Vietnam National University of HCMC
International University
School of Computer Science and Engineering

UI/UX Design & Evaluation
★ Human Perception★

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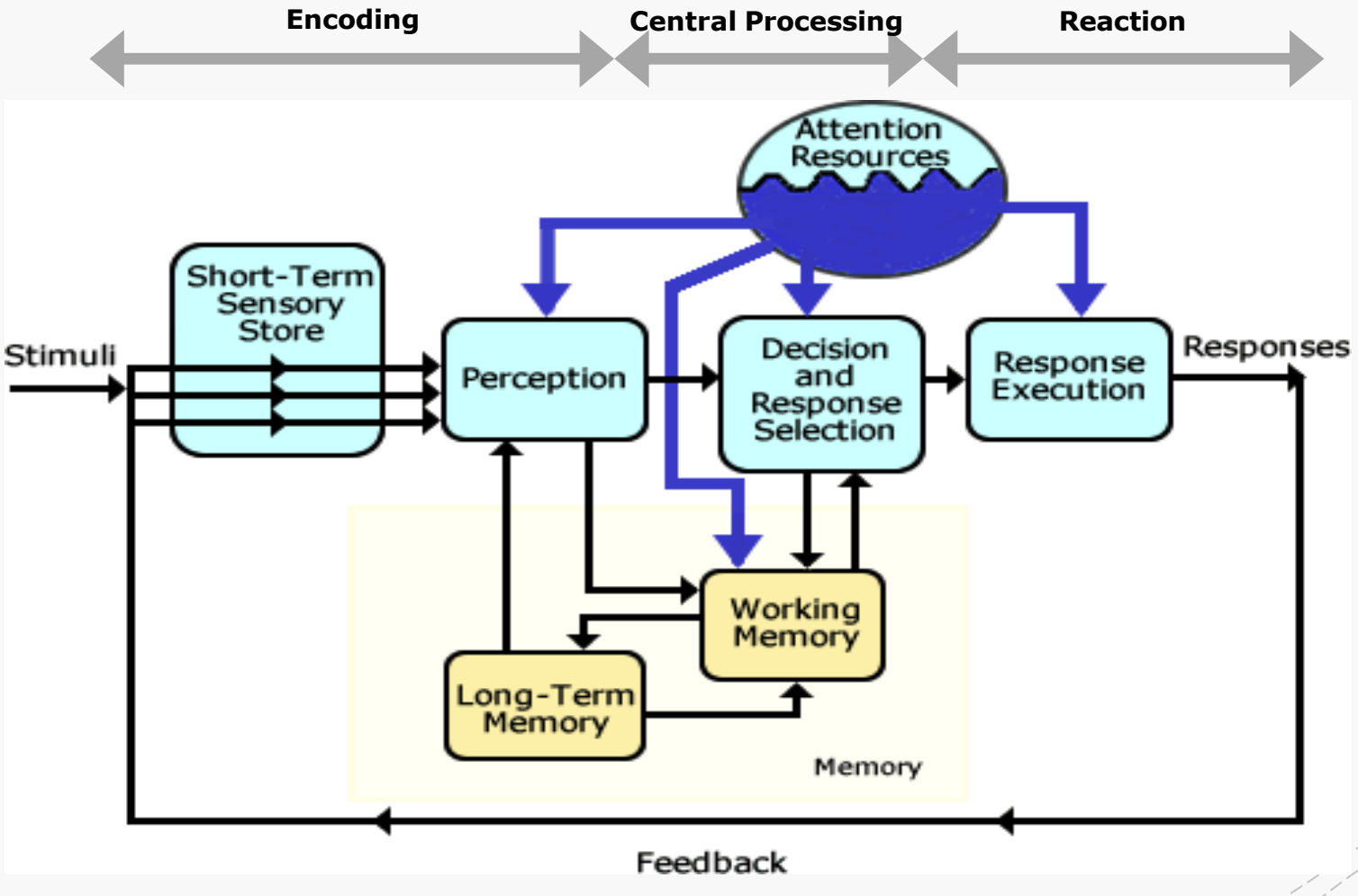
Course Overview

1. Introduction to HCI
2. Needfinding
3. Defining needs and tasks
4. Prototyping
5. Design guidelines, principles, and heuristics
6. **Human abilities and theoretical models**
7. Visual design and design patterns
8. Heuristic evaluation
9. Usability testing
10. Advanced interactions

COGNITIVE PSYCHOLOGY

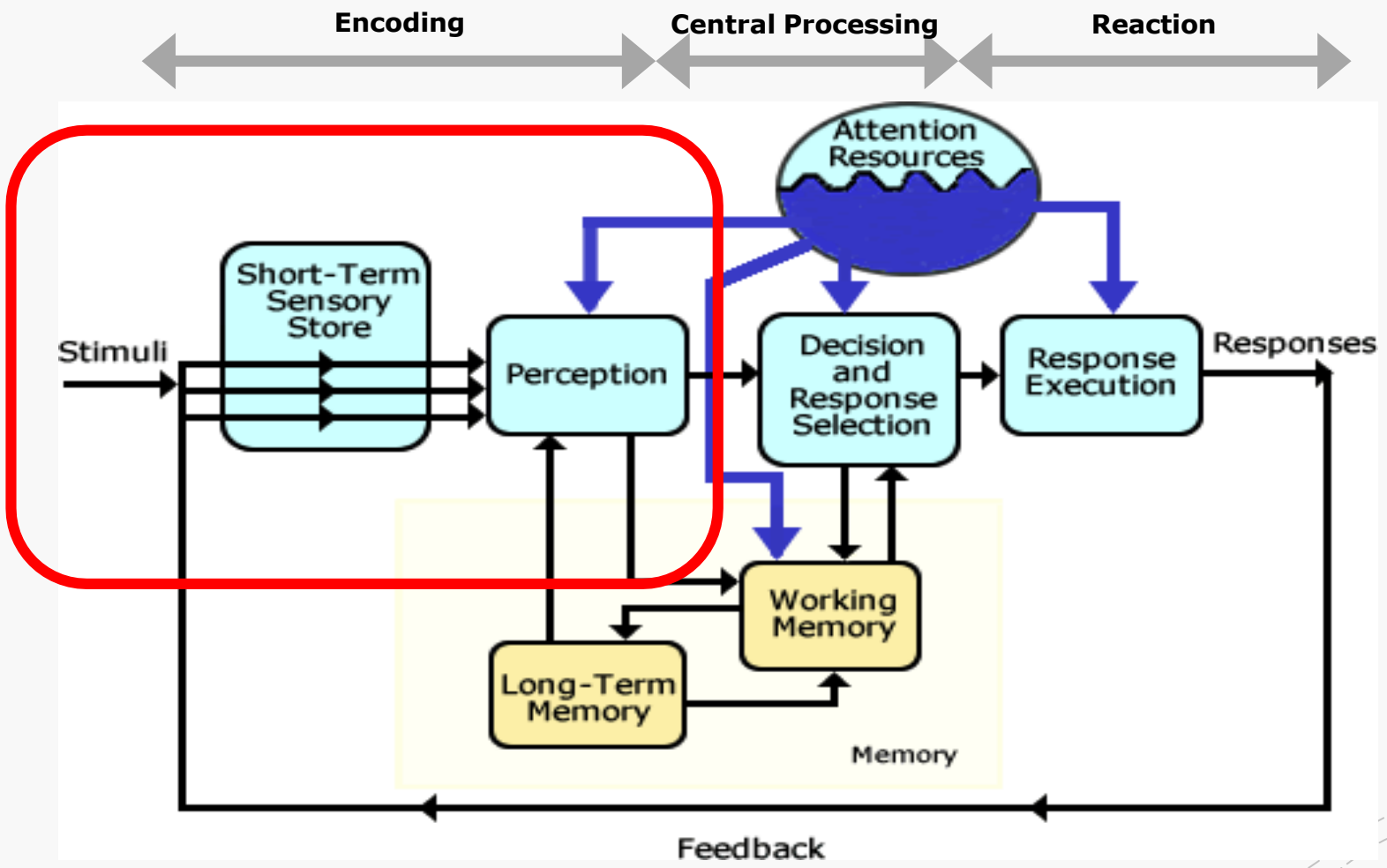
- Perception (Input mechanism of Human)
  - Sensory memory
  - Sensory Processing (Visual perception, Auditory perception, Haptic perception)
- Movement (Output mechanism of Human)
- Cognition (Processing mechanism of Human)
  - Cognitive memory (Working memory, Long-term memory)
- Cognitive Processing (Decision making, Problem solving, Reasoning)

