2PSC60

# Improvement of Sensor for Electromagnetic Articulography to Reduce Detrimental Effects of Sensor Attachment on Articulation

Yukiko Nota (ATR-Promotions), Tatsuya Kitamura (Konan University), Michiko Hashi (Prefectural University of Hiroshima), and Hiroaki Hatano (ATR Hiroshi Ishiguro Laboratories)

## Background and Purpose

- The NDI Wave speech research system (hereafter WAVE)[1]: an electromagnetic articulography system which tracks the position and direction of small wired sensors attached in and outside the mouth during speech
- Sensor attachment appears to have a detrimental effect on intelligibility and speech quality[2].
  - ✓ The original sensor cable for WAVE is thick and stiff, and likely to interfere with natural articulation.
- We improved the original sensors for the WAVE system to reduce the effect of sensor cables on articulation and examined if the degree of speech distortion is less with the proposed sensors than with the original sensors.

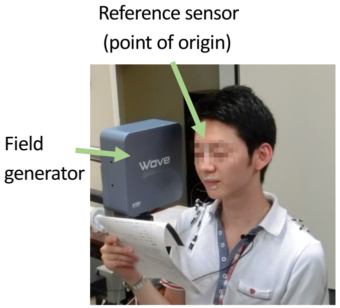


Fig.1 Wave system

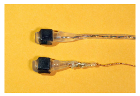

Fig.2 Original (top) and proposed(bottom) sensors

## Methods

- Cable replacement (Fig. 2).
  - ✓ The original cable
    1. cut at approximately 10 mm from the sensor unit(size:3x3x2mm)
    2. soldered to thinner (0.1 mm diameter) and more flexible cable
       - ✓ the soldered part was coated with a silicon tube and covered with medical superglue for insulation.

- Normal subjects produced speech with original and proposed sensors.
  - ✓ Subjects: two males and two females in their 60s
  - ✓ Location of the sensors : see Fig.3.
  - ✓ Sixteen sequences were produced (/VsV/, /VtV/ and /VrV/ where each of the five Japanese vowels was used for V and one /aiueo/ sequence ).
  - ✓ Recording latency: immediately after sensor attachment and 10 minutes later.
  - ✓ The order of data acquisition with the original and the proposed sensors: counterbalanced between speakers

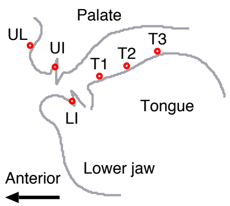


Fig.3 Midsagittal sensor placement

- Evaluation of the degree of speech distortion
  - ✓ Judges: Three Japanese speech and language pathologists(SLPs)
  - ✓ Speech materials: 256 sequences (16 sequences *2 sensor type* 2 recording latency * 4 speakers) presented in random order.
  - ✓ SLPs graded the degree of distortion in the most distorted phoneme of each stimulus on a scale of one ("least distorted") to seven( "most distorted").

## Results

- Distortion scores for each sensor type and for each recording latency (Fig. 4)
  - ✓ A significant main effect of sensor type (two-way ANOVA: $F(1,765) = 14.57$, $p < .05$)
    - Speech with the proposed sensors was judged to have a lesser degree of distortion than speech with the original sensors.
  - ✓ The effect of recording latency was not significant ($F(1,765) = 0.00$, $p = .98$) .
  - ✓ No interaction between sensor type and recording latency ($F(1,765) = 0.47$, $p = .49$).

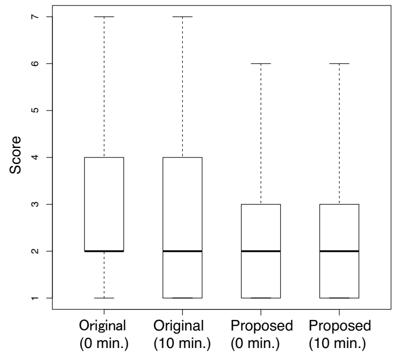


Fig.4 Distortion scores for each sensor type and for each recording latency

- Formant frequencies of vowels in /VsV/ and /VtV/ with original and proposed sensors and without sensors, in 10-minute-after-attachment condition for three speakers (Fig.5)
  - ✓ Using proposed sensors tended to cause less changes in F1 and F2 formant frequencies relative to without sensors than the original sensors.

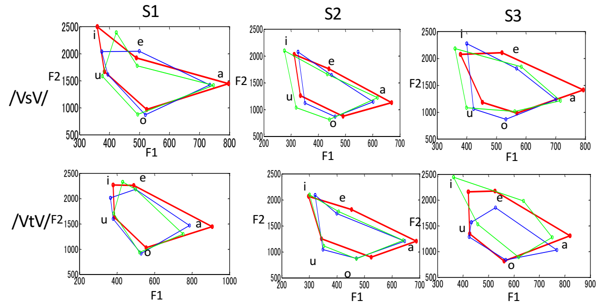


Fig.5 F1 and F2 frequencies of vowels in /VsV/ and /VtV/ with original(blue) / proposed(green) sensors and without sensors (red), for three speakers.

## Discussion

- We modified WAVE sensors by replacing cables with thin and flexible ones
- The proposed sensors appeared to disturb speech less than the original.
  - ✓ The thin cables may have decreased foreign-body sensation in the mouth
  - ✓ The lightness and flexibility of the cables could have resulted in less encumbrance in articulation.

## References and Acknowledgments

[1] http://www.ndigital.com/msci/products/wave-speech-research/
[2]Meenakshi, N., Yarra, C., Yamini, B. K., and Ghosh, P. K. (2014). "Comparison of speech quality with and without sensors in electromagnetic articulograph AG 501 recording," Proc. Interspeech 2014, 935-938.

The experimental protocol was approved by the ethical and safety committees of Konan University.
This research was partly supported by JSPS KAKENHI Grant Numbers 24652085, 25280026, and 25280066.