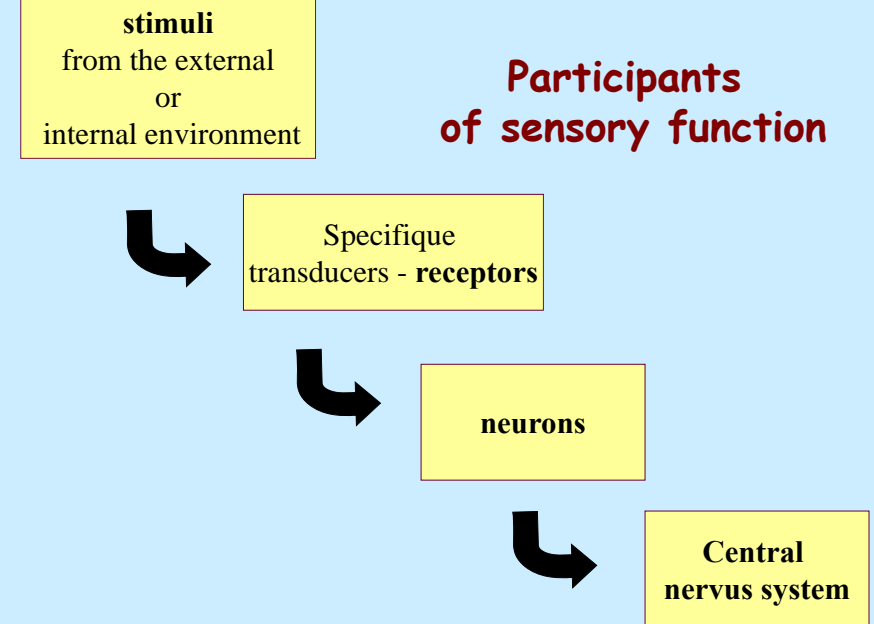


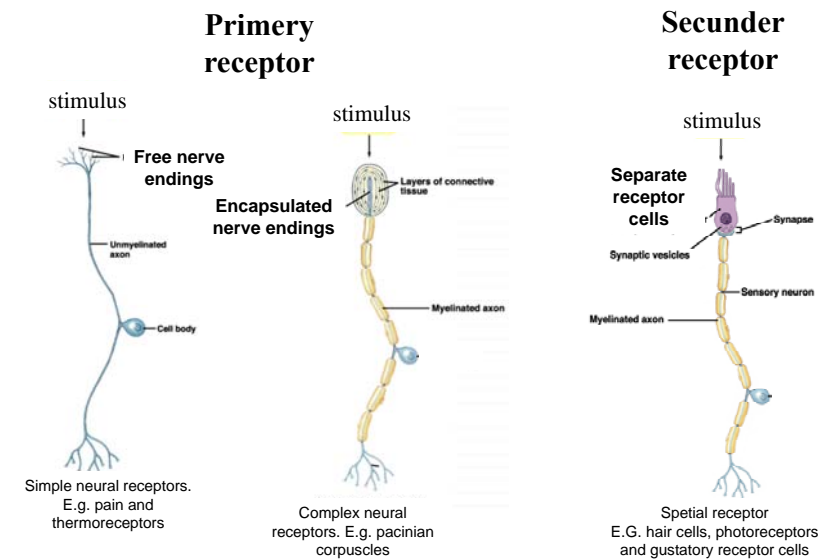
## Biophysical principles of sensory function



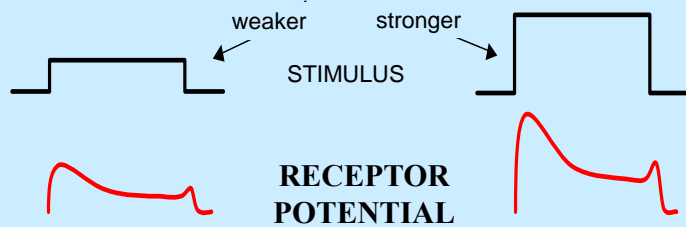
## Parameters of the stimulus

**What?**  
**Where?**  
**How much?**  
**How long?**

## Types of Sensory Receptors



## Reaction of receptor cell for specific stimulus

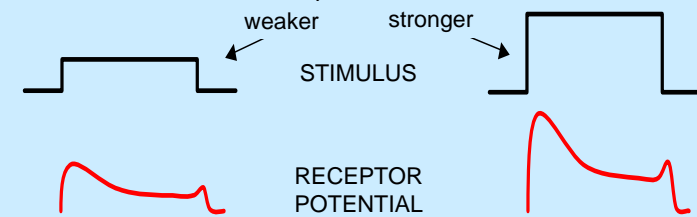


**Answer is general and uniform:**

*alteration of the membrane potential on receptor cell*

## RECEPTOR POTENTIAL

Analogue signal conversion



Its amplitude is proportional to the stimulus amplitude.

