

Response Threshold Distributions to Improve Best-of-n Decisions in Minimalistic Robot Swarms

1 Abstract

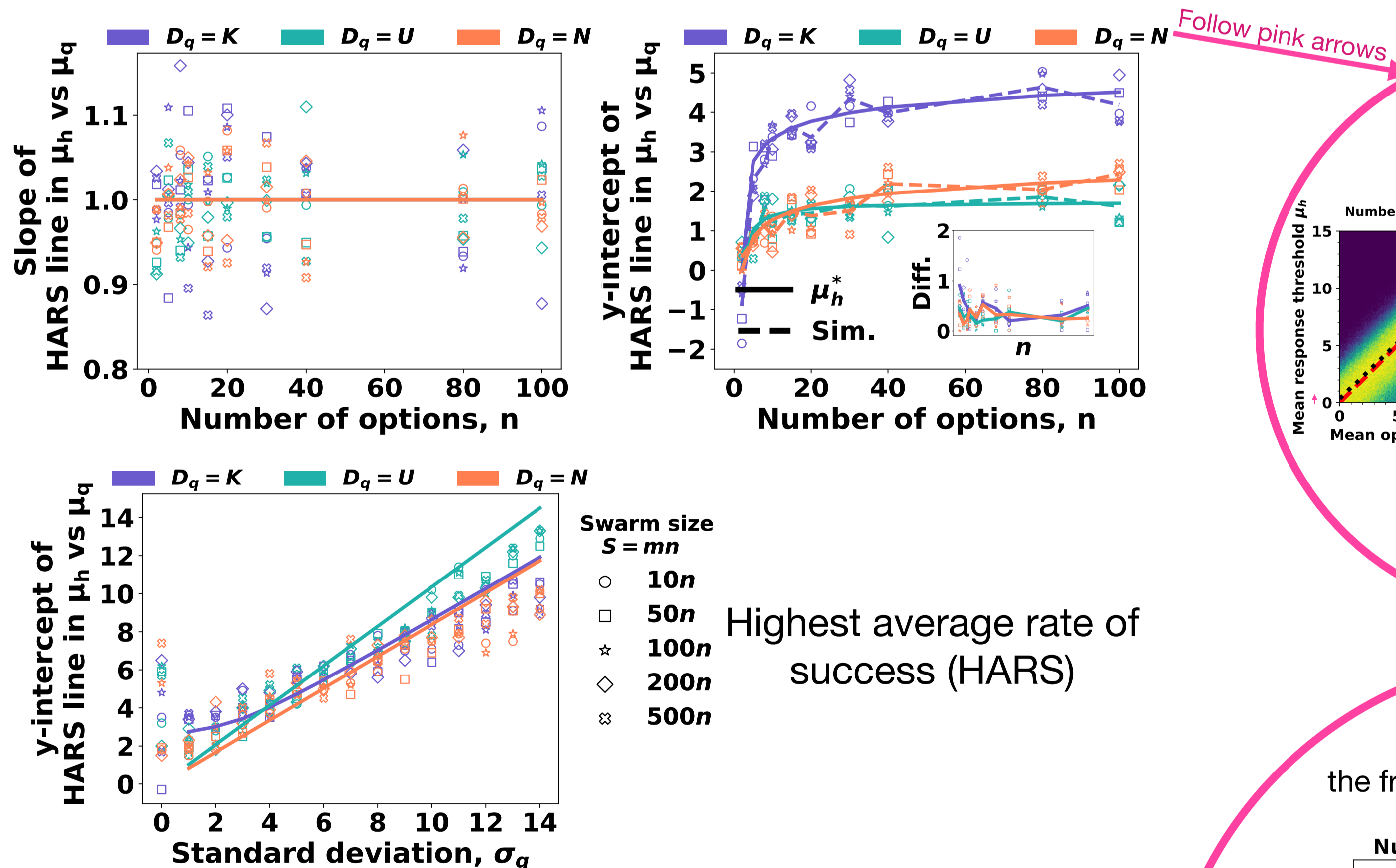
- Swarm of nano-robots can revolutionise treatment of diseases like cancer & precision drug delivery in-vivo.
- Such robots are **tiny and lack resources** like memory, computational power, communication limitations.
- The **number of robots** required is **high**, the task needs to be performed **autonomously**.
- How can we make such robots capable of adaptively making decisions autonomously ???

