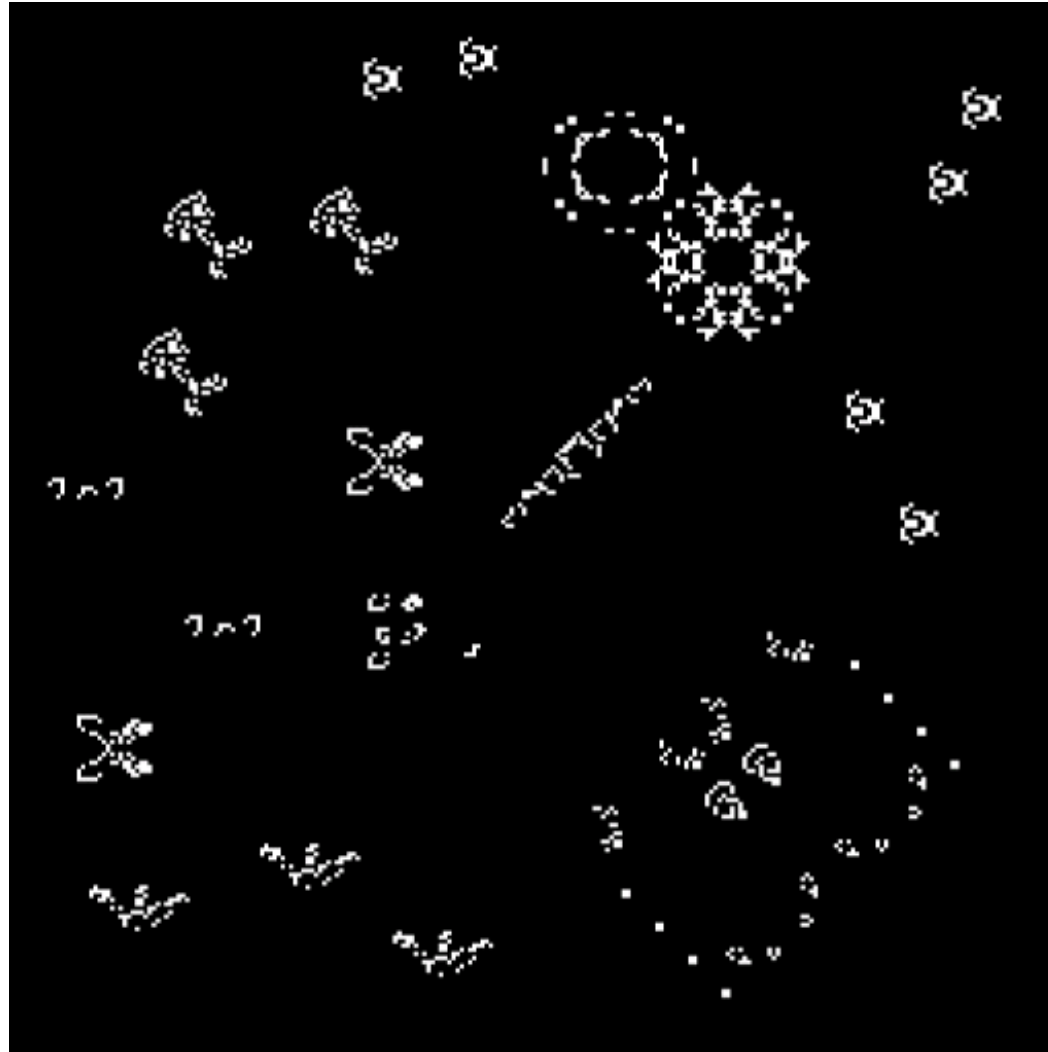


# Discovering Sensorimotor Agency in Cellular Automata using Diversity Search

Gautier Hamon, Mayalen Etcheverry, Bert Wang-Chak Chan,  
Clément Moulin-Frier, Pierre-Yves Oudeyer  
**INRIA, University of Bordeaux**

