

The Perception and Action Cycle (PAC)



Perception and Action Cycle (PAC)

- The circular interaction between an organism and its environment during a sensory-guided sequence of behaviour towards a goal.
- Each action causes changes in the environment that are again picked up by the perceptual system, which is then informed by memory and decision-making and leads to further action.
- Each action causes new changes that are analyzed and lead to further action, and thus the cycle continues.



Illustrative everyday example – Picking up a cup



Illustrative everyday example – Picking up a cup



Sense/Perceive



Simulate



Action

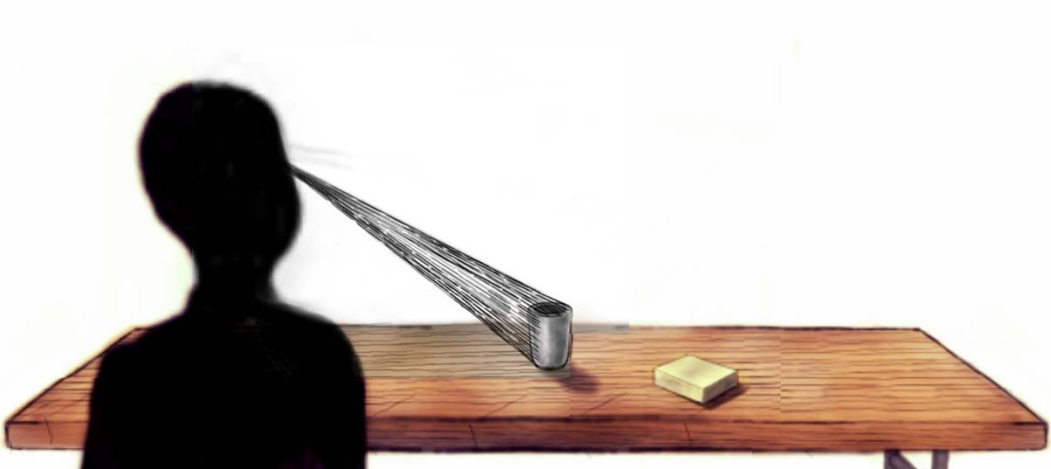


Goal

The eyes detect reflected light from the visible (proximal) side of the cup...



Sense/Perceive



The light stimuli are then used to inform a reaching and grasping action.



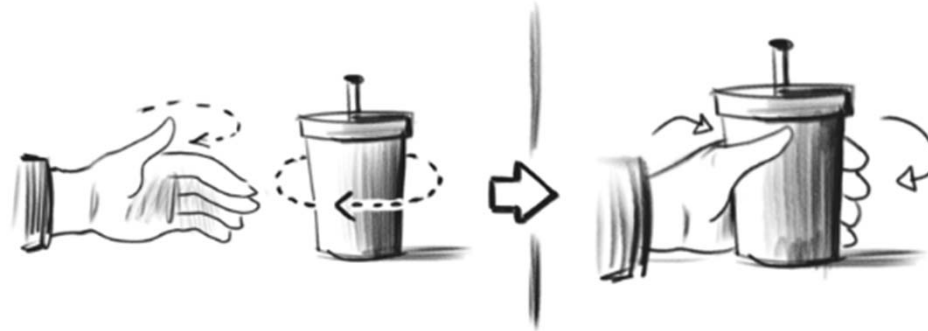
Action



Sense/Perceive



During reach the hand prepares to grasp the cup in anticipation of the complete shape and unseen (distal) side of the cup.



Action



Sense/Perceive



Action & Feedback



But what is happening between perception and action that enables this appropriate response to the environmental stimuli?



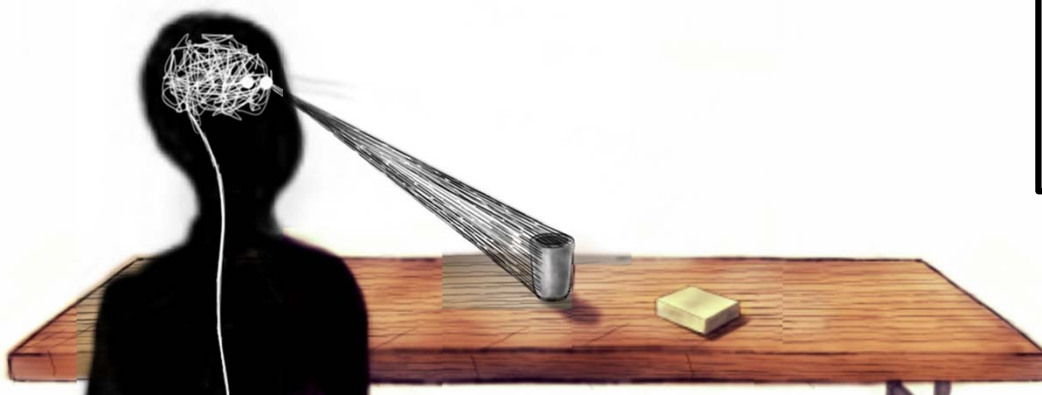
Action



Sense/Perceive



Action & Feedback



But what is happening between perception and action that enables this appropriate response to the environmental stimuli?

