Using Eye-tracker to enhance gaze independent BCI with patients

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1. Goal

This work is about a visual reactive BCI which is used for communication purposes with patients who experience ocular impairment. An eye tracker and EOG channels are used in addition to the EEG channels.

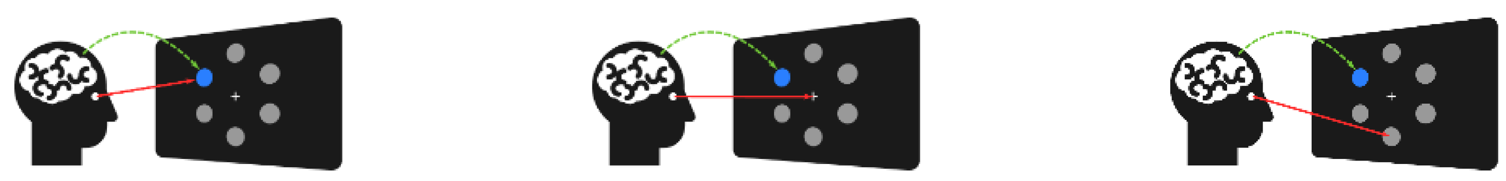
Goal of the study : Using these three sources of information in order to enhance performance

2. Important concepts

Visual BCI ERP-based systems = Brain Computer Interface based on event-related potential (ERP) which utilize visuospatial attention (VSA) to identify targets displayed on a screen.

Purpose of this system : to be use by tetraplegic patients, who can experience locked-in syndrome, but one of the symptoms can be the deterioration of gaze movement.

Different types of visuospatial attention (Treder et al., 2011) :



