DEVELOPING A SYSTEM TO ASSESS THE SKILLS OF JAPANESE WAY OF TEA BY ANALYSING THE FORMING SOUND: A CASE STUDY

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The Japanese way of tea is one of the most traditional activities to treat and serve guests with "*matcha* tea" The manner to serve and the procedure for making a bowl of *matcha* tea are assumed to be the art performance and they are called "*otemae.*" Particularly, the skills of making *matcha* tea are one of the important factors that affect the taste of *matcha* tea. The purpose of this study is to develop a system to help beginners' learning of *otemae*. As the first step, in this study, we investigated the sound generated by the expert when makeing the *matcha* tea, and the possibility of estimating each step from the sound. As a result, our method could detect each step of procedure for making *matcha* tea from the envelope of the sound when the expert makes a bowl of *matcha* tea. Our method could also detect the differences of sound among the types of tea whisk.

INTRODUCTION

The Japanese way of tea, called "*Sado*" or "C*hado*" in Japanese, is one of the most traditional activities to treat and serve guests with "*matcha* tea (finely powdered green tea)." The manner to serve and the procedure for making a bowl of *matcha* tea are assumed to be the art performance and they are called "*otemae*" (Fig. 1). Particularly, the skills of making *matcha* tea are one of the important factors that affect the taste of *matcha* tea.

In *otemae*, the *matcha* powder is put into a tea bowl and hot water is poured on it. The *matcha* powder and hot water are whipped using a tea whisk made of bamboo, until the *matcha* tea becomes frothy. It takes years to master the making of good foam on the *matcha* tea. In a previous study, actually, Tujimoto et al. reports that the size of bubbles foamed on the *matcha* tea made by experts was smaller than those made by non-experts [1].

However, as the tea bowl is made of ceramic and the color of the *matcha* tea is dark green, we cannot observe how the experts foam fine bubbles with the tea whisk under the water surface level in the tea bowl. The experts themselves categorize their procedures for making the *matcha* tea in four steps as follows:

(1) Mix the *matcha* powder and hot water
(2) Foam the *matcha* tea
(3) Continue making smaller and smoother bubbles
(4) Finish up by drawing a circle with the tea whisk in the tea bowl

Experts also report that they feel the state of the *matcha* tea through the tea whisk, which gives a cue for them to proceed to the next step. However, it is very difficult even for the experts to describe in detail what they actually feel through the tea whisk, and therefore it is difficult to teach.

Figure 1. Performing "*otemae*"

The purpose of this study is to develop a system that helps beginners' learning of *otemae*. As the first step, in this study, we investigated the sound generated by the expert when making the *matcha* tea and the possibility of estimating each step from the sound. If the sound is available, we may become, in the future, able to assess the learners' level of skills by comparing such sound with that of the experts, and help learners make a faster progress. In the fields of learning language and music performance, researches are also proceeding with method of training using sound information in order to learn efficiently [e.g. 2, 3]. The biggest advantage of the assessment by sound is that recording the sound is easier than capturing the motion, and there is no need to attach any devices and sensors to their body.

In addition to this, we compared the difference in sound among the types of tea whisk. Because the shape of tea

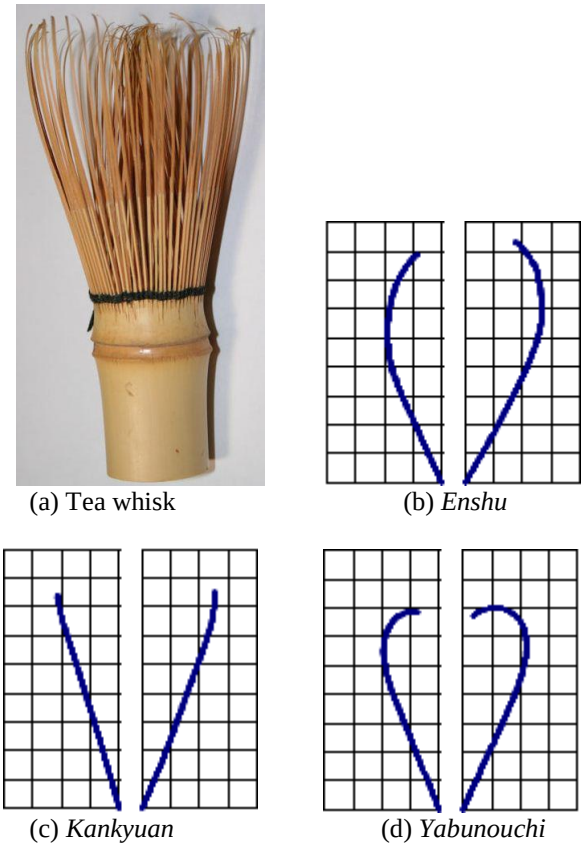


Figure 2. Top left panel (a) shows a picture of a typical tea whisk. Other three panels show the shape of the upper side of three tea whisks in section that were used in our experiment.

