TITLE: Social influence and stubbornness in animal model populations during cognitive processes for decision-making and action selection

ABSTRACT (max 300 words):
The objective of this study is to understand whether and how individuals interact to form and evolve opinions related to topics that include survival, social and reproductive aspects. In particular, this opinion dynamics can influence the decisions taken at the population or single level, to support cooperative or selfish behaviors.

If we want to understand how the brain works during these cognitive processes, it is essential to consider its functions in the context of behavior and we need ways to quantitatively and accurately describe it, in all its complexity. Moreover, we need to selectively interfere and measure nervous function of specific circuits that could be implied in the specific behavior under observation. To this aim, an optimal approach resorts to an animal model to gain the possibility of measuring population behavior in strict and controlled experimental conditions. This model would be also suitable to be genetically manipulated and to be utilized for neuronal activity recording and stimulation using modern electrophysiological and optogenetic techniques.

Given these premises, the proposed project aims to explore in a *Drosophila melanogaster* population the information spread dynamics and the interplay of self-appraisal, social influence, and stubborness in determining value-based decision-making and action selection.
The following steps will be pursued, building on preliminary results reached by the proponents:
1) the spread of information within a group of flies in controlled environmental conditions will be quantitatively identified through behavioral measurements: opinion exchange is associated to agents encounters, where the quality of the meeting can be accurately detected and measured by meeting directions and timings
2) opinion dynamics mathematical modeling tools will be designed consistently with the experimental evidence to analyze and predict the possible communications between Drosophila' agents: stubborn agents may be interpreted as individuals that have an exclusive information that cannot be altered by others.
3) as a final effort, evolutionary relevant scenarios will be obtained representing the community interactions and behavior, **to verify if** specifically characterized stubborn subpopulations **are able to transfer useful informations to un-informated flies.**

REFERENCES (Max 5):

[Fiore2015] Fiore VG, Dolan RJ, Strausfeld NJ, Hirth F. Evolutionarily conserved mechanisms for the selection and maintenance of behavioural activity. PhilosTrans R Soc Lond B Biol Sci. 2015

[Ofstad2011] Ofstad TA, Zuker CS, Reiser MB. Visual place learning in Drosophila melanogaster. Nature. 2011

[Pasquaretta2016] Pasquaretta C, Battesti M, Klenschi E, Bousquet CA, Sueur C, Mery F. How social network structure affects decision-making in Drosophila melanogaster. ProcBiol Sci. 2016

[Friedkin2016] N. E. Friedkin, A. V. Proskurnikov, R. Tempo and S. E. Parsegov, Network Science on Belief System Dynamics under Logic Constraints, Science, Oct. 2016

[Mei2018] W. Mei, N. E. Friedkin, K. Lewis, and F. Bullo. Dynamic Models of Appraisal Networks Explaining Collective Learning. IEEE Transactions on Automatic Control, 2018

PARTICIPANTS (PI and co-PIs):
PI: Prof Aram Megighian PI
External: Prof Angelo Cenedese

EXPERIMENTAL DATA:

To be acquired	X
Already acquired (ready to be used)	X

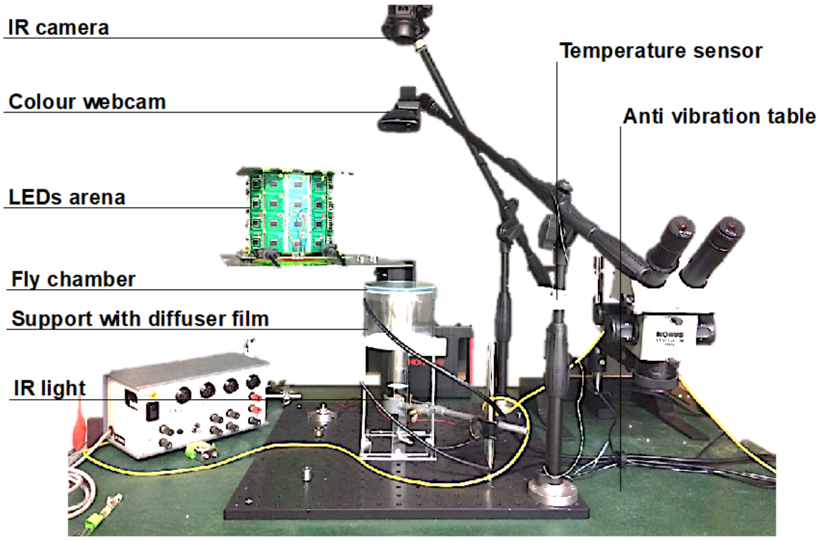
- Experiments design

By analysing 10 min continous video trackings of free walking locomotor behavior of individuals from different *Drosophila* populations of our laboratory we implemented and positively evaluated a model of opinion and behavior dynamics in fly populations [F.Minchio, Master Th. Automation Eng.]. The model, considers each fly as an agent of an influence network, and, particularly, allowing the possibility that flies might never change their opinions despite social interactions, considers also agents' "stubbornness".

