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# Contribution of ultrasound visualisation to improving the production of the French /y/-/u/ contrast by four Japanese learners

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The goal of our study is to test if ultrasound visualisation serves as a useful feedback tool in helping Japanese learners of French to better produce the phonemic contrast /y/ - /u/.

## Introduction

It has been widely shown that the vowel system of the first language (L1) has a significant impact on the acquisition of the vowels of second languages (L2). Front rounded vowels are known to cause difficulty to speakers of languages without such vowels, and consequently the realisation of front-back contrast poses a challenge (Flege, 1987; Rochet, 1995; Levy & Law 2010, inter alii).

The high front rounded /y/ and the high back /u/ are phonemically contrasted in present-day Parisian French, and achieving this contrast is of great importance for learners of L2 French. It was shown that native speakers of Tokyo Japanese tend to produce the French /u/ with a higher F2 than French speakers, which is rather perceived as /ø/ by native listeners of French (Kamiyama & Vaissière, 2009). This is related to the nature of the high non-front /u/ in Tokyo Japanese, commonly transcribed [u]. From the acoustic point of view, it shows a higher F2 (> 1000 Hz) than the French /u/ and from the articulatory point of view, the tongue is less far back and the lips are less rounded than the French /u/ (Bothorel *et al.*, 1986; Uemura & Takada, 1990).

It is therefore necessary for Japanese-speaking learners of French to position their tongue as far back as native speakers of French do when producing /u/. However, because back tongue position cannot be typically observed during speech, the nativelikeness of it is usually assessed by perceptual evaluation only. On the other hand, ultrasound tongue imaging, which is the most non-invasive, safe, quick and low-cost technique used to observe tongue during speech, allows direct and real-time control over tongue position, and for this reason it was hypothesised that ultrasound visualisation may help L2 learners to acquire the necessary tongue positions. In order to test this assumption, a series of 3 training sessions using ultrasound image feedback were conducted with 4 Japanese-speaking learners of French. Below, we present data of two of these participants, as well as data from two control Japanese-speaking learners of French who did not receive ultrasound training.

## Method

All Japanese participants were intermediate (B2 and B1, respectively) learners of L2 French, attending a 12-week French pronunciation course in Paris. All were adult females (31-33 years old), native Japanese speakers (born near Tokyo), and they all started learning French as adults and lived in France. Additionally, one 42-year-old female French speaker (NS) was recorded to obtain native speaker data.

Two of the presented speakers, AK and CS, received three 45-minute training sessions in which ultrasound was used as a visual aid in controlling the tongue position to achieve the target vowels. The training began with isolated vowels, progressed to non-words with different phonetic contexts, real words and short sentences. The exact protocol was adjusted to the proficiencies and preferences of each participant. In contrast, speakers, YSG and YF, did not receive any training with ultrasound and served as control subjects.

In order to inspect the differences in the articulation of [y] and [u], ultrasound and acoustic data were recorded at the same time, with the two signals synchronised, using Articulate Assistant Advanced software (Articulate Instruments Ltd, 2008). Participants wore a special headset to stabilise the probe under the chin and to secure the same scanning view during the recording session. Participants AK and CS were recorded three times: at the beginning of the pronunciation course before the first ultrasound

training session (pre-training: R1), one week after the last training session (post-training: R2) and two months after the post-training recording (follow-up: R3). Participants YSG and YF were recorded twice: at the beginning and at the end of the pronunciation course. The native French speaker was recorded only once.

The corpus consisted of ten repetitions of (1) [y] and [u] in isolation, as well as [a], [i] and the Japanese [u] (only in post-training), (2) alternation between [y] and [u], (3) disyllabic non-words CVCV where V is /y/ or /u/, and C is /p/, /t/ or /k/, (4) 28 real words and (5) four sentences. In this paper, only the results of isolated vowels are presented.

The acoustic data, recorded at 22050 Hz, 16 bits, were subjected to the analysis of the first four formants, measured at 25%, 50% and 75% of vowel duration. This allowed inspecting the vowels in F1/F2 plots, measuring the Euclidean distance (ED) in order to quantify the degree of realisation of the contrast, and to calculate the difference between F3-F2 for [y] and F2-F1 for [u] (Georgeton *et al.*, 2012). The ultrasound data allowed visualisation of tongue positions and comparison between [y] and [u] at the three recording sessions. It is important to note that individual tongue curves can be compared only within the session and not between them as the probe cannot be positioned exactly at the same place in different recordings. Additionally, the end points of the curve do not mark the end point of the tongue (especially the tip of the tongue) but the end points of the visible tongue on an ultrasound image.