whisk differs according to schools (Fig. 2), there is the possibility that the experts may change the way they use the tea whisk according to its shape. If there are any differences, the system has to be designed to distinguish the shapes of tea whisk, or use properties that would be independent of the shapes of tea whisk as an index to assess them.

EXPERIMENT

To estimate how the experts feel the state of *matcha* tea through the tea whisk, the sound generated by the expert when making the *matcha* tea was recorded. At the same time we observed the differences of sound depending on the shapes of tea whisk.

Participant

Participant was one of grand tea masters in the "*Urasenke*" school. The number of years of experience is over 30.

Apparatus

The sounds were recorded digitally, using a liner PCM (Pulse Code Modulation) recorder (LS-10, Olympus). The internal microphone of this linear PCM recorder was used.

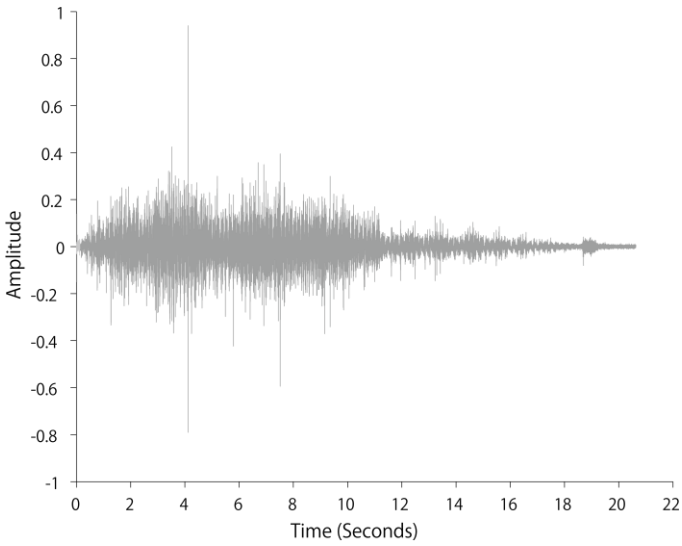


Figure 3. An example of waveform when the expert made a bowl of *matcha* tea with the *Enshu* tea whisk.

The sampling frequency was 44,100 Hz and quantization bit rate was 16 bit. The recordings were performed in a soundproof room. The floor of the soundproof room was covered with *tatami* mats (thick straw mats) to make it closer to the usual environment as much as possible. In addition to this, the whole experiment was recorded by video.

A complete set of tea things that is most commonly used was prepared. The brazier to boil water was powered by electricity to keep the temperature of hot water constant. The three differently-shaped tea whisks were prepared (Fig. 2). The names of each tea whisk are "*Enshu*", "*Kankyuan*" and "*Yabunouchi*" respectively.