HUMAN INFORMATION PROCESSING MODEL



Wickens' Model of Human Information Processing

HUMAN INFORMATION PROCESSING MODEL



Wickens' Model of Human Information Processing

HOW DO WE PERCEIVE REALITY?

We understand the world through our senses:

- Sight, Hearing, Touch, Taste, Smell (and others..)

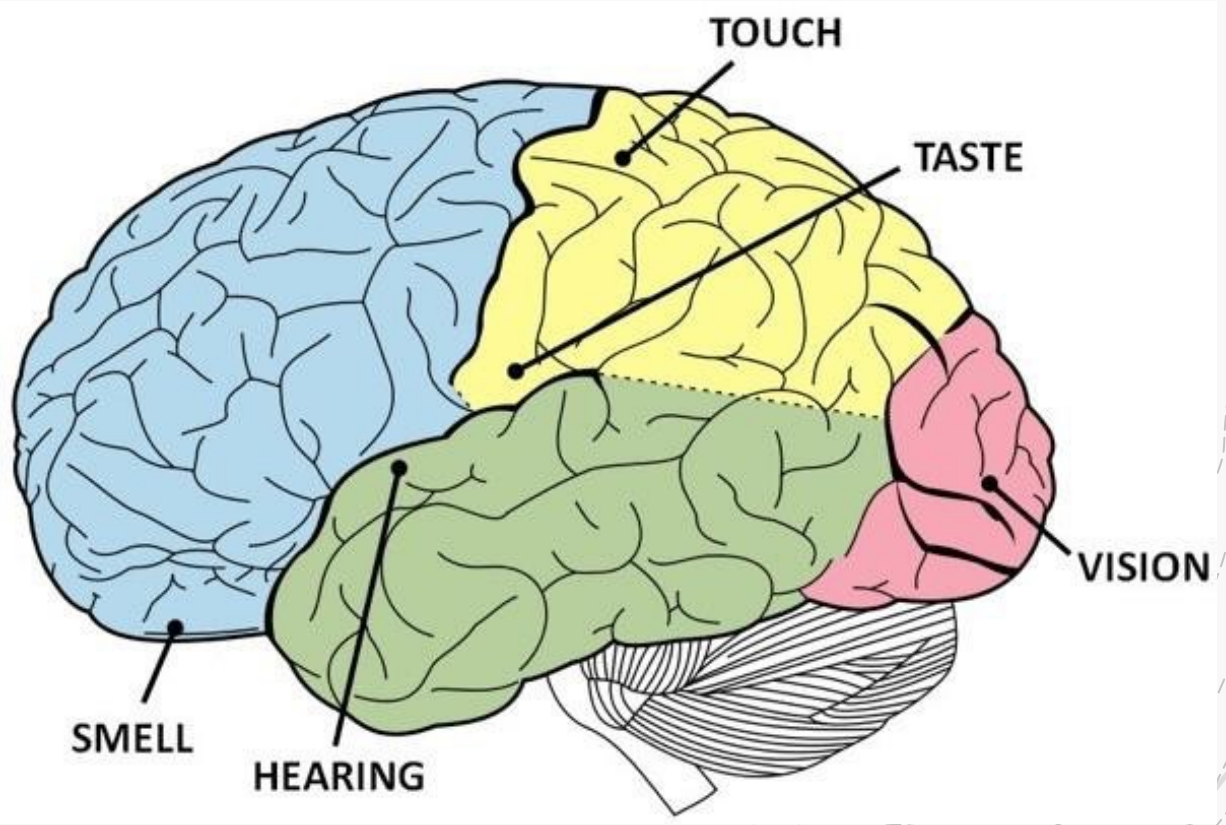
Two basic processes:

- Sensation – Gathering information
- Perception – Interpreting information


Mouth
Eye
Nose
Hand
Ear

RELATIVE IMPORTANCE OF EACH SENSE

- Percentage of neurons in brain devoted to each sense
- Sight – 30%
- Touch – 8%
- Hearing – 2%
- Smell - < 1%



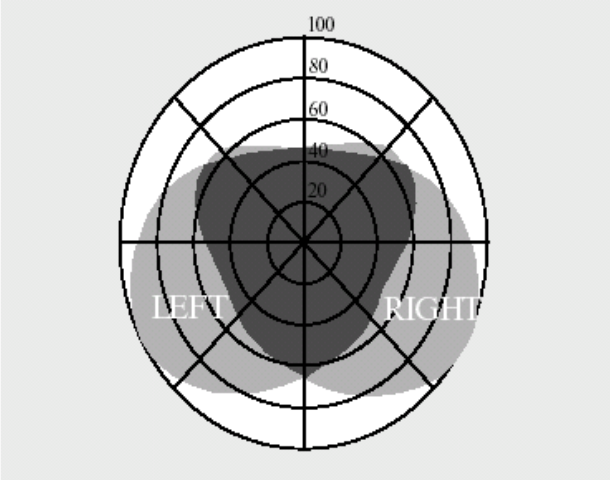
OTHER LESSOR KNOWN SENSES...

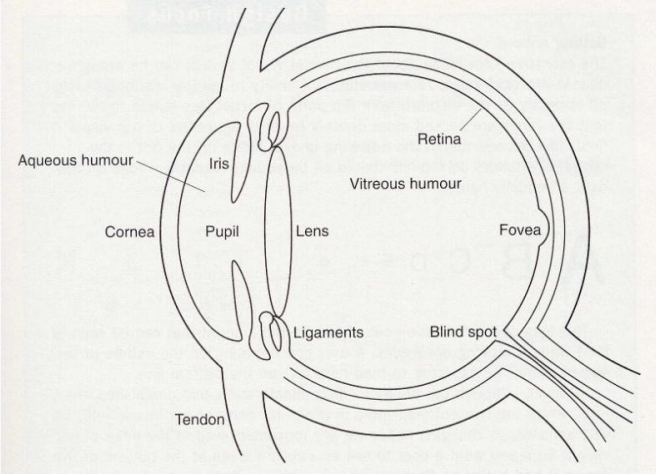
- Proprioception = sense of body position
  - what is your body doing right now
- Equilibrium = balance Acceleration
- Nociception = sense of pain
- Temperature Thirst
- Micturition
- Amount of CO_2 and Na in blood