Mental simulation



Memory as resource for simulation



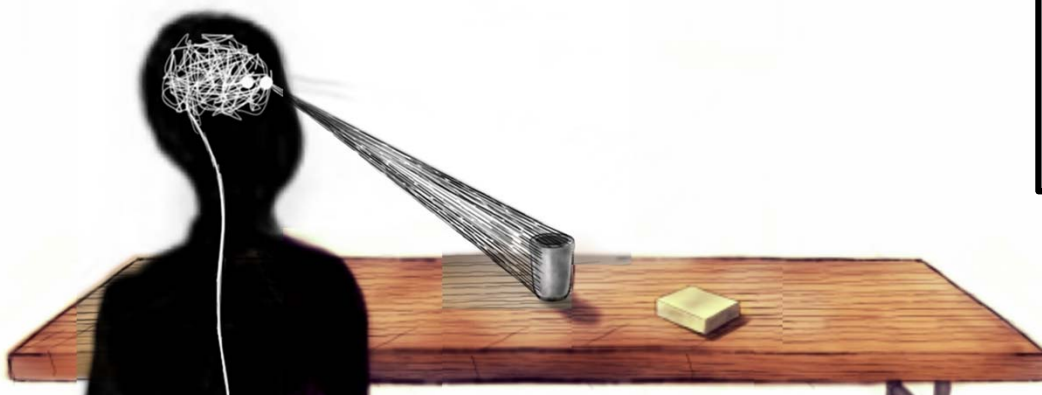
Action



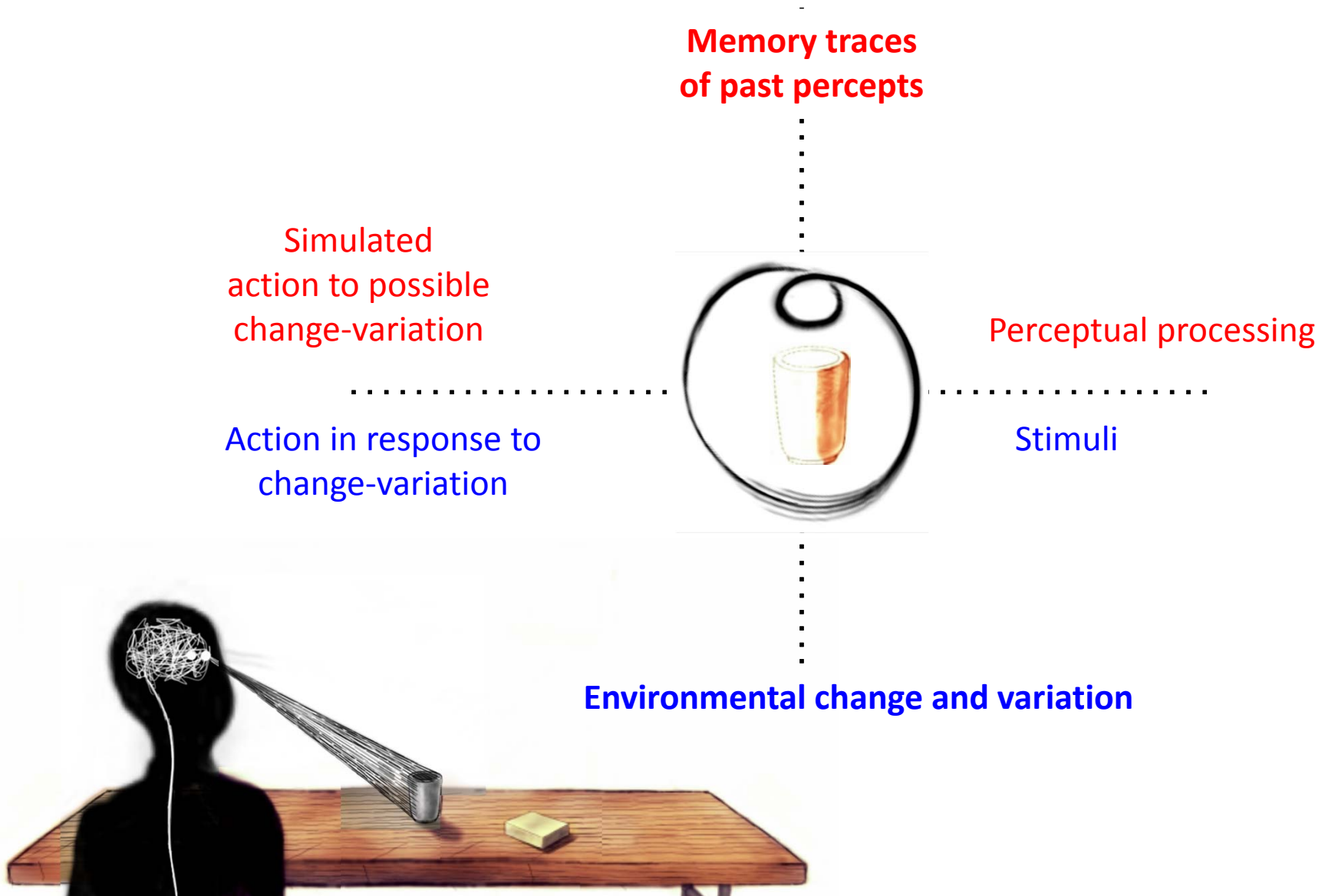
Sense/Perceive



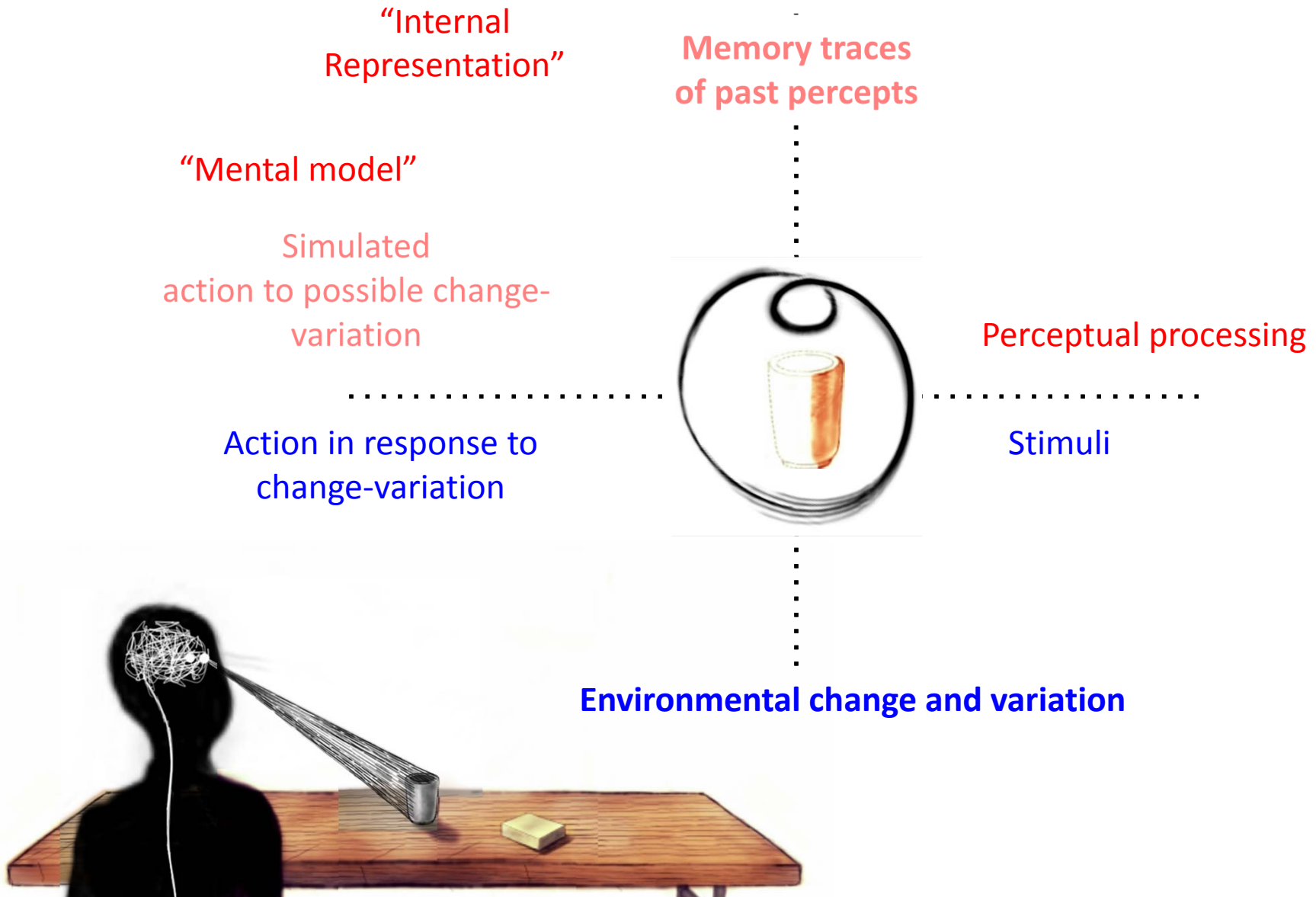
Action & Feedback



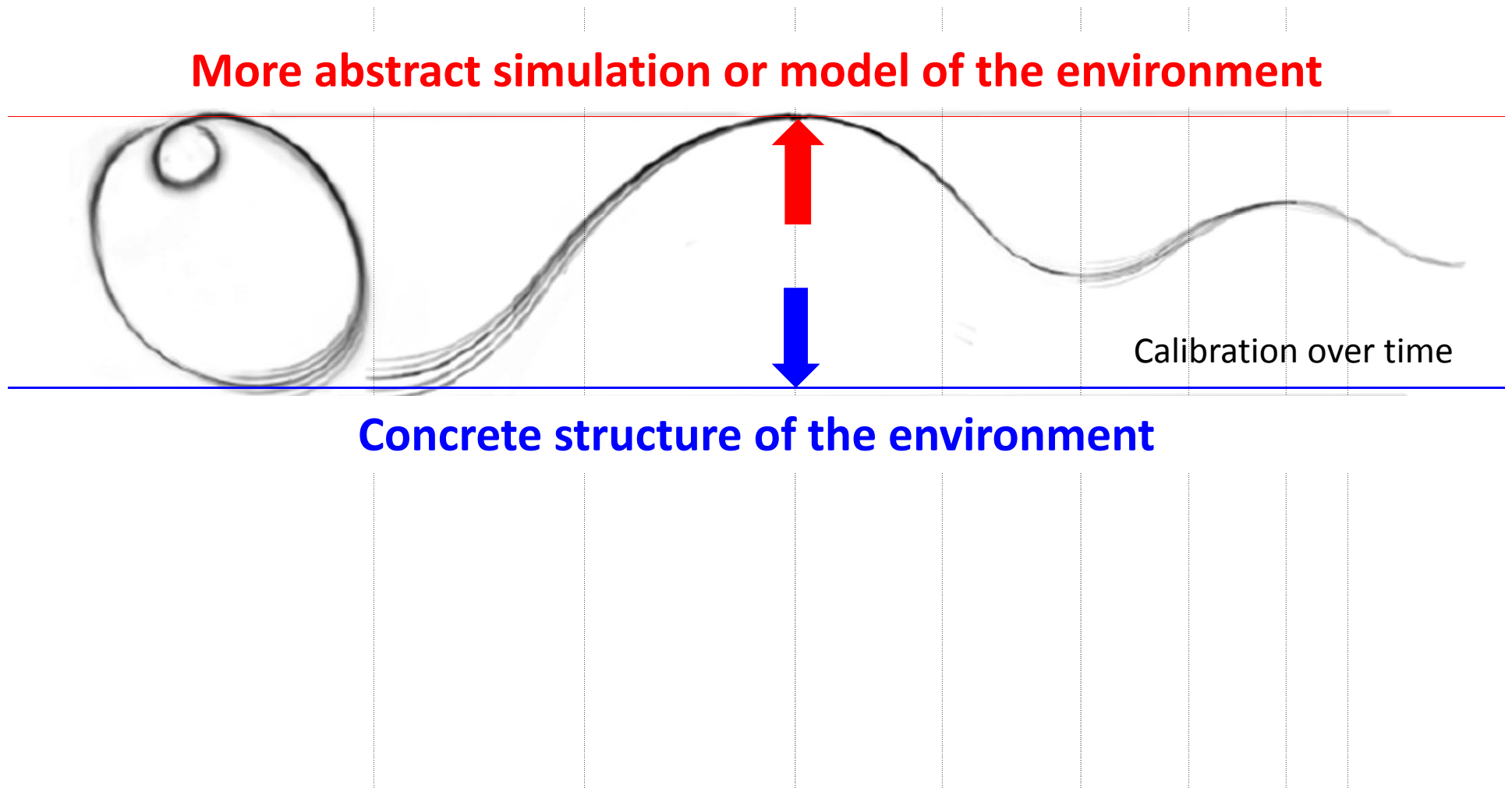