Overt attention — Covert attention — Split attention

Legend : Red = gaze position, Green = visuospatial attention

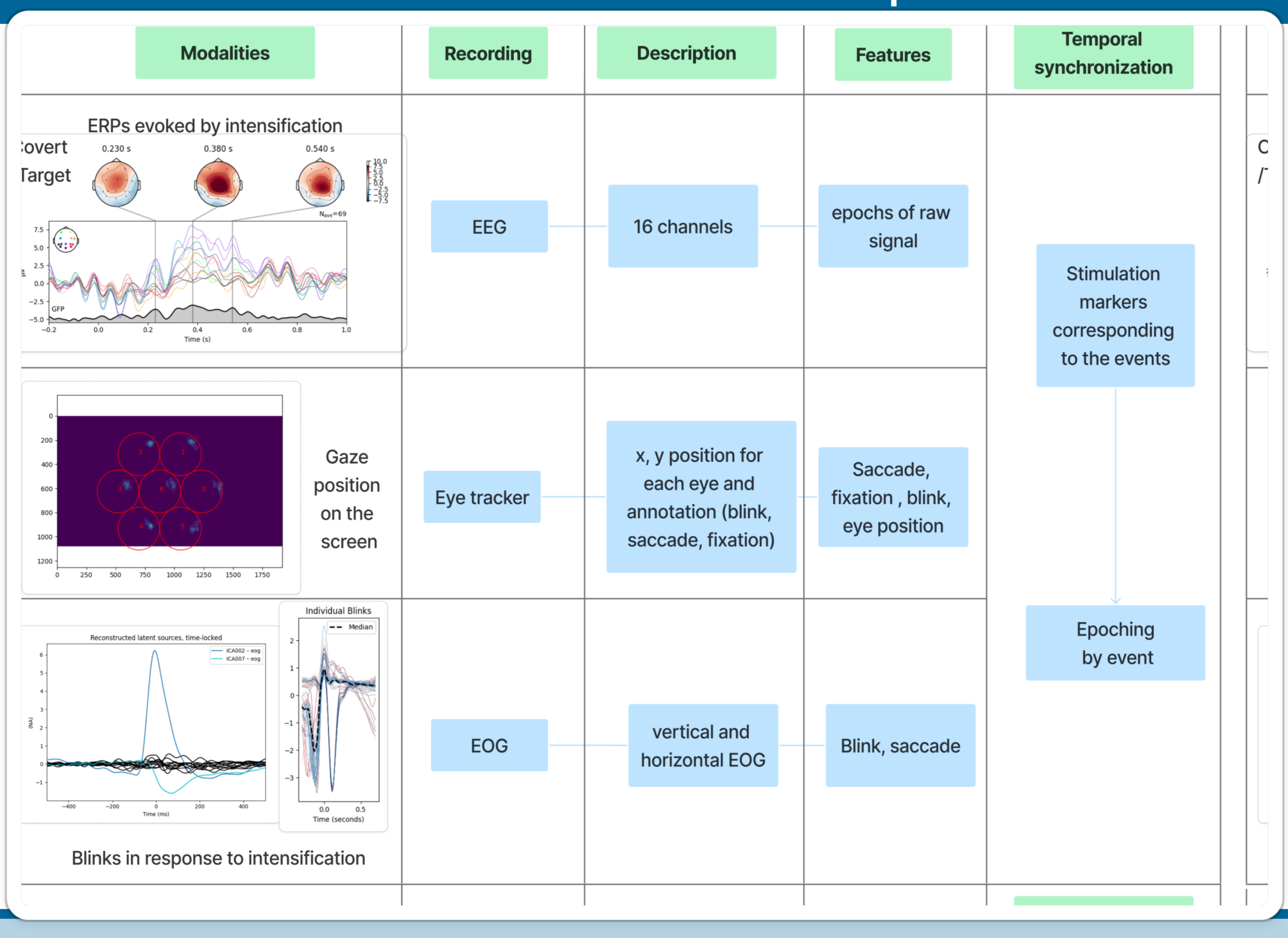
3. Study context

Study : A study is currently being carried out on patients with or without ocular impairment, exploring different visuospatial attention conditions. Patients are selecting target on a screen that are displayed with a Hex-o-Spell (Treder et al., 2011).
A previous study has also been done with healthy subjects controlling for the same visuospatial attention conditions (Van Den Kerchove et al., in review).

Study question : Are the selections made by an ERP-based BCI more reliable if eye-tracking and EOG data is taken into account in addition to EEG data, especially in covert attention with patients who have ocular impairment?

Even if the final goal is to apply this method to patients, to have a proof of concept that data fusion allows a better performance in covert or split attention, we will do this study on the data on healthy subjects.

4. Data description



5. Additional data information

	EEG	Eye Tracker	EOG
Uncertainty	noise and muscular artefact	depending on calibration and ocular impairment	noise
Strategy : uncertainty	notch filter and ICA with EOG	verify accuracy of calibration and correlation with EOG	notch filter
Incompleteness		missing values	
Strategy : incompleteness		linear interpolation	

6. Data fusion

Different sources of data have their own characteristics and limitations. So, taking into account these three components at the same time requires data fusion that can handle data conflict and inaccuracy of data.

