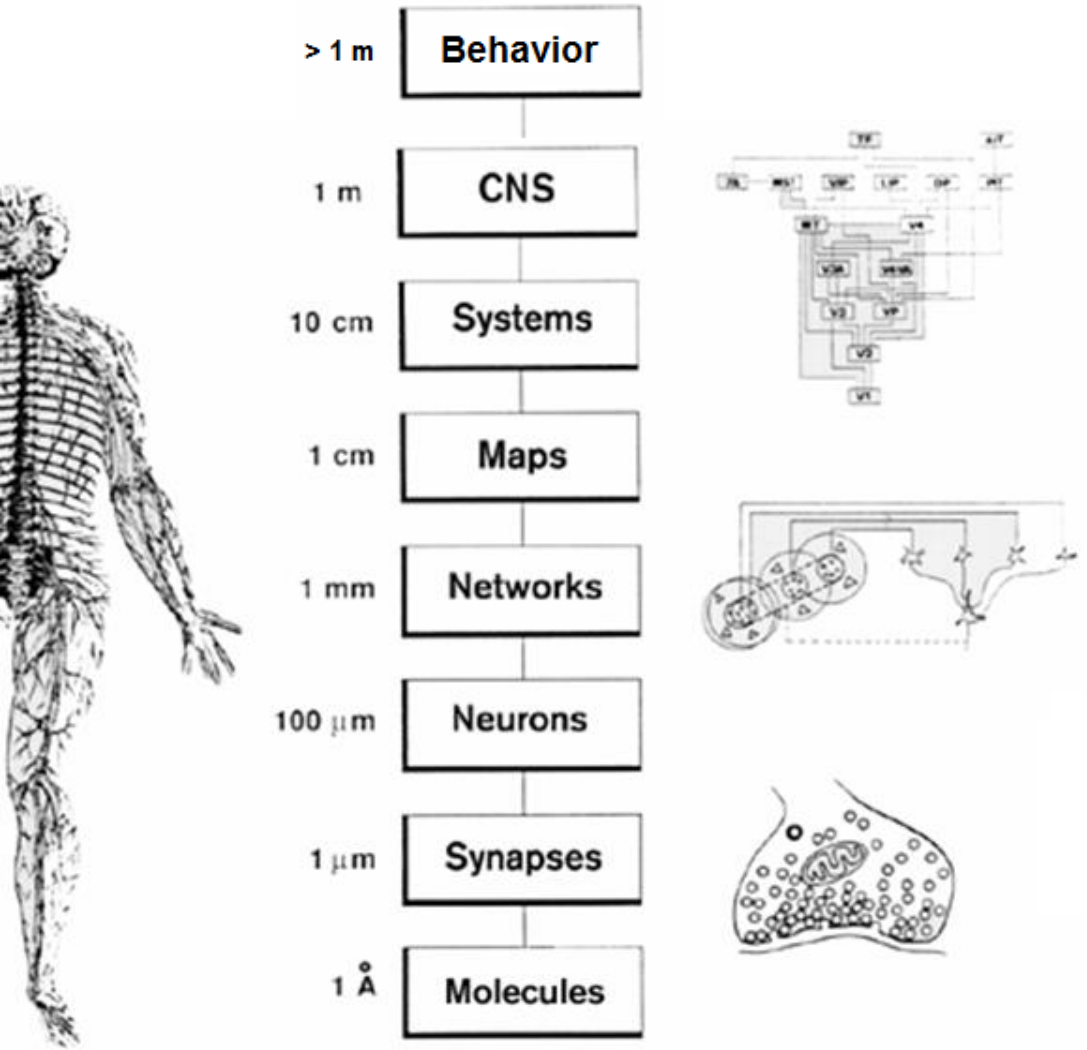


Levels of Analysis and Explanation

10/6/14

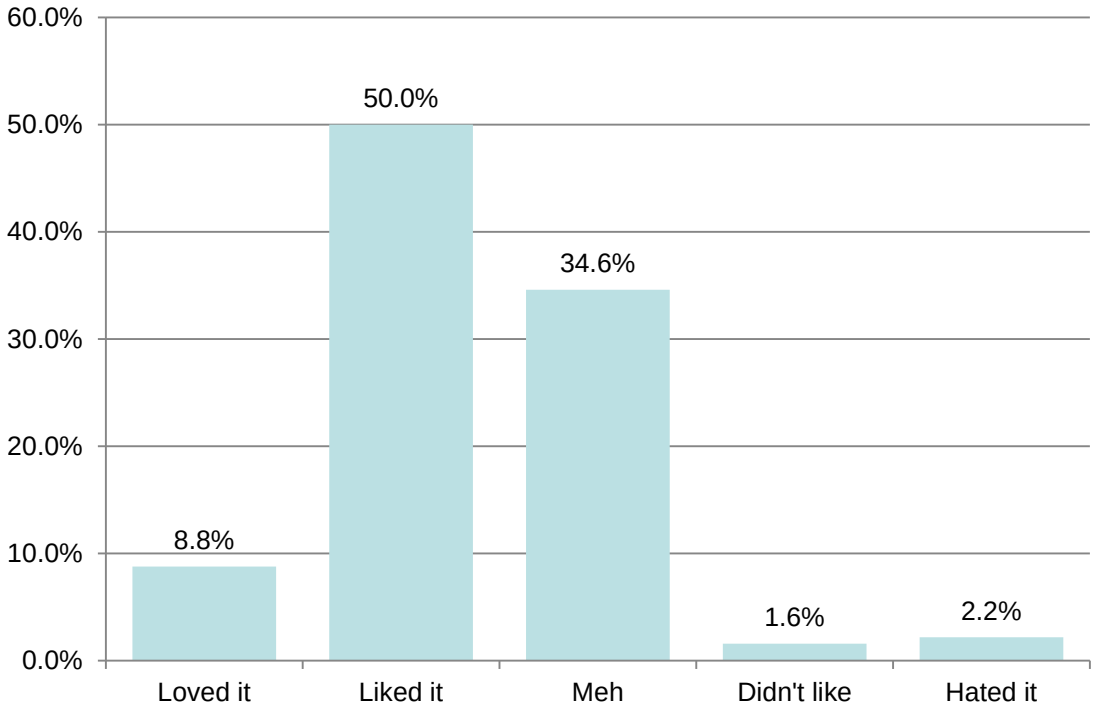
Reminders

Labs and Section:

- Sections began this week.
- You can switch sections, but check with the IA/TA first to make sure there is room.
- Labs are done in section. First lab next week.
- Lab sheets are provided in section, but will also be available for review on TED.