Its duration is identical to the stimulus duration

It is a local potential change.

It is not Na-potential.

## Stimulus

## Code

**What?**



**Type of receptor**

**Where?**



**Receptive field**

**How much?**



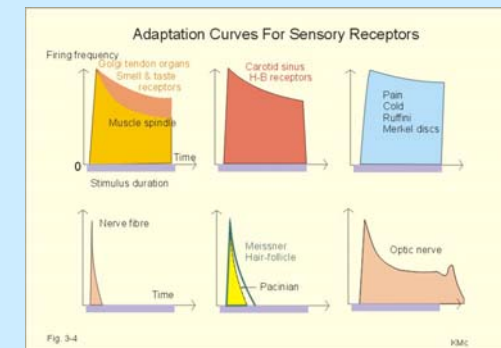
**Amplitude of receptor potential**

**How long?**



**Duration of receptor potential**

## Adaptation of Receptors



**Rapidly adapting** receptors (Rapid receptors): e.g. pacinian and hair receptors  
detect the change in stimulus strength (detect movement)

**Slowly adapting** receptors (Tonic receptors): e.g. joint capsule, muscle spindle  
detect continuous stimulus strength (give report to the brain about the status of the body).

**Non adapting** receptors: pain receptors and chemoreceptor

## Transition of information from receptor to neuron / axon

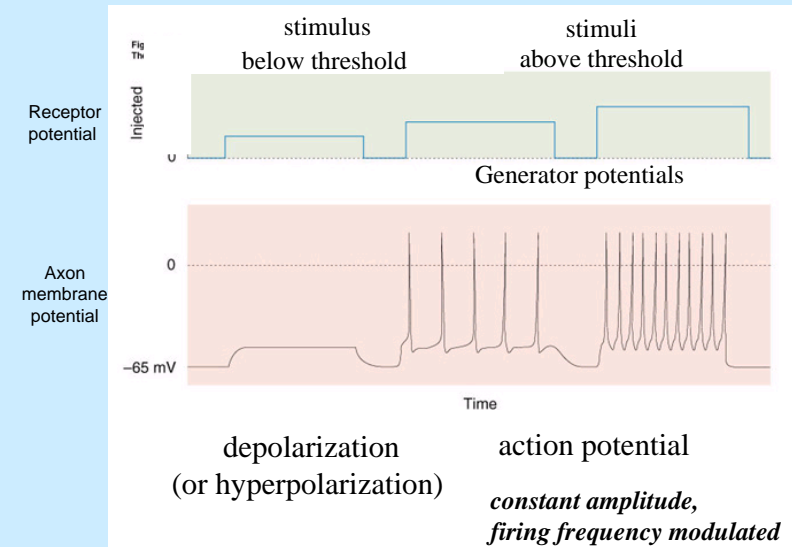
Secunder receptor  $\Rightarrow$  synapse  $\Rightarrow$  axon

receptor potential      neurotransmitter      ?  
   quantity  
   quality

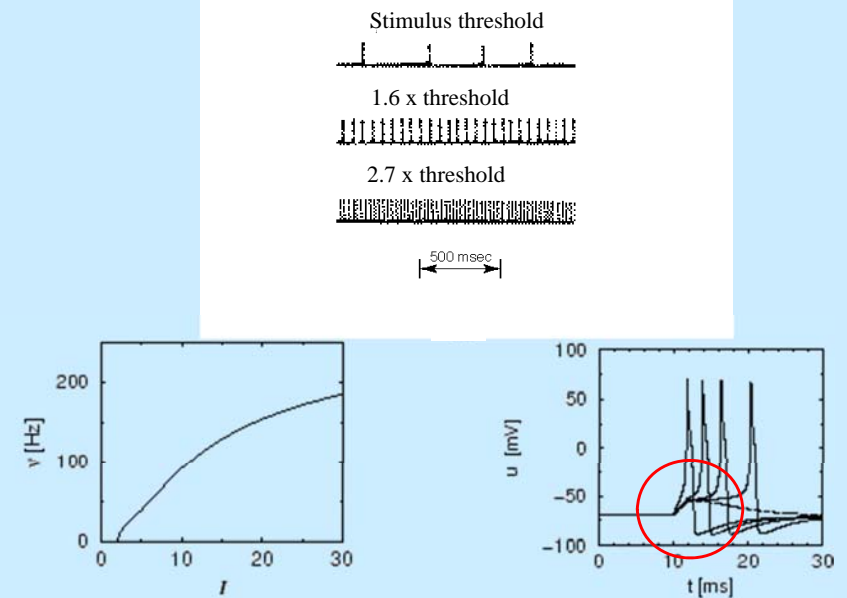
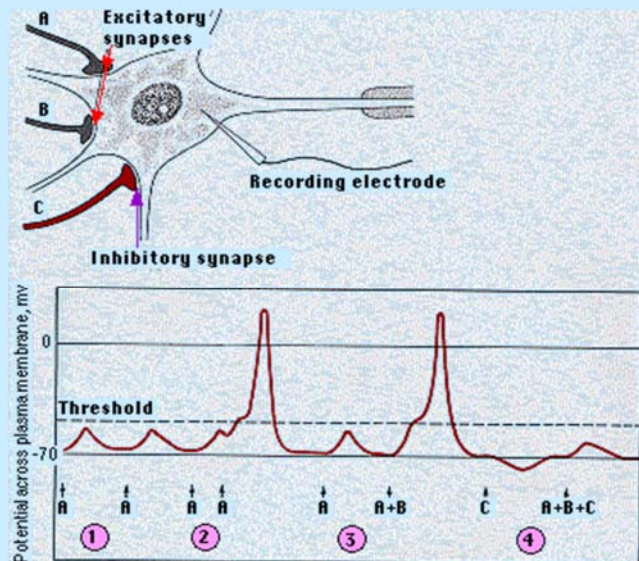
Primery receptor  $\Rightarrow$  local currents  $\Rightarrow$  axon

