

Robot Perception

ESE 6800 / CIS 7000
Antonio Loquercio

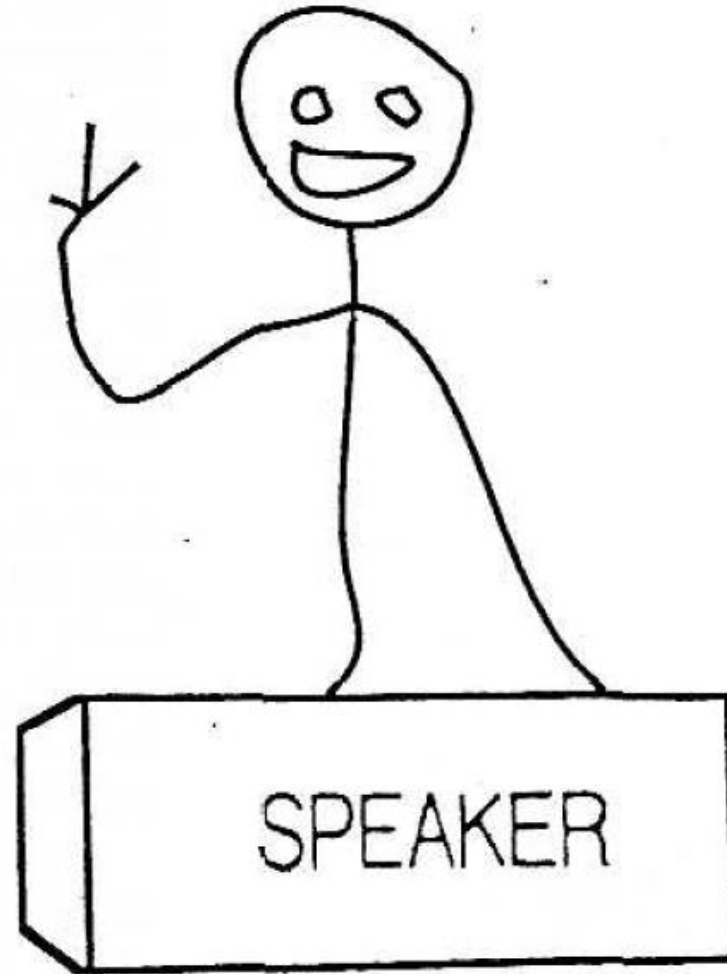


**Adult male
Antheraea
polyphemus**

Yes, we likely throw away a lot



What we think we see



What we really see

The AI viewpoint

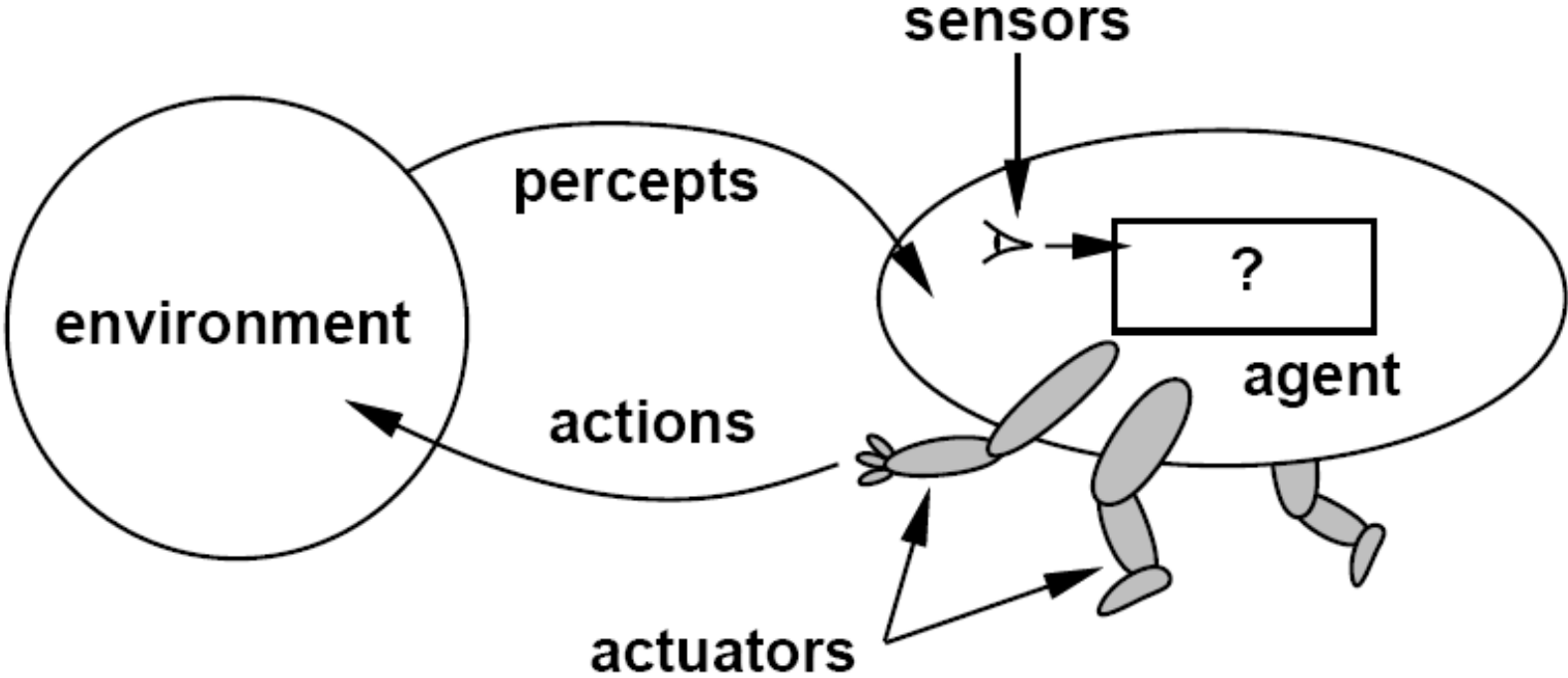


