguistics systematically. Second, when I was taking linguistics classes at Keio, many of the professors who taught me had their Ph.D. from graduate school in the U.S.. Third, the linguist I wanted to work with at the time was at SUNY



Speech is something very familiar in our daily lives, yet its research requires a lot of knowledge from various disciplinary fields. Elaborate elements of human cognitive functions are capsulated in what we speak or hear.

Yukiko Sugiyama

is a linguist who specializes in phonetics. Mainly using Japanese as the target language, she studies speech communication by analyzing speech data and conducting perception experiments. She was born in Aichi Prefecture and completed her bachelor's degree in English and American literature at Keio University. She completed her master's course in linguistics at University at Buffalo, the State University of New York, and obtained her Ph.D. in linguistics in 2008 from the same institution. In 2009, she joined Keio University as an assistant professor at the Department of Foreign Languages and Liberal Arts, the Faculty of Science and Technology. She is also a member of the Institute of Cultural and Linguistic Studies at Keio University. In 2016, Dr. Sugiyama was promoted to her current position as an associate professor. In 2017, she was honored with the Best Lecturer's Award.



at Buffalo.

In the beginning, I was interested in semantics. However, my interest gradually shifted to phonetics, my current research theme. With semantics, I often found it difficult to analyze the data objectively because my judgement intervened in the analysis. By contrast, approaches used in phonetics were clear-cut because no matter how subjective you might become (you should try not to though), the object that you deal with has a physical reality. The object of analysis is clearly separated from the analyzer.

Studying in the United States brought with it a number of valuable encounters. There was an overseas student who came from Togo on a scholarship from her government. When I saw her very humble lifestyle, I could really feel my privileged environment. On another occasion, a student from Saudi Arabia told me about the strict control of freedom of speech in his country. Through these experiences, I literally felt the diversity of countries and their cultures.

My research life in Buffalo lasted as long as nine years partly because I shifted my specialization to phonetics along the way. I returned to Japan in 2008.

After serving as a part-time lecturer for Waseda University, I joined Keio University in 2009

My affiliation at the Faculty of Science and Technology has been an advantage in terms of my research as well. Last year, I sat in on an applied mathematics class to learn the basics of signal processing, such as the Fourier transform, and asked one of the students who took my class before to help me keep up with the class. In this faculty, students and the faculty members work closely and they take good care of their students.

My return to Keio has also provided me with delightful opportunities to work together with Prof. Masumi Kindaichi (now an Emeritus Professor), who was a lecturer for an NHK Russian language program on the radio, which I listen to as an undergraduate, and Prof. Kyoko Ohara, who I asked for advice before going to the United States to study.

For the past several years, I have been helping out with the

workshop called “My Voice” which Prof. Shigeto Kawahara at the Institute of Cultural and Linguistic Studies organizes. This workshop introduces how to use “My Voice,” software which can be downloaded free on the Internet. With this software, you can communicate with your family using your own voice even if you have lost your voice or cannot speak due to illness. You will need to record your voice (vowels and consonants) beforehand though.

In your daily life, you may seldom become conscious of your own voice, but it is a very important part of your identity. Through this workshop I've come to think so more strongly than before. I'd like more people to know “My Voice” and make good use of it.

How do you spend your days off?

I refresh myself mostly by trail running and climbing mountains. In short, trail running is running in mountainous areas. My favorite places not far from where I live are the Takao and Tanzawa mountains. I plan several routes beforehand using a map, and leave home early in the morning to go trail running. It's really refreshing to run through scenic areas in a superb natural environment.

◎ Some words from students . . . ◎

● Interest in “voice” led me to take Dr. Sugiyama's class. She is gentle but passionate when teaching us. One of the examples of her unique teaching style is that she sometimes lets students play the role of teacher. Meanwhile, she enjoys the students' class together with other students. Dr. Sugiyama introduced the “My Voice” workshop to me, which I'm helping with editing the recorded speech. Collaboration with medical doctors and occupational therapists is expanding my view of the world.

(Reporter & text writer : Madoka Tainaka)

For the full text of this interview . . .

<http://www.st.keio.ac.jp/kyurizukai>

Yukiko Sugiyama's

ON and OFF

Both in ON or OFF hours,
I'm always amid cheerful voices.