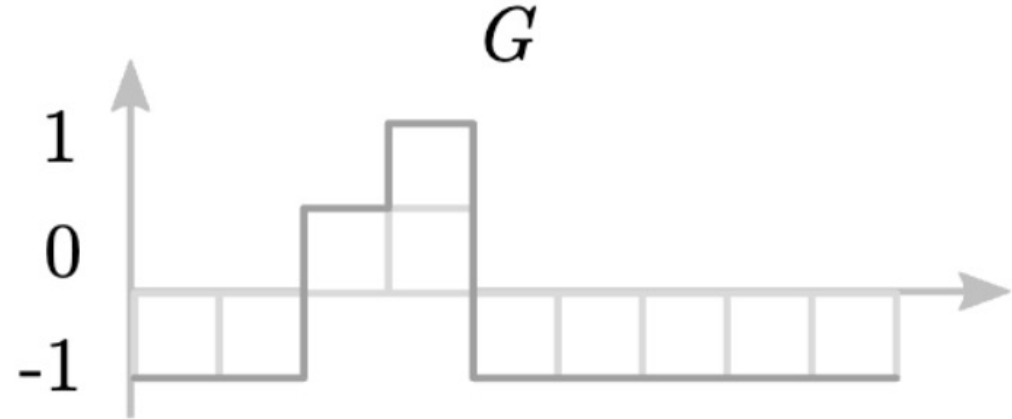
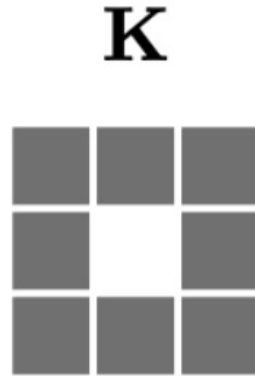
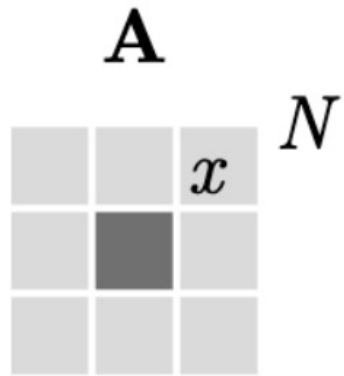
# Conway's Game of Life