Figure from [Russell & Norvig](#)

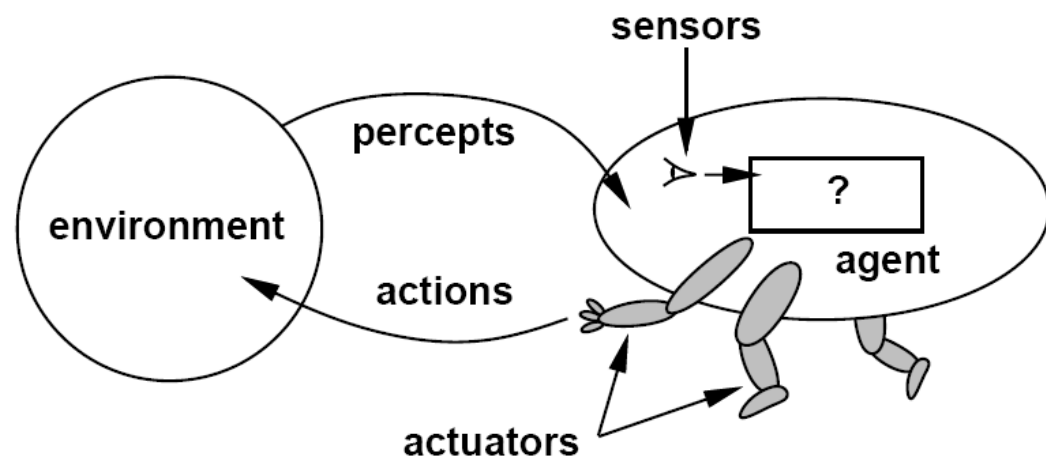


Figure from [Russell & Norvig](#)

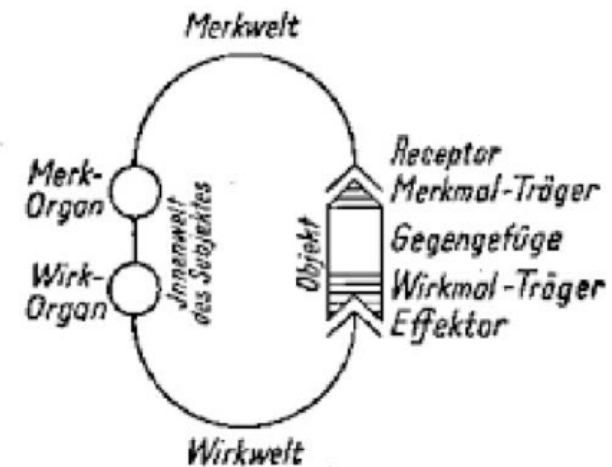


Abb. 3. Funktionskreis

Von Uexküll's basic sensorimotor loop (Funktionskreis). Here is a summary translation of the German terms:

Merkwelt the space of distinguishing marks. I will often say "space of cues";
Wirkwelt the space of actions of which the organism is capable. **Merkwelt** and **Wirkwelt** together make up the **Umwelt** of the organism, a part of the physical environment;

Merkorgan sensory organ, e.g., an eye spot;

Wirkorgan action organ, e.g., a muscle;

Objekt an object in the environment, it is an external observer's term for the **Gegengefüge**, that is the "counter structure" that interacts with the loop;

Receptor this is the **Merkmal-Träger**, the carrier of distinguishing marks;

Effektor this is the **Wirkmal-Träger** the carrier of actions. The **Merkmal-Träger** and **Wirkmal-Träger** together make up the **Gegengefüge**;

Innenwelt des Subjektes is the "life world." It is the inner counterpart of the external objects.

Figures from von Uexküll's *Theoretische Biologie*, 1920

Explanation from Sentience, Koenderink

Reflex agent



- Consider how the world IS
- Choose action based only on current percept
- Do not consider the future consequences of actions

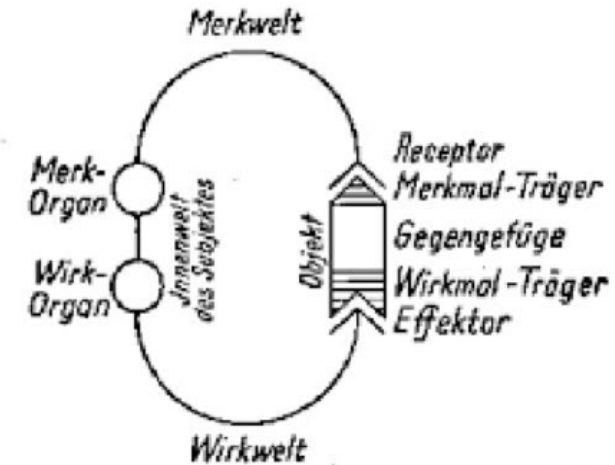


Abb. 3. Funktionskreis

Von Uexküll's basic sensorimotor loop (Funktionskreis). Here is a summary translation of the German terms:

Merkwelt the space of distinguishing marks. I will often say "space of cues";
Wirkwelt the space of actions of which the organism is capable. **Merkwelt** and **Wirkwelt** together make up the **Umwelt** of the organism, a part of the physical environment;

Merkorgan sensory organ, e.g., an eye spot;

Wirkorgan action organ, e.g., a muscle;

Objekt an object in the environment, it is an external observer's term for the **Gegengefüge**, that is the "counter structure" that interacts with the loop;

Receptor this is the **Merkmal-Träger**, the carrier of distinguishing marks;

Effektor this is the **Wirkmal-Träger** the carrier of actions. The **Merkmal-Träger** and **Wirkmal-Träger** together make up the **Gegengefüge**;

Innenwelt des Subjektes is the "life world." It is the inner counterpart of the external objects.