"My Voice"

I'm helping with the workshop called "My Voice" organized by Prof. Shigeto Kawahara of the Institute of Cultural and Linguistic Studies. "My Voice" is free software designed to read text using the sampled voice of your own. This software allows you to use your own voice to communicate with your family members even if you have become unable to speak due to a disease such as amyotrophic lateral sclerosis (ALS). <http://heartyladder.net/xoops/>

Craft making

I enjoy making things by hand, items like *kanoko shibori* (tie-dyed cloth), *chinkin* (gold-inlaid laquerware), a basket, nanoblocks, and etc. But recently I've been avoiding this hobby partly because I don't have enough room to put all these things and I try not to abuse my eyes as much as I can.



Cross-country skiing

In the past three years, I visited Kijimadaira Village in Nagano Prefecture to learn cross-country skiing. But in reality, it's more like just playing in the snow rather than seriously learning it. As such, my skill hasn't improved as expected. I can enjoy the superb silver-white world on fine days.

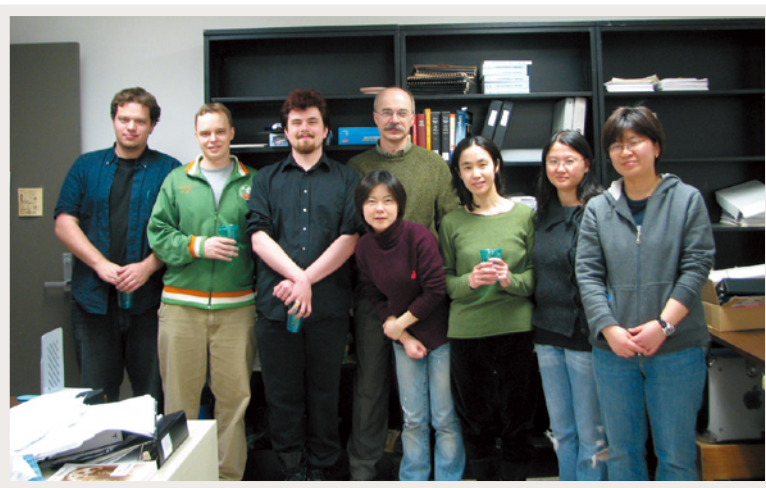


Global Leadership Seminar (GLS)

In our Global Leadership Seminar, we go on a field trip during summer and spring holidays. In spring, we visit Tamkang University in Taiwan. Groups of five to six students (Taiwanese and Japanese mixed) make presentations on a given theme. Even after the session, some students stay in contact and visit each other.

Mt. Yarigatake

This photo was taken when I climbed Mt. Yarigatake during the Golden Week holidays in May this year. I put on crampons and climbed up the steep slopes provided with chains and ladders, while stabbing an ice ax into the frozen snow to maintain balance. I found a surprising amount of snow remaining near the summit when I got there. Shown in photo is the Yarigatake cottage area as viewed from near the summit. Despite my fear of heights, I found myself on the summit before I knew it.



Buffalo

Taken in Buffalo, this photo shows me posing together with my advisor Prof. Jim Sawusch and several students who worked with him at the time. I was a student in the Linguistics Department and Prof. Sawusch belonged to the Psychology Department. Although it is unusual for a professor from a different department to be a primary advisor for a dissertation, I asked him to be so because he was a specialist in speech perception.

