

# ULTRASOUND OVERLAY VIDEOS AND THEIR APPLICATION IN INDIGENOUS LANGUAGE LEARNING AND REVITALIZATION

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## 1 Introduction

In second language (L2) acquisition, learners make use of not only auditory but also visual information to acquire the speech sounds and patterns in a new language. With respect to the latter, ultrasound has been demonstrated to be an effective tool in L2 pronunciation learning for facilitating visualization of the articulatory processes involved in speech production [8, 10, 11, 12]. Safe, non-invasive, and versatile, ultrasound allows learners to directly observe their articulator movements (and compare them with those of an instructor or native speaker), allowing them to make articulatory adjustments to improve their pronunciation.

However, ultrasound-based pronunciation instruction faces challenges as well. With current technology, it is best used in one-on-one contexts or with small groups [8], and interpreting the displays requires specialized knowledge in both articulatory phonetics and ultrasound imagery.

To make ultrasound visualization accessible and interpretable to a broader audience, we developed a series of ultrasound overlay videos which combine ultrasound images of tongue movement in speech with external profile views of a speaker's head [1]. Initially, the video library consisted of 91 videos, corresponding to each sound in the International Phonetic Alphabet (see [enunciate.arts.ubc.ca](http://enunciate.arts.ubc.ca)), and it was intended for use primarily by university-level linguistics students and learners of widely studied languages such as Japanese. However, an unexpected outcome of this project has been a broad interest from First Nations communities and allies, who recognized the potential benefits of using this technology in Indigenous language learning and revitalization. In this paper, we report on our work with four First Nations groups to develop customized ultrasound overlay videos for their languages.

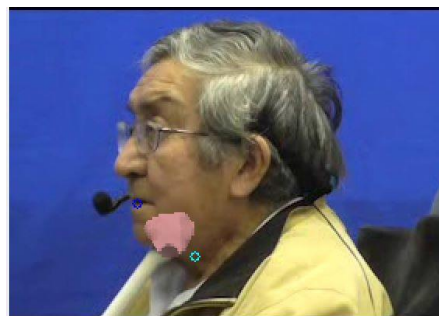
## 2 Methods

### 2.1 Ultrasound Overlay Video Library

The procedure for developing the original 91 videos was time-intensive. After recording and time-aligning ultrasound and exterior videos, the process of generating the overlay from the raw footage consisted of three steps completed frame-by-frame for each video: erasing all but the tongue image from the ultrasound video, brightening and colouring pink the tongue image, and scaling and overlaying the tongue image on the facial image [1].

### 2.2 Customization

In response to the interest in customizing ultrasound overlay videos for different linguistic communities, we developed a software package to automate the overlay process. Using time-aligned ultrasound and exterior video clips, the software generates a tongue trace that is scaled, shaded, and superimposed on the face. The image can be manually adjusted frame-by-frame; even with such adjustments, developing overlay videos is much faster and easier with the software than with the previous manual methods.



**Figure 1:** Screenshot from customized ultrasound overlay video of WSÁNEĆ elder and SENĆOFEN speaker Lou Claxton

## 3 Case Studies

### 3.1 Halq'eméylem (Coast Salish)

Critically endangered, Halq'eméylem has only one fluent first language (L1) speaker, but a growing number of L2 speakers and learners. Halq'eméylem has a rich consonant inventory, including plain, ejective, and labialized obstruents at various places of articulation. This yields a number of contrasts that are challenging for learners, most of whom are L1 English speakers. These contrasts were the focus of this case study; we recorded the one L1 speaker producing near-minimal pairs of Halq'eméylem words highlighting challenging contrasts; examples are given in Table 1.

**Table 1:** Examples of Halq'eméylem words recorded

Contrast	Word 1	Word 2
Plain/Ejective	tá:l	t'á:l
	qwélqwel	qw'él
Alveolar/Dental	tale	th'ále
Velar/Uvular	k'ák'elha	q'áq'el

The intention is to use the resulting ultrasound overlay videos in the production of digital storybooks that are used for language teaching purposes.

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### 3.2 Secwepemc (Interior Salish)

Like Halq'eméylem, Secwepemc is critically endangered, has a rich phonetic inventory that poses challenges for learners. The Splantsin Tsm7aksaltn has produced a 'Sounds of Secwepemc' resource that exemplifies the sounds of the language with words from the Eastern dialect [5]. We are developing ultrasound overlay videos to supplement the audio clips for each of these words with one of the L1 speakers in the Splantsin community.