Figures from von Uexküll's *Theoretische Biologie*, 1920

Explanation from Sentience, Koenderink

The New Loop

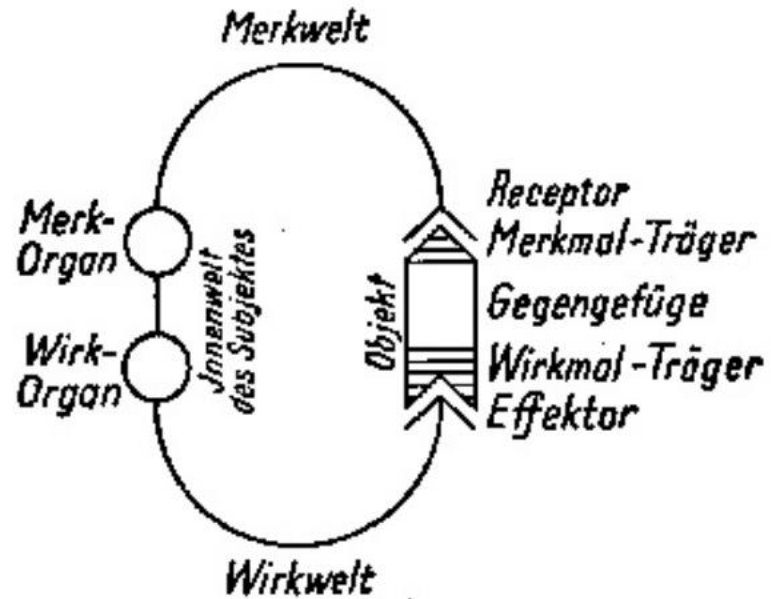
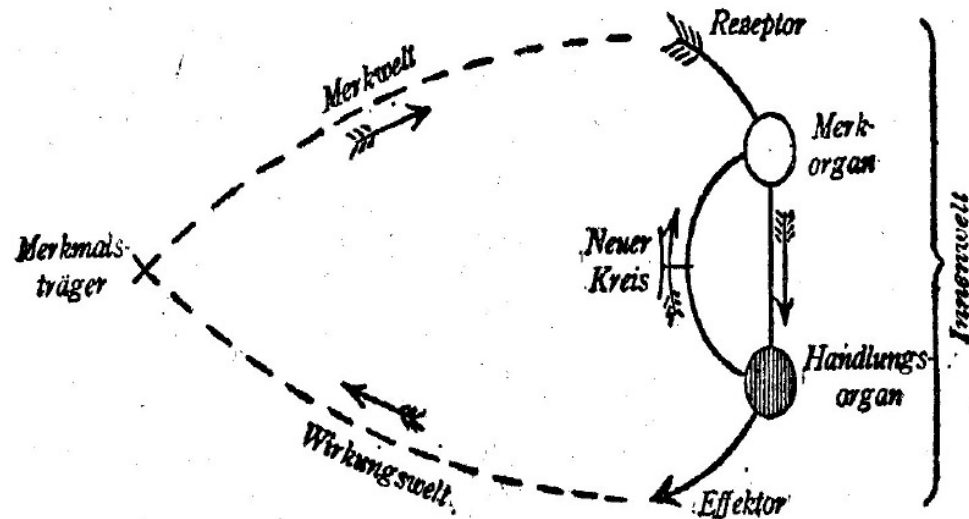


Abb. 3. Funktionskreis

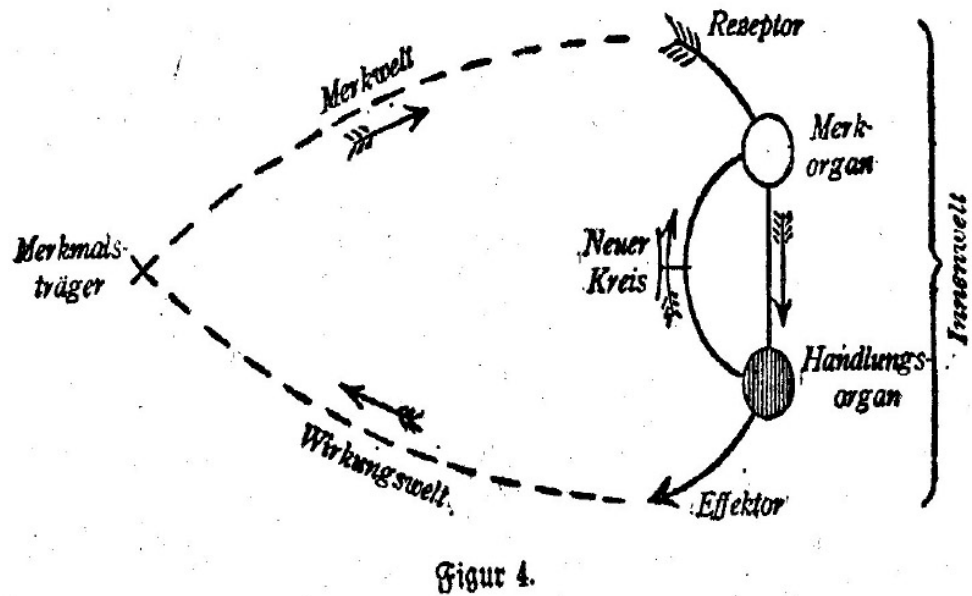


Figur 4.