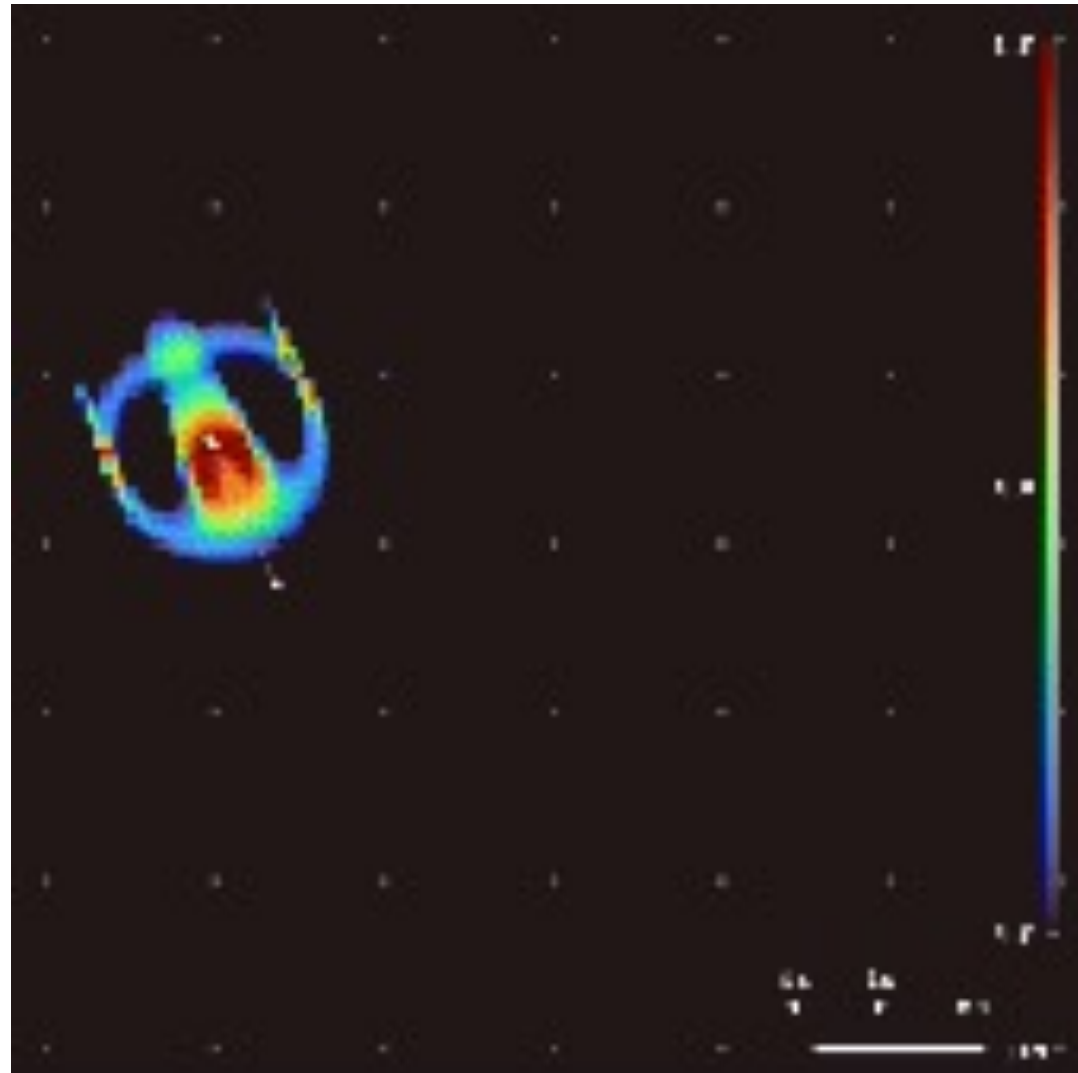
# Update rule in life game

2 live neighbors  $\rightarrow$  survival

3 live neighbors  $\rightarrow$  birth