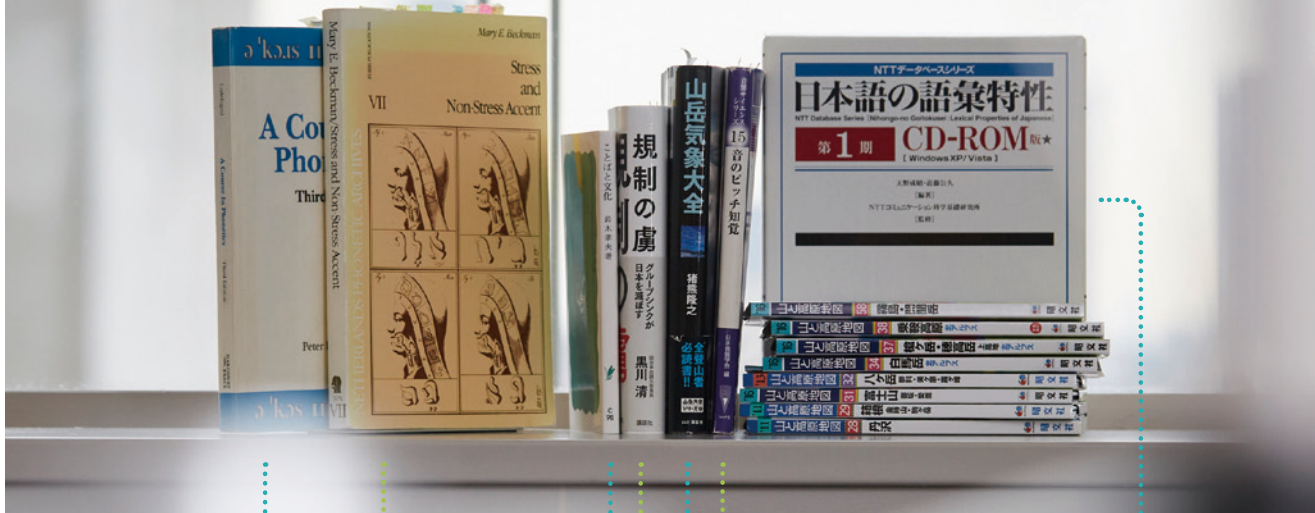


Utsukushigahara Trail Running Race

This photo was taken in 2015 when I ran a trail running race in Utsukushigahara together with my friends. We live in different places and have different jobs, but we became acquainted through running. Not only do we enjoy the race itself, but we also have fun spending time together.

私の 本棚

My favorite books



Too famous a phonetics book

● A Course in Phonetics

Not only phoneticians but also anyone who has studied linguistics in North America knows this book. The author is famous for having supervised pronunciation and phonetic notation for the movie "My Fair Lady" released in 1964. On the website of this book, you can listen to speech sounds of various languages of the world (<http://www.phonetics.ucla.edu/index.html>).

How are Japanese sounds different from English ones?

● Stress and Non-Stress Accent

This is one of the origins of my interest in phonetics. It's truly trailblazing research, empirically comparing the characteristics of Japanese pitch accent and those of English stress accent in terms of acoustics as well as in terms of functions. It's a difficult book to understand. As a graduate student, I read it desperately and repeatedly discussed it with my advisors and colleagues.

Mysteries of Japanese organizations

● Kisei no toriko—grouptink ga nihon o horobosu [Regulatory Capture: Groupthink Destroys Japan]

While living in the United States as a graduate student, I interacted with a number of students from various countries. This made me realize that Japan is such a nice country to live in and that Japanese people are economically privileged. At the same time, as this book and the book "Shippai no hoshitsu [The Essence of the Failure]" point out, I am often puzzled by why some leaders in Japan behave in the way they do, like not taking responsibility for their decisions, their tendency to think only of immediate profit without having a grand design, and their unreasonable optimism which lacks a sense of crisis management.

How language affects the way you see the world

● Kotoba to bunka [English title: Words in Context]

An excerpt of this book appeared in my high school textbook of modern Japanese. I was fascinated to learn that language and culture are so closely related that the way you see the world may be different if the language you speak is different. Takao Suzuki, the author, was once the head of the Institute of Cultural and Linguistic Studies on the Mita Campus, of which I am currently a member. It was a great honor to have had the opportunity to talk to him in person after I came to Keio.

Wonders of the human body

● Oto no picchi chikaku

[English title: Pitch Percept of Tone]

Pitch refers to the percept of a fundamental frequency. Japanese is called a pitch accent language, in which words are distinguished by the height of tone in addition to vowels and consonants. Typical examples are "hashi (chopsticks)" and "hashi (bridge)" in standard Japanese. You may think that pitch perception is very easy and almost automatic, but many mysteries still remain about its mechanism. The human body is full of mysteries.

Alpine climate is a lot of fun!

● Sangaku kisho taizen

[The Complete Book of Alpine Climate]

Alpine weather changes quickly. Having good knowledge of weather helps you avoid accidents in mountains. I started reading this book hoping to avoid weather-induced accidents, but as I kept reading, I became more and more interested in weather itself. However, the more I learn, the more I realize how complicated it is, only to think that it is out of reach for an amateur like myself.

