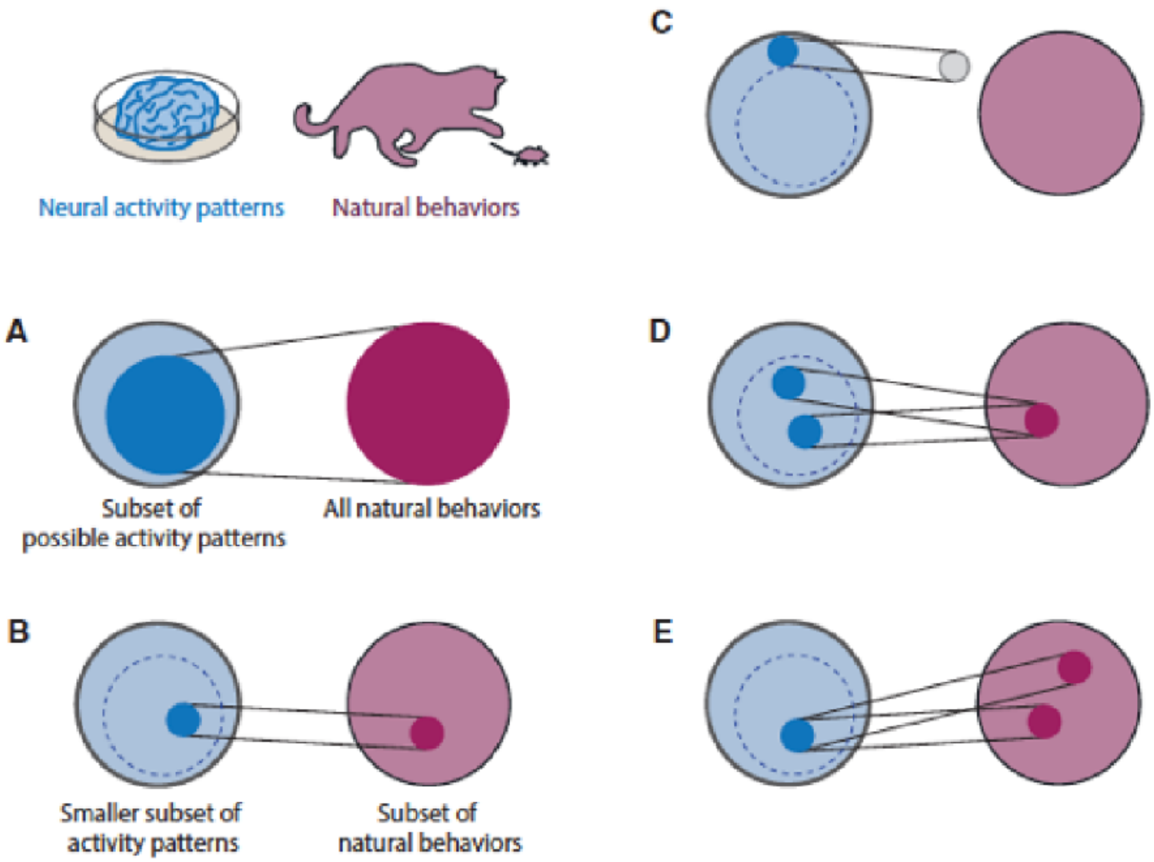
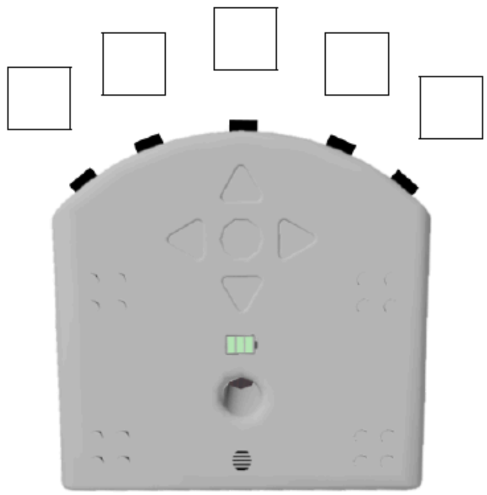
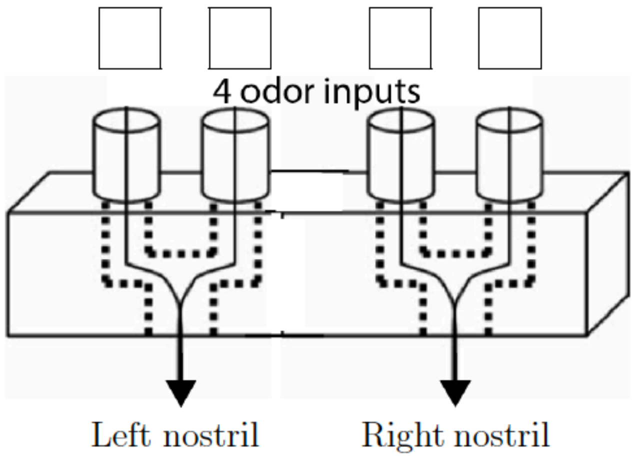
Explain the meaning of the following three diagrams (panels C, D, and E) regarding how neural activity patterns can map onto the space of behaviors.
(3 sentences, **3 pts**).