2 Problem Formulation

- Which **response threshold PDF** allows the swarm of simple robots to best **distinguish** the option with the **highest quality** given you know the **number of options** in the environment and the **options' quality distribution** ???
- Each robot estimates the quality of a random option and gives a **binary response**—accept or reject (thumbs up/down) —depending on the quality being above or below its threshold (emojis).
- Our **results** form the **basis** to develop future decentralised algorithms for swarms of reactive binary robots (thumbs up/down) able to make best-of-n decisions.

3 Finding the Best Mean Response Threshold μ_h^*

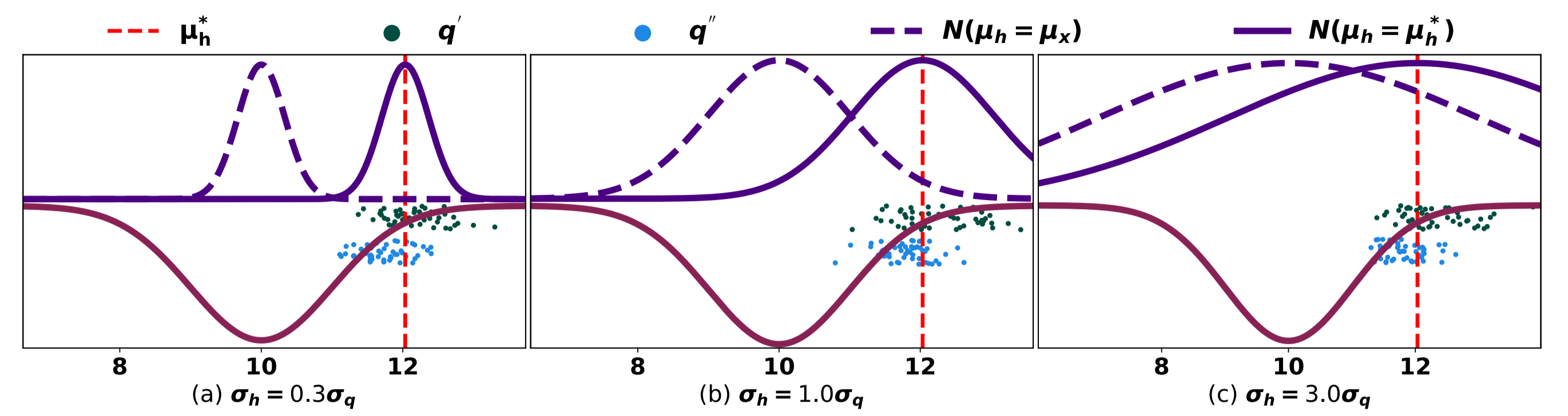
Note the effects of changing the number of options on the mean and standard deviations at the bright region.



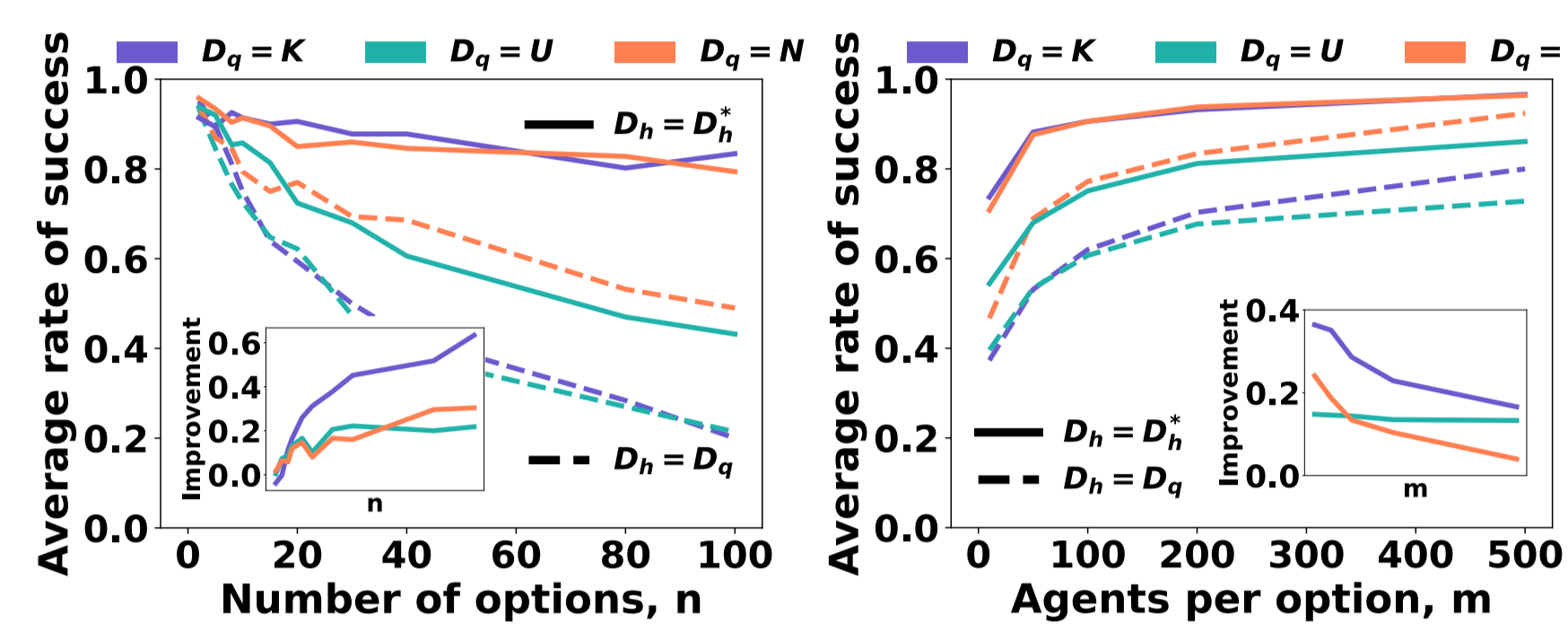
4 Finding the Best Std. Dev. Response Thresholds σ_h^*