Simplified PAC Model



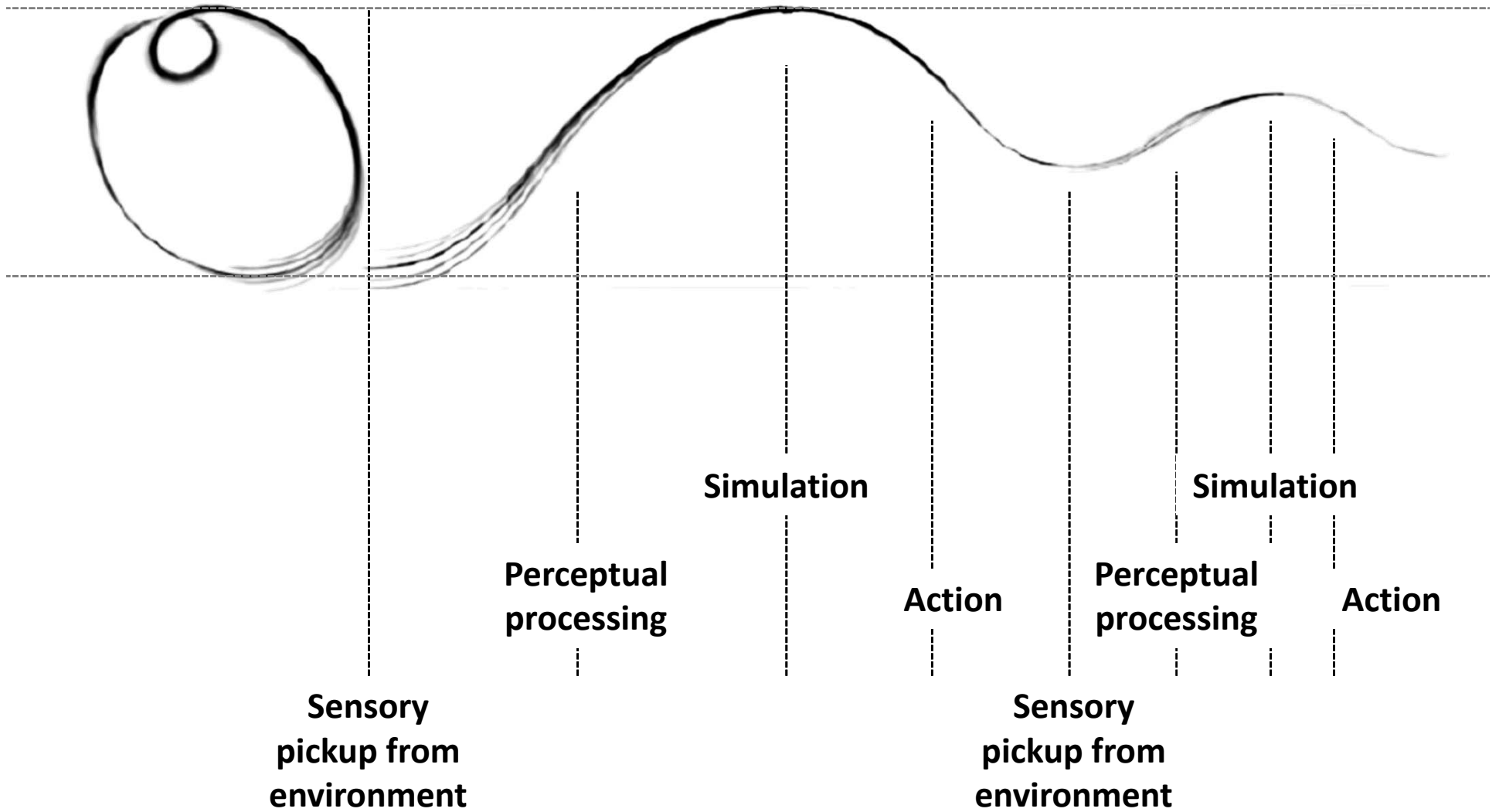
Simplified PAC Model



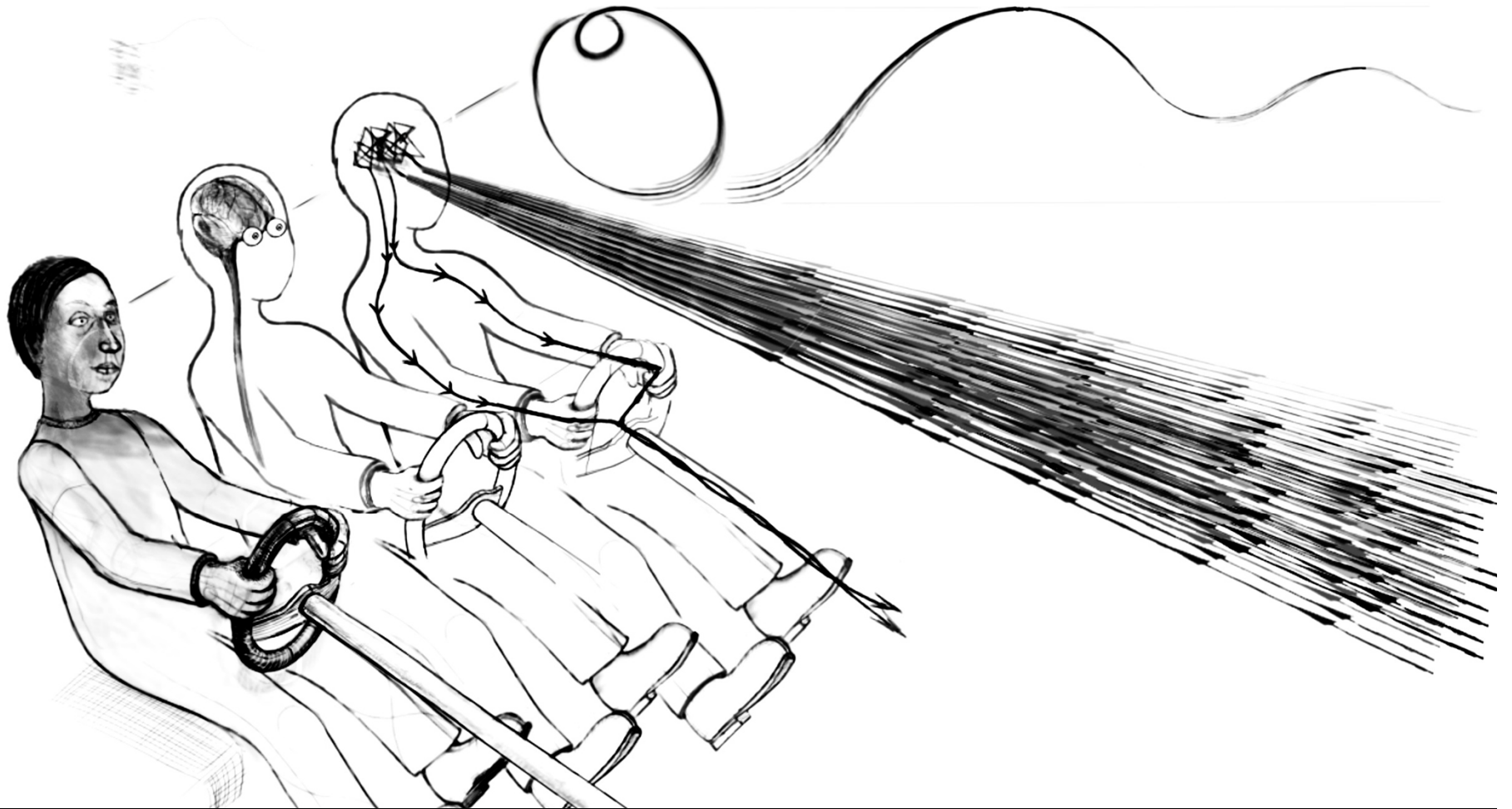
PAC over space-time



PAC over space-time



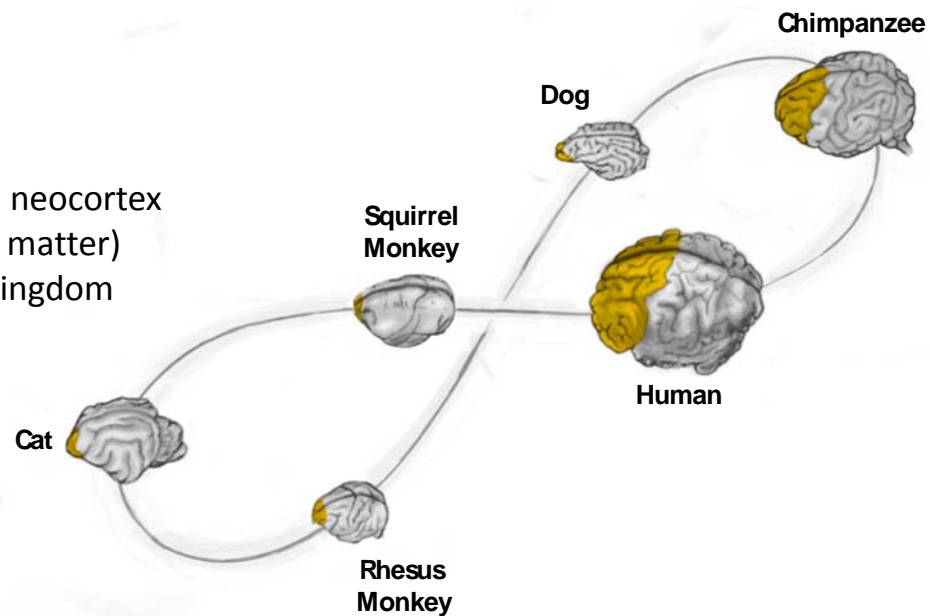
Learning to drive



Perception is for Action

- The ultimate purpose of perception is to inform action
- The more complex the behaviour of an organism, the more complex its cognitive system

Humans have the largest neocortex
(relative to total brain matter)
of the entire animal kingdom

