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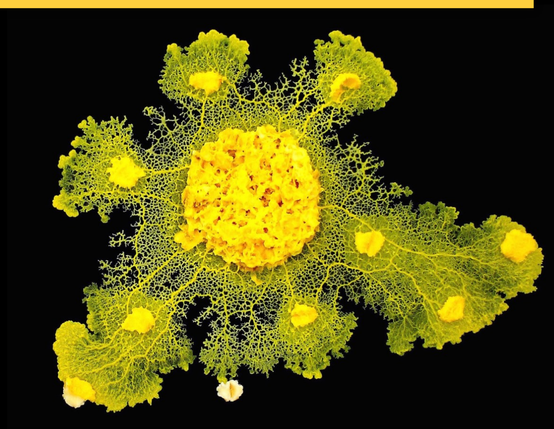
Physarum Polycephalum violates Weber's law

INTRODUCTION



The acellular slime mold *Physarum Polycephalum* is a giant multi nucleated unicellular with impressive abilities including the ability to avoid risky situations. Yet, little is known about the mechanisms slime molds might use to compare the level of risk when making a decision. In this study, our goal was to determine if *P. polycephalum* follows a Weber's law which states that any comparison is based on the ratio between the stimuli compared; as the ratio becomes smaller the comparison becomes more difficult. Sodium chloride was used to create various levels of risk as NaCl is noxious substance for *P. polycephalum*.

***Objective* : Determine if *Physarum polycephalum* follows a Weber's law when gauging risk level.**

Weber's law prediction : stimuli are perceived in relative terms not in absolute terms.

METHODS

We used an Australian strain of *P.polycephalum*. We placed each slime mold between two bridges made of Agar gel 1%. Each bridge contained different NaCl concentrations (**Fig1**). We use 6 references concentrations **C1** ranging from 1 to 6 (g.L-1), and several test concentrations **C2**. The behavioural response measured was the distance travelled on each bridge (**D1** and **D2**) after 18h.

1- Aversion experiment:

We first run a control experiment to test the aversion of slime molds for NaCl. We run two different choices: 0 vs 1g.L-1 NaCl and 0 vs 2g.L-1 NaCl. In 46 cases out of 48 replicates and in all 48 replicates the distance travelled on the bridge free of NaCl was higher than the distance travelled on bridge with NaCl for 0 vs 1g.L-1 ($P < 0.001$ – paired T-test) and 0 vs 2g.L-1 ($P < 0.001$ – paired T-test) respectively.

2- Speed experiment :

We estimated how NaCl concentration affected slime molds speed. Slime molds were confronted with two bridges containing the same concentration of NaCl. We tested all the **C1** concentrations. We demonstrated that the slime mold speed (Total distance travelled **D1** + **D2** / Time) decreased with the concentration of NaCl ($R2=0.6$, $P<0.001$ glm) (**Fig 2**).