Getting started

How did you like using iClickers in the past?



Getting started

i>Clicker Quick Start

- Any version of the i>Clicker is okay.
- If you forgot your iClicker, no problem. Just see me briefly after lecture.
- You need to register through TED. If you haven't, we still collect the responses – they just aren't assigned to a name until you register.
- Choose the correct frequency code for this room [**AD**].
  - Power the iClicker.
  - Hold power down until the frequency flashes.
  - Enter **AD**.
  - Should get a check mark when it finds the base station.
  - Can use someone else's iClicker, but not both at the same time in this class.
  - May need to change this each time if you use the iClicker for another class.

From last time

Progress check

Human sensory systems can be best thought of as:

A. automatic in nature.
B. decoupled from the external environment.
C. passively receiving sensory stimuli.
D. actively engaging sensory stimuli.

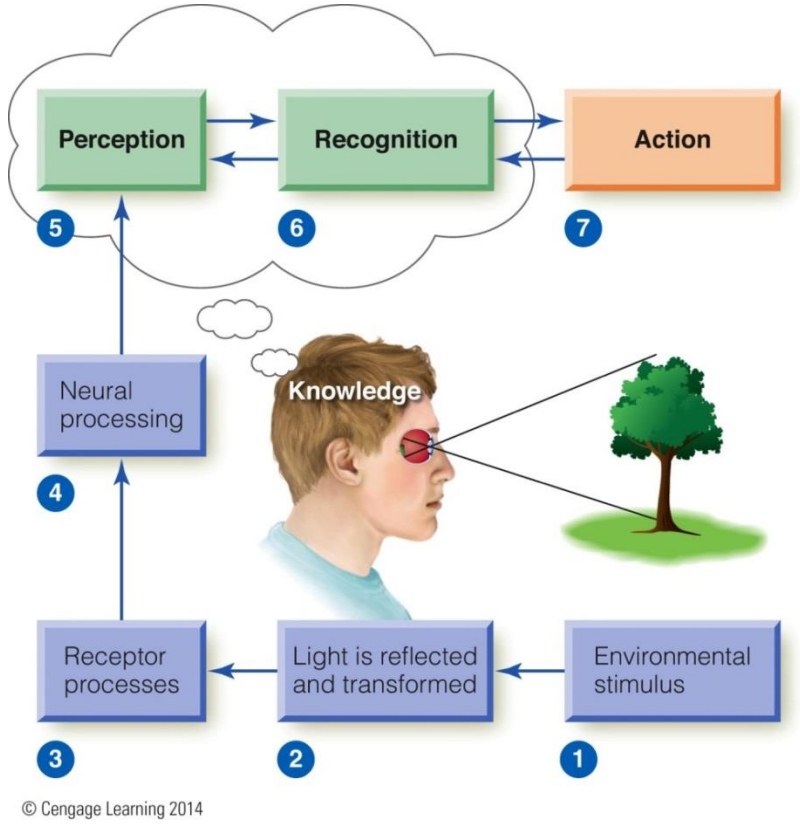
Today

The study and measurement of perception

- The perceptual process
- Defining measurement of perception
- Parsing perception:
  - The empirical (reductionist) approach and Marr's levels of analysis
- *Qualitative* approaches to measurement:
  - Description and recognition
- *Quantitative* approaches to measurement:
  - Detection and magnitude estimation

Perception as an active process

This is a continuous, dynamic endeavor. Each engagement with the sensory environment involves many iterations of this process.



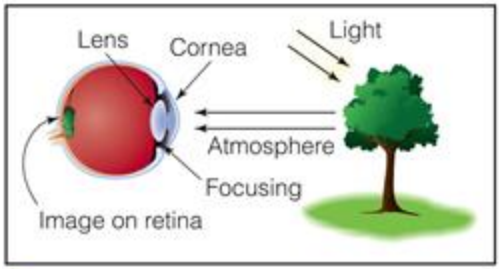
We are constantly re-orienting to the environment.

Figure 1.1 The perceptual process. **See pages 5-10**.

Perception as an active process

1 Environmental Stimulus

- In this first step, we orient our sensory apparatus toward a **distal stimulus** in the environment.



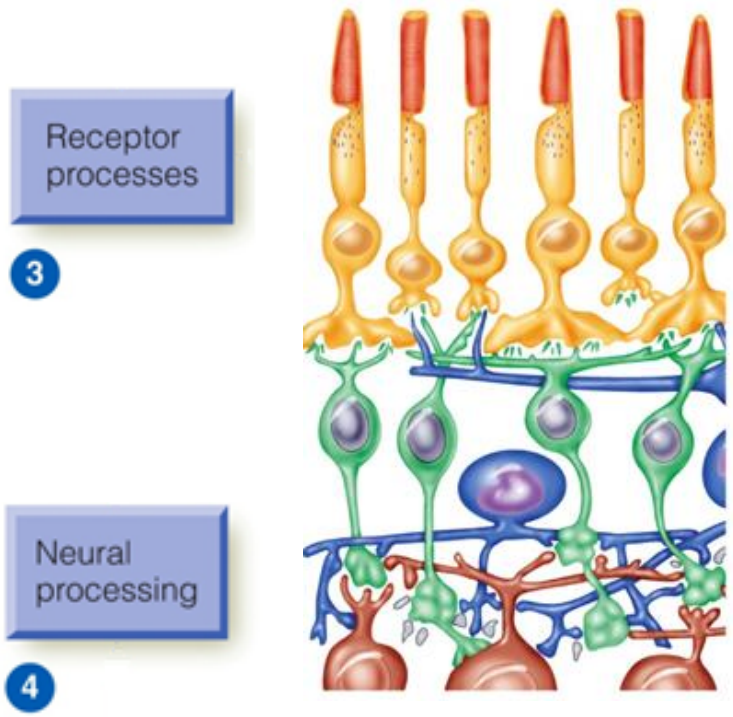
2 Light Reflected and Transformed

- The sensory signal from the distal stimulus is transmitted and transformed to become a pattern – the **proximal stimulus** – on the sensory organ.