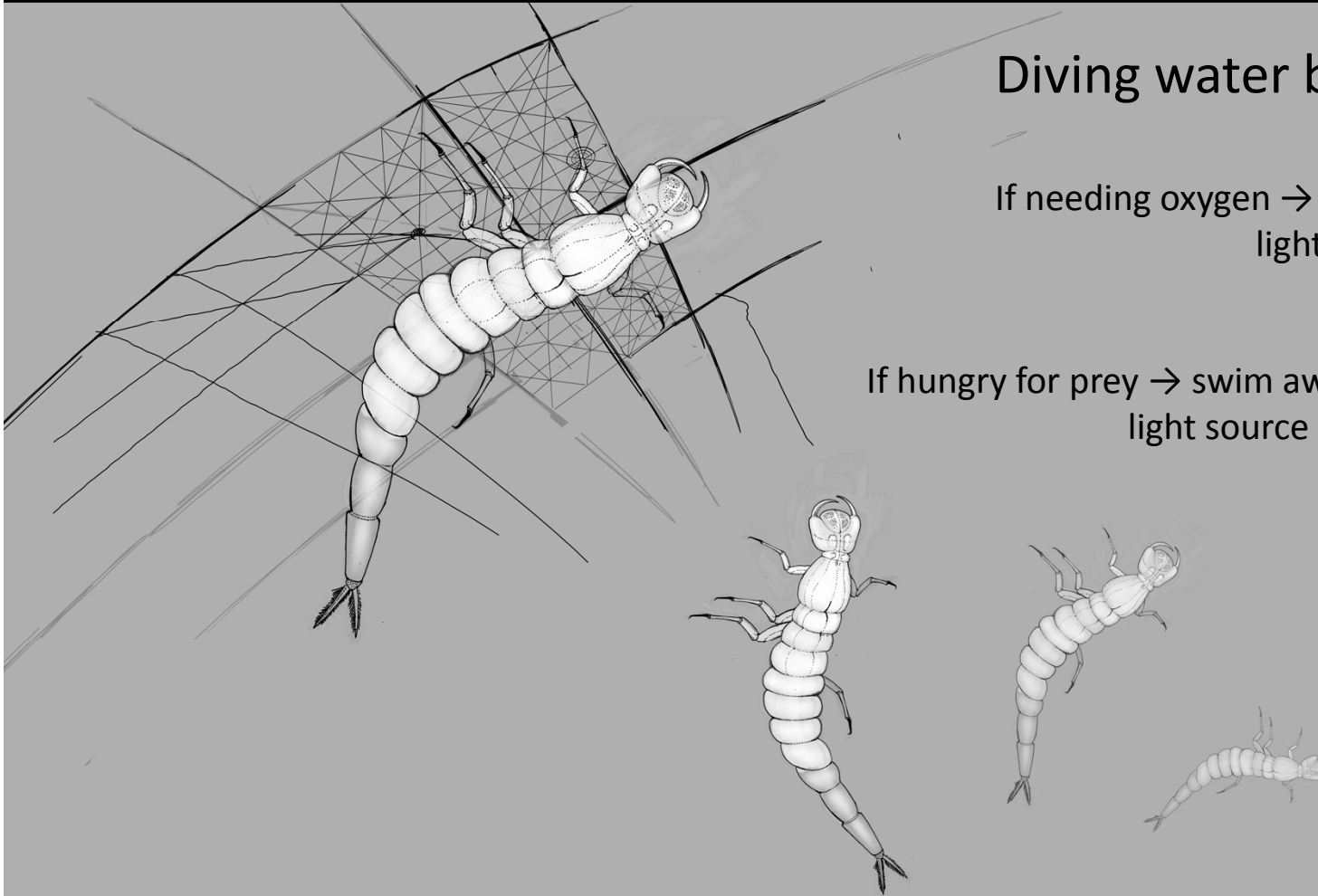


Simpler organisms have simpler PAC systems relating sensory input to behaviour

Diving water beetle larvae

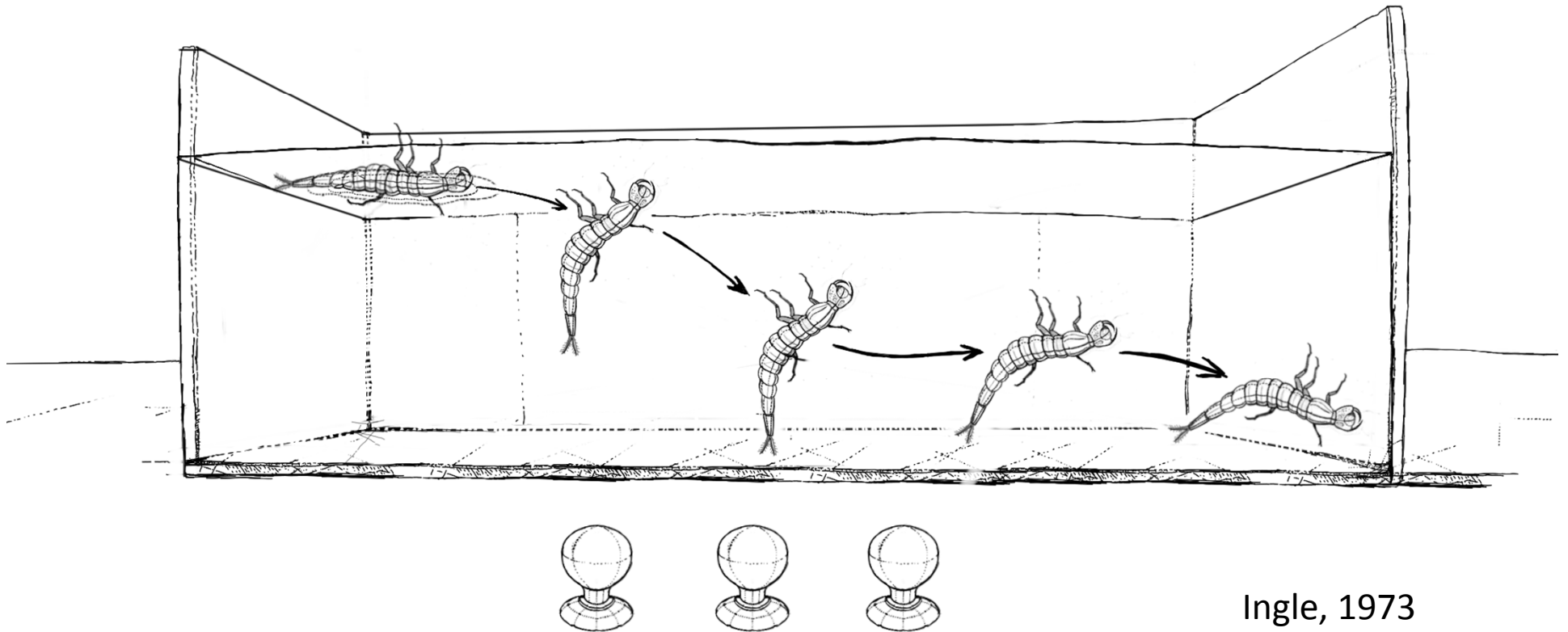
If needing oxygen → swim to ambient
light source at water surface

If hungry for prey → swim away from
light source at water surface (dive)



In simpler organisms there is a more direct link between perception and action

Shining ambient light from below with an artificial light source reverses the diving beetle larvae's behaviour and causes it to drown/starve



Multiple PAC systems can combine for adaptive behaviour

In the early 1970's, a neuroscientist by the name of David Ingle performed some experiments with frogs that reveal the principles of co-existing and independent perception-action systems.

Ingle discovered that the brains of frogs have **two separate perception-action systems** that work independently

The first controls the frog's snapping response for feeding...

...and the second controls its jumping response for avoiding predators.



The direction of both of these behaviours (snapping and jumping) depends on the frog's visual input.

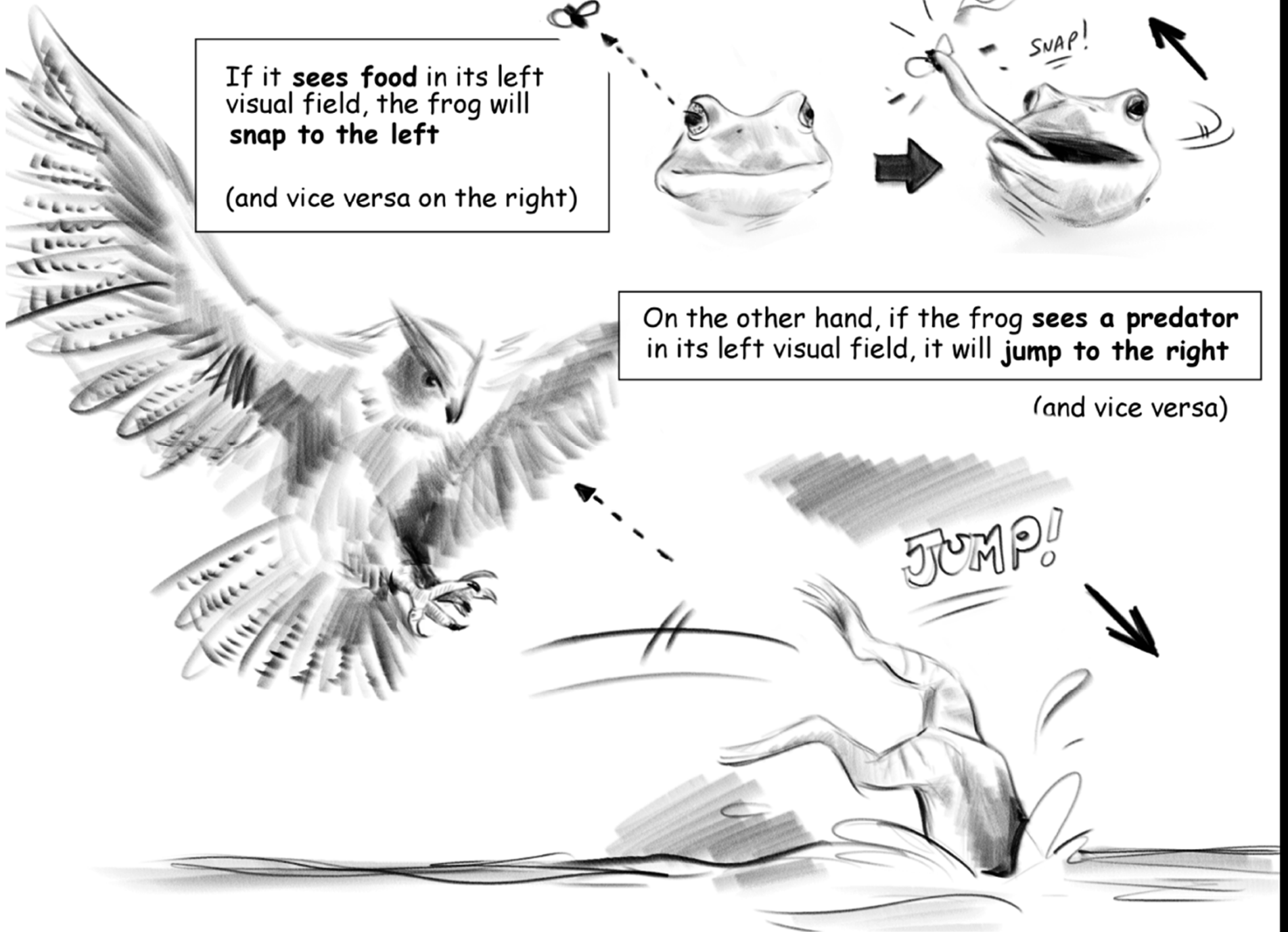
If it **sees food** in its left visual field, the frog will **snap to the left**

(and vice versa on the right)



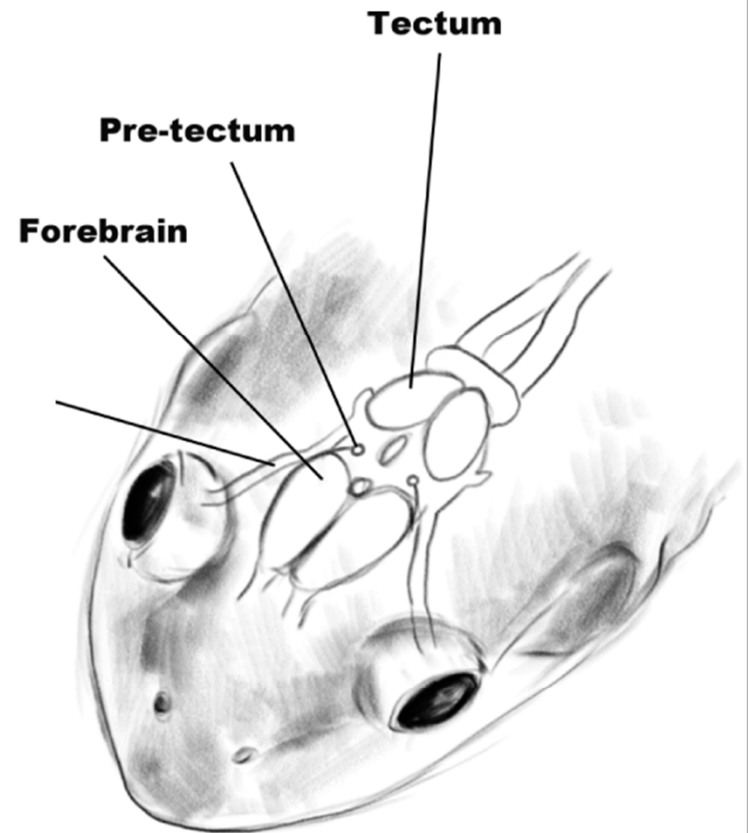
On the other hand, if the frog **sees a predator** in its left visual field, it will **jump to the right**

(and vice versa)



A frog's brain contains retinal pathways extending from its eyes to the **optic tectum** - a visual processing centre in its brain. Ingle surgically rewired the frog's retinal projections to the opposite sides of its optic tectum. To the frog, this meant that objects that appeared in the left visual field now appeared to come from the right visual field.

