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# Towards an HD-sEMG mask to measure orofacial muscle activity during speech production



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## Context

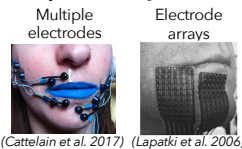
### Orofacial movements

- Facial expressions
- Speech
- Eating (swallowing, suction, mastication)
- Music (whistle, brass instruments)

### Applications

- Speech pathology
- Modeling
- Automatic recognition
- Animation of avatars

### Acquisition systems



(Cattelain et al. 2017) (Lapacki et al. 2006)

→ In particular: characterization of effort and coordination of speech articulatory movements in typical and disordered speech

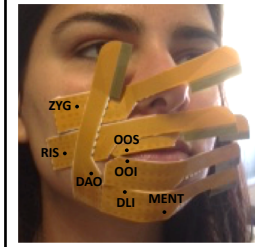
## Objectives



### Interest and feasibility of an HD-sEMG facial mask ?

- Compatibility with natural movements
- « Sticking power » of the electrodes
- Information redundancy
- Discrimination of basic orofacial movements
- Prediction of articulatory effort (as measured though inter-lip force)

## Material & Method



- 1 participant
  - 6 arrays of 8x4 electrodes, with Inter Electrode Distance : 5mm
- 192 electrodes  
→ 7 well-chosen electrodes



- Microphone
- Force sensor between the lips
- 7 orofacial movements
- Speech (/ama/)

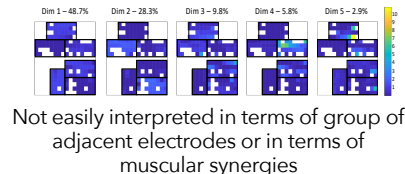
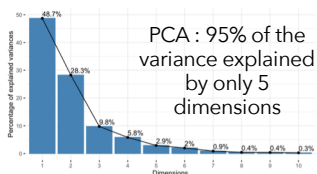
## 1- Feasibility

- Layout of the arrays that respects the “naso-labial fold” on the cheek and the “mental crease” on the chin
- Only intense rounding and spreading of the lips restrained by the non-elasticity of the electrode arrays

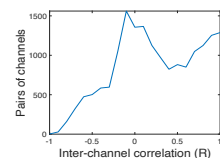


- 2.3 “bad channels” per electrode array (over 32)
- Not increased by some movements or over time
- Significantly higher for chin array ( $4.2 \pm 2.0$ ), compared to the others ( $1.9 \pm 0.9$ ).

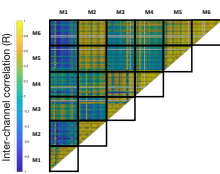
## 2- Information redundancy



Not easily interpreted in terms of group of adjacent electrodes or in terms of muscular synergies

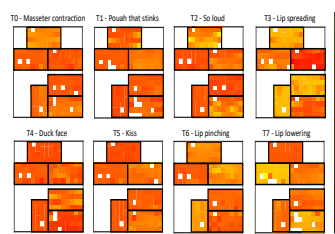


- 21.1% of electrode pairs highly correlated signals ( $|R| > 0.75$ )
- 55.5% of the electrode pairs poorly correlated ( $|R| < 0.5$ )
- Not too redundant information.

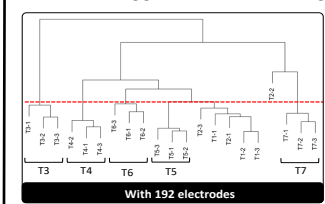


- Most of the high-correlated pairs of electrodes are adjacent ones in a same array
- High correlation between upper cheek array and lower lip array ( $R=0.53$ ), and lower cheek array ( $R=0.70$ )
- Muscle array ?

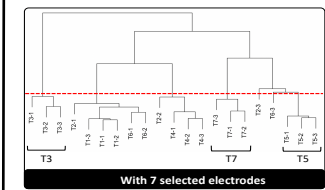
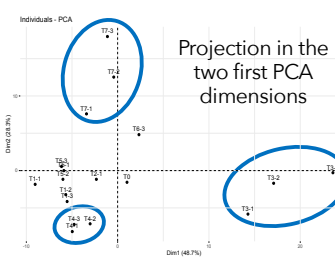
## 3- Discrimination of basic movements



### Hierarchical Agglomerative Clustering

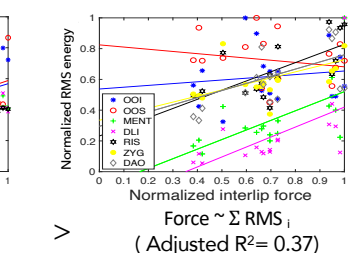
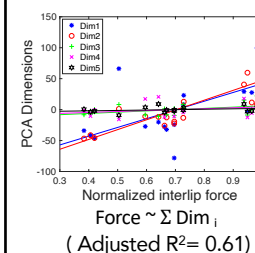


→ Unsupervised classification of 5 movements (T3, T4, T5, T6, T7)



→ Only 3 movement (T3, T5 and T7)

## 4- Prediction of articulatory efforts



Force  $\sim \Sigma$  Dim<sub>i</sub> (Adjusted  $R^2=0.61$ )

Force  $\sim \Sigma$  RMS<sub>i</sub> (Adjusted  $R^2=0.37$ )

## Conclusions

- **Feasibility**  
Proof of concept. Elastic support appears necessary to respect skin deformation and enable unconstrained gestures
- **Interest, compared to multiple pairs of electrodes**  
High inter-electrode correlation, but enables a better discrimination of movements and better prediction of articulatory efforts.  
A greater IED would remain acceptable, especially on the cheek

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