Predictive agent



- Consider how the world **WOULD BE**
- Decisions based on (hypothesized) consequences of actions
- Must have a model of how the world evolves in response to actions



Vision is a creative process

“Perceptual organization”
cannot be primarily a
bottom-up process
as Marr saw it



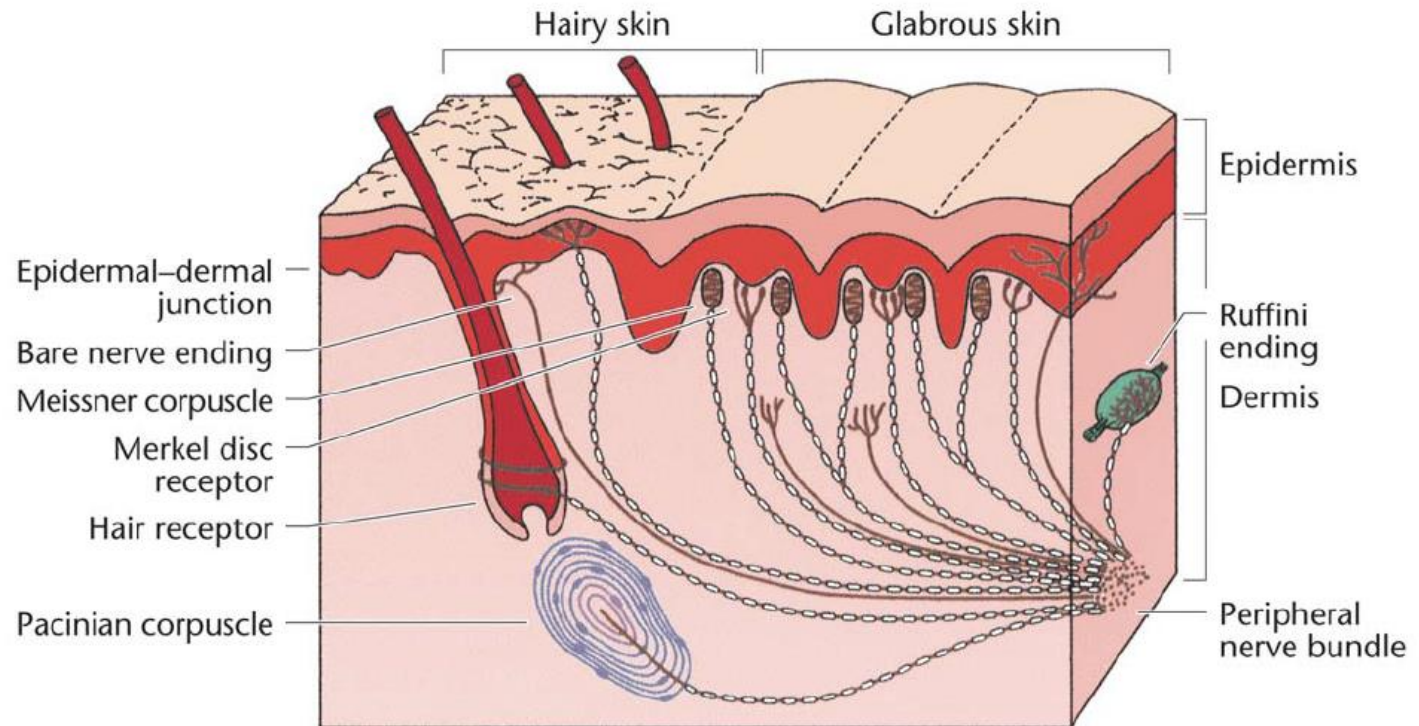
Figure 3-1. The interpretation of some images involves more complex factors as well as more straightforward visual skills. This image devised by R. C. James may be one example. Such images are not considered here.