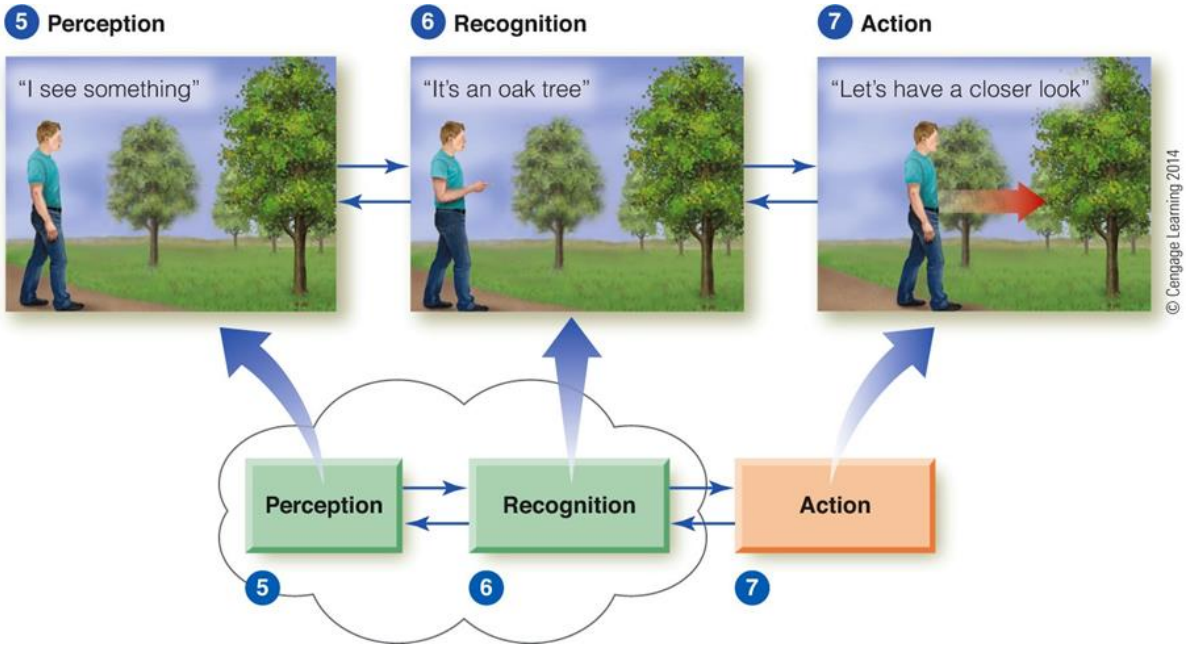
Perception as an active process

- In the next step, the energy of the stimulus (light, air pressure, motion, etc.) is **transduced** into the electrical energy used by the nervous system.

- These new neurobiological signals are processed and transmitted to **primary sensory cortices** in the brain, where the signals are processed further.



Perception as an active process



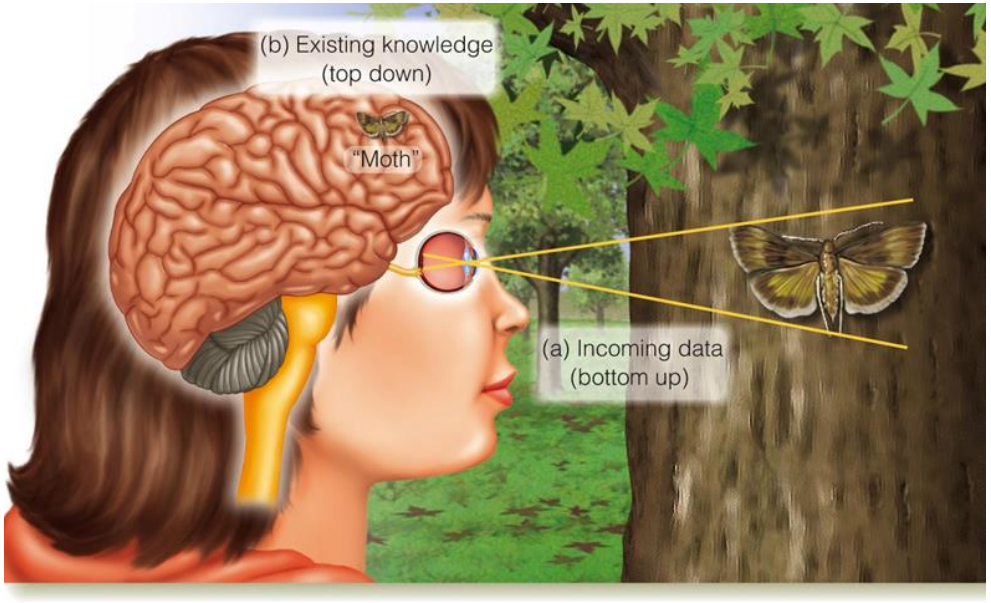
- By step 5, we **consciously perceive** (or detect) the stimulus in our sensory environment.
- Further processing may allow us to **recognize** (or categorize) the object.
- We can then act to gain more stimulus information or interact with the object.