The minimum standard deviation where performance is highest will enable us to utilise the number of robots intelligently.

Thus allowing us to utilise the robots intelligently.



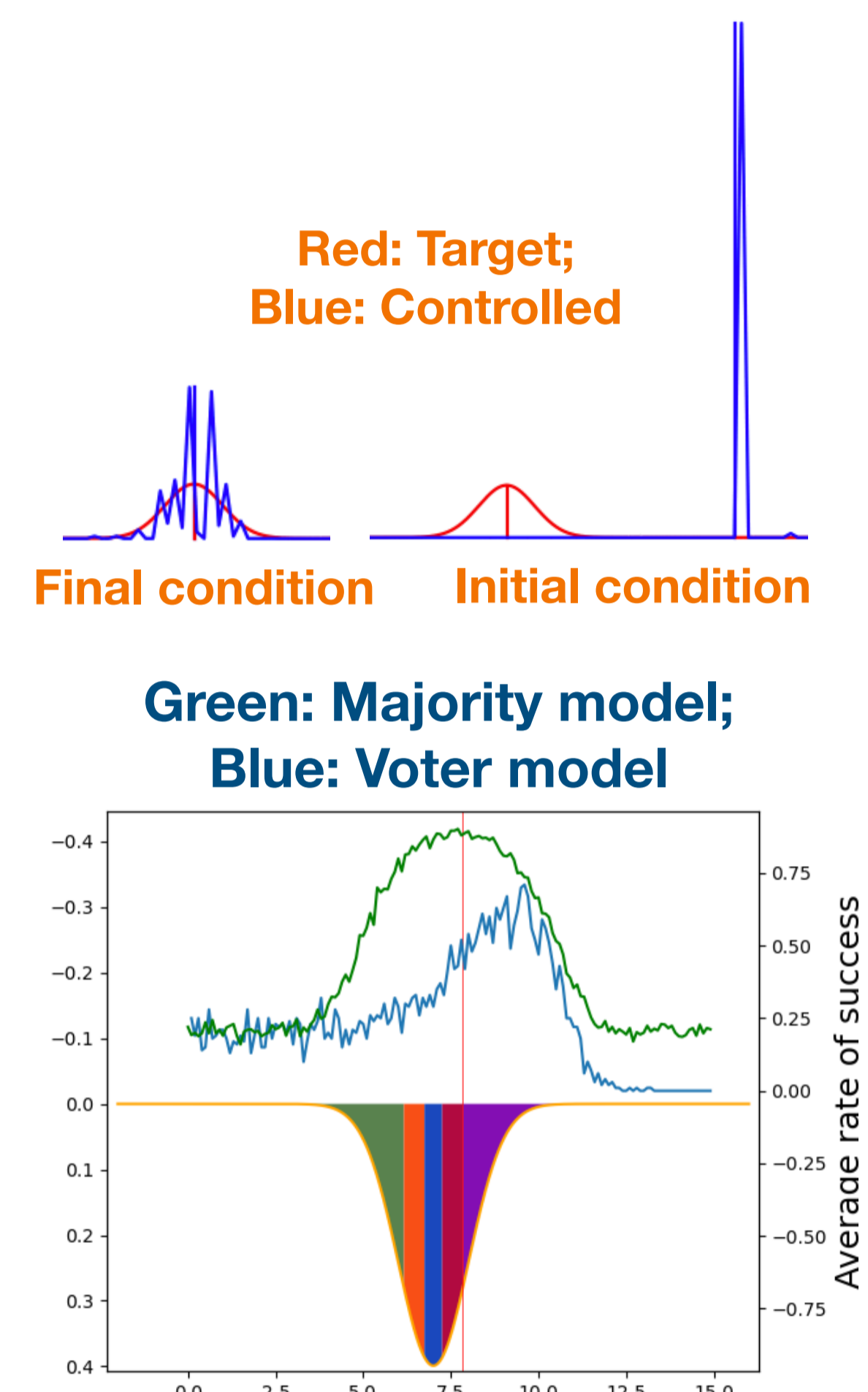
5 Improved Collective Performance



Performance increases both with increasing the number of options & with reducing the number of robots assigned per option.

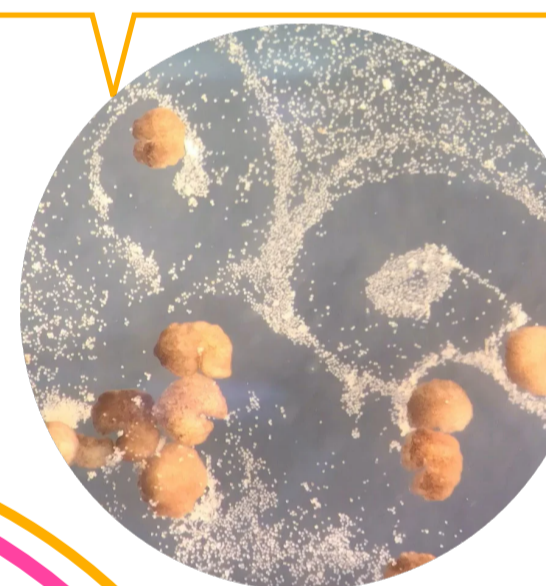
6 Future Directions

- Allow the robots to **autonomously adapt** their response thresholds using **minimal memory** of binary values.
- Include the **consensus phase**.