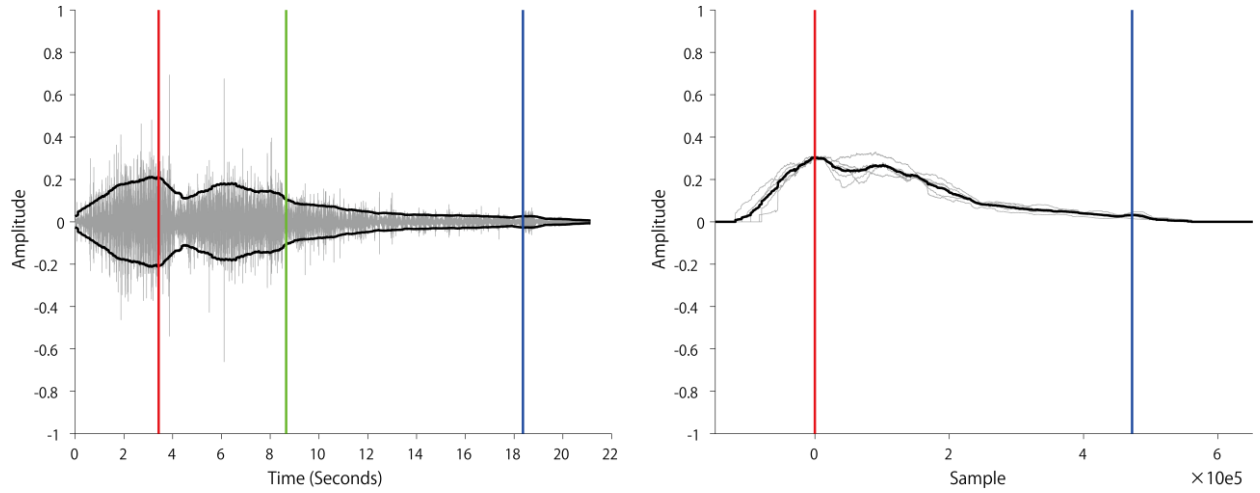
Procedure

The expert performed *otemae* as usual and made five bowls of *matcha* tea with each type of tea whisk. The order of the tea whisk used was randomized. The total number of trials was 15. The amount of *matcha* powder was 3 grams.

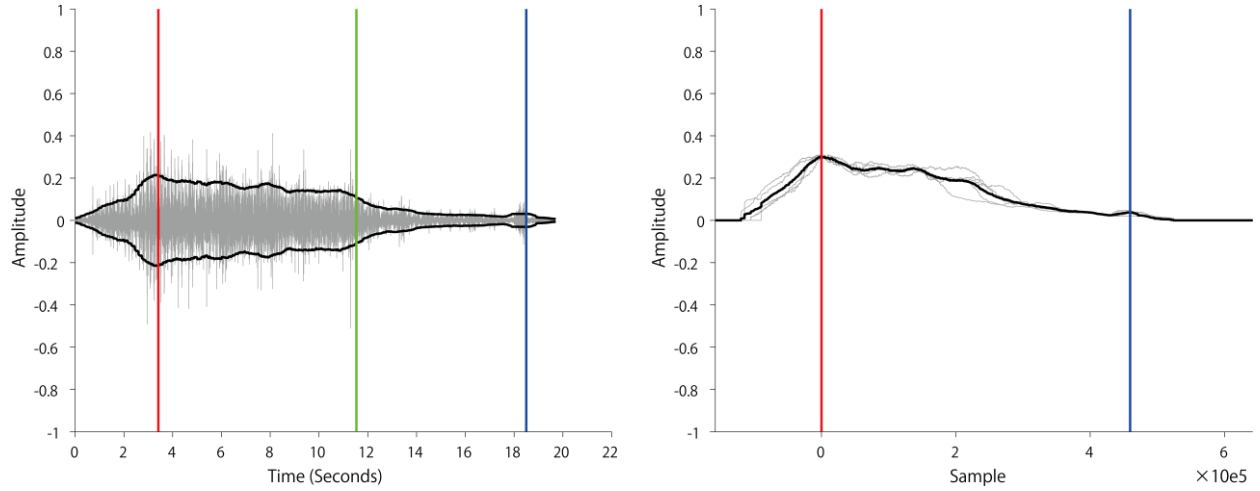
RESULTS

Figure 3 shows an example of waveform when the expert made a bowl of the *matcha* tea with the *Enshu* tea whisk. There are four observable points as follows:

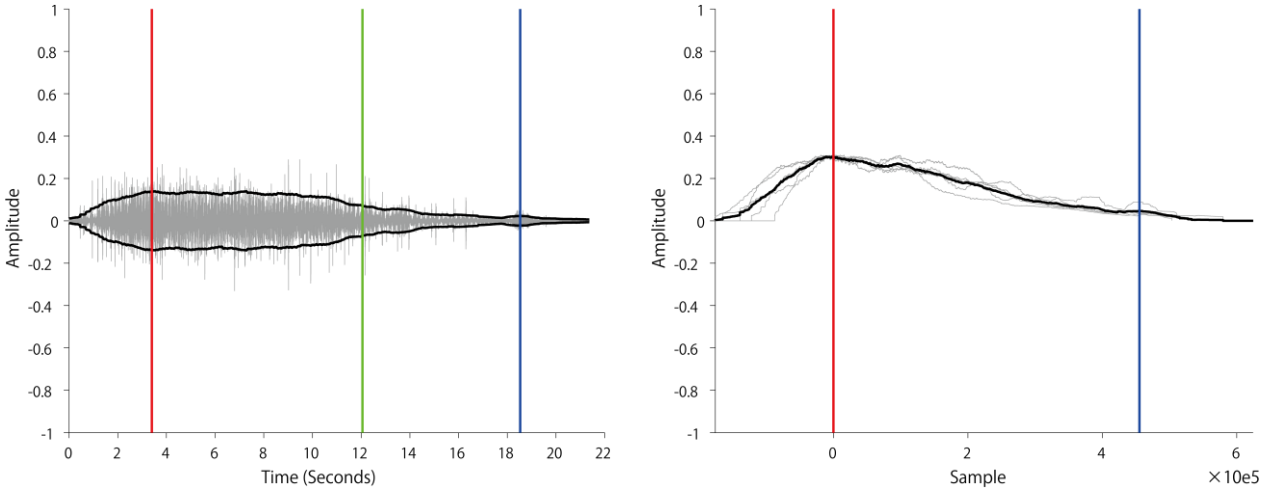
(1) The amplitude increased for about the first four seconds and reached the first peak.
(2) Between about 4 and 10 seconds, the amplitude was almost steady.
(3) Between about 10 and 12 seconds, the amplitude decreased rapidly, and after that it decreased gradually until the time it reached about 19-second.
(4) Between about 19 and 20 seconds, the last small peak appeared.



(a) *Enshu*



(b) *Kankyuan*



(c) *Yabunouchi*

Figure 4. The left panels show original waveforms (gray lines) and the typical envelopes (black bold lines) of each tea whisk condition. The red vertical line indicates the first peak. The green vertical line indicates the time when the amplitude decreased the half of the first peak. The blue vertical line indicates the last peak. The right panels show the standardized envelopes of all trials (gray lines) and the averaged standardized envelope (black bold lines) for each tea whisk conditions. The red vertical line indicates the first peak. The blue vertical line indicates the last peak.

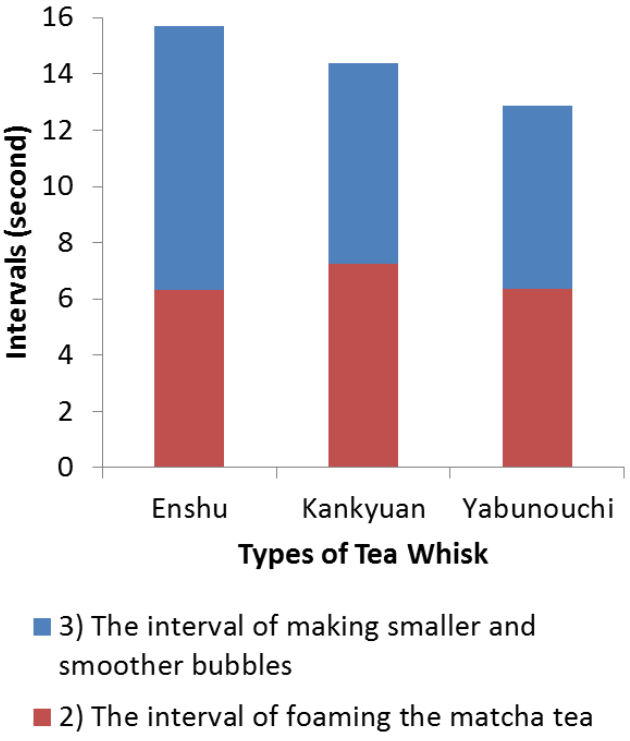


Figure 5. 2) The intervals of foaming the *matcha* tea and 3) making smaller and smoother bubbles for each type of tea whisks.

It appears that each point corresponds to each step of procedure in making the *matcha* tea respectively, as we mentioned in the introduction.

To observe the further details, the envelopes of waveform in each trial were obtained (Fig. 4) by calculating the root mean square (RMS) power of waveform. The range of RMS was 44,100 samples (1 second) and the RMS powers were calculated per one sample point (Fig. 4, the left panels). Figure 4 shows the typical envelopes for each tea whisk condition. The red vertical line indicates the first peak. The green vertical line indicates the time when the amplitude decreased by half of the first peak. In this paper, we defined the interval between the red and the green vertical lines as the second step of the procedure as (2) the intervals of foaming the *matcha* tea in Figure 5. The blue vertical line indicates the last peak. We further defined the interval between the green and the blue vertical lines as the third step of the procedure as (3) making smaller and smoother bubbles in Figure 5. We also defined the interval between the first peak and the last peak as (2+3) the interval between the first and the last peaks.