receptor potential      current intensity      ?

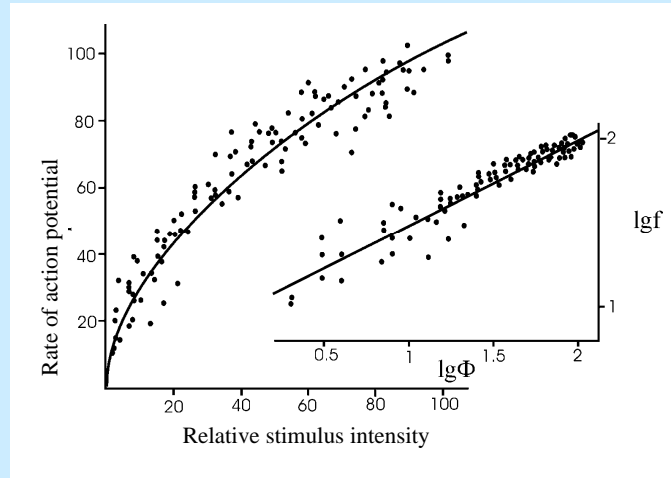
## Receptor potential acting on nerve cell membrane



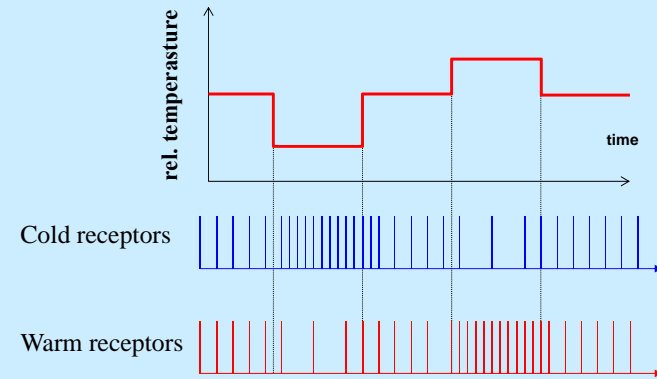
## Temporal and spatial summation



## AP frequency and stimulus intensity



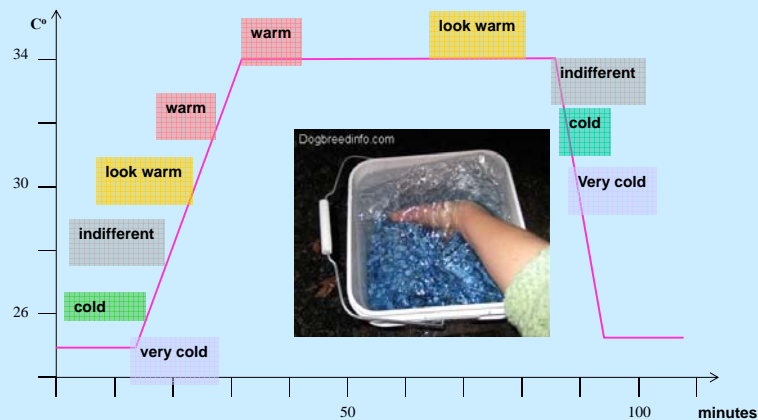
## Persistent APs



For a warm receptor warming results in an increase in their action potential discharge rate, cooling results in a decrease in discharge rate. For cold receptors their firing rate increases during cooling and decreases during warming. Some cold receptors also respond with a brief action potential discharge to high temperatures, i.e. typically above 45°C, and this is known as a paradoxical response to heat.