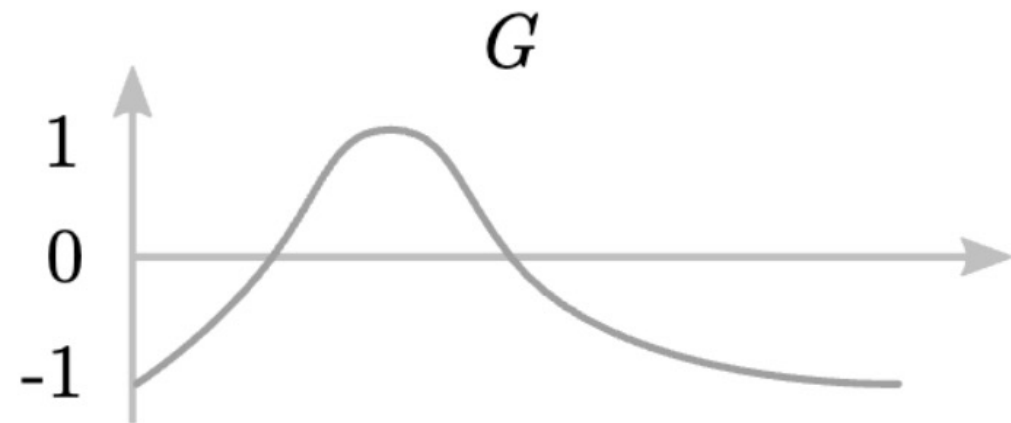
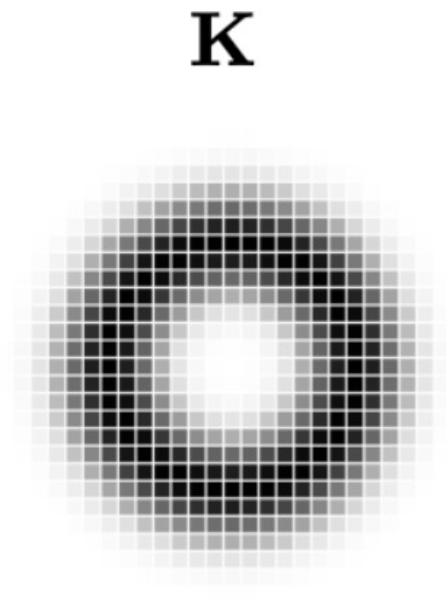
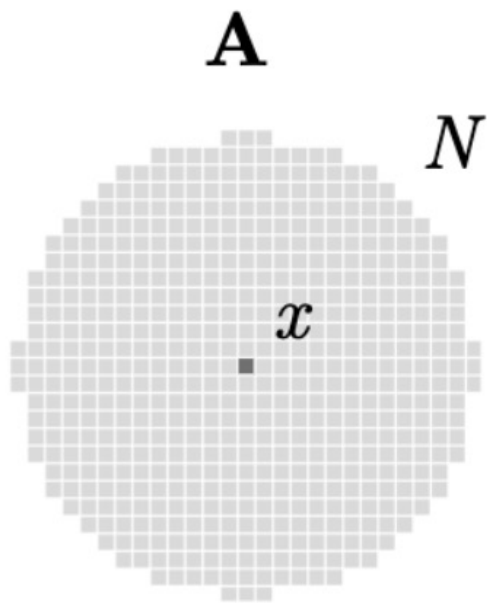