Perception as an active process

Perception versus **recognition**

- We can see (perceive) something clearly, but not be able to recognize it as belonging to a particular category.
- "…a continuous surface unfolded on itself. It appears to have five outpouchings, if this is the word."
- In the extreme case of **visual form agnosia**, common objects cannot be recognized.

Perception as an active process



- Previous **knowledge** (experience) affects many levels of the perceptual process.
- This **top-down processing** biases your perceptions, leading you toward certain conclusions/actions.
- This is complementary to **bottom-up processing**, which is driven more by the properties of the stimulus.

Measuring perception

How do we measure effects at each stage of the perceptual process? Where do we start?

- First, we need to define some terms.
- Next, we develop a framework for empirically examining and testing specific sensory systems.
- And since perception is such a complex process, we will need to ensure that our framework can examine many different conceptual levels of activity.
  - We would also like to address other biological and artificial systems.

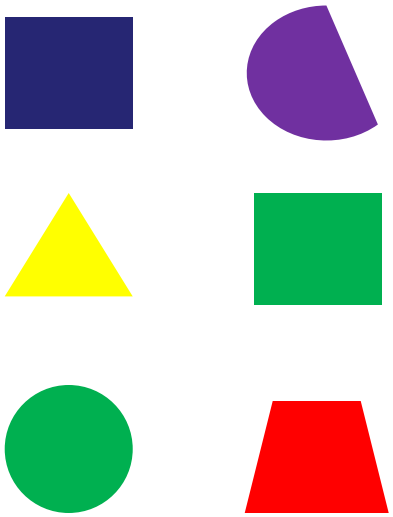
What is measurement?

Measurement is assigning numbers (or categories) to observable events.

- In perception (i.e. *detection*) and recognition (i.e. *classification*) experiments, you want to measure something inside someone else's head.
  - For example: experience of a certain color, hearing a sound, detecting a taste, etc. These are sometimes called sensory **qualia**.
  - These can't be *directly* observed by anyone but the person having the experience. They are necessarily *subjective*.

So, how can we measure perception if we (scientists) don't have access to it?

Do aliens perceive colors and shapes?



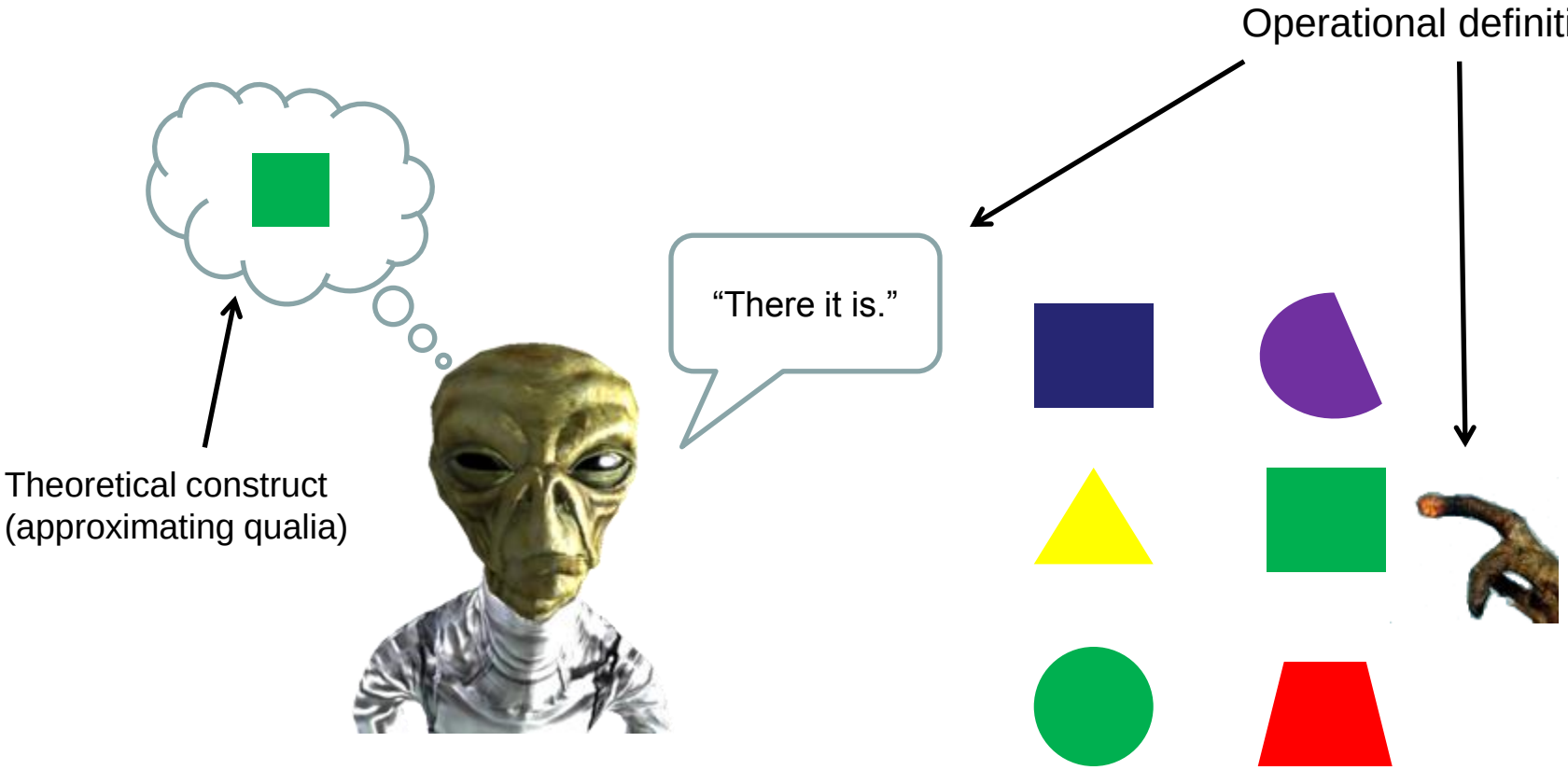
“Find the green square.”