## Thermal receptors

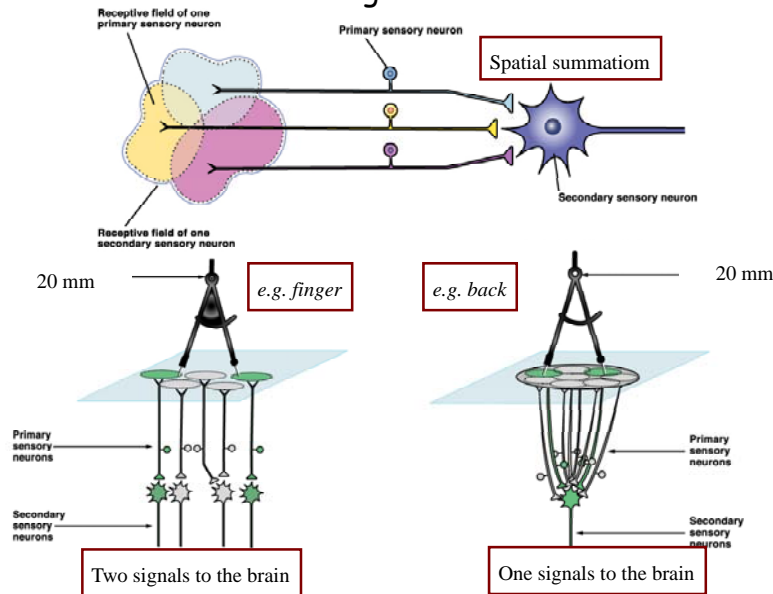
codes absolute and relative changes in temperature



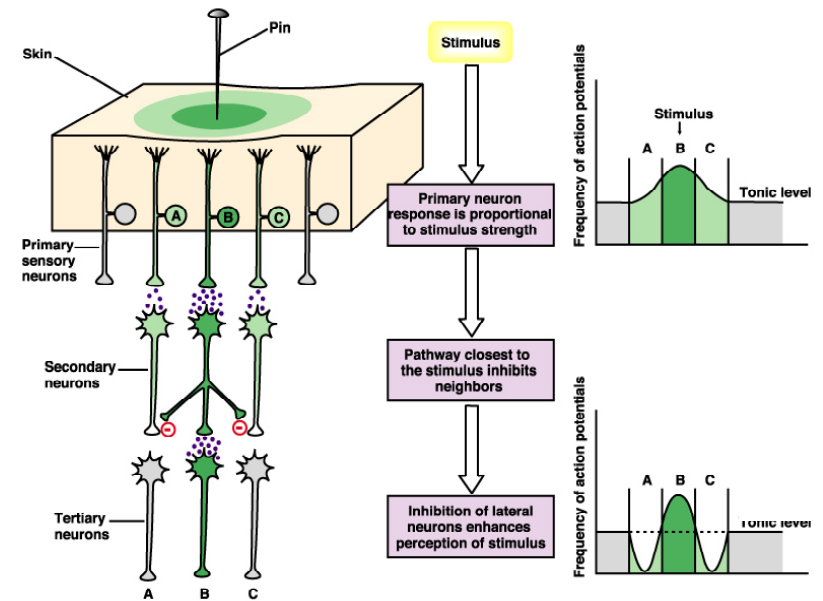
CNS is composed of neuronal pools with **different mechanisms of signal processing.**

Excitation  
Facilitation  
Inhibition  
Convergence  
Divergence

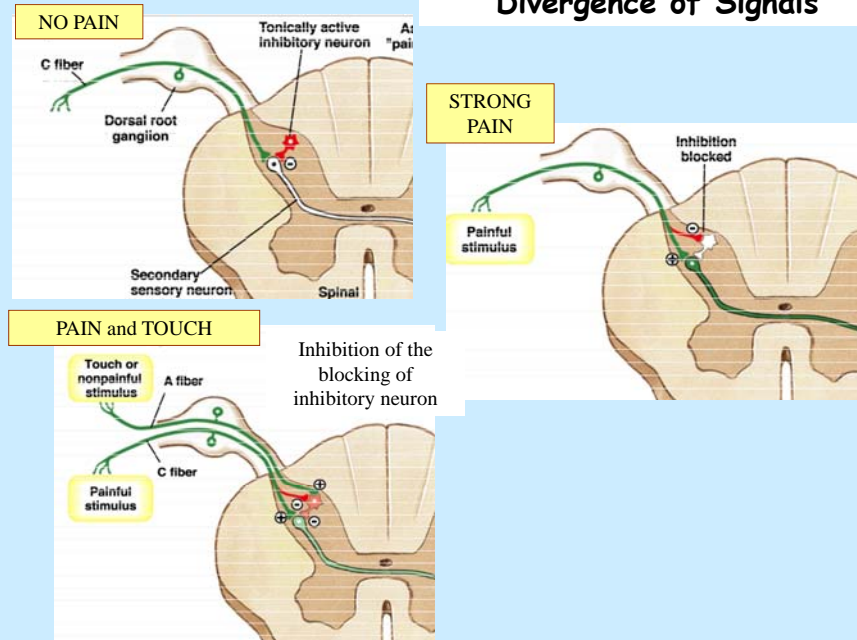
## Convergence of Signals: multiple inputs uniting to excite a single neuron