- Determine the **minimal required sociality** to correlate the adaptive behaviour of robots to the number of options.



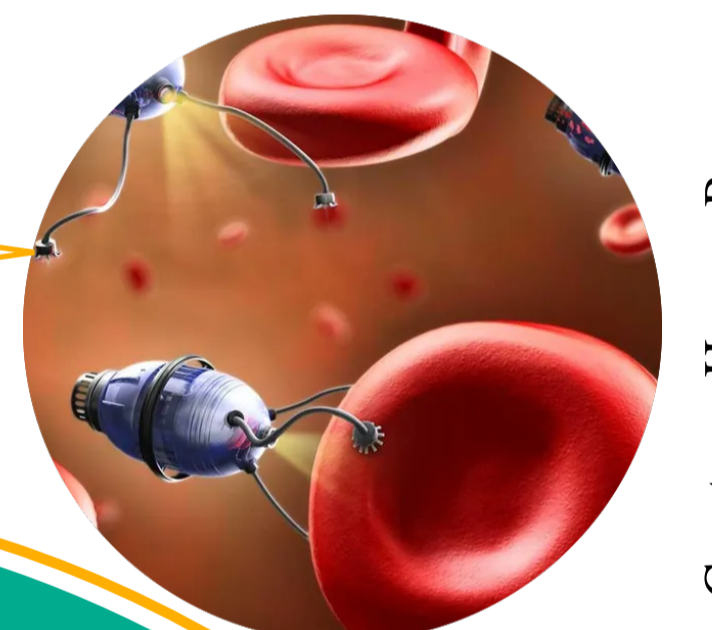
Applications

Biodegradable robots swarm for small scale monitoring and transport



Courtesy: Josh Bongard et al.

Swarm of Nano-robots that operate in blood vessels



Courtesy: Human Paragon

Minuscule Robots, Can you decide which is the largest Ball?

Use Response threshold PDF with this mean to improve success rate

$$\int_{-\infty}^{\mu_h^*} D_q(x|\mu_q, \sigma_q) dx = 1 - \frac{1}{n} \quad (1)$$

Mathematical Formulation

Reasoning

Histogram shows the frequency of the largest sample

Red: Predicted; Black: Fitted