# Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

## Supervisor information

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| **Country** | France |

## PhD information

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| **Title** | Oculomotor markers of normal cerebral response and effect of normal ageing - joint analysis of eye movements and EEG – |
| **Main topics regards to CSC list (3 topics at maximum)** | The working and development of the brain<br>Ageing: prevention and treatment of illnesses of the senior citizen |

| **Required skills in science and engineering** | Signal Processing, Statistics and Programming (MATLAB or Python) |
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# Subject description (two pages maximum)

**Main objectives of the PhD**

Because eye movements recruit a well-known network of cortical and subcortical structures, involved in a wide range of cognitive functions (visual perception, attention, motor and executive control), eye-tracking has become a preferred tool to explore how eye movements are related to many aspects of cognitive and cerebral functions. Importantly, abnormal eye movements can also be characteristic of psychiatric, developmental or ophthalmologic disorders (e.g., schizophrenia, mood disorders, autism spectrum disorder, dyslexia, and glaucoma, Wang et al., 2015) as well as neurodegenerative diseases (e.g., Alzheimer's, Huntington's or Parkinson's disease, Munoz and Everling, 2004; Rommelse et al., 2008).

Using a specific experimental paradigm called saccadic choice task, this thesis will study the mechanisms of saccade programming, using the co-registration and the co-analysis of both eye movements and electroencephalography signals. The final aim if the PhD is to use the joint analysis of signals to provide a more precise and sensitive definition of normal eye movements (recorded on healthy participants in different groups of ages) and neural activity linked to these eye movements recorded during the saccadic choice task. This should serve as a standard to further investigate the effect of normal ageing on eye movements and the neural activity.

Objectives of the thesis (1) to record eye movements and EEG activity during the saccadic choice task in a large sample of healthy individuals (from young adults to elderly), (2) to develop new algorithms to analyze jointly eye movements and EEG activity, (3) to establish normative oculomotor parameters and cortical activity through saccade related potentials (SRPs, average of EEG activity triggered on the saccade onset) of the normal cognitive functioning and, finally, (4) to measure the effect of age on these eye movement parameters and saccade related potentials to access the cognitive decline with normal aging.

**Context**

In the ViBS team (GIPSA-lab), recent studies have been used the co-registration and the joint processing of participant's EEG and ocular activities during visual tasks to better understand our visual perception. Such co-registration has shown a strong potential to access the time course of neuronal activities according to the succession of eye movements (fixations and saccades). Studies, both methodological (Kristensen et al., 2017a; 2017b) and behavioral (Devillez et al., 2017) have shown the interest of analysis both signals (ocular and EEG).

The saccadic choice task has been proposed to investigate the speed of complex stimulus recognition. In this task eye movements are used as a behavioral response to investigate the speed of object recognition and more especially face recognition. In this paradigm two images are simultaneously displayed on a screen in the left and right visual fields. One image contains a target stimulus (e.g., a face) and the other one a distractor (e.g., a vehicle). Participants have to perform a saccade as fast as possible toward the target stimulus (e.g., a face) (Kirchner and Thorpe, 2006;

Crouzet, et al., 2010). Although this task requires multiple processes (i.e. simultaneous processing of two images, a categorical decision, programming and execution of an eye movement toward the target), it has been shown that human observers are able to initiate accurate saccadic responses toward a face with extremely short latencies of just 100-110 ms (Crouzet, et al., 2010). We showed that such fast saccade toward faces could be in part explained by the spatial frequency content of faces (Guyader et al. 2017). Overall, these eye-tracking data suggest that faces contain specific information that influences the programming of saccades by triggering extremely fast and automatic orienting responses toward them. These studies only focused on the analysis of saccade latency and accuracy. However, others eye movement parameters might be relevant to better understand the programming of saccade; for example the precision of saccade (i.e. the distance between the ending point and the target point) or the amplitude of saccade (i.e. the distance between the starting and ending point). In the classical view, the saccade amplitude is thought to be programmed at its onset and that it could not be influenced by new visual information once initiated (although small online corrections can be observed based on internal feedbacks) (Quaia et al, 1999).

In a very recent paper, we replicated previous findings indicating that, relative to vehicle stimuli, face stimuli elicit faster saccades, but also more involuntary error saccades when they are defined as distractors (Kauffmann et al., in revision). Critically, the examination of saccade amplitude during this task additionally revealed two new main findings. First, we observed that amplitude of saccades was modulated by the content of the target/distractor stimuli: Saccades toward vehicles (faces as distractor) were shorter than saccades toward faces (vehicle as distractor). Second, we observed that error saccades were shorter than correct saccades suggesting their interruption to initiate a corrective saccade. Taken together all these results suggest that faces influence the programming of saccades and in case of error saccades a corrective saccade might be programmed on parallel to the saccade error.

We want to further investigate the time course of such parallel saccade programming using the co-registration of eye movements and EEG signals. We will analyze and compare the cortical activity through SRPs and compare these potentials according to the saccade type: correct, error and corrective. We expect to find differences between the potentials of correct and error saccades with different activity appearing before the saccade onset to explain the smallest amplitude observed for error saccades compare to correct saccades. These results in healthy participants for different groups of ages (20-30, 30-40, 40-50 and older than 50) should serve as a signature of the normal eye movements and related cortical activity through the different group of participants. We expect to identify reliable oculomotor markers of normal cerebral response

**Bibliography**

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