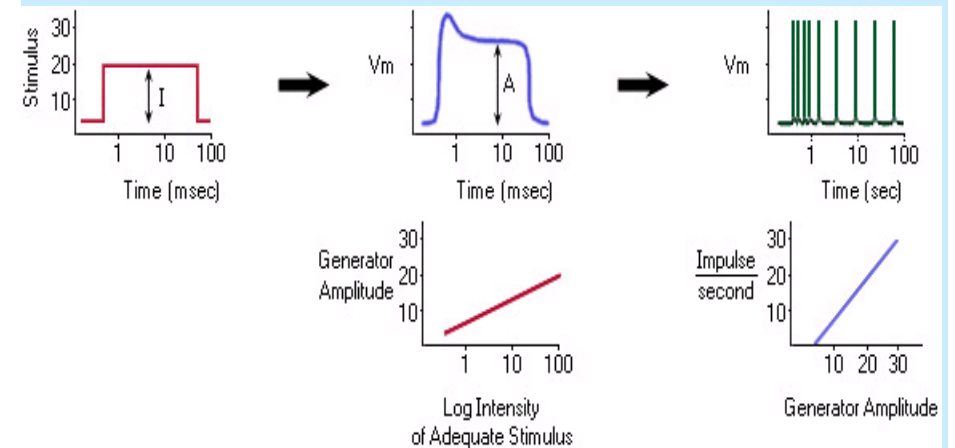
## Divergence of Signals



## Divergence of Signals



## Summary



## Psychophysics

Study the relationship between stimuli  
&  
our psychological response to them

## Investigation of threshold stimulus

### Absolute threshold

This is the minimum amount of a stimulus that is necessary for us to notice it 50% of the time

**Decision method** – yes - no

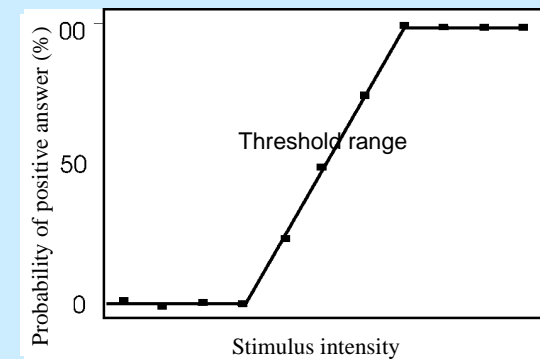
### Determination of threshold by simple decision

answer					
stimulus	V1	V2	V3	V4	YES (%)
I1	NO	NO	NO	NO	0 (0)
I2	NO	NO	NO	NO	0 (0)
I3	NO	NO	NO	NO	0 (0)
I4	NO	NO	NO	NO	0 (0)
I5	NO	NO	NO	NO	0 (0)
I6	YES	NO	NO	NO	1 (25)
I7	YES	NO	YES	NO	2 (50)
I8	YES	NO	YES	YES	3 (75)
I9	YES	YES	YES	YES	4 (100)
I10	YES	YES	YES	YES	4 (100)
I11	YES	YES	YES	YES	4 (100)
I12	YES	YES	YES	YES	4 (100)

Increasing intensity  
↓

### Determination of threshold by simple decision

### Absolute threshold



**Threshold is a variable**

## Threshold studies

**Absolute threshold** – the smallest intensity of stimulus to be recognized

**Decision method** – yes - no

**Adjusting method** – (see audiometry experiment)

**Differential threshold** : smallest difference between two intensities to be recognized as different

**Forced decision method**

**Just Noticeable Difference:** Smallest difference in amount of stimulation that a specific sense can detect

$$\text{Just Noticeable Difference} = I - I_0$$

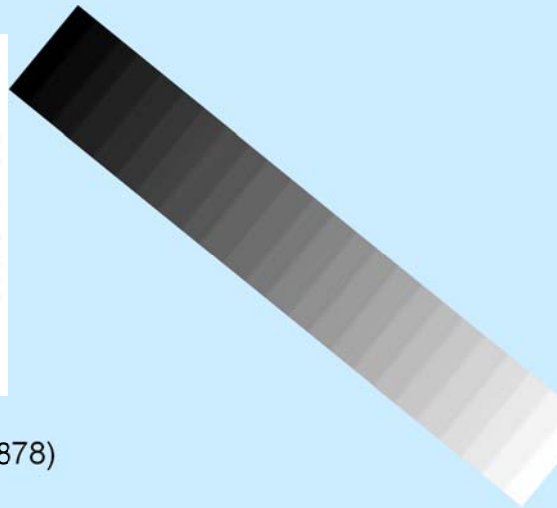
Intensity recognised  
as different

Reference intensity



**Ernst Weber** (1795-1878)

"just-noticeable difference" (JND)

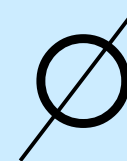


How much more you have to be offered to change your workplace?

