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Technology Brain Computer Interface for Autonomy: Patient-adapted ergonomic headset for dry-EEG P300 speller

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Abstract: Recent work demonstrates feasibility for ALS patients to communicate via P300 speller [1], but end-user's expectations are not met concerning comfort and ease of use, particularly for patient under heavy pathology [8]. One challenge for daily use [8],[9] is to provide patients with gel-free headsets that are easy to put on and comfortable while providing enough signal quality for accurate P300 classification.

Our proposal is to custom design a silicone headset to fit patient's head morphology [5], paying attention on good pressure distribution and hair layer penetration. We will firstly show feasibility of Dry P300Speller with State-of-the-Art amplifier, then analyze electrode impedance variation over time while the headset is worn, and its relation to P300 classification accuracy.

Challenges & Requirements

Overcome the gap between Wet (Fig.1) and Dry EEG (Fig.2)

- Adapted electronics
- Compromise between comfort and signal quality [4]
- Adapted Impedance threshold (e.g 20kOhm for wet (see Fig.3))

Ease of use [9]

- Easy to put on by a non-expert (<3 min)
- Gel-free operation
- Reduce numbers of channels [2],[3],[6] (<9) (especially occipital areas)
- Allow communication with correct Speed

Fit the patient's expectations

- Extract patient head shape from 3D scan [5]
- Being reliable for long time (12 months)
- Being worn comfortably during long time recording (weight supported by head <400g)

Fig. 1: Textile commercial headset, wet EEG



Fig. 2: Prototyping with silicone & dry electrodes ANT B.V



Impedance analysis (1h) for the working mode explicated by Fiedler [4], revealed that our prototype stand with a **mean impedance of 50 kΩ** and a variability of 71.6 kΩ (see Fig.3), with the worst contact being 534 kΩ, still in the 1MΩ range defined by literature.

Impedances								total
Moyenne / channel	35.1	53.5	16.1	173.5	9.8	11.5	3.9	49.9
	Cz	Pz	P3	P4	Cpz	C3	C4	
Variabilité 2-60	242.3	111.5	30.4	38.4	3.2	4.1	0.1	71.6

Fig. 3: 1 hour Impedances Analysis per channel: mean and variability

Conclusion

- **Good performance** compared to WET(see Fig.4,5)
- **Better usability:** gel-free operation but more flash needed
- **System simplification:** size & weight already reduced
- Effectiveness of the dynamic data collection: **early stopping**

Perspectives

- Better knowledge of aging process of electrodes
- Add mechatronic parts to increase efficiency (e.g active PCB for each electrodes)
- Increase portability by user-centered design
 - Reduce weight / Become wireless / Upgrade aesthetics & autonomy

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Cross-validation test accuracy is 83.5953% (sig
Cls vs cls      1      2
Target 1:      33.4  66.6 %, 329 examples
Target 2:       3.9  96.1 %, 1317 examples
Training set accuracy is 88.1531% (optimistic)
Cls vs cls      1      2
Target 1:      46.2  53.8 %, 329 examples
Target 2:       1.4  98.6 %, 1317 examples
    
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Fig. 4, 5: Experiment result-training acc.=88% charact. selection=90%

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