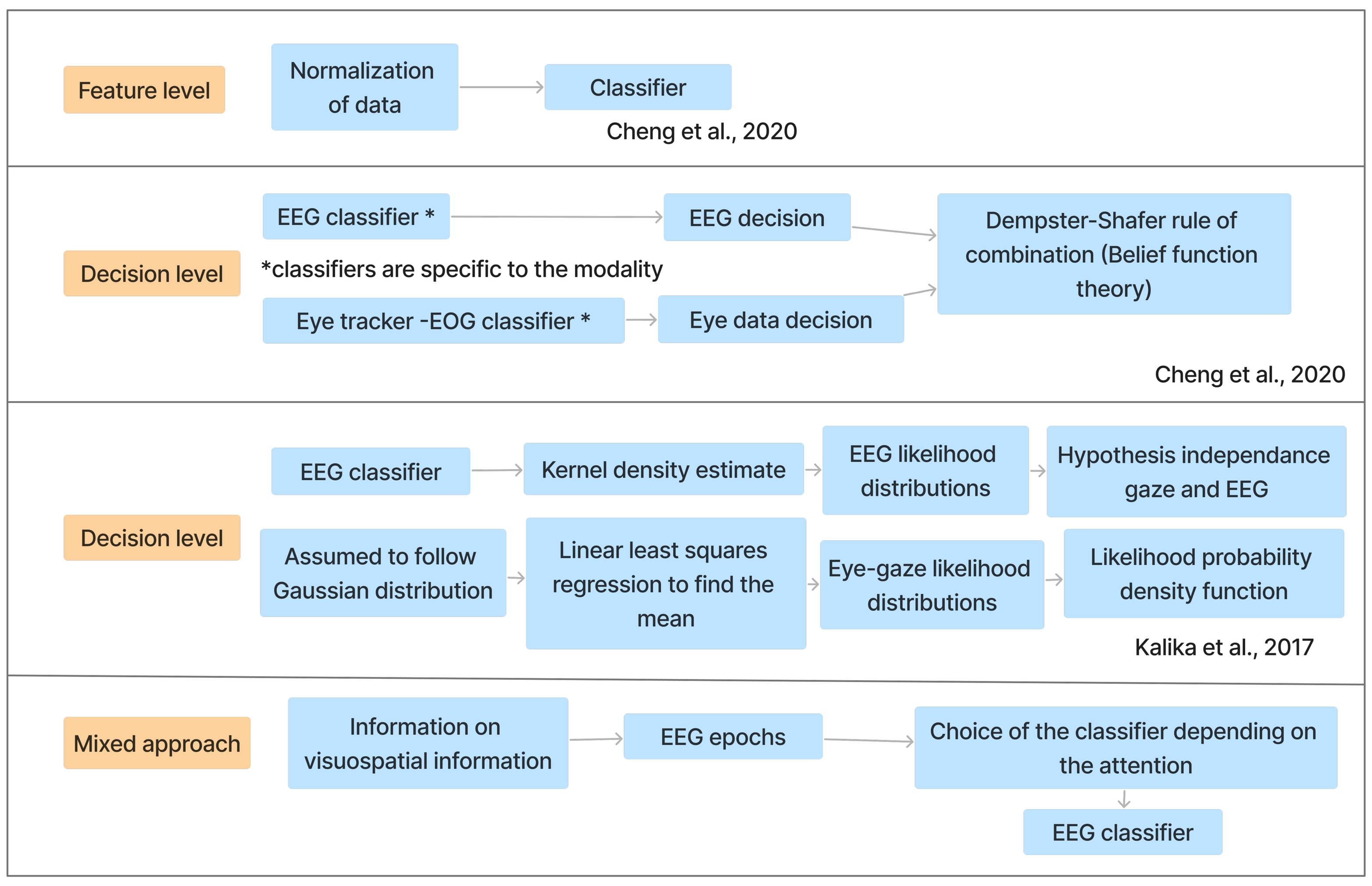
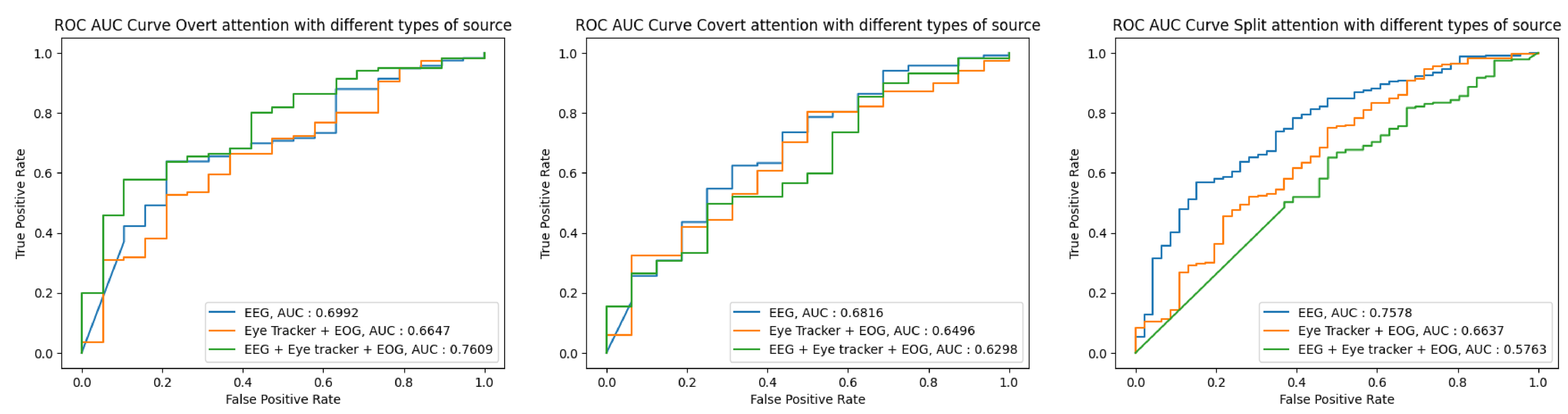


Figure 1: Diagram of the different possibility of fusion on different levels : input are EEG, eye tracker and EOG epochs, output is the final decision

7. Preliminary results



Method : 1 healthy subject / LDA classifier trained on epochs (EEG, ET+EOG or EEG+ET+EOG), then, ROC and AUC score
Results : In overt attention, we can see a higher performance for the use of the three-source model (EEG+gaze tracking+EOG). Contrary to our expectations, the three-source model does not increase performance in covert and split visuospatial attention.
Follow-up : We used a binary classifier for the gaze position, even if there were six targets. Moreover, for the eye tracker data, some special feature such as fixation or saccade could be used instead of the position only.

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Kalika, D., Collins, L., Caves, K., & Throckmorton, C. (2017). Fusion of P300 and eye-tracker data for spelling using BCI2000. Journal of neural engineering, 14(5), 056010.
Treder, M. S., Schmidt, N. M., &Blankertz, B. (2011). Gaze-independent brain–computer interfaces based on covert attention and feature attention. Journal of neural engineering, 8(6), 066003.
Van Den Kerchove, A., Si-Mohammed, H., Van Hulle, M. M., &Cabestaing, F. (in review). Correcting for ERP latency jitter improves gaze-independent BCI decoding.

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