The definitive version of the Japanese language database!

● Nihongo no goitokusei

[English title: Lexical Properties of Japanese]

This is a database rather than a book. The speed and accuracy with which you recognize a word are subject to factors such as how familiar you are with the word and the number of words that sound similar to that word. Therefore, these factors need to be controlled when conducting experiments. This database is very valuable because it contains detailed vocabulary information of some 100,000 Japanese words.

Why do we study foreign languages?

Yukiko Sugiyama

What are your reasons for studying foreign languages? Because these are required classes? Because foreign language proficiency is an advantage for finding employment? Or because we are in an age of globalization?

As an English language teacher, I would like my students to become competent in English so that they can use it as a convenient communication tool. More importantly, I would like them to experience the fun of learning a language itself.

For example, among the many languages of the world, there are languages that have only three vowels. On the other hand, there is a language that is said to have nearly 40

vowels. English has three cases, namely the nominative case, the objective case and the possessive case. The Finnish language has as many as 15 cases. Speaking of numbers, English has a distinction between singular and plural nouns in addition to the distinction between countable and uncountable nouns. Furthermore, some languages make a three-way distinction between countable nouns: dual numbers in addition to singular and plural numbers. By contrast, in Japanese, the distinction between singular and plural nouns is very vague. With still another language, the speaker must indicate the information source (the speaker himself/herself saw it, or he/she heard it from another person, etc.) about the content of the utterance. These are only a few examples of how languages can differ from one another. I cannot help being amazed at the diversity of

languages.

Whether you like it or not, or whether it's right or wrong, it's undeniable that English is now the common language of the world. Although it may seem strange for me to say this, given that I am an English language teacher, I don't like to see foreign language learning being narrowed down only to English.

Not only does each language have its own grammar and sounds, but it also reflects the values and culture of the place where it is spoken. Whether or not you become proficient in a language, the more you learn about it, the deeper its world becomes, thus stimulating and satisfying your intellectual curiosity.

Everyone, please do not let yourself fall into utilitarianism. Instead, expose yourself to various languages in the world.

Science and Technology Information

A new attempt of our faculty

“Faculty briefing sessions” targeting high school student guardians

Ever accelerating globalization and advancement in IT characterize our modern business scenes. This calls for young people to have capacities and human qualities, such as: (1) good at mathematics; (2) advanced programming skills and IT literacy; (3) good at negotiations in both Japanese and English; (4) a far-sighted decision-making ability; and (5) a personality loved by everyone. We must remember that university education that was successful in the past does not necessarily mean success in the future.

To meet these requirements of the times, Keio University's Faculty of Science and Technology is addressing a variety of new attempts.

To explain our initiatives in this respect,



from this academic year we began offering briefing/open-campus sessions targeting guardians of prospective high school students in addition to open-campus sessions targeting high school students wishing to join our faculty as freshmen. To promote open-campus sessions not only for Keio High School students but for students from outside as well, our faculty delivers messages to guardians through lectures by the Dean and PR department manager while offering opportunities for guardians to look around the Yagami Campus where our faculty is located.

Being a new attempt, it was extremely difficult for us to estimate the number of participating guardians. But once the session opened, we found participating guardians number about a half that of the prospective students, to our pleasant surprise. Also, many husband-and-wife couples participated. The Q&A session following the briefing was also very active. We were confident of success of the open campus as it made the participants feel the advanced nature of the Yagami Campus.

In the days ahead, the Faculty of Science and Technology will continue to supply information through briefing and open-



campus sessions. We will deliver information about these events on our faculty website on a regular basis. Please check it if you are interested.

<http://www.st.keio.ac.jp/>

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Editor's postscript

A person full of energy in spite of her petite figure – this was the first impression of Dr. Sugiyama. However, I must say that her overflowing energy was not overpowering at all but was something like brightly shining sunlight. I saw her as a person capable of attentive consideration for others and the environment around her, which is very attractive. She claims trail running to be a mere hobby but it's surely beyond the level of a hobby. With a bright smile, she said, “Route planning itself is also fun.” I was convinced that students love and respect her because of this splendid personality. (Ayumi Higuchi)