Ingle observed that, after surgery, when he would present food to the frog in its left visual field, it would snap to the right and find nothing there.



What astonished Ingle, however, is that this did not alter the frog's jumping behaviour

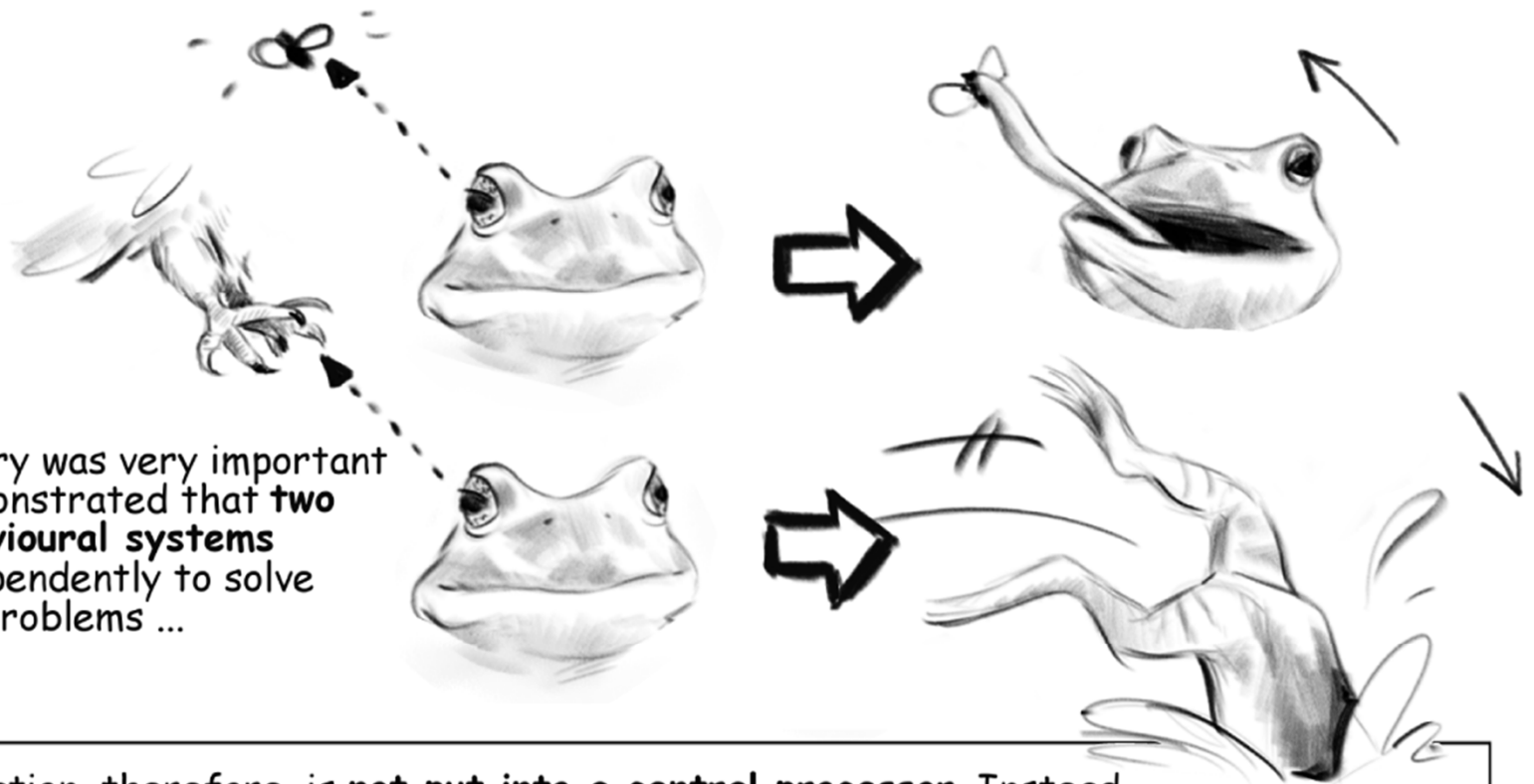


When presented with danger on the left, the frog still **correctly jumped to the right...**



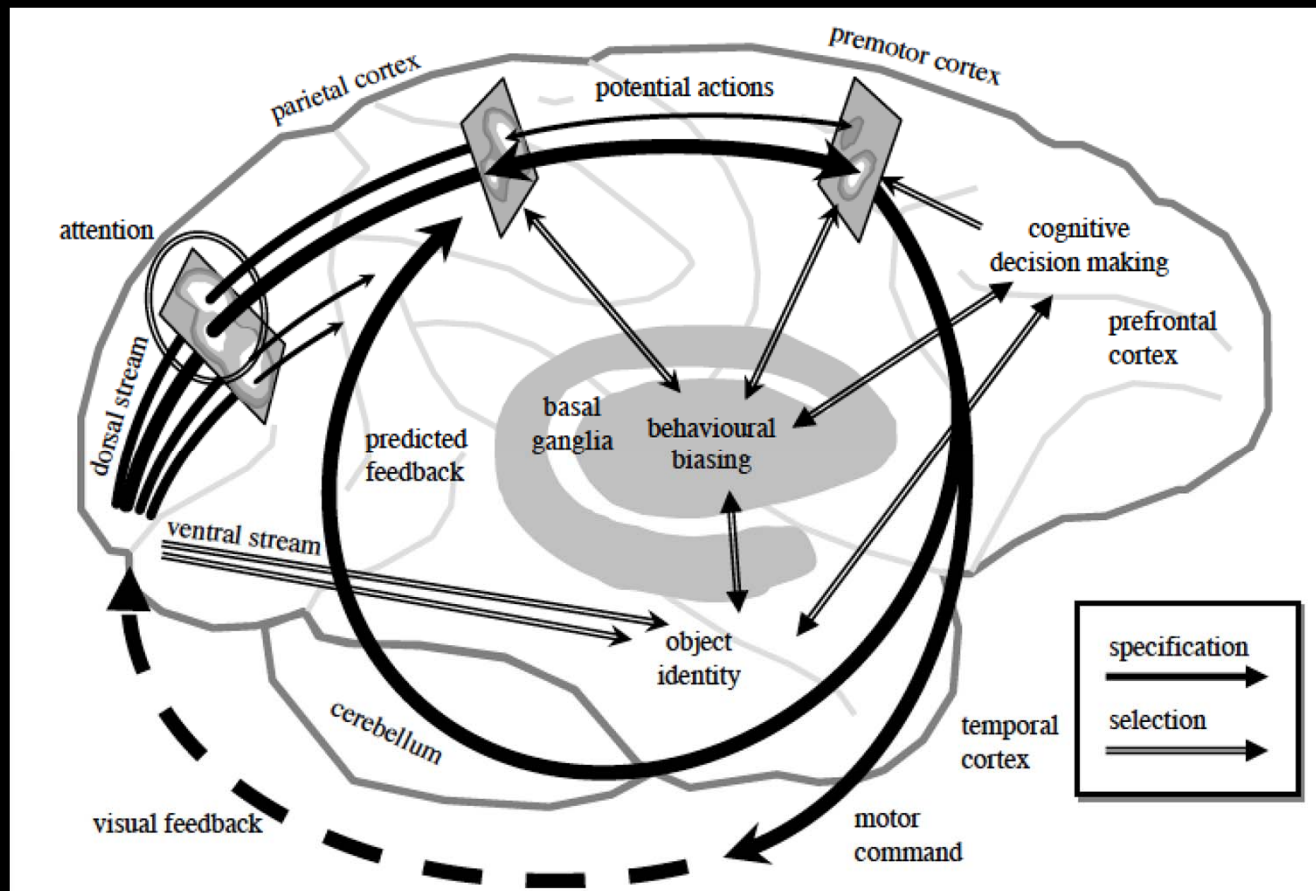
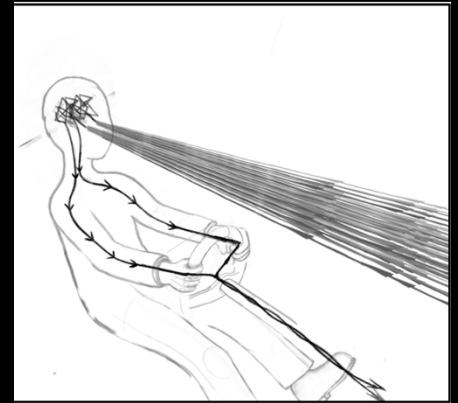
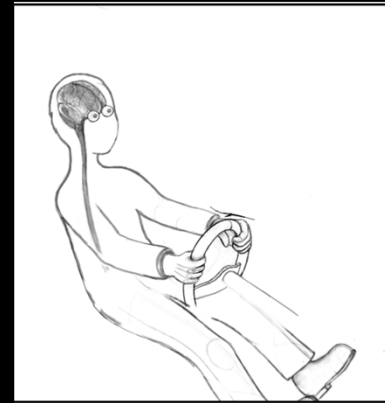
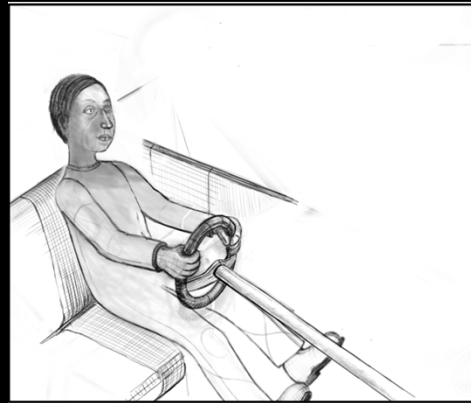
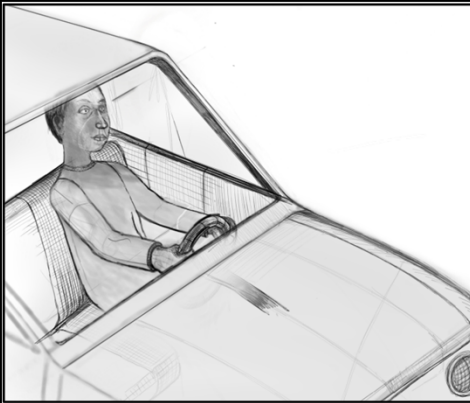
In this way, Ingle found **two sets of retinal projections** that lead to different parts of the frog's brain. He found that he could independently manipulate each of the frog's two behaviours.