50000 + 5000



500000 + 5000



$$\text{JND} = I - I_0$$

Higher initial stimulus – bigger JND

### Weber's law

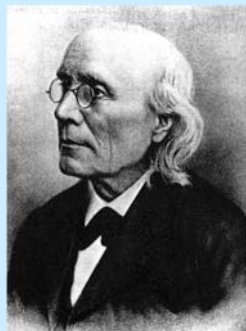
The size of the JND is a constant proportion of the initial stimulus. With other words the ratio of the increment threshold to the background intensity is a constant.

$$\frac{\Delta I}{I_0} = k$$

$k$  : Weber ratio – can be determined by experiments

Each of the sensory perceptions has a consistent sensitivity to change.

<i>stimulus</i>	<i>Weber ratio</i>
brightness	0,079
loudness	0,048
touching	0,022
pressure	0,02
tasting (salt)	0,083
electric shock	0,013



$$\Delta I = I - I_0$$

$\Delta I$  is a function

$\Delta I$  is the function of stimulus intensity

**Gustav Theodor Fechner**  
(1801-1887)

RRGGGH...25...

RRGGGh...5200!!!!

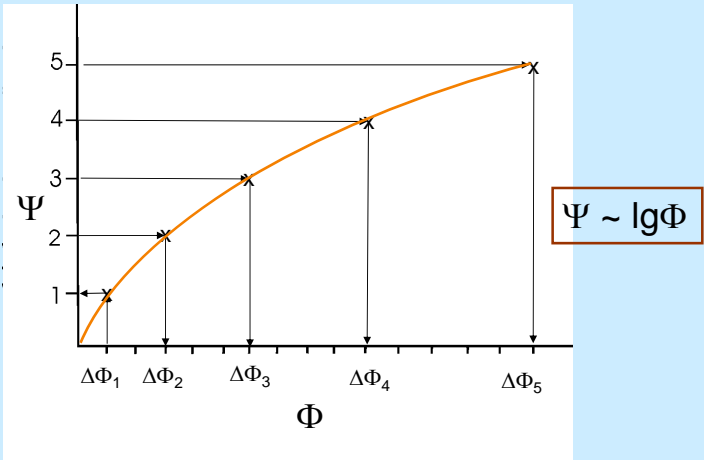


Fechner : connection between stimulus intensity and sensation magnitude



Fechner assumed that the relative change of the stimulus is proportional to the change in the sensation magnitude

$$\Delta\Phi/\Phi \sim \Delta\Psi$$



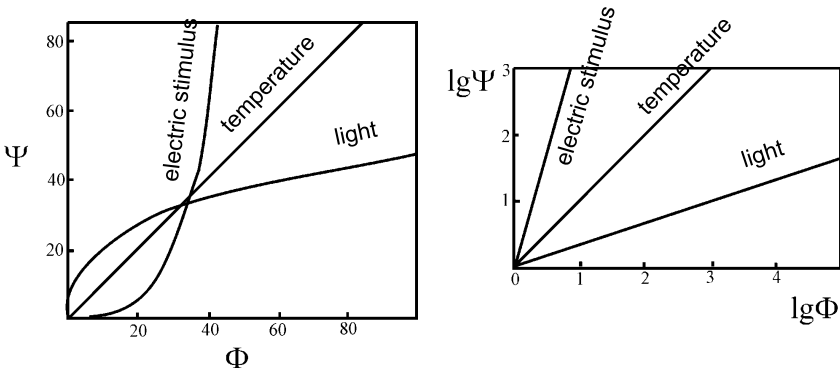
Establish relationship between relative stimulus intensity ( $\Phi/\Phi_0$ ) and psychological magnitude ( $\Psi$ ).