SIGHT

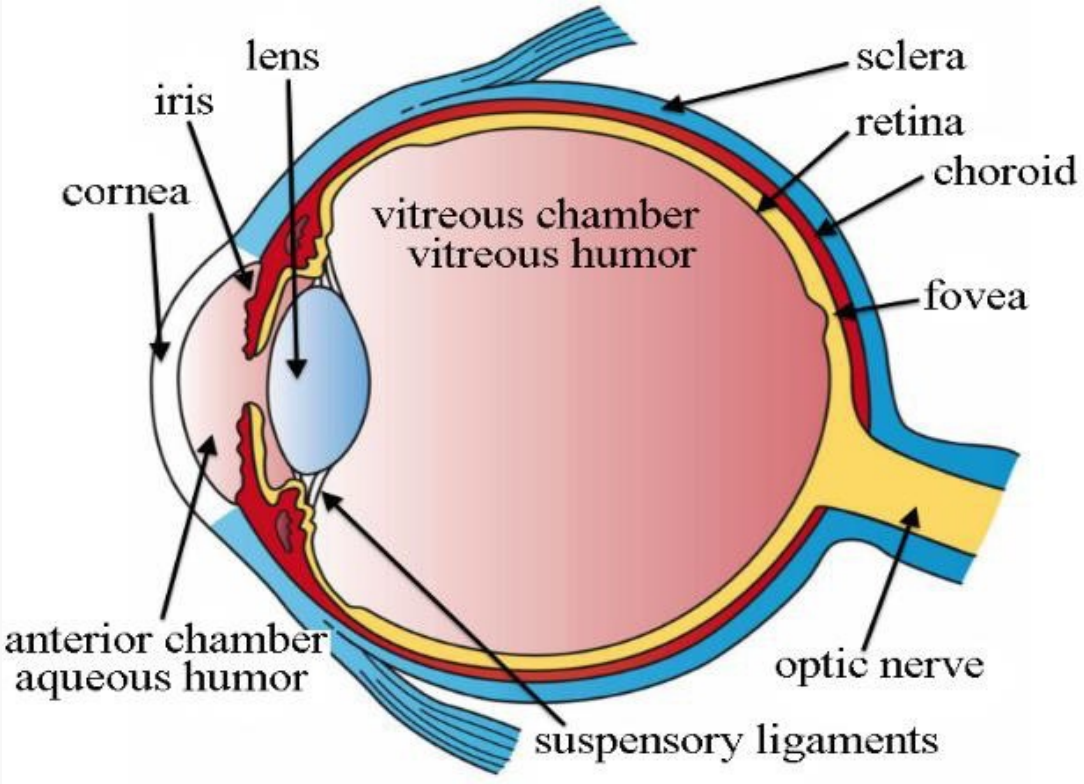
VISION

- The source of more than 80% of information
- 75% of the human visual operations are related to Fovea (area of highest resolution; about 2 degrees of arc)



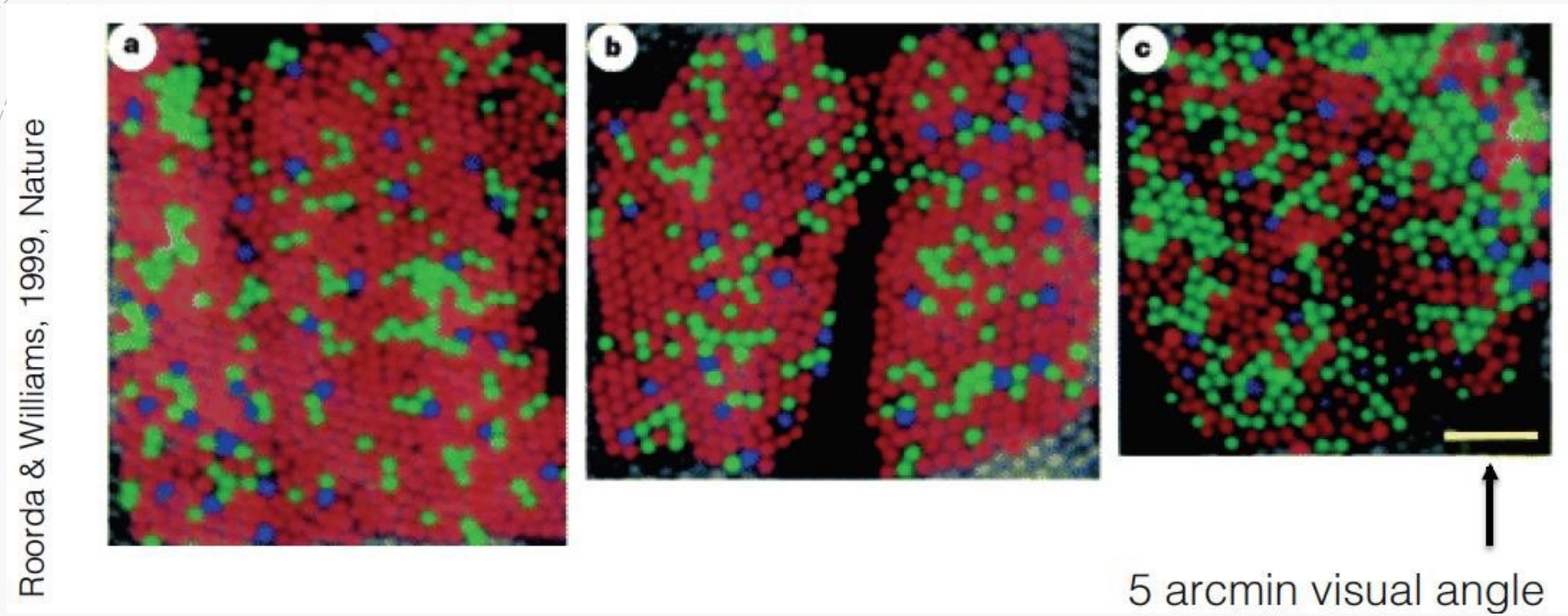


THE HUMAN EYE



- Light passes through cornea and lens onto retina
- Photoreceptors in retina convert light into electrochemical signals