What is measurement?

Measurement is assigning numbers (or categories) to observable events.

- The experiences in the head of the subject are called sensory **qualia**. Scientists can't directly observe these.
- *Unobservable* entities (e.g. color perception) are called **theoretical constructs** – we believe they exist in some sense, but can't be observed directly.
- We need to create an **operational definition** for the internal theoretical construct. This assigns observable behavior as a proxy for the unobservable mental entity and allows you to infer its presence.
- Precision here is necessary for science, but is also theoretically limiting.

Do aliens perceive colors and shapes?

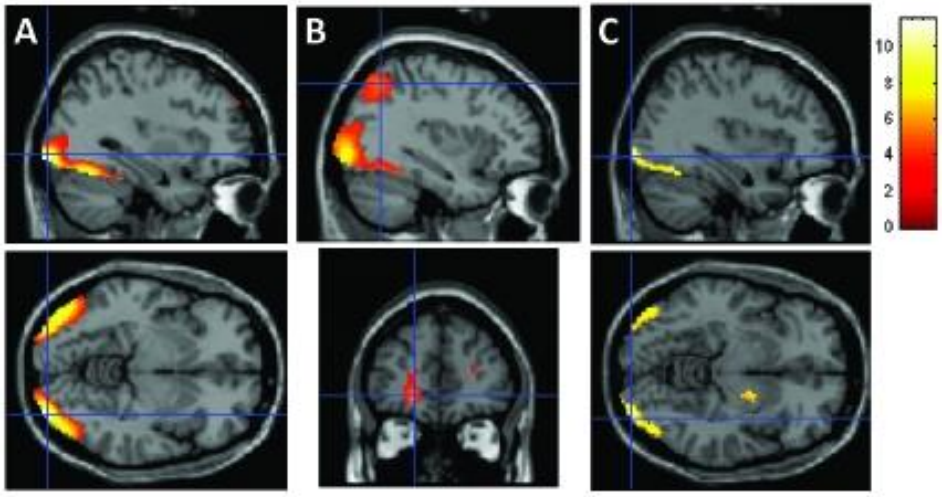


“Find the green square.”

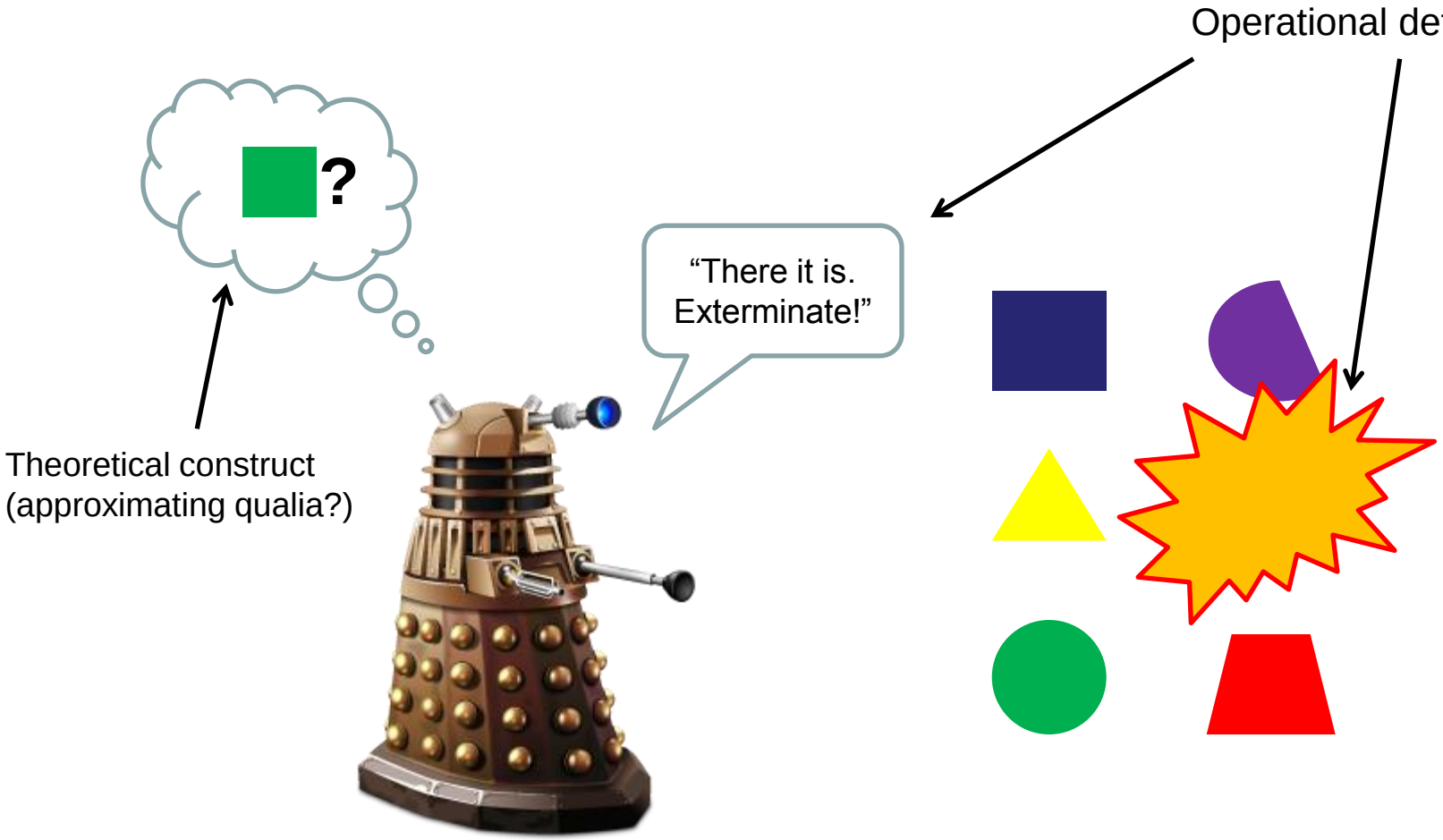
What is measurement?