Proprioception

- Aristotle in "De Anima" listed 5 senses: sight, hearing, touch, taste and smell.
- Bell (1826) proposed a sixth sense – the "muscular sense", which was renamed as "proprioception" by Sherrington.
- Proprioception refers to the awareness of the position or movement of the body or parts of the body relative to each other
 - **Musculoskeletal system** : sensors in muscles, tendons and joints
 - **Vestibular system** in the inner ear: semicircular canals & otoliths

The sense of touch

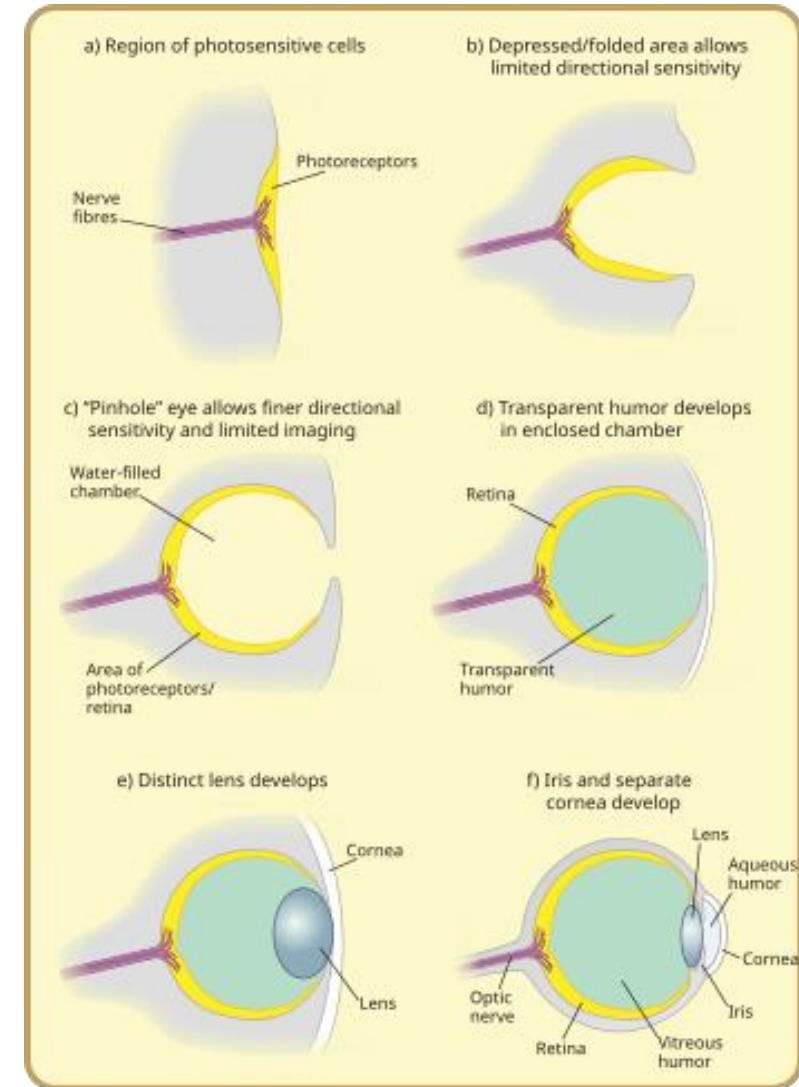
- When the skin is contacted by an external stimulus, its surface is indented or stretched as the skin is flexible.
- The mechanical deformation is detected by **mechanoreceptors** that signal location of contact, force exerted, motion speed, and pressure
- Other receptors underneath the skin sense warmth, cold, pain, itching.