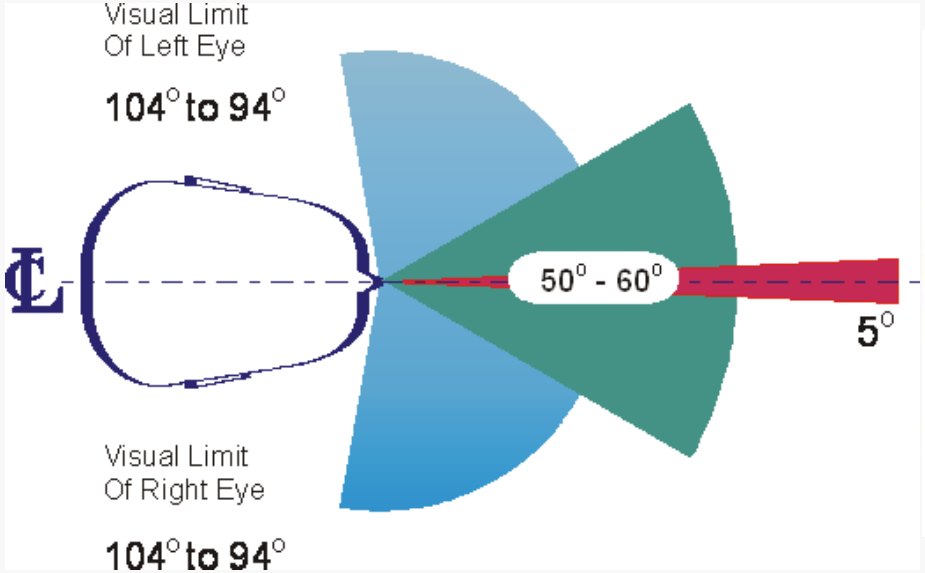
PHOTORECEPTORS – RODS AND CONES

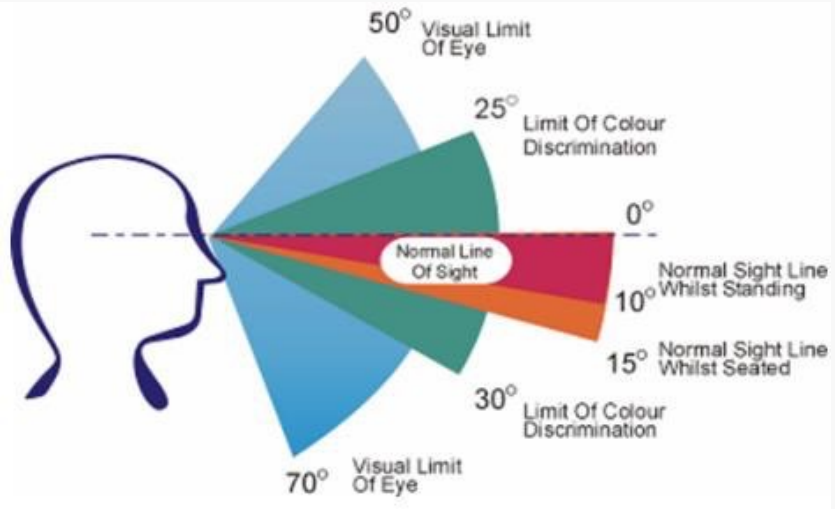


Retina photoreceptors come in two types, Rods and Cones

- Rods – 125 million, periphery of retina, no color detection, night vision
- Cones – 4-6 million, center of retina, color vision, day vision

HUMAN HORIZONTAL AND VERTICAL FOV



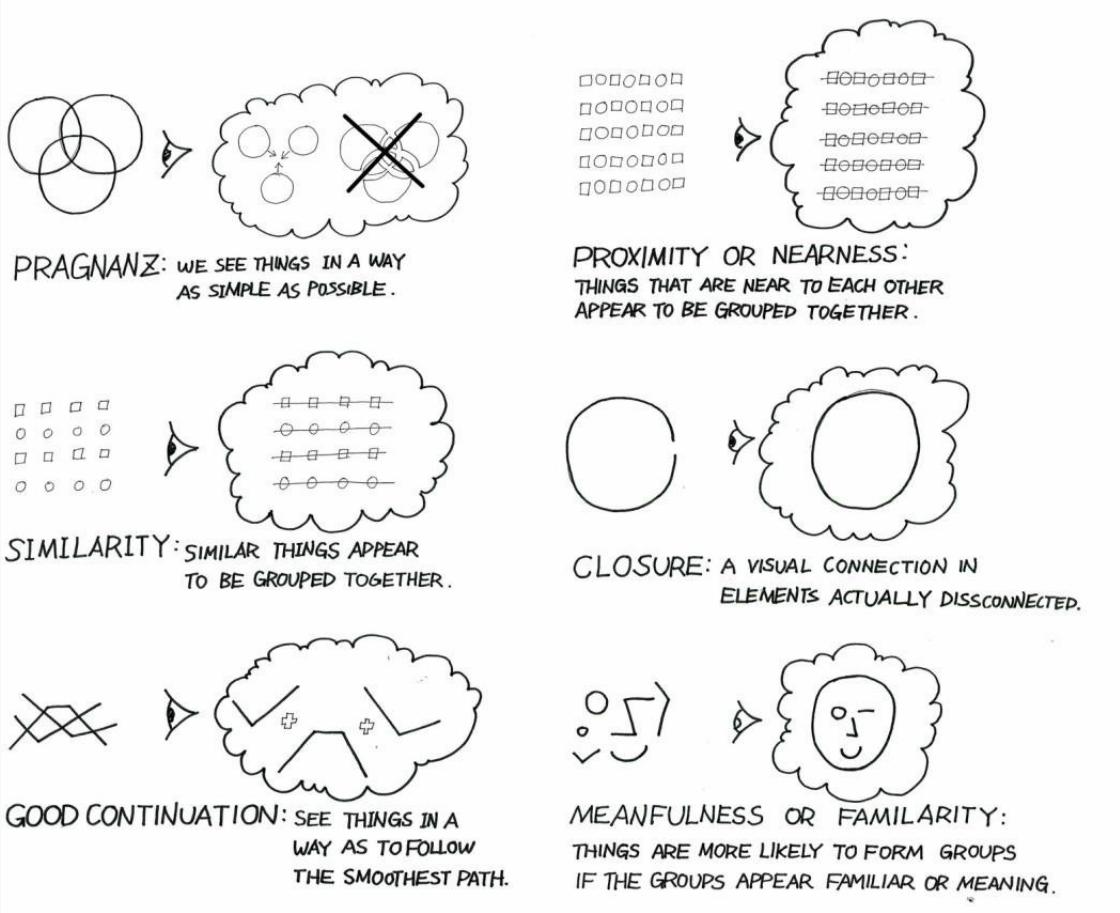


- Humans can see ~135 vertical (60 above, 75 below)
- See up to ~ 210 horizontal FOV, ~ 115 stereo overlap
- Color/stereo in center, Black & White/mono in periphery

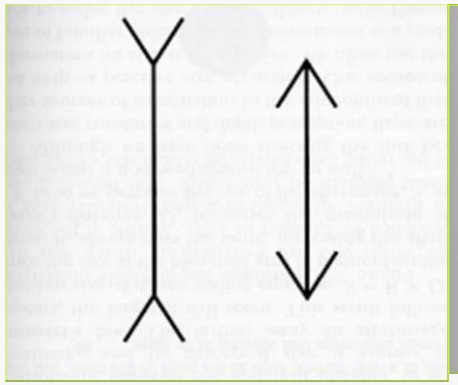
COLORS HAVE DIFFERENT CULTURAL ASSOCIATIONS

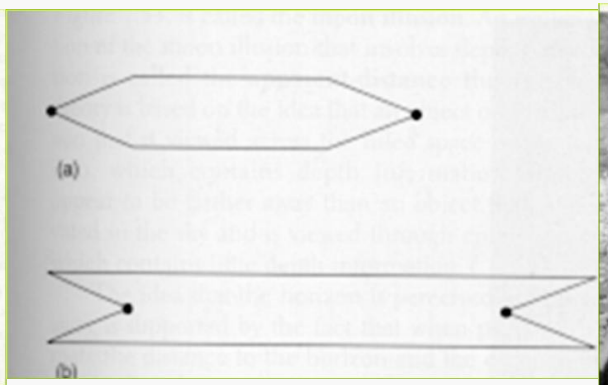
Hong Kong Chinese (N=784)			Americans	
Concept	**Color**	**%**	**Color**	**%**
Safe	Green	62.2	Green	61.4
Cold	White	71.5	Blue	96.1
Caution	Yellow	44.1	Yellow	81.1
Go	Green	44.7	Green	99.2
On	Green	22.3	Red	50.4
Hot	Red	31.1	Red	94.5
Danger	Red	64.7	Red	89.8
Off	Black	53.5	Blue	31.5
Stop	Red	48.5	Red	100
Courtney (1986), Bergum and Bergum (1981) Choice of 8 different colors				