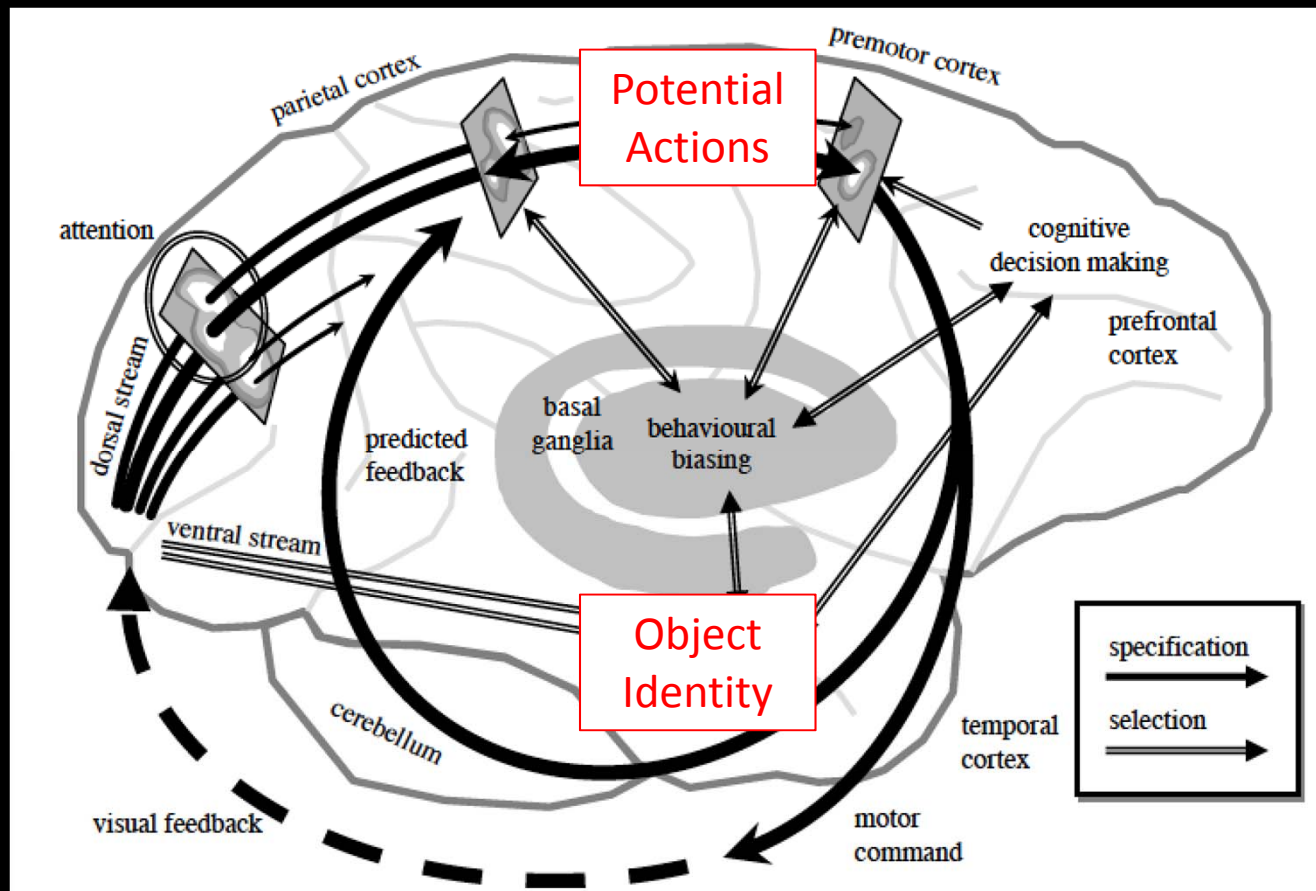
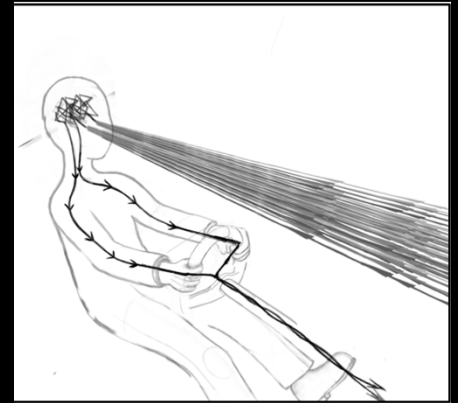
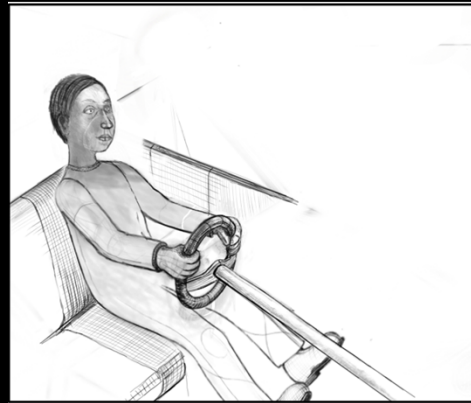
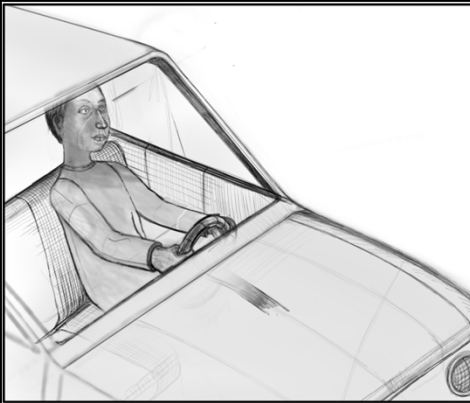
Retinal projections to the optic tectum govern the frog's feeding behaviour in response to visual input, while separate retinal projections of the pre-tectum (which Ingle did not manipulate) govern jumping behaviour...