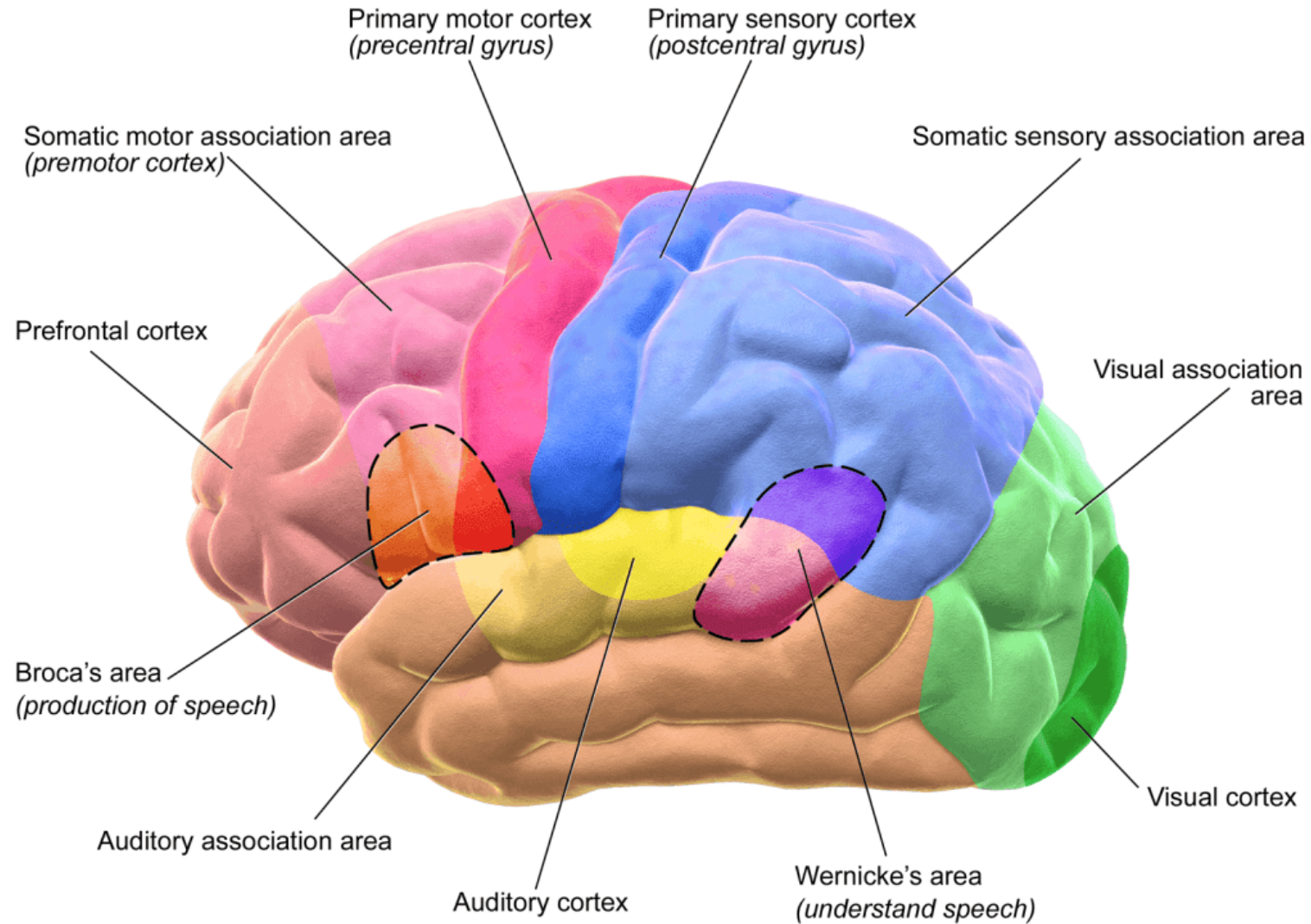


The connection between senses

- **Photoreceptor** cells probably evolved multiple times from molecularly similar chemoreceptor cells.
- “**Light Switch**” theory of Andrew Parker: the evolution of advanced eyes started a “arm race” that accelerated evolution during the Cambrian period.
- The brain machinery to process vision bears remarkable similarities to the one used by other sensors.



The somatosensory cortex



Could a Neuroscientist Understand a Microprocessor?

Eric Jonas^{1*}, Konrad Paul Kording^{2,3},

1 Department of Electrical Engineering and Computer Science, University of California, Berkeley

2 Department of Physical Medicine and Rehabilitation, Northwestern University and Rehabilitation Institute of Chicago, 345 E Superior St., Chicago, Illinois, 60611

3 Department of Physiology, Northwestern University, 303 E Chicago Ave, Chicago, Illinois 60611

* jonas@eecs.berkeley.edu

Abstract

There is a popular belief in neuroscience that we are primarily data limited, and that producing large, multimodal, and complex datasets will, with the help of advanced data analysis algorithms, lead to fundamental insights into the way the brain processes information. These datasets do not yet exist, and if they did we would have no way of evaluating whether or not the algorithmically-generated insights were sufficient or even correct. To address this, here we take a classical microprocessor as a model organism,