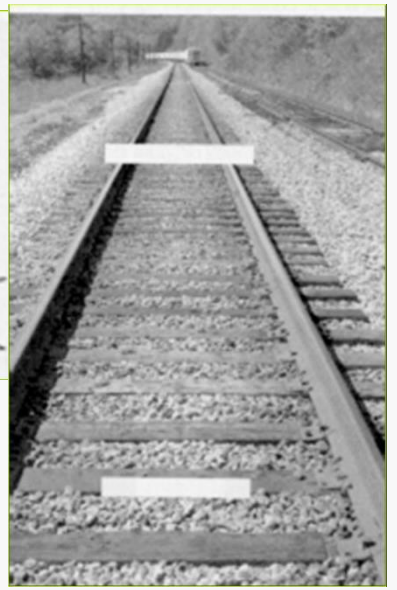
GESTALT LAWS

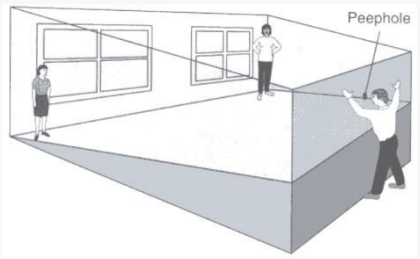


VISUAL ILLUSIONS: MULLER-LYER ILLUSION



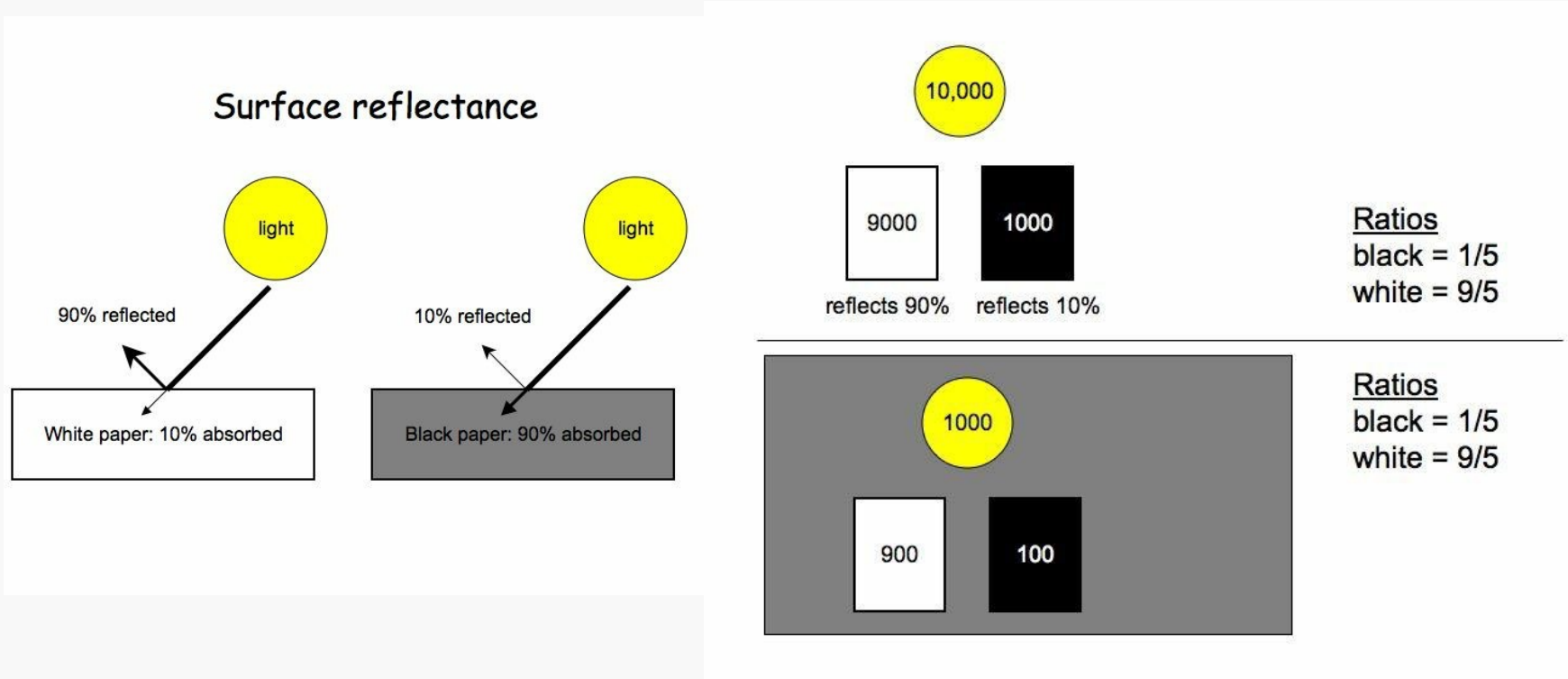






BRIGHTNESS PERCEPTION

brightness constancy

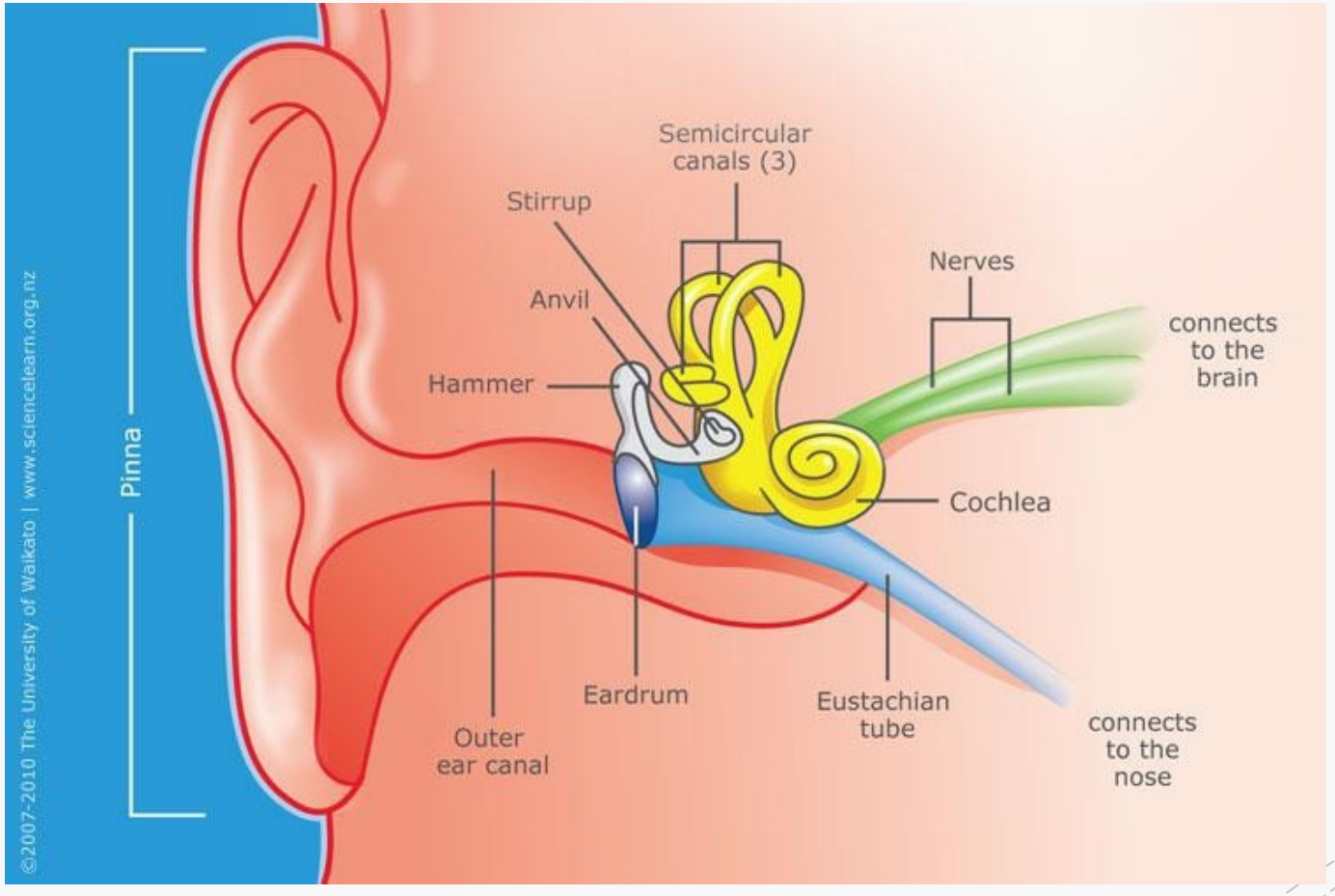


MOTION PERCEPTION

- The human visual system can process 10 to 12 separate images per second, perceiving them individually.
- Because of the persistence of vision phenomenon and the phi phenomenon, a sequence of fast changing images is perceived as a smooth motion
- Frame rate should be at least 24 f/s
- Phi phenomenon: the optical illusion of perceiving continuous motion between separate objects viewed rapidly in succession