Ingle's discovery was very important because it demonstrated that **two separate behavioural systems** developed independently to solve two different problems ...

Visual information, therefore, is **not put into a central processor**. Instead, the nervous system is modular—it is composed of **independent perception-reaction systems**.

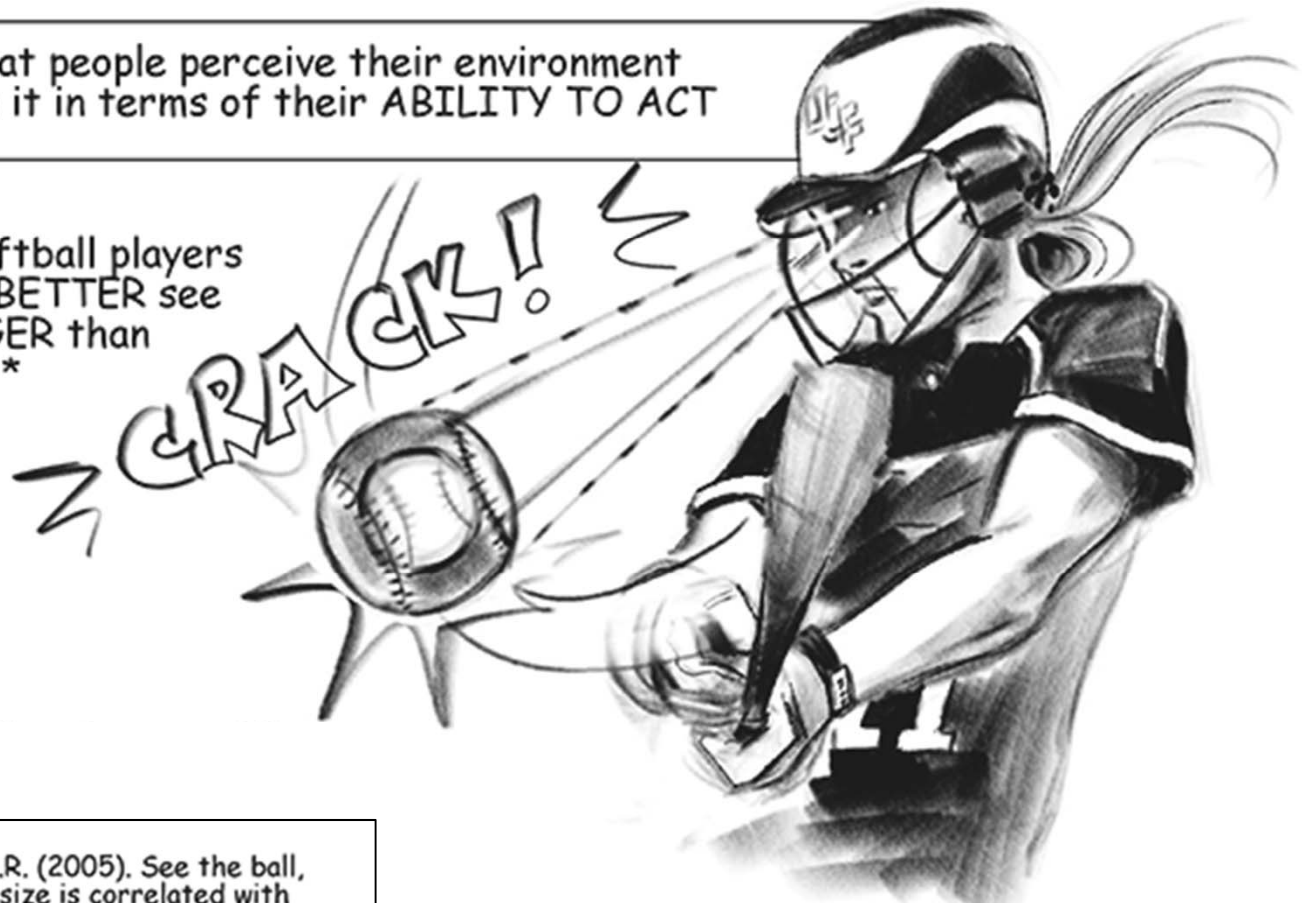




Perception and Action systems in humans are linked and influence each other

Studies* show that people perceive their environment and events within it in terms of their ABILITY TO ACT

For instance, softball players who are hitting BETTER see the ball as BIGGER than it actually is ... **



** Witt, J.K. & Proffitt, D.R. (2005). See the ball, hit the ball: Apparent ball size is correlated with batting average. *Psychological Science*, 16, 937-938.

The objects of perception are *Affordances*

Another example of action-specific effects is that hills look **STEEPER** (and also farther away) when wearing a heavy backpack ... ***

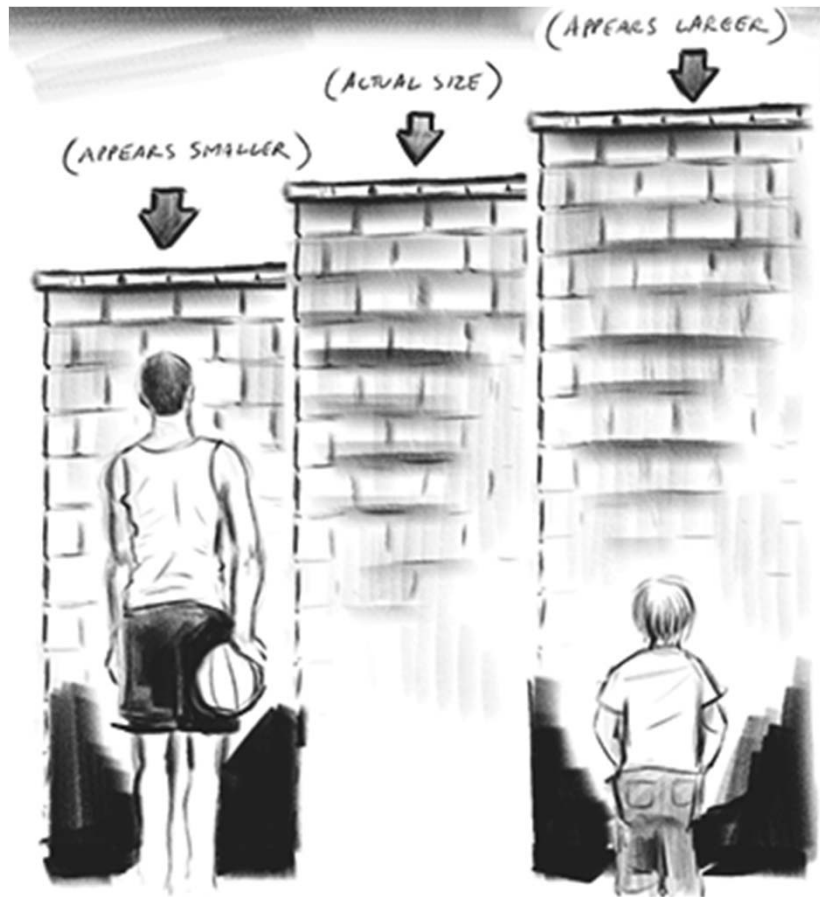


Perception is used to determine and exploit the *affordances* in the environment.

Affordances refer to the possibilities for action in the environment and are inherently defined in relation to the limitations of the organism.

*** Bhalla, M. & Proffitt, D.R. (1999). Visual-Motor recalibration in geographical slant perception. *Journal of Experimental Psychology: Human Perception & Performance*, 25, 1076-1096.

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* Witt, J.K. (2011). Action's effect on perception. *Current Directions in Psychological Science*

Conclusion Summary

- Perception Action Cycle
- Perception is *for* Action
- PAC systems co-exist with other PAC systems
- Affordances are the objects of perception