Operational definitions are a special concern in Cognitive Science because we use a large variety of measures and are interested in many types of systems.

- For example: blood flow in the brain (measured with fMRI) is used as an operational definition of activity associated with task performance.



Do artificial systems perceive colors and shapes?

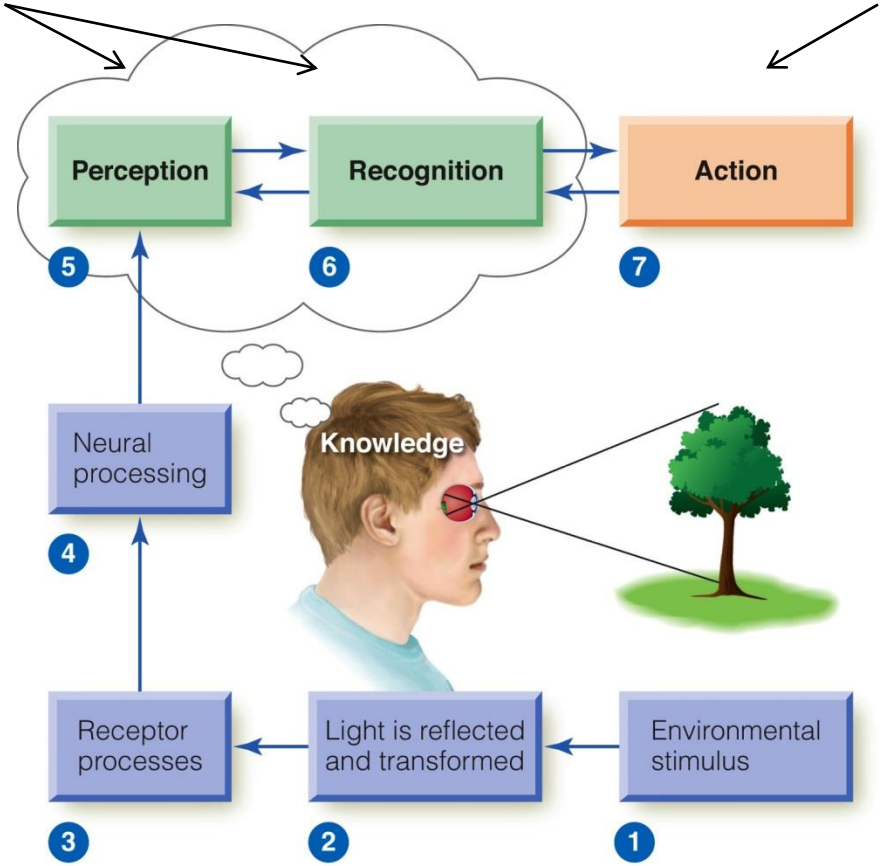


“Find the green square.”

Measuring perception

Theoretical constructs

Operational definition



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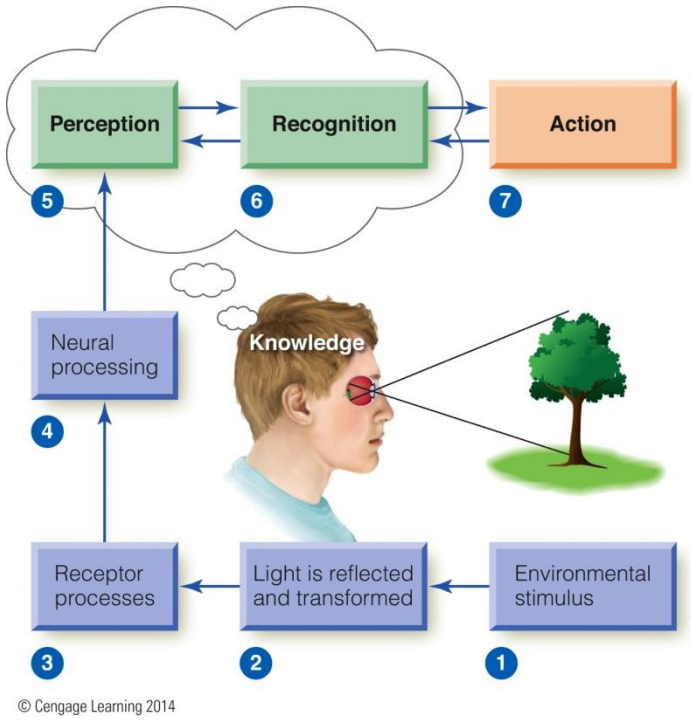
Measuring perception



This model provides a framework for studying some elements of perception, but it is incomplete.

- For example, it can't provide a high level description of what problem the sensory system solves. (For example, what does your sense of smell do for you?)
- In the present form, it seems limited to (human) biological agents. What about computer vision?
- How can we relate the high-level questions to the low-level analyses?

Measuring perception

David Marr's levels of analysis:

1) Computational Level (most abstract)

   - What problems does the system solve (and why)?

2) Algorithmic Level

   - How does it solve these problems? What representations does it use?

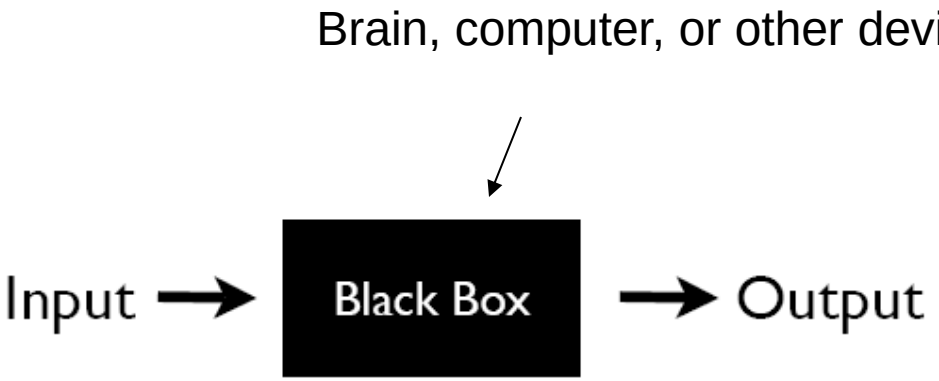
3) Implementation Level (most concrete)

   - How is this instantiated in the brain or system?

