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



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Context

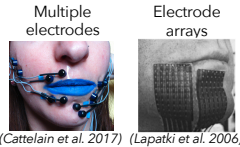
Orofacial movements

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

Applications

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

Acquisition systems



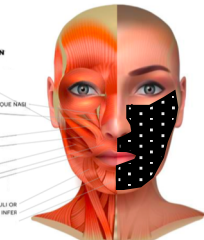
(Cattelain et al. 2017) (Lapatki et al. 2006)

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

Objectives

MUSCLES OF MASTICATION

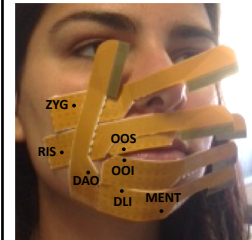
- NOSE**
 - LEVATOR LABII SUPERIORIS ALAQUE NASAE
 - LEVATOR LABII SUPERIORIS
- CHEEK**
 - ZYGOMASSICUS MINOR
 - ZYGOMASSICUS MAJOR
- MOUTH**
 - BUCCHINATOR
 - CORNICULARIS ORIS
 - FIBRILLA
- CHIN**
 - DEPRESSOR ANGLI ORIS
 - DEPRESSOR LABII INFERIORIS
 - MENTALIS



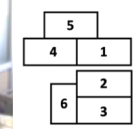
Interest and feasibility of an HD-sEMG facial mask ?

- 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/)

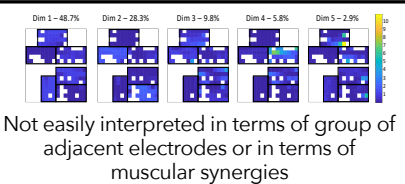
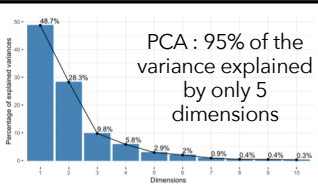
1- Feasibility

- 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

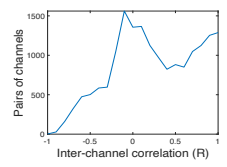


- 2.3 “bad channels” per electrode array (over 32)
- Not increased by some movements or over time
- Significantly higher for chin array (4.2 ± 2.0), compared to the others (1.9 ± 0.9).

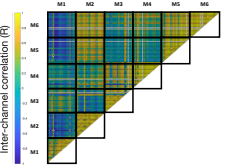
2- Information redundancy



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

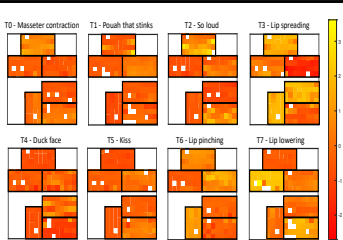


- 21.1% of electrode pairs highly correlated signals ($|R| > 0.75$)
- 55.5% of the electrode pairs poorly correlated ($|R| < 0.5$)
- Not too redundant information.

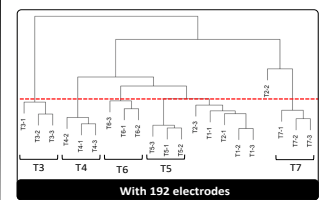


- Most of the high-correlated pairs of electrodes are adjacent ones in a same array
- High correlation between upper cheek array and lower lip array ($R=0.53$), and lower cheek array ($R=0.70$)
- Muscle array ?

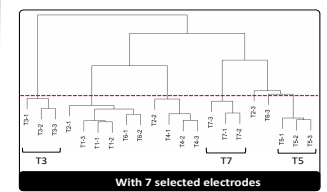
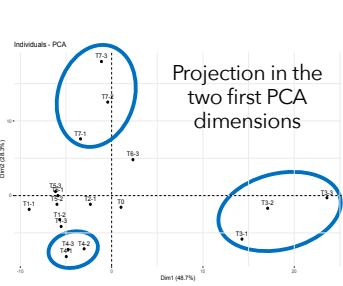
3- Discrimination of basic movements



Hierarchical Agglomerative Clustering

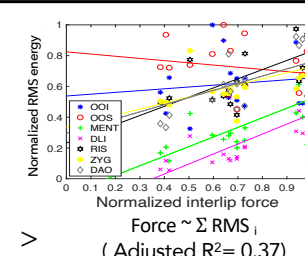
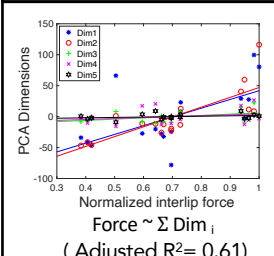


→ Unsupervised classification of 5 movements (T3, T4, T5, T6, T7)



→ Only 3 movement (T3, T5 and T7)

4- Prediction of articulatory efforts



(Adjusted $R^2 = 0.61$)

(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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