- Persistence of vision is a phenomenon of the eye by which an afterimage is thought to persist for approximately one twenty-fifth of a second on the retina

HEARING

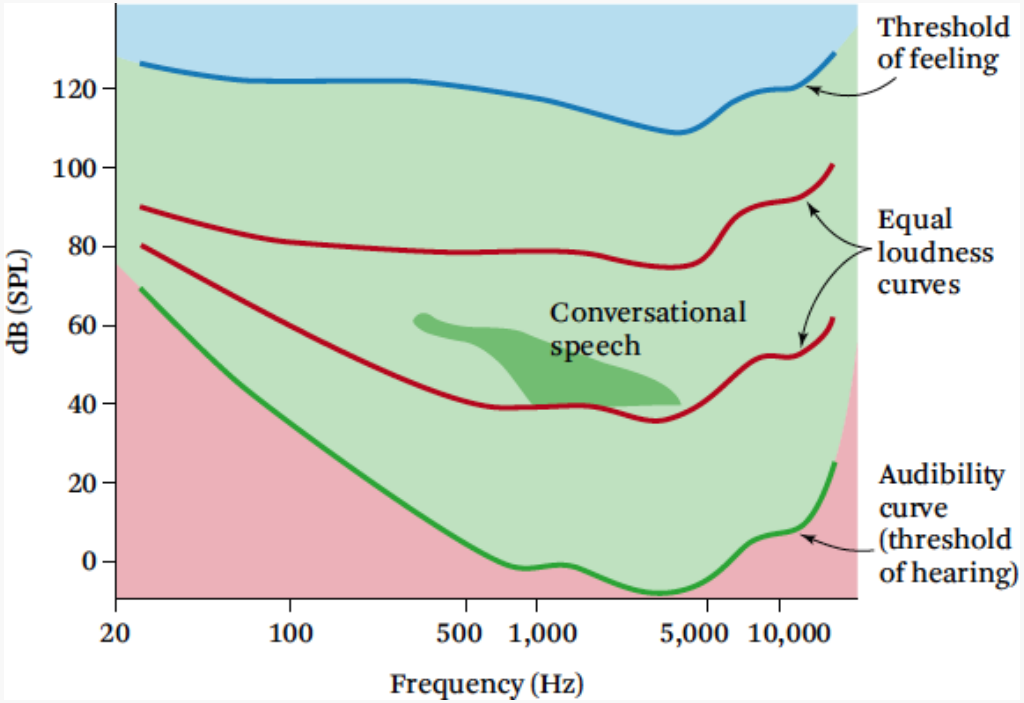
ANATOMY OF THE EAR



AUDITORY PROCESSING

- Perceptual characteristics of sound
  - Pitch (20 Hz ~ 20,000 Hz)
  - Loudness
  - Timbre: depends primarily upon the spectrum of the stimulus, but it also depends upon the waveform, the sound pressure, the frequency location of the spectrum, and the temporal characteristics of the stimulus
  - Duration
- Sequential processing
- Duration of sensory storage is relatively shorter than visual
- Cocktail party effect: very sensitive to the changes of familiar sound, e.g., one can hear voice in a very noisy environment

