Introduction to the main methods for perception measurement

DT2350 Human Perception for Information Technology

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HT2016

Sensation and perception

Sensation

- Detection of a signal in the environment through out senses
- Biochemical and neurological responses to external stimuli
- *e.g.* sensation in hearing: waves of pulsating air collected by the outer ear and transmitted through the bones of the middle ear to the cochlear nerve

Perception

- The organization, identification, and interpretation in order to represent, understand and interact with our environment
- Where is the object, what is it, is it moving, how does it affect me?

Sensation and perception

Sensation

- Detectio
- Biochem
- *e.g.* sens ... ter ear and transmitt ... rve

Perceptio

- The orga ... o represent, understand and interact with our environment
- Where is the object, what is it, is it moving, how does it affect me?

Perception is not a simple passive registration of sensory input, it is a process where we actively select, order and interpret information in order to understand and interact with the environment.

Sensation and perception

Sensation

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> *Perception is not a simple passive registration of sensory input, it is a process where we actively select, order and interpret information in order to understand and interact with the environment.*

Perceptio

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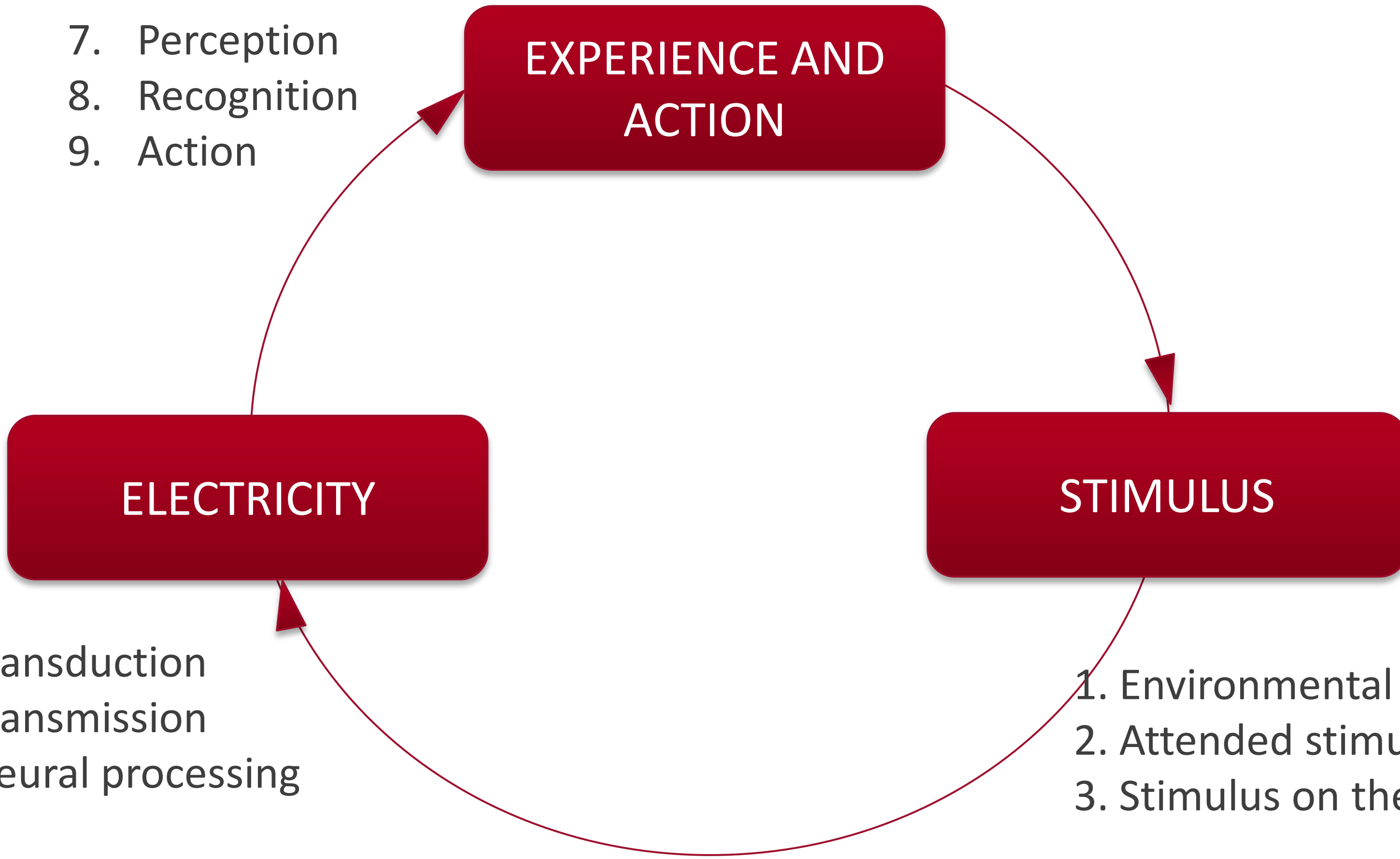
- Where is the object, what is it, is it moving, how does it affect me?

How do physical processes get transformed to rich perceptual experiences?

The dynamical perceptual process

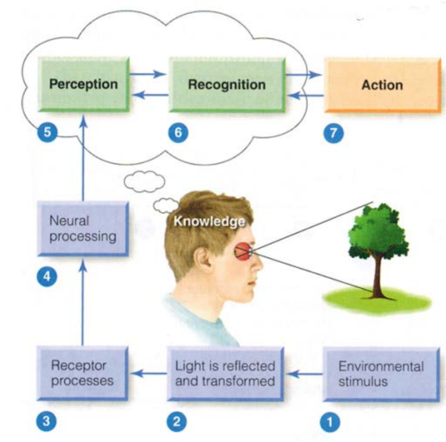
7. Perception
8. Recognition
9. Action



4. Transduction
5. Transmission
6. Neural processing

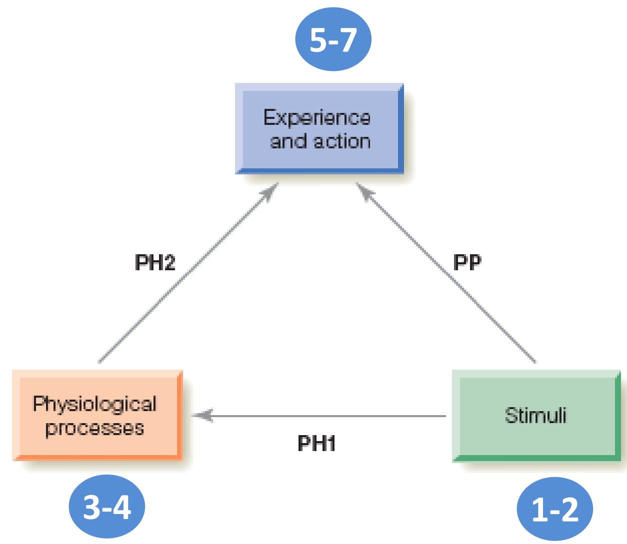
1. Environmental stimulus
2. Attended stimulus
3. Stimulus on the receptors