On the Thymio robot shown below, we are able to position infrared sensors for obstacle detection and avoidance. Indicate, by 'X'ing two boxes below, where one should position two infrared sensors to achieve the robotic box clustering described in the 'Maris' robotics experiment. Explain why you chose these positions.
(Mark two boxes above the Thymio robot and write a 2-3 sentence explanation, **3 pts**).



In the diagram below, a device was manufactured with four channels leading to the two nostrils of a human subject. As in Porter et al., the subject cannot see, hear, or feel touch. Indicate by 'X'ing two boxes on the image which nasal device channels should be blocked to achieve optimal inter-nostril scent tracking. Explain why you chose to block these particular channels.
('X' two boxes. Write a 1-2 sentence explanation, **3 pts**)



As discussed in Yamins et al., what are the key differences in how visual information is encoded between cortical areas V4 and IT (to which V4 outputs project)? Specifically, which of these areas is more position and perspective invariant? (1-2 sentences, **1 pt**)

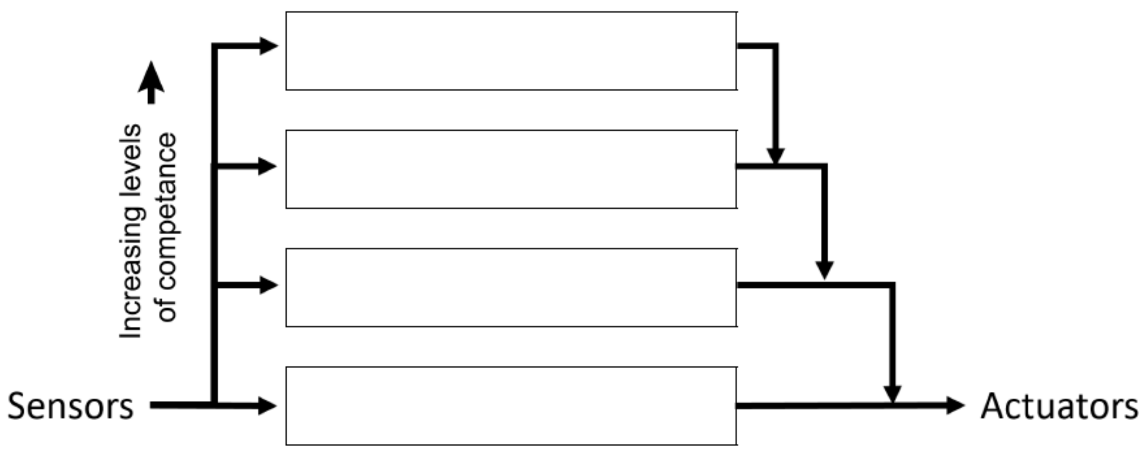
In Yamins et al., a well-performing network built using hierarchical modular optimization (HMO) had 4 layers. Which layer of the HMO exhibited encoding properties similar to area IT? Which layer had encoding similar to area V4? (2 sentences, **2 pts**)

List the three behavioral rules used to give rise to flocking in the Boids simulation.
(3 words, **3 pts**)

Name one example scenario for which one would benefit from using swarms of robots rather than one individual robot?
(1 sentence, **2 pts**)

In Kim et al., two different models of the ring attractor are proposed: local and global. Explain the following features of the models: (i) Which one is local and which one is global? (ii) What is the difference between blue and red lines? (iii) What is meant by the thickness of each line? (iv) Which of these models turned out to be more consistent with the data from 2-photon imaging and optogenetic activation experiments in Kim et al.?
(4 sentences with 1 sentence answering each question, **4 pts**)

Label the Subsumption architecture below with the following 4 levels of competence: Avoid obstacles; Build a map; Explore the world; Go to resources (4 labels, 1 in each empty box, **4 pts**)



In Root et al., how are olfactory projection neuron responses to odor stimuli different between starved and fed flies? How are odor search behaviors different between starved and fed flies? (**Do not** describe the underlying molecular mechanisms).
(2 sentences, **2 pts**)

In Kim et al., two different models of the ring attractor are proposed: local and global. Explain the following features of the models: (i) Which one is local and which one is global? (ii) What is the difference between blue and red lines? (iii) What is meant by the thickness of each line? (iv) Which of these models turned out to be more consistent with the data from 2-photon imaging and optogenetic activation experiments in Kim et al.?
(4 sentences with 1 sentence answering each question, **4 pts**)

Velocity commands for the wheels control the heading and translational velocity of the Thymio robot. In Week 7, we learned about differential drive kinematics. When the wheels' velocities change, the robot rotates around a point (ICC – *Instantaneous Center of Curvature*) lying on the wheels' axes. Because the angular velocity is the same for both wheels, we obtain the following equations[1]:

$$\omega\,(R + b/2) = V_R \tag{1}$$

$$\omega\,(R - b/2) = V_L, \tag{2}$$

where b is the distance between the wheels, R is the distance between ICC and the center of mass of the robot, ω is the rate of rotation, and V is the translational velocity of the wheel as shown in Figure 1. After some simple algebraic operations we obtain:

$$R = \frac{b}{2}\frac{V_L + V_R}{V_L - V_R};\ \omega = \frac{V_R - V_L}{b} \tag{3}$$

(a) Describe (i) R, (ii) ω, and (iii) the center of rotation and robot movement for three cases. First, $V_R = V_L$. Second, $V_R = -V_L$. Third, one of V_L, V_R is zero and the other is positive. **(3 pts.)**

(b) Name two approaches that can be used to improve the path integration algorithm. **(2 pts.)**