# Lenia



# Kernel, growth function

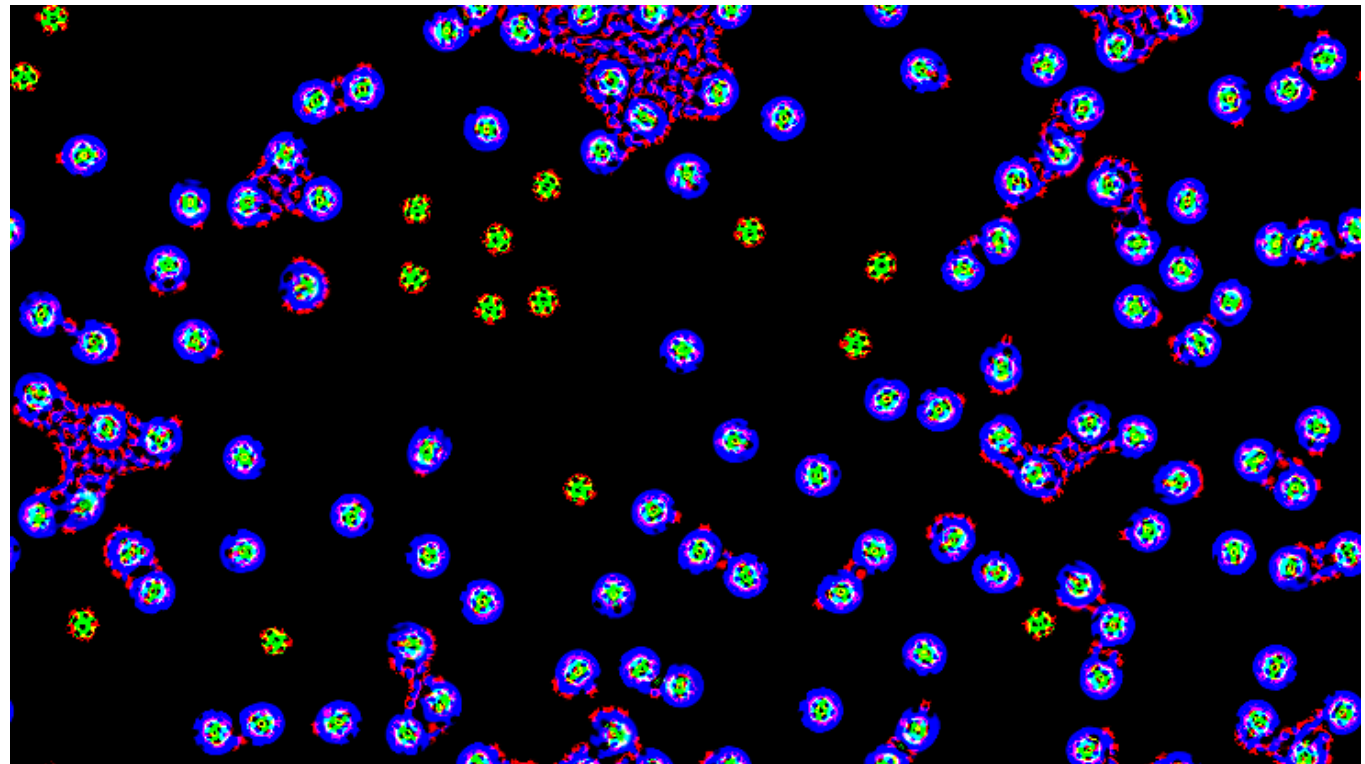
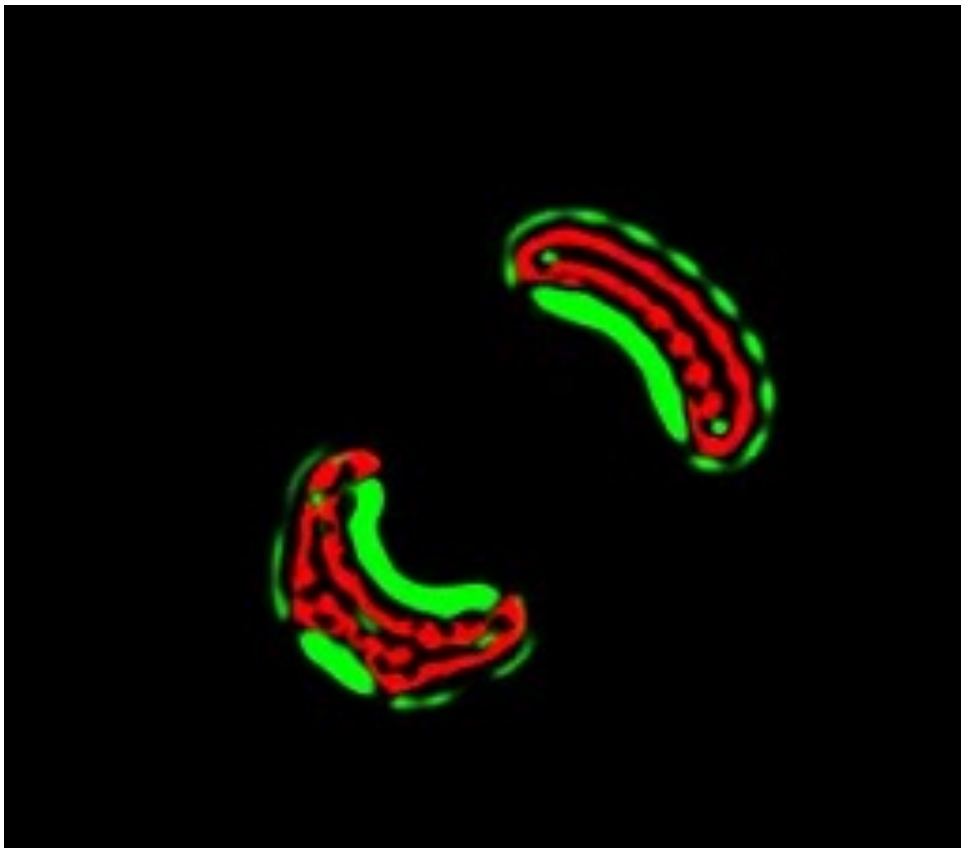
Convert neighborhood state into update with gaussian function