## Results

First, the acoustic data of NS are similar to those of the 40 female native speakers of French in Georgeton *et al.* (2012).

### Speakers with ultrasound training (experimental group)

Overall, both acoustic (Figure 1) and articulatory data (Figure 2) show improvement in the [y] – [u] contrast for these two Japanese learners (AK and CS).

F1-F2 acoustic spaces of [u] and [y] almost overlap at R1 for both learners, but are distinct at R2 and R3 as shown by considerably significantly greater ED (Figure 1: for ED: independent t test for AK: 1. between R1 and R2:  $t_{29}=-2.3$ ;  $p<0.05$ ; 2. between R2 and R3:  $t_{29}=-3.4$ ;  $p<0.01$ . Independent t test for CS: 1. between R1 and R2:  $t_{29}=-4.4$ ;  $p<0.0001$ ; 2. between R2 and R3:  $t_{29}=-2.1$ ;  $p<0.05$ ). Similarly, both learners articulate [u] and [y] almost at the same place in the oral cavity at R1 but show more separation between the tongue contours at R2 and even greater distinction at R3 (Figure 2). This change is especially visible for AK who approaches NS at R3 both in the ED and in the tongue positions.

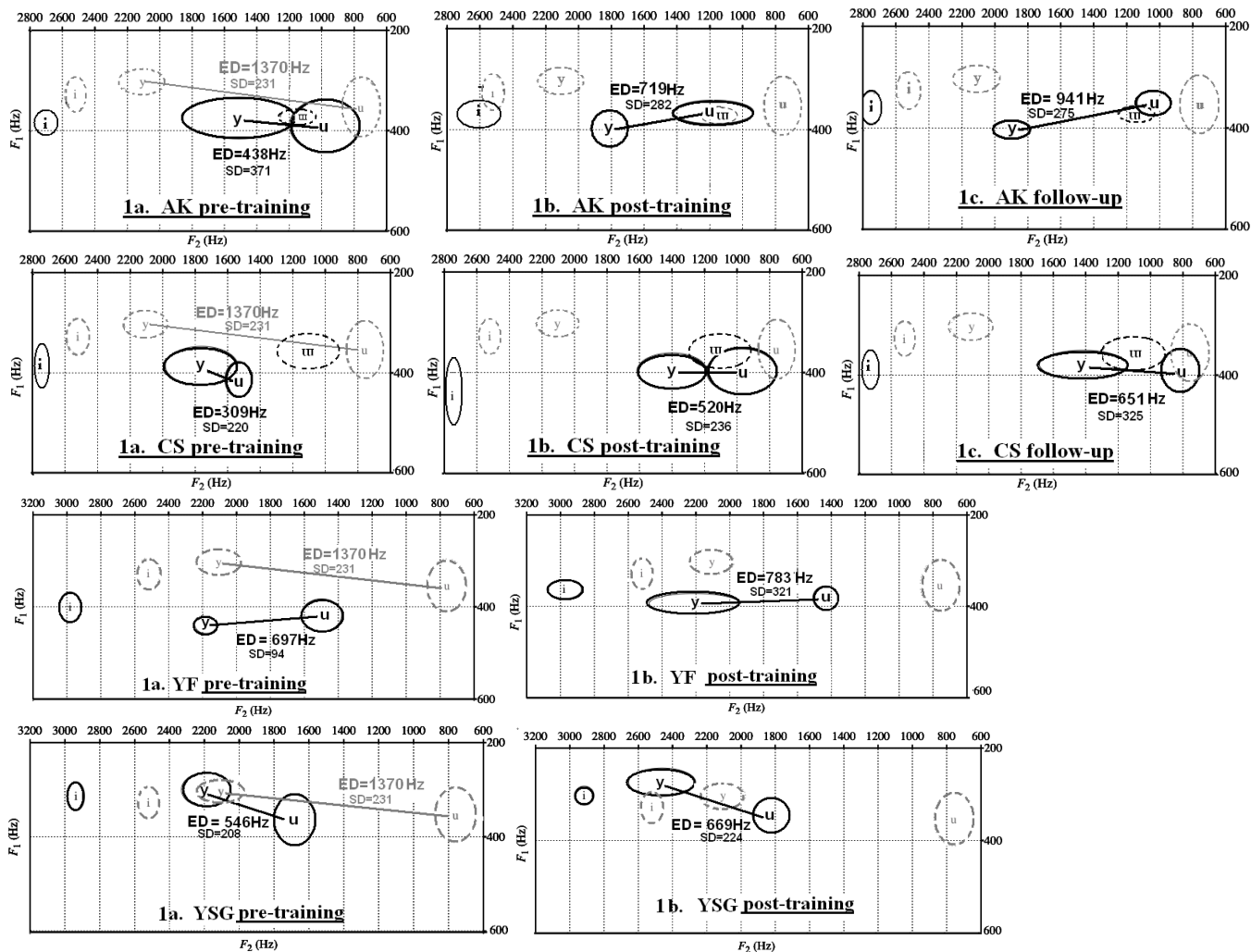
Interestingly, the two learners achieved articulatory distinction between the two vowels differently. While the decrease in F2-F1 distance for CS suggests that [u] is steadily posteriorised from R1 to R3, the decrease in F3-F2 distance for AK suggests that [y] is becoming progressively anterior. None of the learners showed decrease in both of these parameters (Table 1).