The dynamical perceptual process



7. Perception
8. Recognition
9. Action

EXPERIENCE AND ACTION



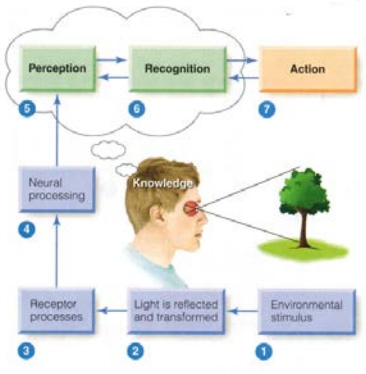
ELECTRICITY

STIMULUS

4. Transduction
5. Transmission
6. Neural processing

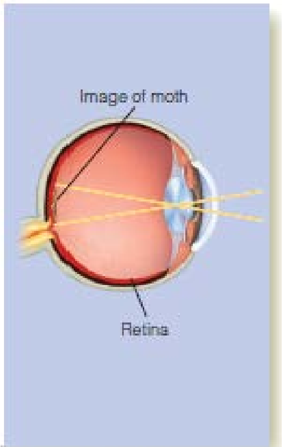
1. Environmental stimulus
2. Attended stimulus
3. Stimulus on the receptors

Perceptual process - Stimulus

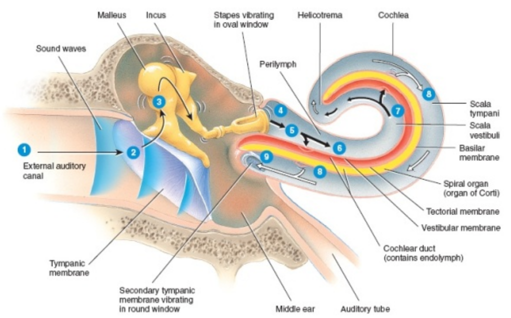


1. Environmental stimulus
   - all of the things in our environment that we can potentially perceive
2. Attended stimulus
   - focus of attention
3. The stimulus on the receptors
   - an internal representation of the stimulus

3. Stimulus on the receptors

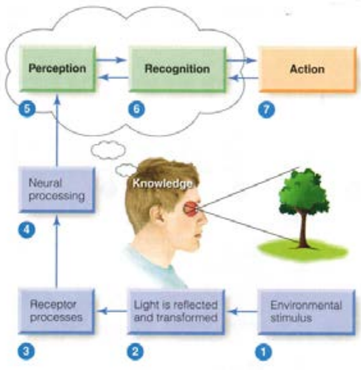


(c) Image on Ellen's retina

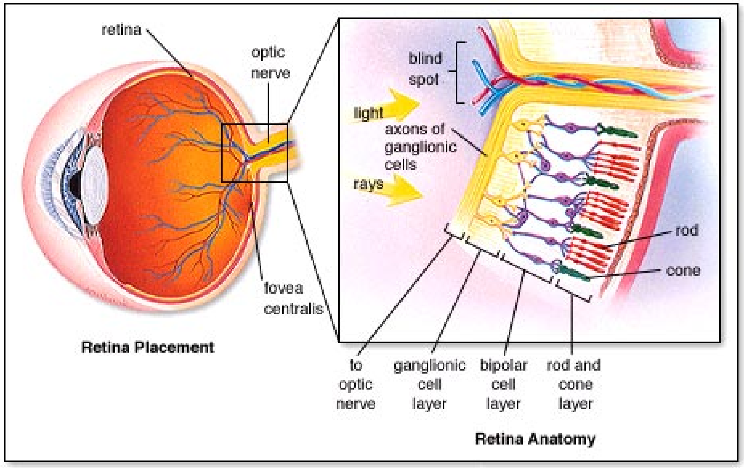


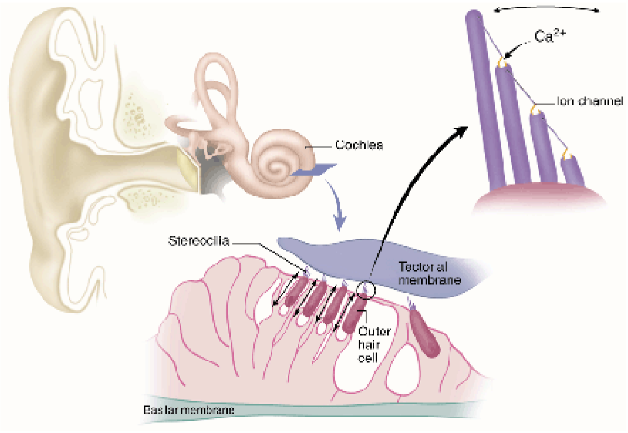
Perceptual process - Electricity

Physiological processes



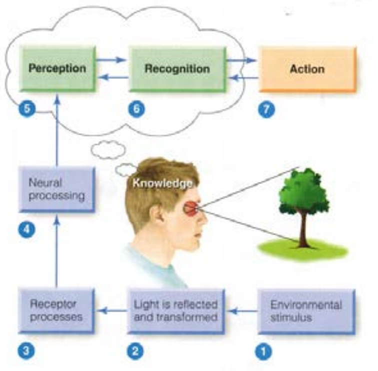
4. Transduction
   - Energy in the environment is transformed into electrical impulses in the neural system.





Perceptual process - Electricity

Physiological processes

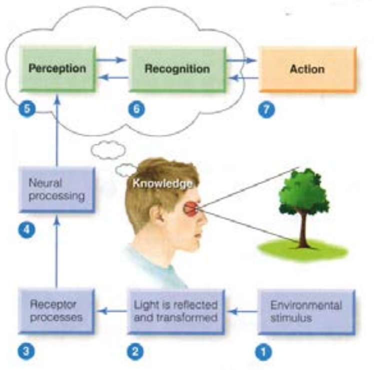


4. Transduction
   - Energy in the environment is transformed into electrical impulses in the neural system.
5. Transmission
   - The transmission of the electrical signals is different from many engineering forms of signal or information transmission.