# Channels

Each channel has its own state and update rule

Channels interact through cross-channel update rules



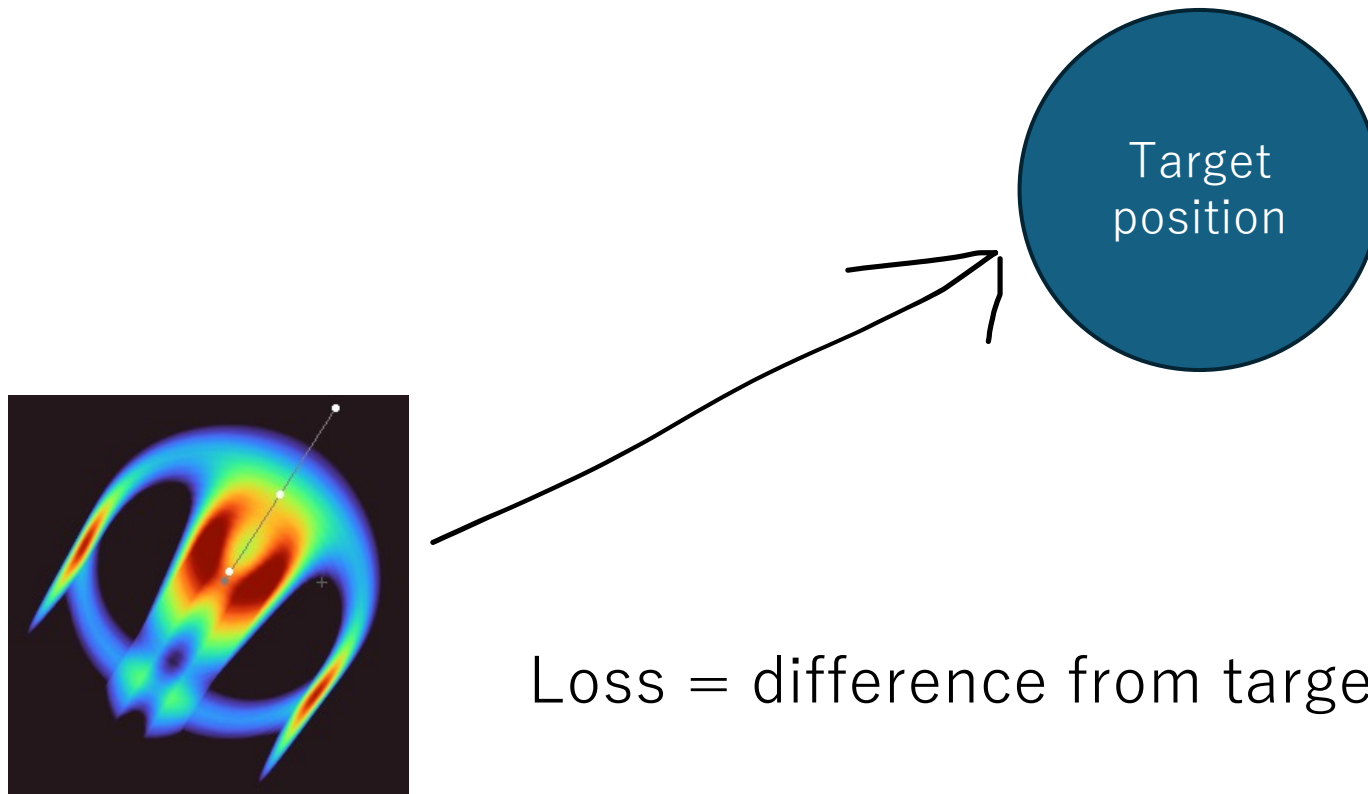
# Purpose

Self-organization of robust, adaptable agents through goal-directed optimization

Agents with sensorimotor capabilities emerge from local update rule

# Learning lenia

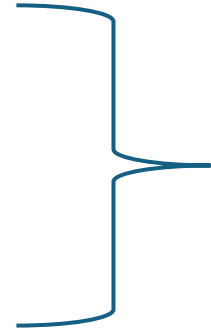
Update parameter with backpropagation of mass location





# Parameter of Lenia

- Kernel shape
- Growth function
- Initial Lenia shape



Training target

- Relation between channels
- etc..