Performed measurements

Stanley Smith Stevens  
(1906-1973)

sensation scale

### Results of experiment



Sensation intensity increases with some expanding stimulus intensity. Equal stimulus ratios produce equal sensation ratios. This law is the power function

$$\Psi \approx \Phi^n$$

The exponent varies with the particular sensory modality, and also within a modality for different stimulus conditions, such as adaptation, inhibition, size, and duration of stimuli.

$$\Psi \approx \Phi^n$$

stimulus	exponent
short light pulses	0,5
smell (heptane)	0,6
loudness (3000 Hz sinus)	0,67
ambient temperature	1,00
taste (salt)	1,30

## Summary

Two different approaches:

*Weber – Fechner :*

$$\Psi \sim \lg \Phi$$

*Stevens :*

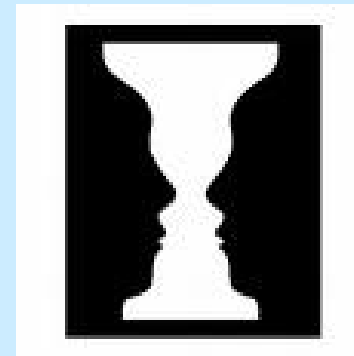
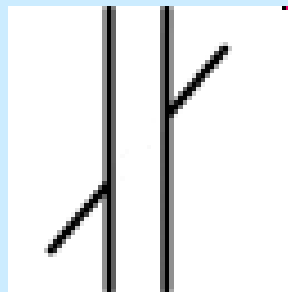
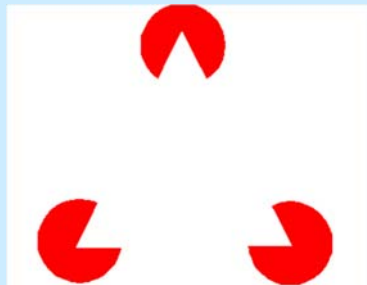
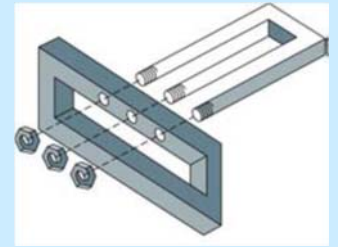
$$\Psi \approx \Phi^n$$