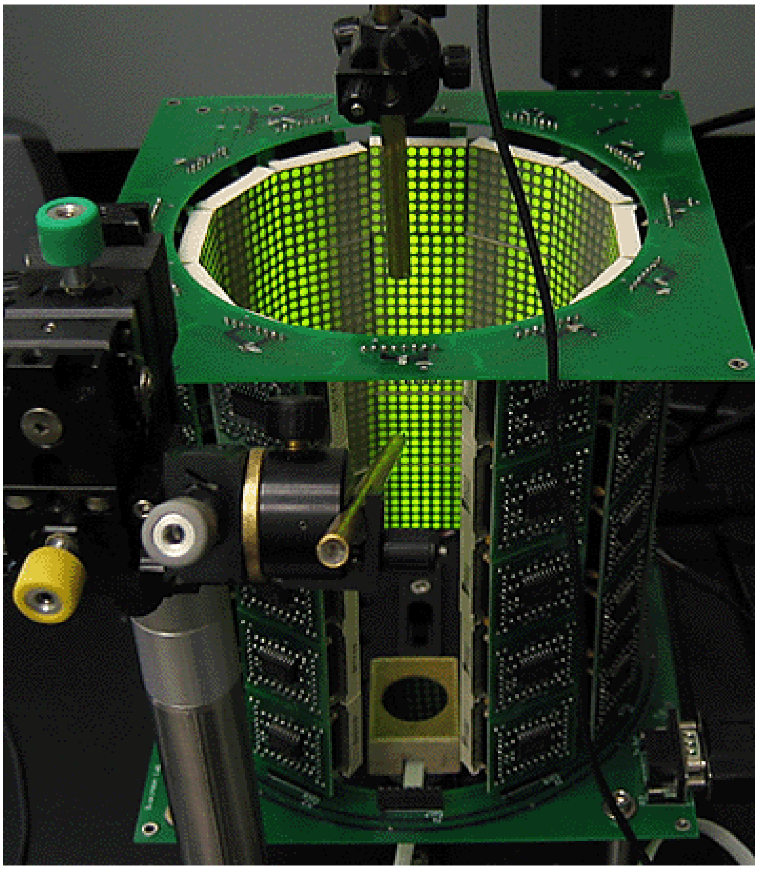
In the first year of PhD programme, we'll analyse long period walking locomotor video trackings (50 min) of fly populations of different number to investigate the role of **time** and **agent number** in our model. Flies are placed in a plexiglass low-ceilinged 20 cm wide arena where they only can walk, but not fly or jump. The arena is omogeneously illuminated without any visual cue. Flies locomotor behavior will be continously video recorded at 20 fps.

In the second and third year of PhD programme, **the spread of information will be evaluated by mixing "informed" agents with "uninformed" individuals.** Flies locomotor behavior will be continously video recorded at 20 fps in IR conditions.

Informed individuals will be learned using a visual place learning test (Ofstad, 2011), by training them to find a hidden "safe" area in an otherwise unappealing environment obtained by optogenetically stimulating flies bitter taste except when they are in the "safe" zone. The position of the "safe" area is found by spatial cues provided by visual stimuli displayed by led array panorama sorrounding the arena with flies.
The position of the "safe" zone is changed in every training trial, while the target and visual panorama are *coupled* so that although the absolute position of the "safe" area changes, its location relative to the visual panorama remains constant.
Over the course of training trials flies improve in the time required to locate the "safe" zone. It was shown that **if all flies were in the same initial conditions (i.e. all with no visual place memory), they were not able to influence each other.**
Therefore we intend to **test if mixing, in the same arena, learned flies, and flies with no visual place memory, should result an improvement of visual place learning by these last.**



In the figure is shown the experimental setup of PI Laboratory with the LED arena (see below) utilized for walking flies visual stimulation. (experiment 2). Above the IR videocamera and below IR emitting light.



Led arena is controlled by a controller driven by a PC using Matlab scripts which allow to built on custom static or dynamic visual stimuli of the desired amplitude and shape.
A led projector (Thorlab) of specific wavelenght is utilized to illuminate from above fly arena and activate photoactivable ion channels expressed in fly brain (optogenetic stimulus)

ETHICS COMMITTEE:

Obtained	
Conditioned submission*	Expected time response (in months):
Not required	X

* request will be submitted only if a PhD student will be associated to the project