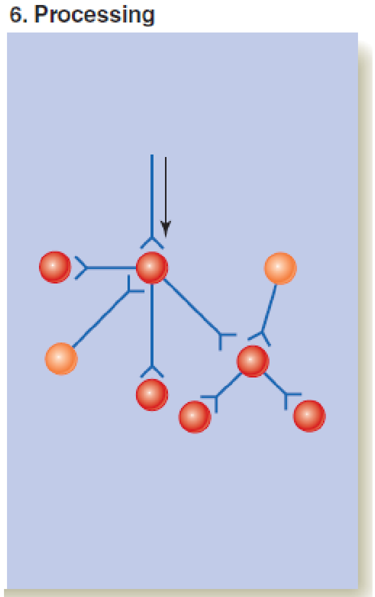
Transmission

Perceptual process - Electricity

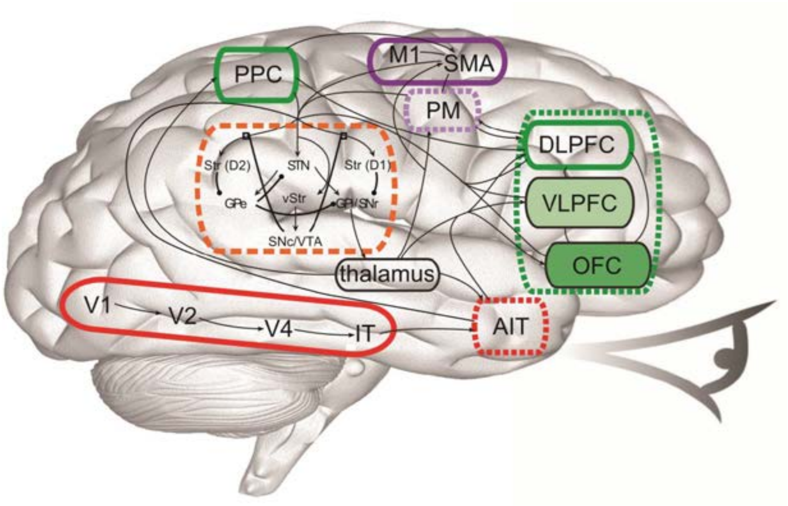
Physiological processes



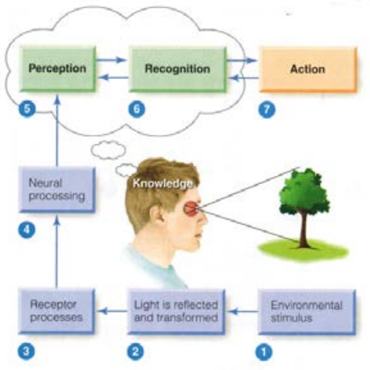
6. Neural processing
 - The electrical signals are then transmitted through networks of neurons to the brain.



(c) Interactions between neurons



Perceptual process – Experience and action



7. Perception
   - The transformation of the electrical signals into a conscious sensory experience, e.g. seeing a tree
8. Recognition
   - Placing the perceived object into a meaningful category (e.g. “a pine tree”), labeling
9. Action
   - motor actions (e.g. to move towards the tree)

Perception vs recognition

conscious sensory experience
(experience of seeing, smelling, hearing etc.)

categorisation, labelling

Perception vs recognition

conscious sensory experience
(experience of seeing, smelling, hearing etc.)

categorisation, labelling

Visual agnosia - an impairment in recognition of visually presented objects

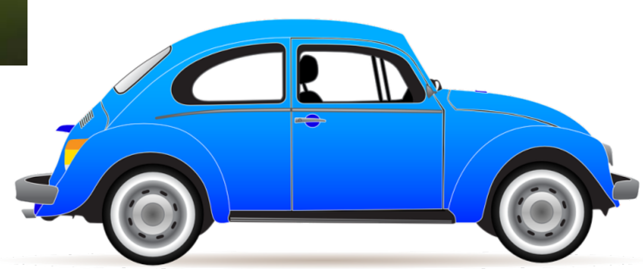
- Subjects that are able to describe parts of objects but have inability to recognize and categories objects as a whole
- The man who mistook his wife for a hat (Sacks, 1985)
  - Dr P. describing his perception of a glove:

  "A continuous surface unfolded on itself. It appears to have 5 outpouchings, if this is the word

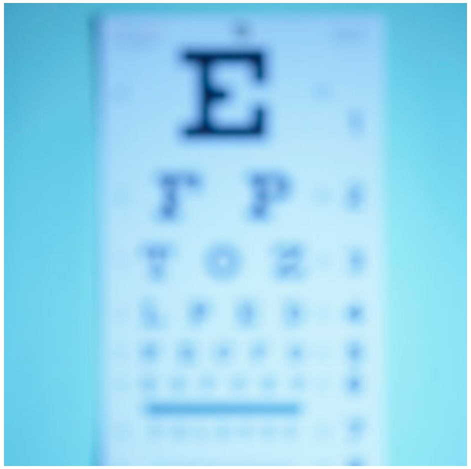
  - Dr P. trying to recognize a glove:

  "A container of some sort. It could be a change purse, for example, for coins of five sizes."

How do we recognise objects?