Marr (1982) *Vision: A computational investigation into the human representation and processing of visual information*

Marr's levels of analysis

1. Computational Level (most abstract)



The type of problem being solved will help determine the nature of the inputs and outputs considered.

Marr's levels of analysis

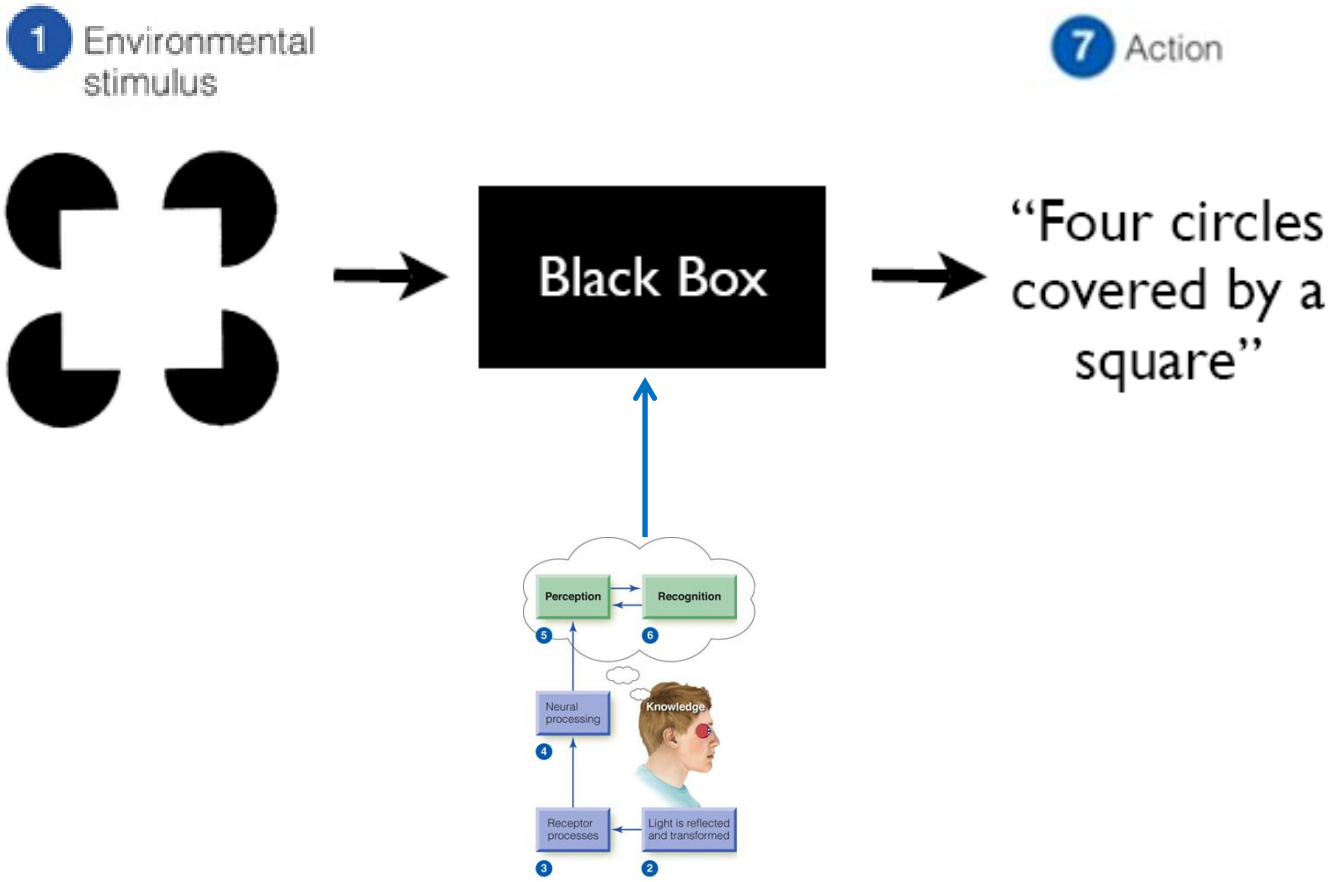
Progress check

Thinking back to our perceptual process diagram, which element seems best matched to the 'input' stage of Marr's computational level?

A. Receptor processes
B. Proximal stimulus
C. Light is reflected and transformed
D. Distal stimulus

Marr's levels of analysis

1. Computational Level (most abstract)



Marr's levels of analysis

2. Algorithmic Level

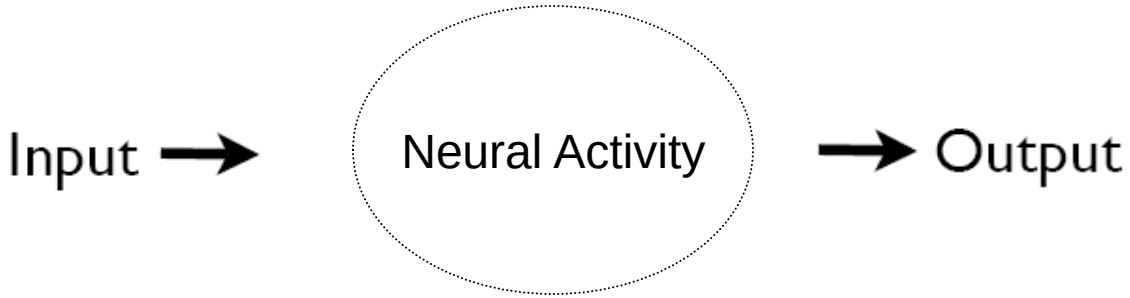
Marr's levels of analysis

2. Algorithmic Level

At this level, we still don't know what kind of system (human brain, computer, alien, etc.) is working on the problem. We only specify the **steps** the system takes and what kinds of information (representations) it manipulates.