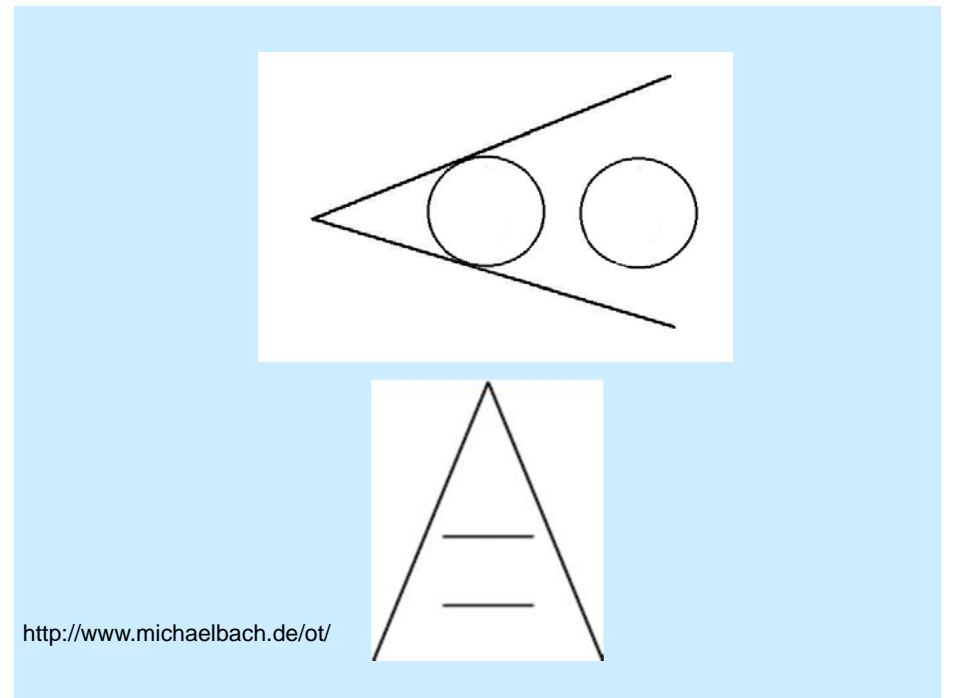
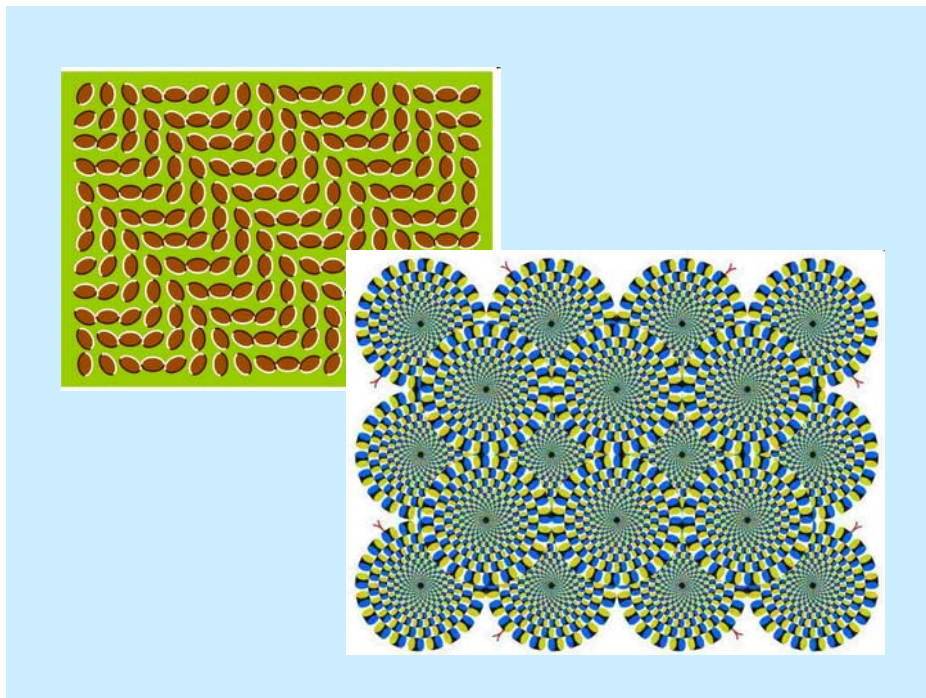
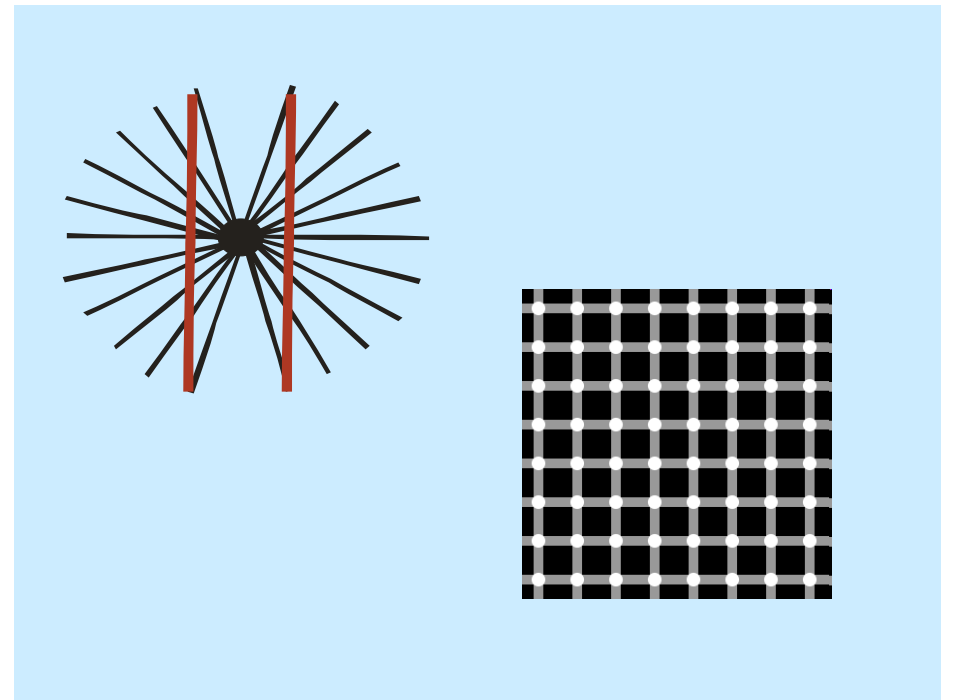
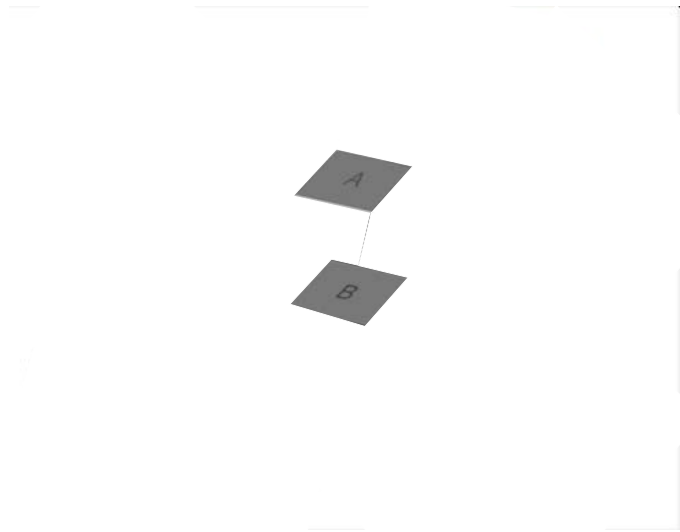
The second one received better experimental support.

## Perception - Organizing sensations into meaningful patterns

- analyzing
- organizing
- understanding

Perception might be correct or false.





<http://www.michaelbach.de/ot/>