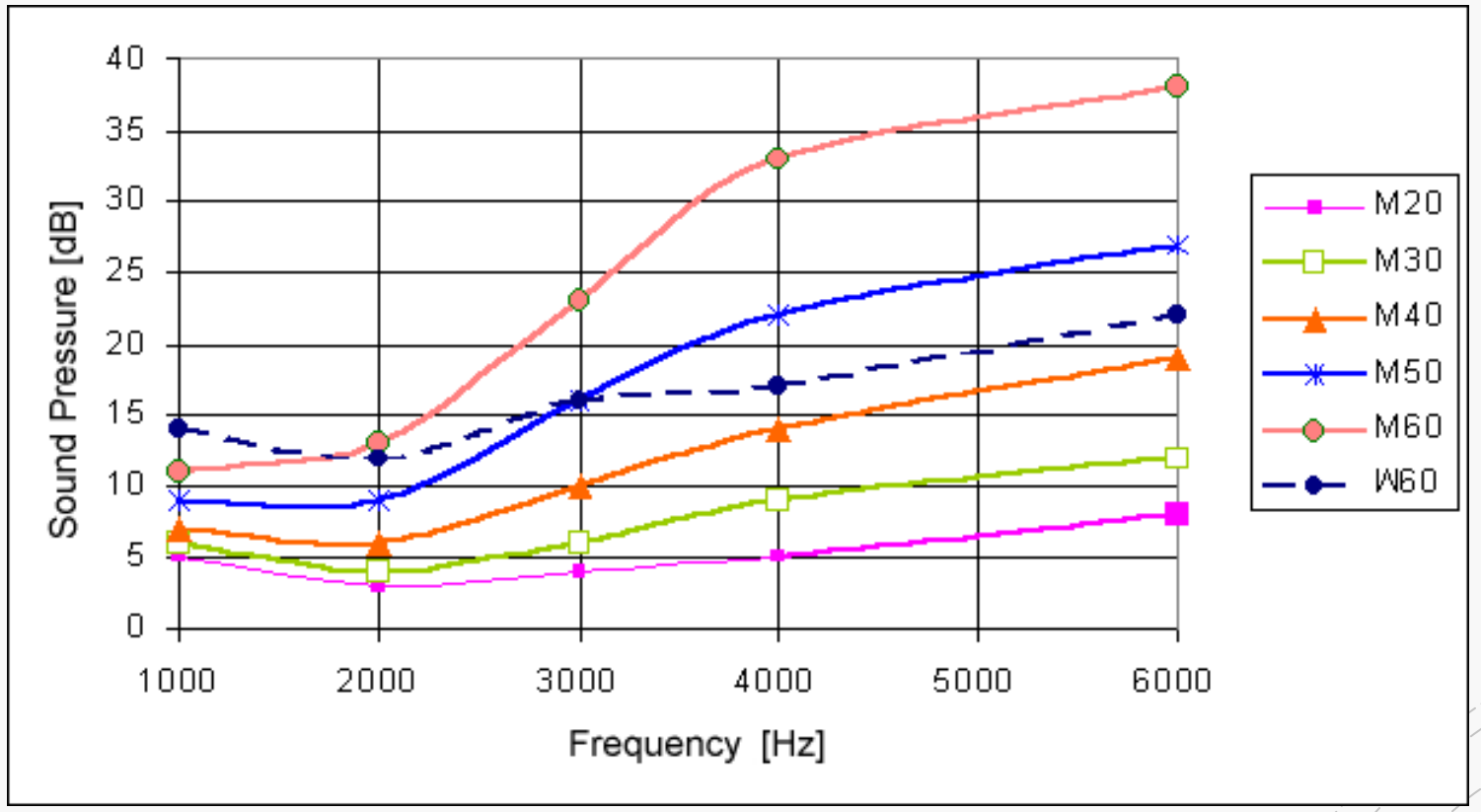
AUDITORY THRESHOLDS



- Humans hear frequencies from 20 – 22,000 Hz
- Most everyday sounds from 80 – 90 dB

ABSOLUTE THRESHOLD OF HEARING

- The smallest sound that a average human can hear

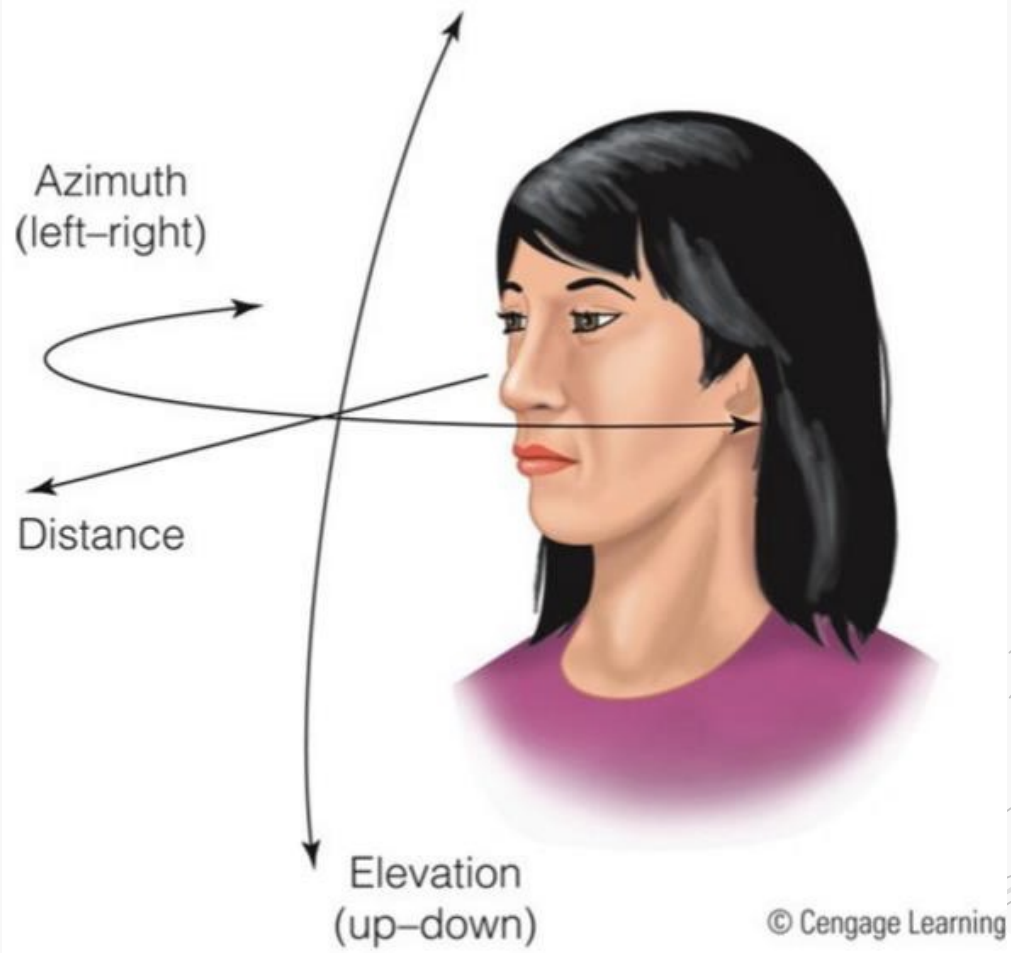


SENSITIVITY OF HEARING

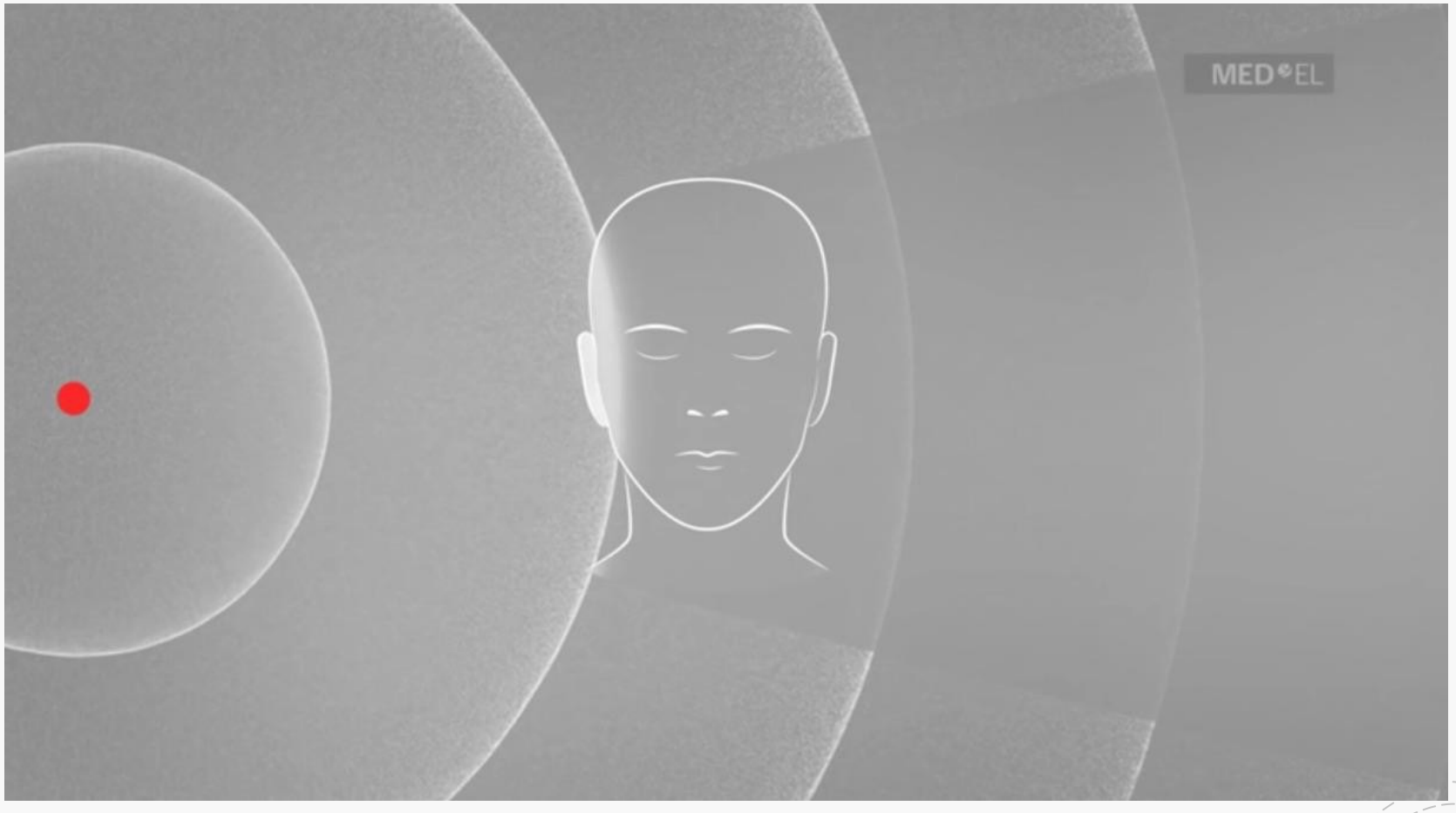
- http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/earsens.html
- https://www.youtube.com/watch?v=YSYAC7sjNCY