# IMGEP

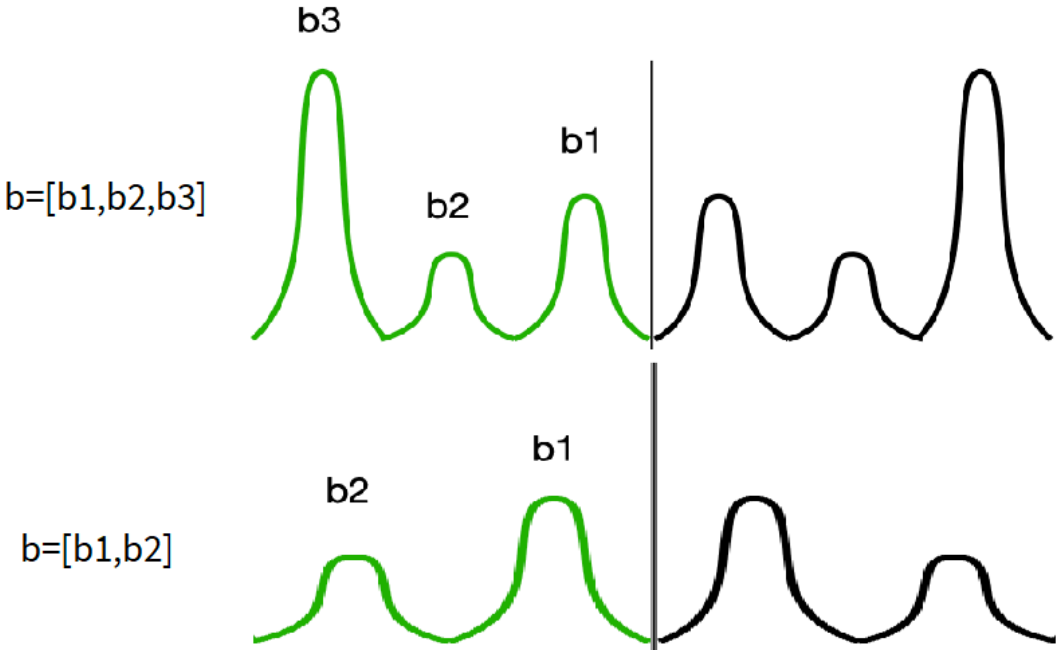
(intrinsically-motivated goal exploration processes)

1. Sample target locations (initially close, gradually further).
2. Select parameters that have reached near the target from past experiences.
3. Optimize the selected parameters using gradient descent towards the target.
4. Test the agent with optimized parameters and record the reached positions.

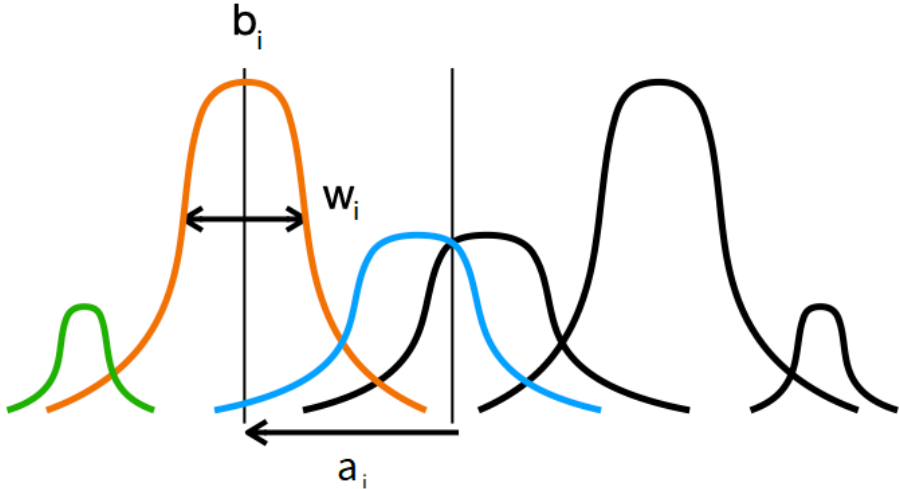
occasionally select random positions to ensure diversity

