Sensor reactions to the intensity of light: comparing biological and electronic sensor

- **Background knowledge:** we know daphnias are receptive to light and can change their phototaxis (negative or positive) depending on the intensity of light. In other words, daphnias goes toward the opposite direction of light following an increase of intensity of light, and they change their phototaxis when the intensity of light decreases (they go toward light source). Moreover, blue light creates positive phototaxis.

- What is the **phenomenon** we want to observe: we want to observe how do daphnia react to the increase of density of light, compared to an Arduino: Does she go faster toward the source of light when it increases, or does she get slower ? How do the arduino react to the different intensities of light ?

- **Question** : Which sensor (biological or electronic) is more receptive to the change in intensity of blue light ? Do the biological and electronic sensors can “perceive” equally the increase of intensity coming from blue light ? If not, what are the differences ?

- **Hypothesis** : We hypothesize that the arduino light sensor will be more accurate than the daphnias at reacting at the increase of intensity of light for blue light.

- **Experiment :** Observing the capacity of daphnias and Arduino sensors to react to the increase of intensity of blue light.

- **Characteristics (as many possible)** of sensor we want to compare:

- Capacity to sense the intensity of light; daphnias are supposed all to react the same way and have the same behaviour (going up or down, phototaxis) depending on the intensity of light: do they all react the same way ? Do the values of Arduino change according to the increasing intensity of light values ?

Parameters we can change:

- Intensity of light

Problems/Bias :

- Factors that can alters the phototaxis: quality of water, quality of light (led problems), interaction between organisms, health of the organism (they are not all at the same

biological conditions: they have been put in mineral water with some nutrients but it might not be their optimal conditions of life).
- Same populations of samples and replicates for all the experiences (we use the same 3 beakers) → This can be a bias or not, as also changing the population could be a bias.
- The daphnias we use for the repetitions of the experience are the same, so they have been exposed at the same lights in the first experience, this can change their behaviour.

Parameters we keep constant**:**

- Any other source of light in the environment
- Sample size and beaker size
- Same temperature of water
- Same water quantity
- Same
- Sample size N=30 (First beaker, x2 replica)

- **Negative/Positive controls:**

- One beaker lightened / One beaker always stays in the dark
- One arduino lightened / One arduino stays in the dark

- **Repetitions/Replica:**

- 2 replicates
- Each population used for every wavelength
- The experiment will entirely be done on friday, some tests on thursday afternoon.
- 4 repetitions

- **Protocol (daphnia) :**

- Put all the daphnias in an aquarium previously prepared.
- Prepare the water needed to grow daphnias in it (let clore evaporates)
    - Mineral Water and micro algae
- The all experience will be done in a dark room (DIY dark room = cardboard dark room), to avoid other lights to interfere with our experience.
- Place a beaker full of water (200mL) on a horizontal, non-reflective surface. Put a moderate amount of Daphnias inside (moderate meaning not too much too avoid overlapping and insure they can all stay at the same level). N=+20
- Write on the beaker every 1 cm
- Place a camera on the side filming the beaker.

- Place a blue light above the beaker vertically at 0 intensity connected to an arduino and a computer to program the good intensity (0 intensity = 4 lux).
- Very slowly change the intensity of the light up. (30 intensity at every step)
- Stop at regular intervals to observe the Daphnias (30 seconds floors) and turn off the light after the 30 second floor to reset the Daphnia.
- Go until you reach the 240 intensity (227 lux).
- Repeat the experience for the Replicates (2). And do the 4 Repetitions of the experience (with the same population of daphnia).
- Analyze the video.

- **Protocol (Arduino)**

- Put the Arduino under the cardboard at the same height as the water level of the Daphnia (200mL)
- Place a blue light above the beaker vertically at 0 intensity connected to an arduino and a computer to program the good intensity (0 intensity = 4 lux).
- Very slowly change the intensity of the light up. (30 intensity at every step)
- The data will be gathered directly thanks to this code (insert link)
- Repeat the experience for the 4 repetitions

Measure:

- **List of Materials/Budget :**
- x3 500mL beakers
- One Arduino and a photo sensor (photocell)
- One Arduino and led lights (blue)
- Smartphone for filming
- Tape to fix the arduino
- Rulers
- Cardboard to create a dark room

- **Characteristics measured for Daphnia:**
- Phototaxic movement : vertical movement → amount of organisms that moved
- Rapidity of vertical movement
- Response time
- Duration of the movement
- How to consider the daphnias that were at that the bottom? Death or not reactive to light?

- **Characteristics of the sensor:**
- Accuracy
- Precision
- Response time

- Saturation point
- range

How to **keep organisms alive** for next weekend: Daphnia must been kept in spring water rich of algae or yeast, must have space to grow and been kept at ambient temperature. Also light is needed, don't put them in the dark.

- **Ethical concern**:

In the event we cannot keep them alive in-between experiments, we shall have to terminate them. This raises ethical concerns on two possible solutions, the first one is about detention conditions. What do we put in the aquarium of the Daphnias. And then if we cannot keep them : how do we give them a painless death.
Moreover, we need to watch the intensity in order not to damage the organisms.

Bibliography:

Daphnia

- Nédélec, François J. "Mechanism of phototaxis in marine zooplankton: Description of the model." (2008).

- van Gool, Erik, and Joop Ringelberg. "The effect of accelerations in light increase on the phototactic downward swimming of Daphnia and the relevance to diel vertical migration." *Journal of plankton research* 19.12 (1997): 2041-2050.

- Steams, Stephen C. "Light responses of Daphnia pulex." *Limnol Oceanogr 20* (1975): 564-70

- Ringelberg, Johannes. "The positively phototactic reaction of Daphnia magna Straus: a contribution to the understanding of diurnal vertical - - migration." *Netherlands Journal of Sea Research* 2.3 (1964): 319IN1335-334IN2406.

Arduino: sources and materials

- http://playground.arduino.cc/interfacing/python
- http://www.mouser.fr/Search/ProductDetail.aspx?R=1980virtualkey54850000virtualkey485-1980
- http://www.mouser.fr/Search/ProductDetail.aspx?R=1384virtualkey54850000virtualkey48 5-1384
- http://www.mouser.fr/ProductDetail/Adafruit/161/?qs=%2fha2pyFaduidPXPXSuFTA5DDZdShRkexJbM%2fC0FaJ9I2cgisBToc9Q%3d%3d

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