Pattern completion



Pattern completion

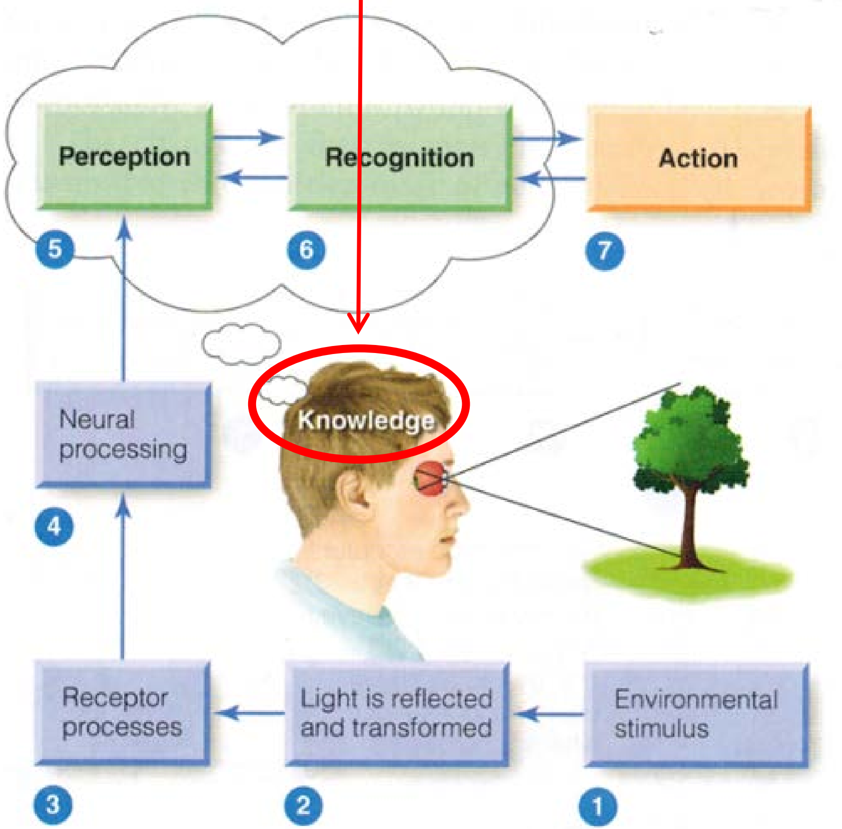
VIKING LINE

Łucznik

Recognition of novel objects

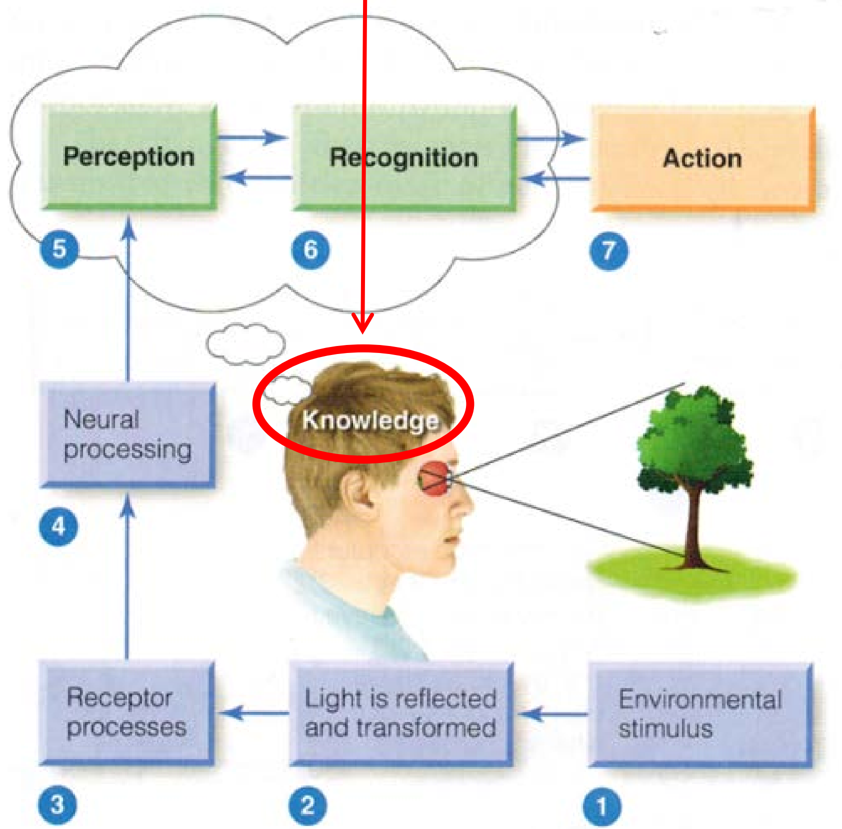
Invariant recognition

The importance of knowledge in the perceptual process



The importance of knowledge in the perceptual process

- any information brought by the perceiver to a perceptual situation
- particularly strong effect on the recognition
- TOP-DOWN vs BOTTOM-UP processing



Bottom-up vs top-down processing

- Data(stimulus)-driven processing
- Features and clues from the external stimulus are exploited
- Information provided by the environmental stimuli rather than knowledge or extra hints are used to identify a pattern
- Rare cases where only bottom-up processing accompanies perception (purely sensory)

BOTTOM-UP

Bottom-up vs top-down processing

There is a Dalmatian in the picture.

TOP-DOWN

- Conceptually driven processing
- Top corresponds to higher / cognitive levels of perceptual processing in the brain

  (long/short-term memory, knowledge, contextual information, expectations, emotions, beliefs etc.)

Bottom-up vs top-down processing

There is a Dalmatian in the picture.

TOP-DOWN

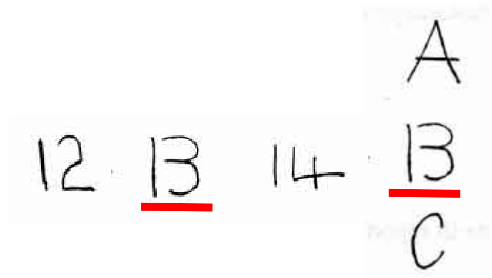
- Conceptually driven processing
- Top corresponds to higher / cognitive levels of perceptual processing in the brain
- Only little information in the environment is needed to trigger the relevant information
- The overwhelming majority of daily perceptual processes include *both* top-down and bottom-up processes.

Context-dependent recognition

Context-dependent recognition

Top-down (knowledge based) processing

knowledge, familiarity
(long-term memory)

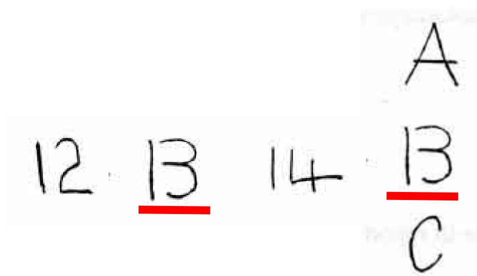


Context

Recent, temporary information

Top-down (knowledge based) processing

knowledge, familiarity
(long-term memory)



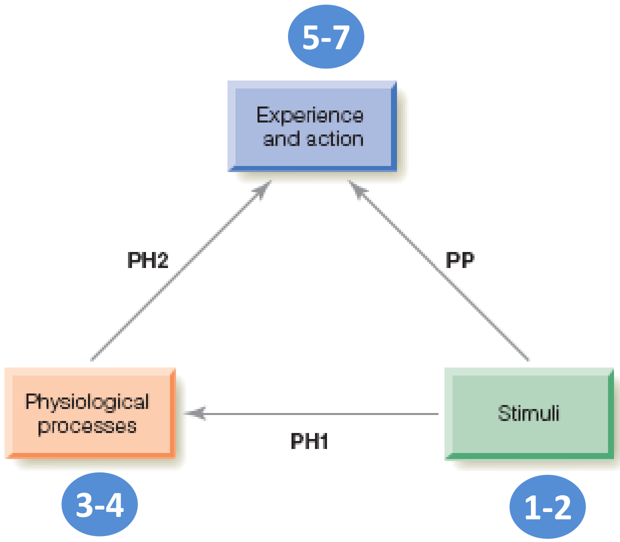
Context

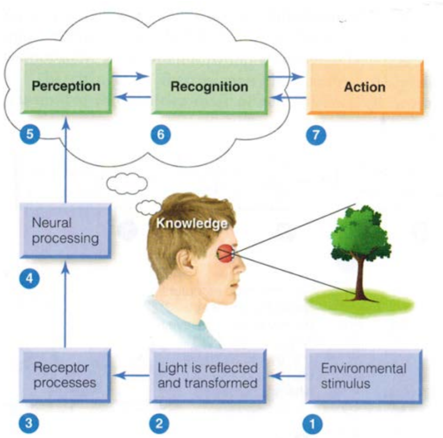
Recent, temporary information

Perceptual sets

- perceptual bias or predisposition or readiness to perceive particular features of a stimulus
- e.g. needs, beliefs, emotions, expectations
- e.g. Sanford (1936); Gilchrist & Nesberg (1952)

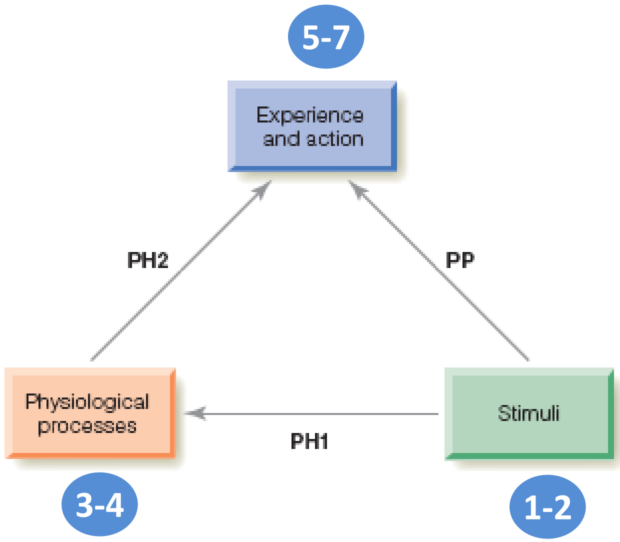
Methodological approaches to perception

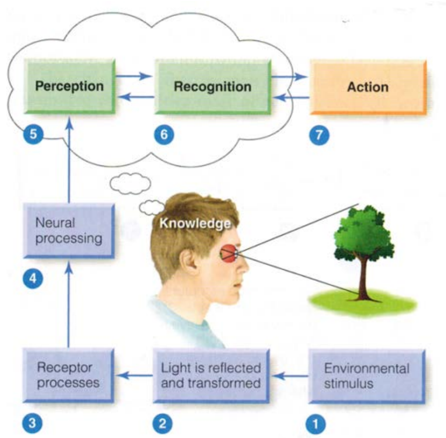




physiological (PH) vs psychophysical (PP)