# Differentiable Lenia shift

**original kernels**  
vector  $[b]$  for the heights of  
fixed concentric rings



**free kernels**  
Sum of Gaussians  
height ( $b$ ), radius ( $a$ ), width ( $w$ )

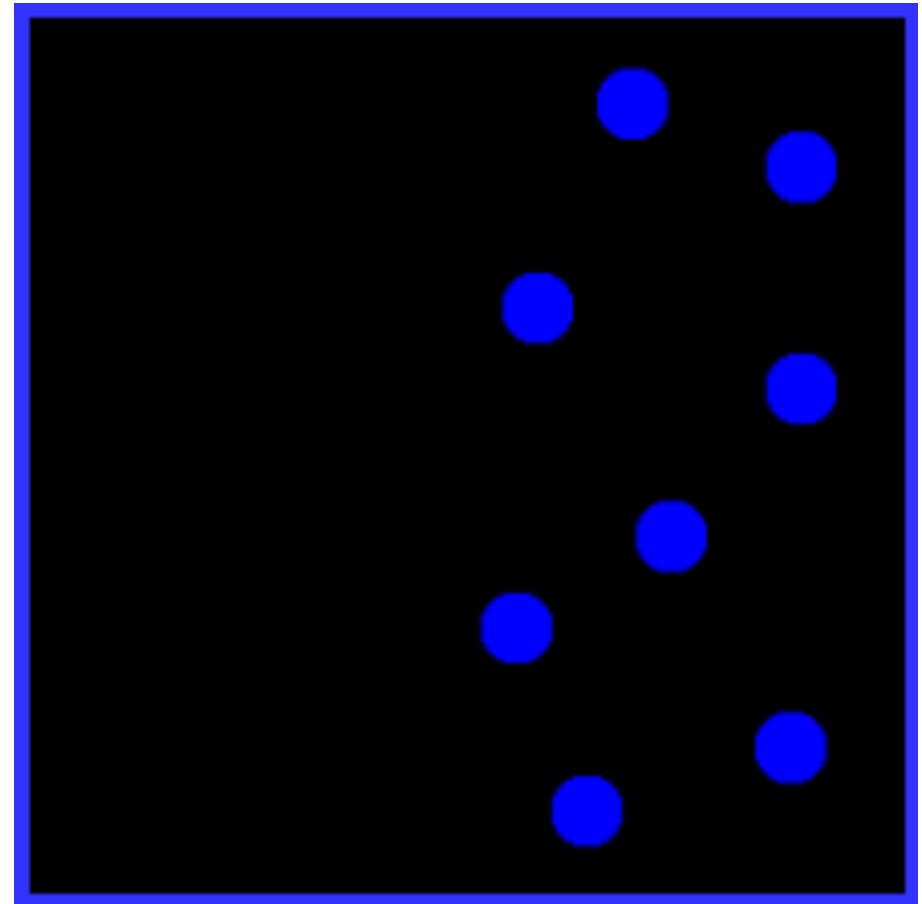


# Environment with obstacle

Channel 1(learnable)



Channel 2(fixed)



# Conclusion

- Without clear notion of body/sensor/actuator, group of simple identical entities can make “decision” and “sense” at the macro scale.

Thank you for your attention