In addition, formants become increasingly stable throughout the vowel portion from R1 to R3: in particular, the diphthongisation ([y] pronounced [jy]) observed in CS's R1 disappeared at R3, which is illustrated by a greater stability of F2.

### Speakers without ultrasound training (control group)

Figure 1 shows the acoustic analysis of isolated vowels of the two control learners. It is striking that the Euclidean distance between [y] and [u] increases very little for each of these learners (paired t test for YF between pre (R1) and post training (R2):  $t_{29}=-1.2$ ;  $p=0.2$ ). [y] is slightly anteriorised but the difference F3-F2 approaches the native subject's values only for YSG. [u] is slightly posteriorised only for YF but the difference F2-F1 of this vowel is significantly higher for the two female control learners than for the native French, even after finishing the pronunciation course (Table 1).

Tongue contours of these two speakers (Figure 2) show an overlap in the articulatory space for the two vowels at R1. At R2, however, the contours show some differentiation between the vowels. The difference is more prominent for YSG, who achieved greater anterior-posterior distinction, while the place of constriction of the two vowels is still very close together for YF.



**Figure 1:** F1/F2 measures: mean (position of vowel symbol) and standard deviation (ellipse). Japanese speakers's data in black, top to bottom: AK, CS (with US lessons), YF and YSG (without US lessons). Native French speaker's data in each chart in grey. From left to right: F1/F2 in pre-training (1a), post-training (1b), follow-up (1c). ED: Euclidian distance (Hz, mean and standard deviation) based on the first three formants between /y/ and /u/.

Speaker	F3-F2 for [y]. NS: 408 (189)			F2-F1 for [u]. NS: 428 (200)		
	Pre-training	Post-training	Follow-up	Pre-training	Post-training	Follow-up
AK	1405 (237)	757 (204)	858 (234)	592 (171)	812 (238)	682 (92)
CS	935 (252)	1198 (271)	1368 (330)	1120 (98)	573 (220)	424 (121)
YF	625 (71)	690 (220)	--	1080 (144)	1052 (72)	--
YSG	651 (172)	485 (168)	--	1318 (96)	1494 (92)	--

**Table 1:** F3-F2 (Hz) for [y] and F2-F1 (Hz) for [u] (mean value on the left, standard deviation in parentheses) for the four Japanese learners and the native speaker (NS)