Methodological approaches to perception

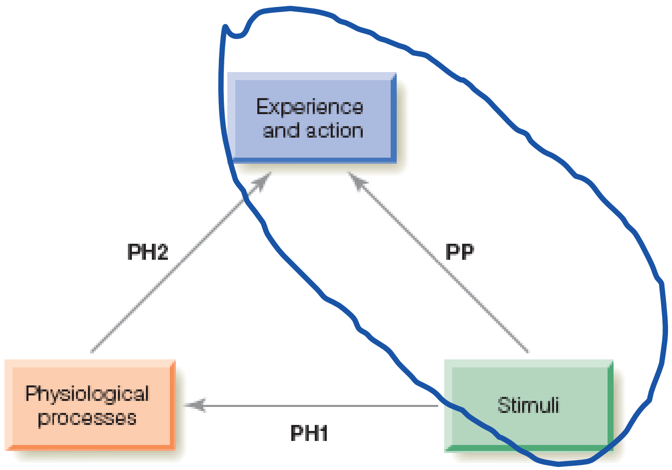


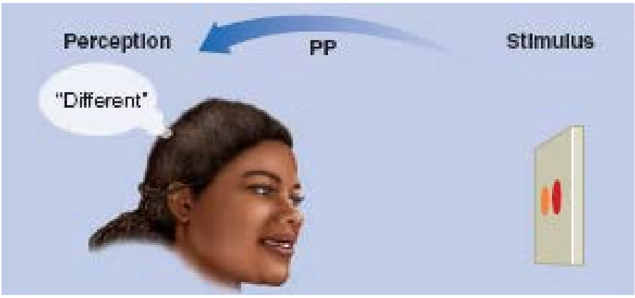


physiological (PH) vs psychophysical (PP)

+ cognitive influences on perception (knowledge dependent effects)

Methodological approaches to perception

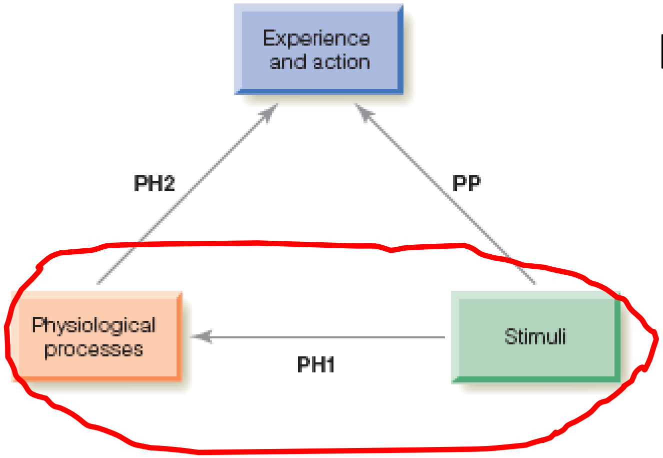




Psychophysical (PP):

physcial properties of stimuli *vs* perceptual responses

Methodological approaches to perception

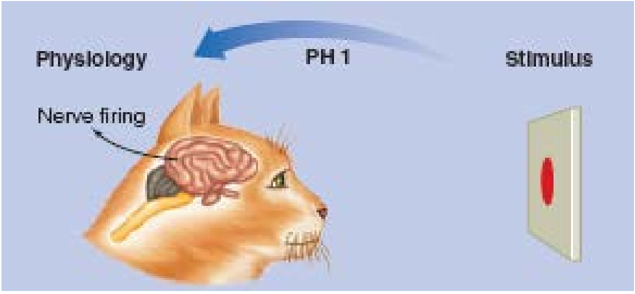


Physiological (PH1):

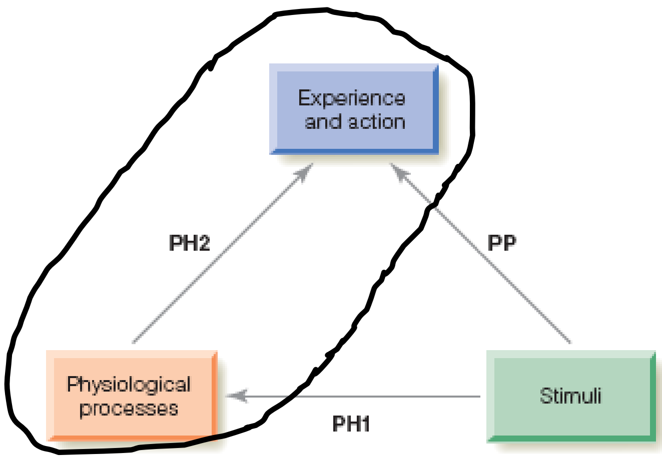
physical properties of stimuli

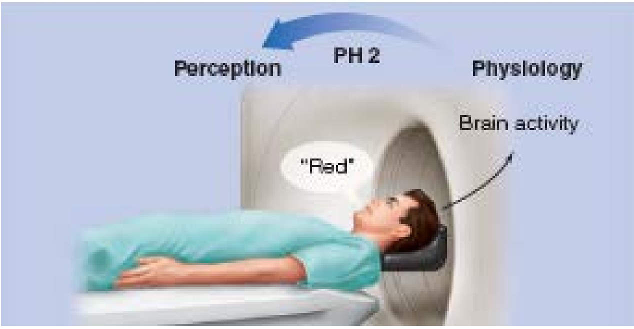
vs

physiological responses



Methodological approaches to perception





Physiological (PH2):

physiological responses

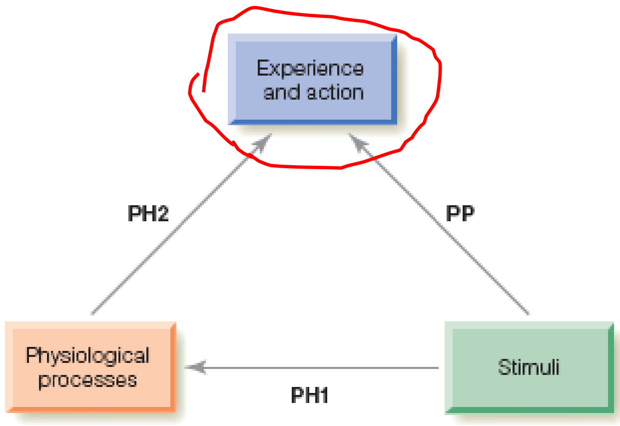
vs

perception

Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- Recognising
- Detecting
- Perceiving magnitude
- Searching
- …….