Marr's levels of analysis

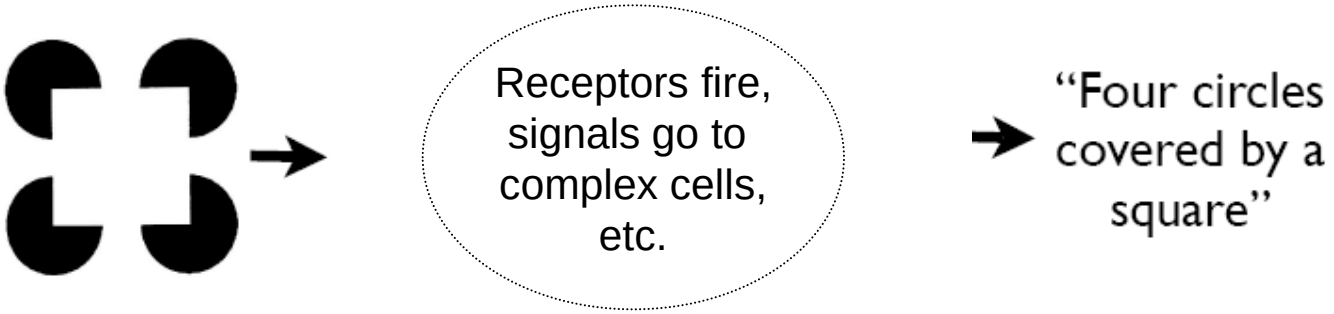
3. Implementation Level



At long last, we look inside the black box. We now see exactly how the system produces its output.

Marr's levels of analysis

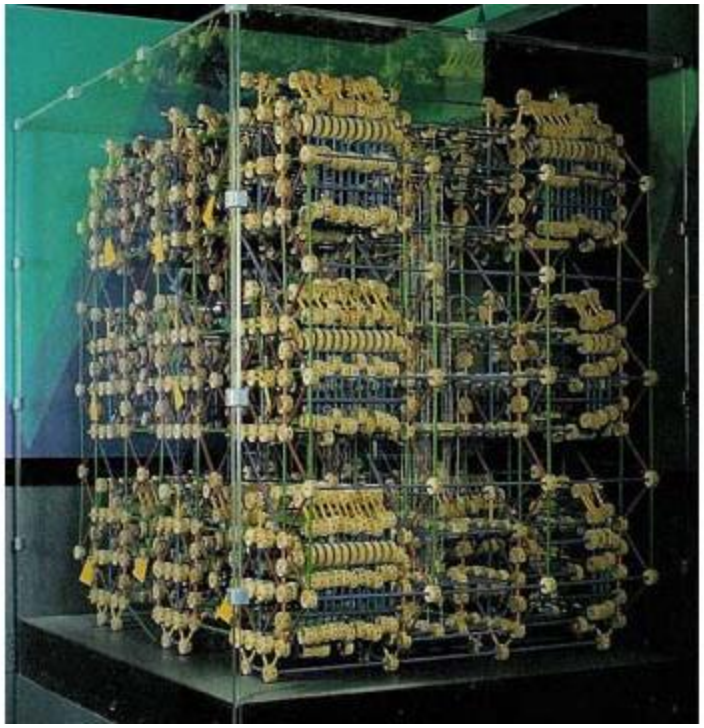
3. Implementation Level



We can specify how the elements of the system work together to enable the algorithm which produces the response.

Marr's levels of analysis

retrothing.com

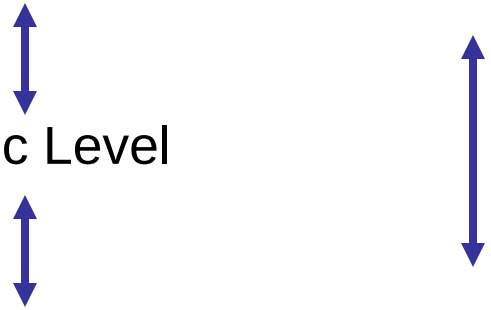


Different systems play tic-tac-toe, each solving the problem with different physical elements/implementations.

Marr's levels of analysis

David Marr's levels of analysis:

1) Computational Level (most abstract)



2) Algorithmic Level

3) Implementation Level (most concrete)

These levels interact. Study of one can inform our approach to another.

Marr's levels of analysis

The level at which you begin your analysis can determine the types of tools and methods you will use. Most importantly, it defines the kind of *explanation* you will provide.

For Sensation & Perception (and Cognitive Science):

1. Computational level → Behavioral explanations

2. Algorithmic level → Computational models, psychological theories, psychophysical laws

3. Implementation level → Physiological explanations

Marr's levels of analysis

Progress check

You are investigating the effect of light intensity on the blink response. A 'bright light response' is operationally defined as 'a prolonged blink'. You record the number of blinks to different intensities of light. Which of Marr's levels of analysis best describes the study?

A. Computational
B. Algorithmic
C. Implementation
D. Both A and B

Marr's levels of analysis

Progress check

In a taste experiment, you believe that the perception of "spicy" flavors requires the activation of pain receptors on the tongue. Using a drug that temporarily inhibits pain receptors, you test a group a subjects on various spicy peppers. As predicted, they report that the peppers did not taste spicy. Which of Marr's levels of analysis best fits your explanation?

A. Computational
B. Algorithmic
C. Implementation
D. None of the above

Summary

- Sensory experience can be conceptualized as part of an active **perceptual process**.
- Though we can't directly observe someone's sensory **qualia**, we can approximate it with a **theoretical construct** and observe specified **operational** characteristics.
- Marr's **levels of analysis** provide a framework for looking at a single phenomenon from multiple, interlocking perspectives.

Next time

- Review chapter 1