To compare the differences among the types of tea whisk, one-way factorial ANOVA (Analysis of Variance) was performed where the tea whisk condition was treated as the main factor.

As a result, for (2) the interval of foaming the *matcha* tea, there was no significant difference among the types of tea whisk. However, for (3) the interval of making smaller and smoother bubbles ($F(2, 14) = 9.02$, $p < .01$) (Figure 5, blue bar), and for (2+3) the interval between the first and the last peaks ($F(2, 14) = 5.73$, $p < .05$), the types of tea whisk showed a significant difference.

To investigate the detailed differences among the three types of tea whisk, we performed an ad-hoc multiple comparison using the Tukey-Kramer HSD test, in which the significant level was adjusted. As a result, (3) the interval of making smaller and smoother bubbles of *Enshu* tea whisk was significantly longer than that of *Kankyuan* and *Yabunouchi* tea whisks. Also, (2+3) the interval between the first and the last peaks of *Enshu* tea whisk was longer than that of *Yabunouchi* tea whisk.

To observe the unified differences among the three types of tea whisk, the envelopes were standardized by adjusting the number of sample point between the first peak and the last peak, and the maximum value of the first peak at 0.3 (Fig. 4, the right panels, gray lines). Also, the averages of the standardized envelopes for each tea whisk condition were calculated (Fig. 4, the right panels, black bold line).

For *Enshu* tea whisk, the averaged standardized envelope had a concave of around $5 \times 10e4$ sample points. On the other hand, the averaged standardized envelope of *Yabunouchi* tea whisks decreased really smoothly. For *Kankyuan* tea whisk, the averaged standardized envelope was the shape between that of the *Enshu* and the *Yabunouchi* tea whisk conditions.

DISCUSSION

It appeared that each step of procedure in making *matcha* tea was corresponded to each property of the sound envelope generated by the expert when making *matcha* tea. Of course, it is difficult to identify the exact step of each procedure. However, proceeding to the next procedure would be gradual. Therefore, our method could provide one of the indices to assess learners' skills.

Our method could also detect some differences among the types of tea whisk. For *Enshu* tea whisk, (3) the interval of making smaller and smoother bubbles was significantly longer than that of *Kankyuan* and *Yabunouchi* tea whisks. The previous study actually reported that *Enshu* tea whisk took a longer time to foam fine bubbles than that of other two tea whisks [1]. (2+3) the interval between the first and the last peaks of *Enshu* tea whisk was longer than that of *Yabunouchi* tea whisk. For (2+3) the interval between the first and the last peaks, *Kankyuan* tea whisk had the length being between *Enshu* and *Yabunouchi* tea whisks. The previous study also reported that the length of time to foam fine bubbles using *Kankyuan* tea whisk was between *Enshu* and *Yabunouchi* tea whisks [1]. These correspondences of the results suggest that our method could estimate the approximate steps of procedure in making *matcha* tea.

As there were differences among the types of tea whisk, the system to assess learners' skill was required to know the types of whisk preliminarily. In that case, we have to prepare the database for all types of tea whisk. However it would be difficult because there are so many types of tea whisk. If there are some relationships between the shape of tea whisks and the time to foam fine bubbles, there is no need to prepare the database for all types of tea whisk. As the next

step, we have to investigate the relationship between the shape of tea whisks and the time to foam fine bubbles.

In this study, the participant was the only expert. To develop the system to assess learners' skills, we have to investigate the differences between experts and non-experts. Our method could detect very small differences, for example, the difference among the types of tea whisk. However, non-experts, especially the beginners, would not understand that kind of small differences. To compare the differences between experts and non-experts, we have to find more meaningful differences useful to beginners as well.

CONCLUSION

The purpose of this study is to develop a system that helps beginners' learning of *otemae*. As the first step, in this study, we investigated the sound generated by the expert when making the *matcha* tea and the possibility of estimating each step from the sound.

As a result, our method could detect each step of procedure for making *matcha* tea from the envelope of the sound when the expert makes a bowl of *matcha* tea. Also, Our method could also detect the differences of sound among the types of tea whisk.

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