Measuring perception – psychophysical aspects

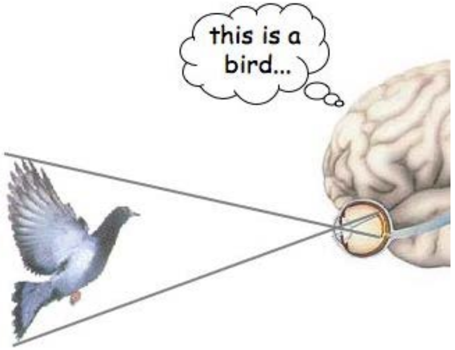
How to measure experience (perception, recognition)?

- **Describing**
  - phenomenological approach (identify phenomena through how they are perceived by the given individual)
  - personal experiences of a stimulus, e.g. sweet, bitter, dark, light, high, low…

Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- **Recognising**
  - provide a label, categorise an object
  - it captures WHAT person perceives



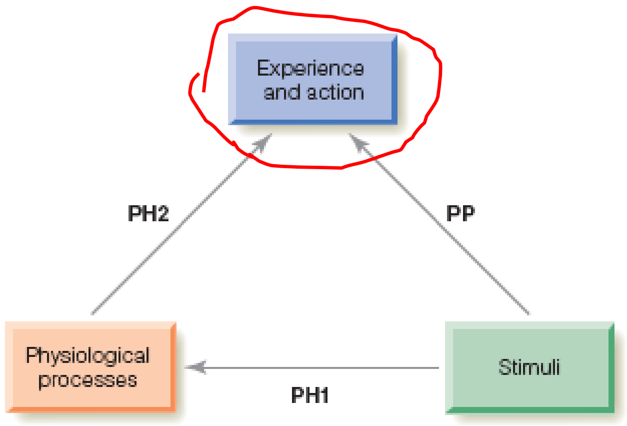
Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- Recognising
- **Detecting**

absolute threshold
(G. Fechner,
Elements of Psychophysics)

difference threshold
(Webber's law)



Measuring the absolute threshold

The absolute threshold –

the lowest stimulus intensity necessary for detection (in 50% of cases)

Measuring the absolute threshold

The absolute threshold –

the lowest stimulus intensity necessary for detection (in 50% of cases)

Determining the absolute threshold

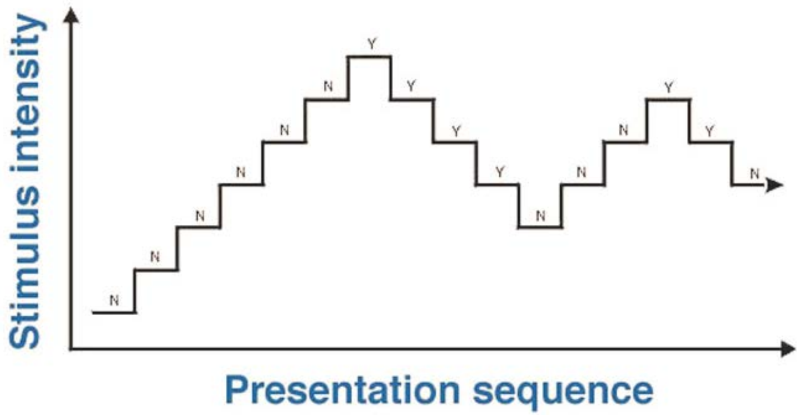
classical psychophysical methods

method of ***limits***

method of ***adjustments***

method of ***constant stimuli***

Method of limits



Trial series

Intensity (arbitrary units)	↓1	↑2	↓3	↑4	↓5	↑6	↓7	↑8
20	Y						Y	
19	Y		Y		Y		Y	
18	Y		Y		Y		Y	
17	Y		Y		Y		Y	
16	Y		Y		Y		Y	Y
15	Y	Y	Y	Y	Y	Y	Y	Y
14	Y	N	Y	N	Y	N	Y	Y
13	N	N	Y	N	Y	N	N	Y
12		N	N	N	N	N		N
11		N		N		N		N
10		N		N		N		N
	13.5	14.5	12.5	14.5	12.5	14.5	13.5	12.5

Crossover values (average = 13.5)

SENSATION & PERCEPTION 3e, Figure 1.7
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Advantages:

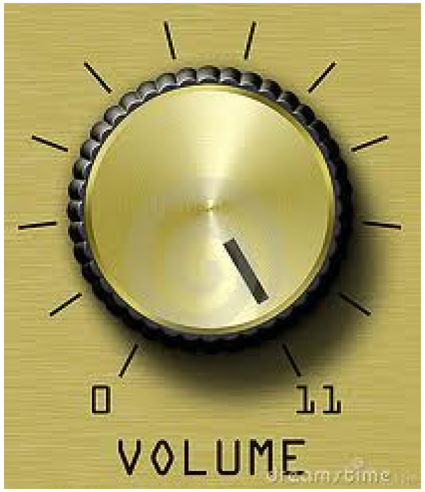
- low observer bias
- simple calculations

Disadvantages:

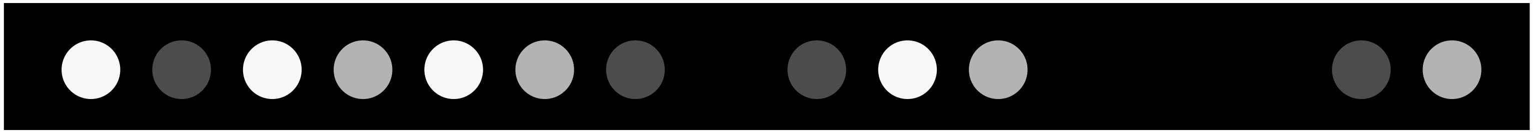
- inefficient
- anticipation bias

Method of adjustment

- The subject adjusts the intensity of the stimulus continuously until they report that they *can* (ascending) or *cannot* (descending) detect the stimulus
- The procedure is repeated several times
- At the end mean is calculated giving the average error which can be taken as the measure of sensitivity