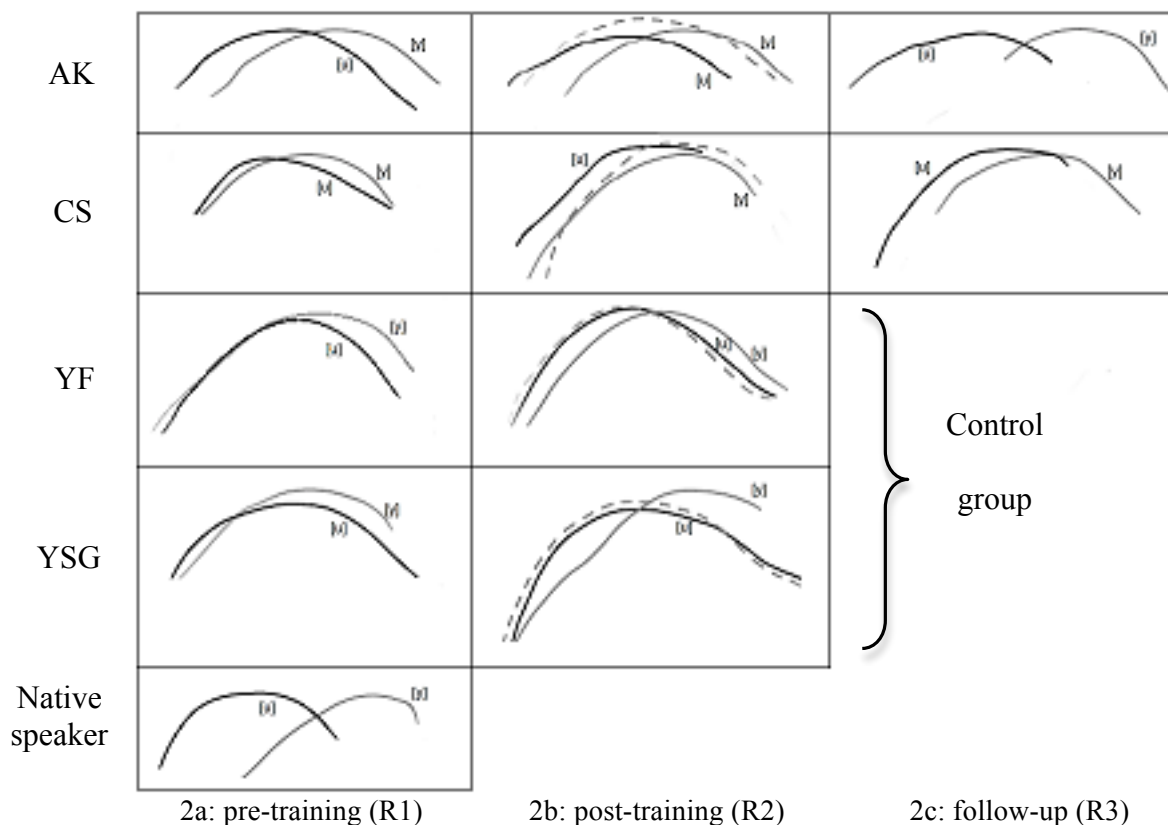
## Discussion and conclusion

First, the results presented here confirm the difficulty of Japanese learners to produce [u] and [y] (Kamiyama and Vaissière 2009). Second, they confirm the benefit of ultrasound visualisation in improving the production of the French /y/-/u/ contrast. Speakers who received ultrasound training achieved a better contrast, which was maintained or even further improved two months later. However, we should note that these lessons focused mainly on the production of [u] as the time constraints did not allow working intensely on both vowels. It is probably for this reason that our two learners' production of [y] is less similar to the NS than that of [u]. In addition, lip rounding and protrusion, which constitute another source of difficulty for the learners, were not directly treated during these lessons so that the learners' attention would be focused on the tongue position.

Another important outcome of this study was that all subjects (including control learners, who

received one ultrasound training session at the end of the second recording) reported that seeing their tongue during speech enabled them, first, to understand what kind of tongue movements are necessary (e.g. how far back the tongue has to be for /u/), second, to control the tongue movement in achieving the correct target position and, third, to become aware of the perceptual characteristics that the ‘new’ articulation causes.

The positive results of this study need to be verified with a larger number of subjects and a more diverse contexts: isolated vowels of two other Japanese learners are being analyzed, as well as nonwords, words and sentences of the four learners. Our future experiments will also include perception tests to examine if the differences observed in articulation and acoustics correspond to differences in French native listeners’ perception of this vowel contrast.



**Figure 2:** Mean tongue position (10 repetitions) for [y] (solid grey curve), [u] (black curve) and [ʊ] (dashed grey curve). Top to bottom: Japanese speakers AK, CS, YF and YSG, and native French speaker (NS). From left to right: pre-training (2a), post-training (2b), follow-up (2c). Front of the tongue is on the right side of each image.

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