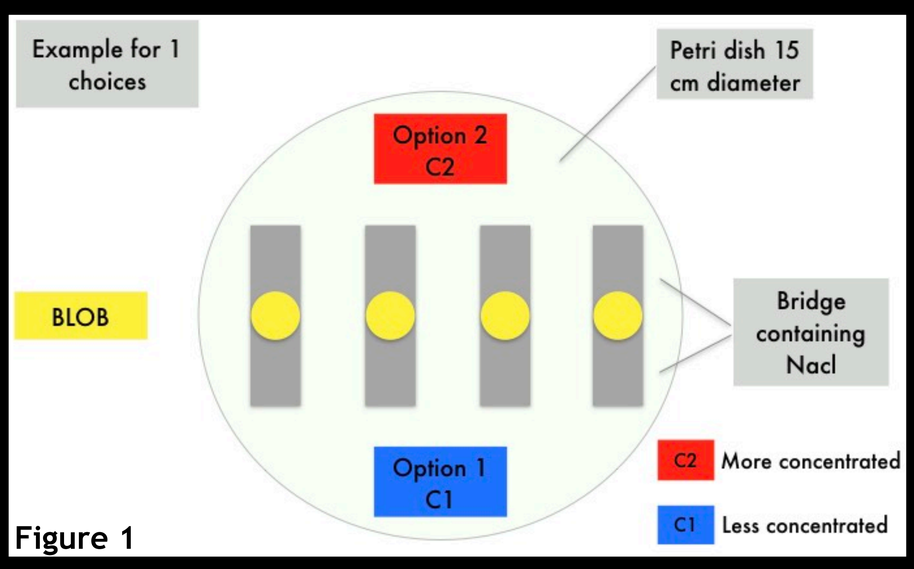


Figure 1

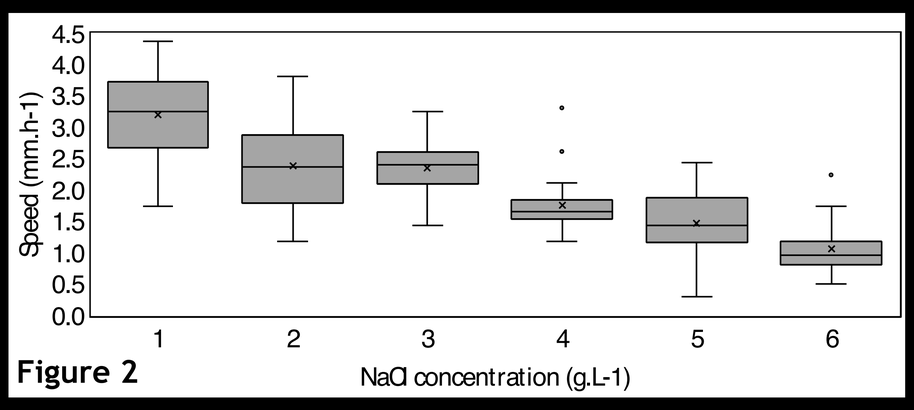


Figure 2

3- Weber Law experiment :

Lastly, we run an experiment to determine if slime molds follow a Weber's law when making a decision. We run 88 choices presenting **C1** vs **C2** with **C2** > **C1**. Each choice were replicated 48 times. Our data allowed us to build two heat maps. Colors indicate performance (P) computed as P= (**D1** - **D2**) / (**D1** + **D2**). When P=1 the slime mold travelled only on **C1** (**D2**=0), when P= -1 the slime mold travelled only on **C2** (**D1**=0) and when P=0 the slime mold travelled over the same distance on **C1** and **C2** (**D1** = **D2**). We showed that contrary to the Weber's law prediction (**Fig 3**), slime molds perceived differences in NaCl concentrations in absolute terms (**Fig 4**) and not in relative terms (**Fig 5**). The smallest change in the NaCl concentration (difference threshold) capable of being perceived is not proportional to **C1**, it remains constant regardless of **C1** (the performance isoclines run parallel to the x-Axis on Fig 4). On the contrary ratio threshold decreased with **C1** instead of remaining constant.