Method of constant stimuli



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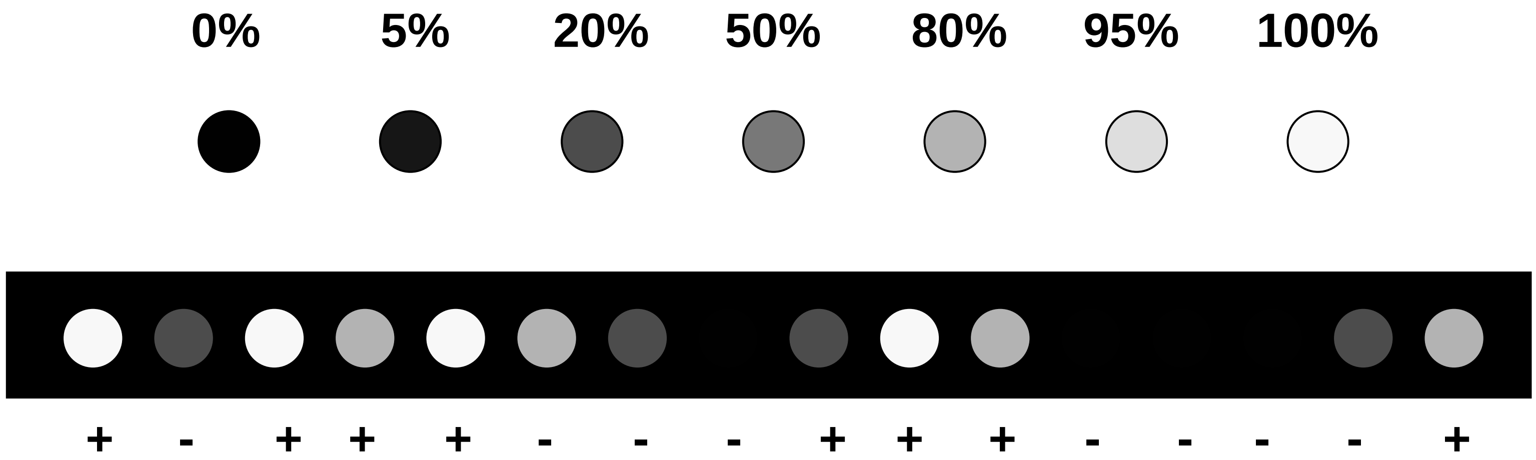
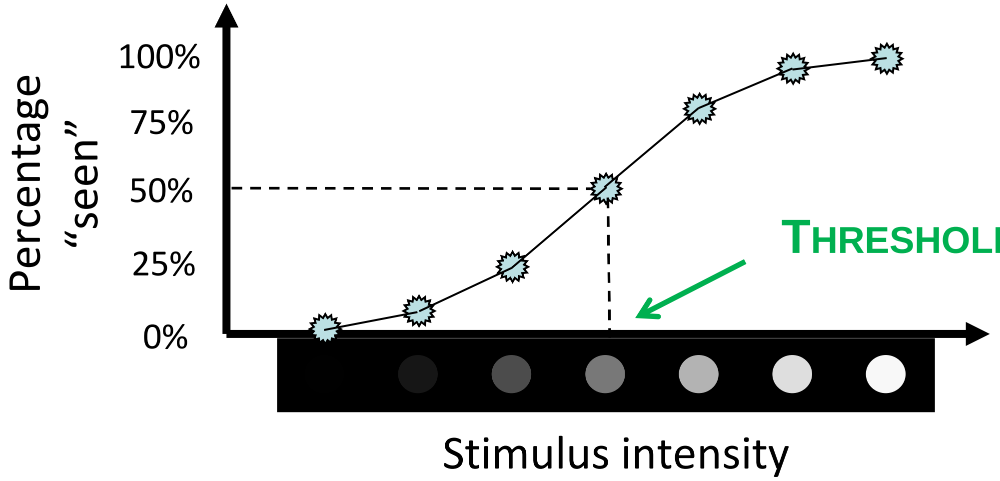
Method of constant stimuli



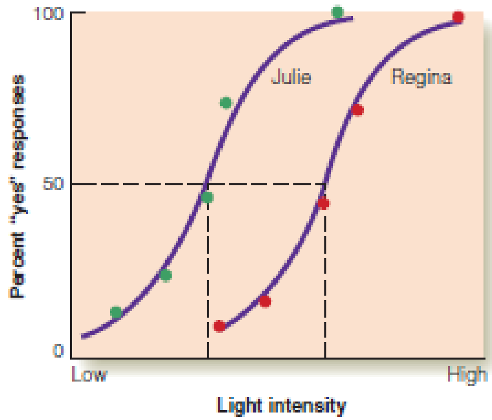
Method of constant stimuli

PSYCHOMETRIC FUNCTION

Plot the percentages against stimulus intensity

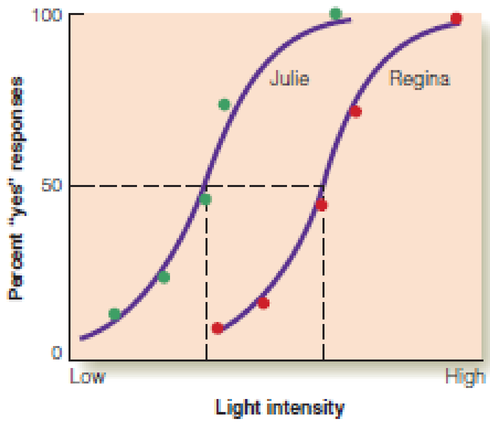


Special considerations in threshold measurements



subjectivity of the response criteria

Special considerations in threshold measurements

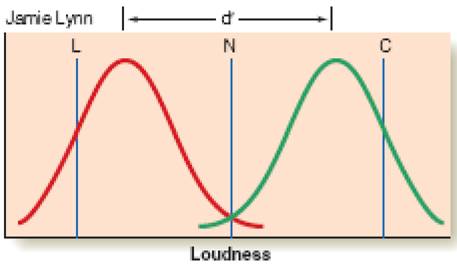


subjectivity of the response criteria

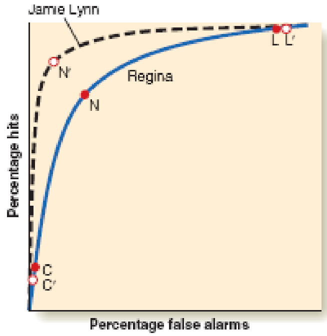
Signal / Noise

Signal Detection Theory (SDT)

sensitivity, (distance)



ROC curve



Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- Recognising
- **Detecting**

absolute threshold
(G. Fechner,
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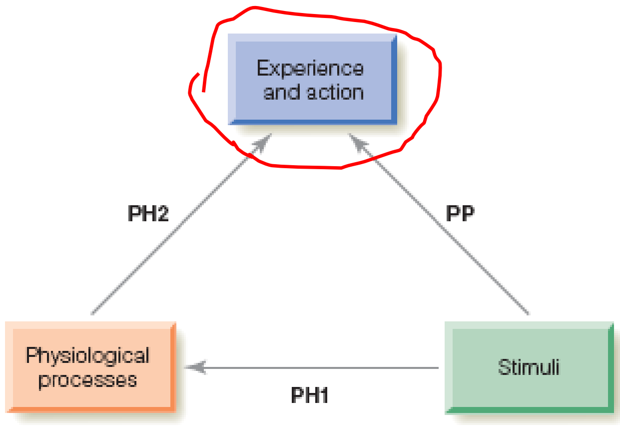
difference threshold
(Webber's law)



Difference threshold (Webber's law)

- Just-noticeable difference (JND): the smallest difference in magnitude that a person can detect
- Point of subjective equality (PSE)
- With the increasing magnitude of the stimulus (S), the size of the difference threshold (DT) also grows

$$DT / S = K$$

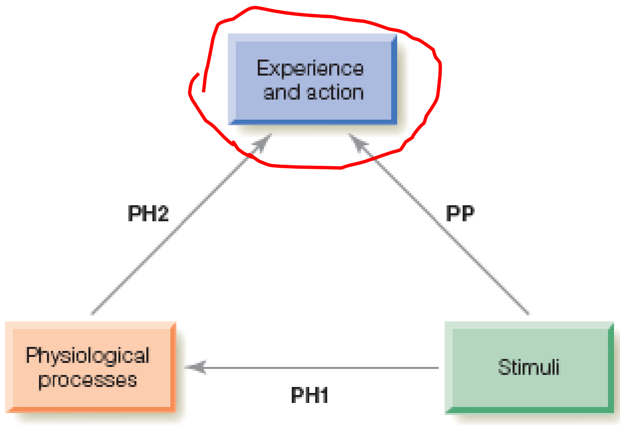
where: K – the Webber fraction

K = 0.01 for lifted weight, 0.04 for sound intensity and 0.08 for light intensity

Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- Recognising
- Detecting
- **Perceiving magnitude**
  - describing effects above threshold
  - Fechner's law
  - Magnitude estimation / scaling method (S.S. Stevens, 1957)

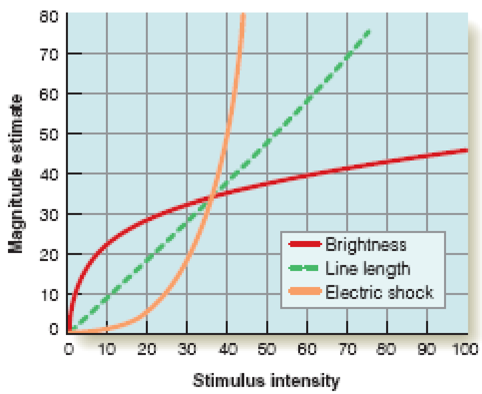


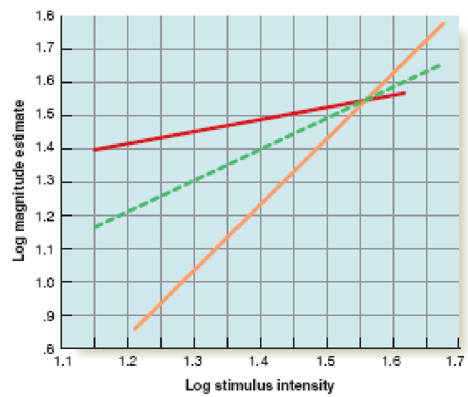
Fechner’s law and Stevens’s scaling method

- Subjective sensation is proportional to the logarithm of the stimulus intensity
- Stevens’s power law:

$$P = K\,S^n$$

where: P – *perceived magnitude*, S – stimulus intensity





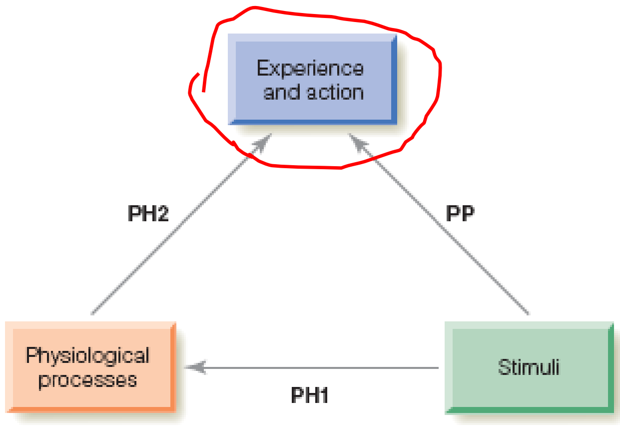
response *expansion* (n>1)

response *compression* (n<1)

Measuring perception – psychophysical aspects

How to measure experience (perception, recognition)?

- Describing
- Recognising
- Detecting
- Perceiving magnitude
- **Searching**
  - looking for specific stimulus object
  - measuring reaction times
  - linked to visual attention



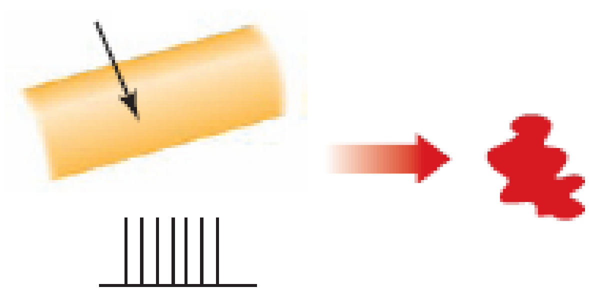
The Mind-Body problem

CORRELATION

"Easy" problem

Connection between physiological responses and perceptual experiences

"neural correlates of consciousness"



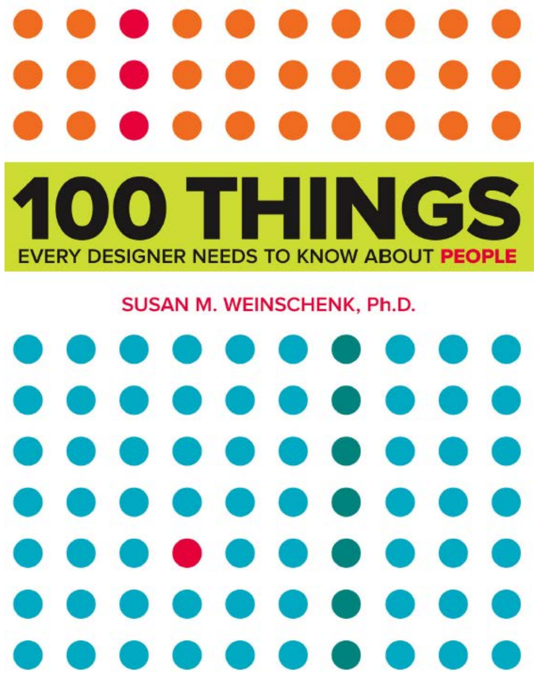
CAUSE

"Hard" problem

How physiological processes CAUSE perceptual experiences.

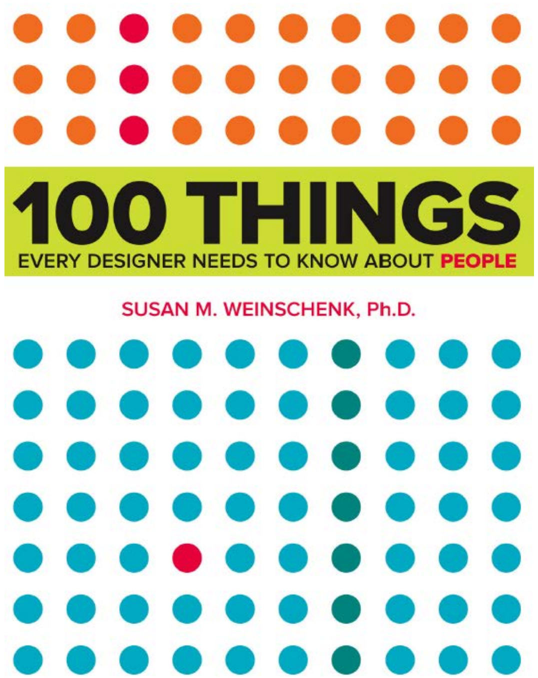
Connection to Information Technology

7. ”People see cues that tell them what to do with an object” – **affordances**



Connection to Information Technology

7. ”People see cues that tell them what to do with an object” – **affordances**



Take-away messages

- Think about affordance cues when you design (cues causing actions)
- Use shading to show when an object is chosen or active
- Avoid providing incorrect affordance cues
- Rethink hover cues if you’re designing for a device that uses touch rather than a pointing device