### 3.3 SENĆOFEN (Northern Straits Salish)

Although there are only two L1 SENĆOFEN speakers, there is a vibrant language revitalization program in the W̱SÁNEĆ community, including a language nest and immersion school. Community members regard pronunciation as important, stressing the need to develop "SENĆOFEN muscles" [3]. This project's aim was to train students in the W̱SÁNEĆ community to create ultrasound overlay videos, thereby building an educational resource for other learners as well as building capacity and expertise for language resource development within the community. Focusing on words that illustrated challenging sounds and clusters, as well as early vocabulary such as numerals, we recorded productions of one L1 speaker, four advanced adult learners, and two children in the immersion program.

### 3.4 Blackfoot (Plains Algonquian)

This project focused on a particular feature of Blackfoot phonology that varies across dialects: word-final vowels. These vowels are seen as emblematic of language loss, assumed to be absent in the grammars of younger speakers and/or disappearing from certain dialects [4, 6]. For some speakers, these vowels are soundless: articulated but inaudible [7], and for others they are not articulated at all, but are nevertheless phonologically active. As such, the final vowels are challenging for learners. We developed ultrasound overlay videos with speakers of three dialects in order to help learners understand the range of variation in the pronunciation of final vowels.

## 4 Discussion

The challenges of pronunciation learning can be compounded for Indigenous languages by both a scarcity of resources (including small numbers of speakers) and the pressures faced by heritage learners to preserve their ancestral language in an authentic way [9]. Some community members may be latent speakers, inhibited due to perceived concerns with their pronunciation, particularly in the presence of elders [2]. The development and distribution of customized ultrasound overlay videos for Indigenous languages may help to address these challenges by giving learners a new way to learn pronunciation, and by creating documentation for future generations. The case studies highlight different ways in which ultrasound overlay videos may contribute to Indigenous language revitalization.

## 5 Future Directions

The next step for these projects is to develop and implement procedures for evaluating the effectiveness of ultrasound overlay videos in Indigenous language learning. As for developing videos for other languages, there is interest from Indigenous communities and allies for languages including Heiltsuk, Hul'q'umi'num', Kwak'wala, and Skwxwu7mesh.

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## References

- [1] J. Abel, B. Allen, S. Burton, M. Kazama, M. Noguchi, A. Tsuda, N. Yamane, and B. Gick. Ultrasound-Enhanced Multimodal Approaches to Pronunciation Teaching and Learning. *Canadian Acoustics*, 43(3). 124-125, 2015.
- [2] C. Basham and A. Fathman. The latent speaker: Attaining adult fluency in an endangered language. *Intl Journal of Bilingual Education and Bilingualism*, 11: 577-97, 2008.
- [3] S. Bird and S. Kell. Pronunciation in the context of language revitalization. Presented at ICLDC 4, 2015.
- [4] A. Chatsis, M. Miyashita, and D. Cole. A Documentary Ethnography of a Blackfoot Language Course. *The Persistence of Language*. Benjamins, 257-90, 2013.
- [5] FirstVoices. [www.firstvoices.com](http://www.firstvoices.com). 2000-13.
- [6] D. Frantz. *Blackfoot Grammar*, 2<sup>nd</sup> ed. U Toronto Press, 2009.
- [7] B. Gick, H. Bliss, K. Michelson and B. Radanov. 2012. Articulation without Acoustics: "Soundless" Vowels in Oneida and Blackfoot. *Journal of Phonetics* 40(1):46-53.
- [8] B. Gick, B. Bernhardt, P. Bacsfalvi, and I. Wilson. Ultrasound imaging applications in second language acquisition. *Phonology and second language acquisition*. Benjamins: 309-22, 2008.
- [9] L. Hinton and J. Ahlers. The issue of "authenticity" in California language restoration. *Anthropology & Education Quarterly*, 30: 56-67, 1999.
- [10] C. Pillot-Loiseau, T. Kamiyama, and T. Kocjančič Antolík. French /y/-/u/ contrast in Japanese learners with/without ultrasound feedback: vowels, non-words and words. Paper presented ICPS, 2015.
- [11] M. Tateishi and S. Winters. Does ultrasound training lead to improved perception of a non-native sound contrast? Paper presented at CLA, 2013.