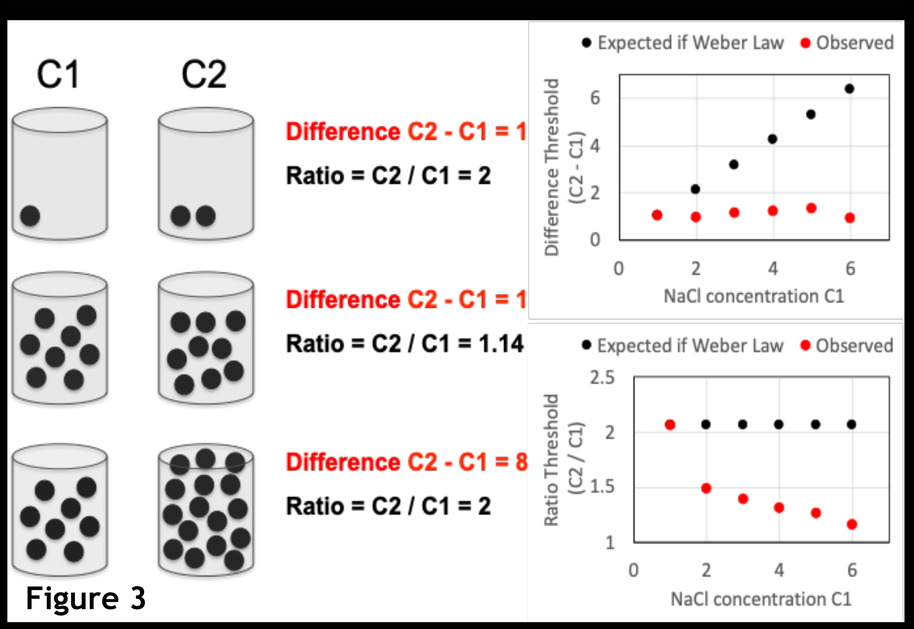


Figure 3

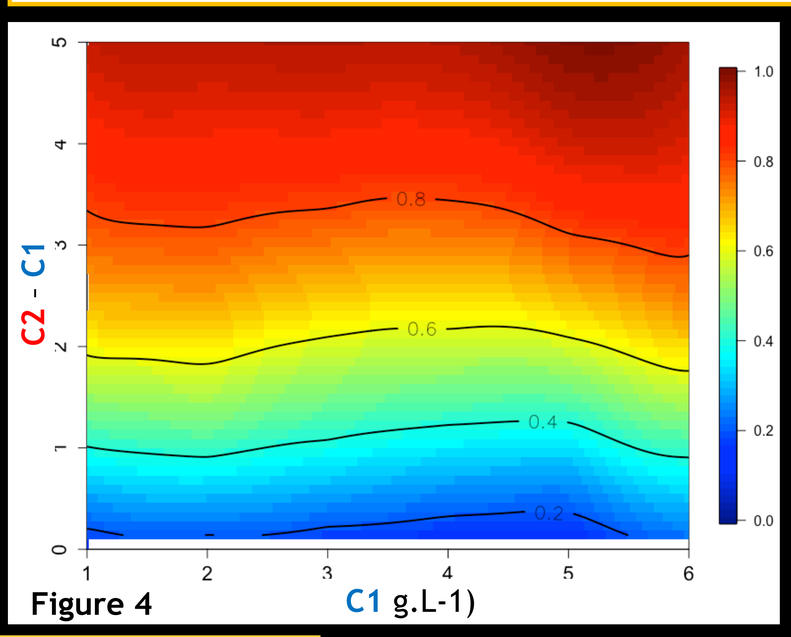


Figure 4

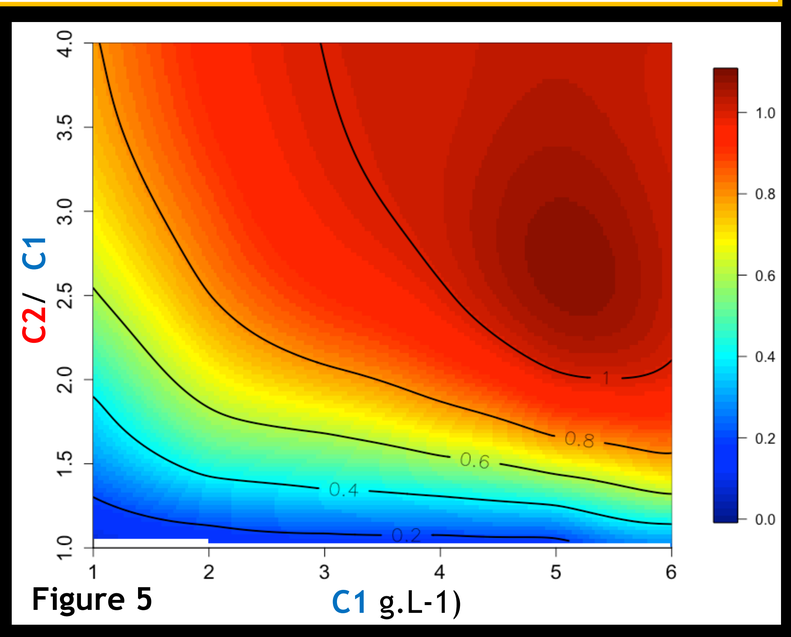


Figure 5

DISCUSSION

The ability to detect small changes in the risk level in the environment is essential to survive. *P polycephalum* is one of few organisms to violate the Weber's law, even *Dictyostelium discoideum* a close related unicellular organism that belongs to the Mycetozoa phylum, relies on Weber's law to detect changes in chemical concentrations. It would be interesting to investigate if *P polycephalum* violates the Weber's law in different context (e.g foraging context).

REFERENCES

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