SOUND LOCALIZATION

- Humans have two ears
  - localize sound in space
- Sound can be localized using 3 coordinates
  - Azimuth, elevation, distance



SOUND LOCALIZATION



https://www.youtube.com/watch?v=FIU1bNSlbxk

ACCURACY OF SOUND LOCALIZATION

- People can locate sound
  - Most accurately in front of them
    - 2-3° error in front of head
  - Least accurately to sides and behind head
    - Up to 20° error to side of head
    - Largest errors occur above/below elevations and behind head
- Front/back confusion is an issue
  - Up to 10% of sounds presented in the front are perceived coming from behind and vice versa (more in headphones)

TOUCH

TOUCH

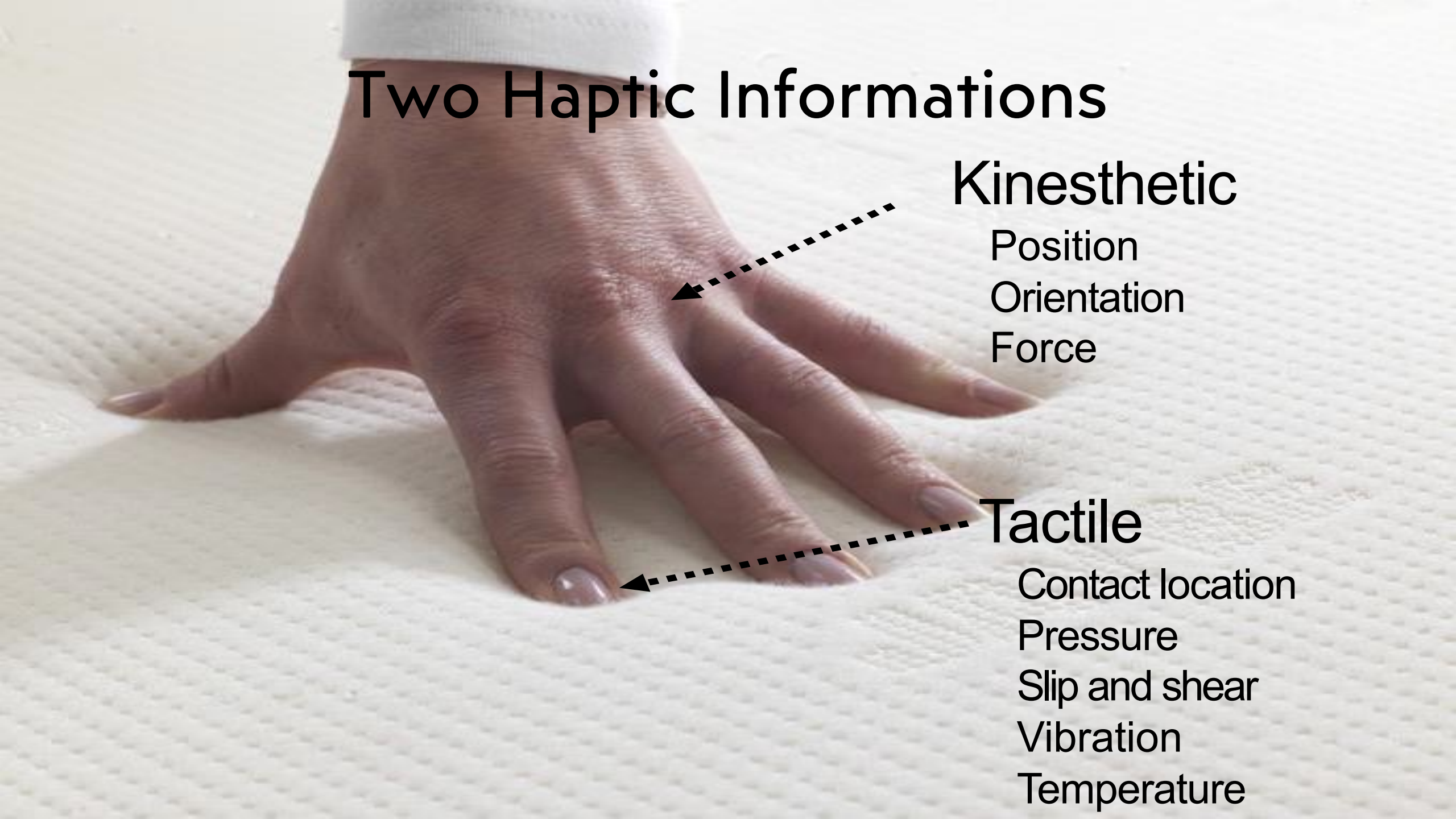
- Mechanical/Temp/Pain stimuli transduced into Action Potentials (AP)
- Transducing structures are specialized nerves:
  - Mechanoreceptors: Detect pressure, vibrations & texture
  - Thermoreceptors: Detect hot/cold
  - Nocireceptors: Detect pain
  - Proprioreceptors: Detect spatial awareness
- This triggers an AP which then travels to various locations in the brain via the somatosensory nerves

SENSORY SYSTEMS

- Sensory receptor organs detect energy or substance

Type of Sensory System	Modality	Adequate stimuli
Mechanical	Touch	Contact with or deformation of body surface
	Joint	Position and Movement
	Muscle	Tension
	Hearing	Sound vibrations in air or water
	Vestibular	Head movement and orientation
Thermal	Cold	Decrement of skin temperature
	Warmth	Increment of skin temperature
Photic	Seeing	Visible radiant energy
Chemical	Smell	Odorous substances dissolved in air or water in the nasal cavity
	Taste	Substance in contact with the tongue or other taste receptor
	Common Chemical	Changes in CO2, pH, osmotic pressure(삼투압)
	Vomeronasal	Pheromones in air of water
Electrical	Electroreception	Differences in density of electrical current

Two Haptic Informations



Kinesthetic

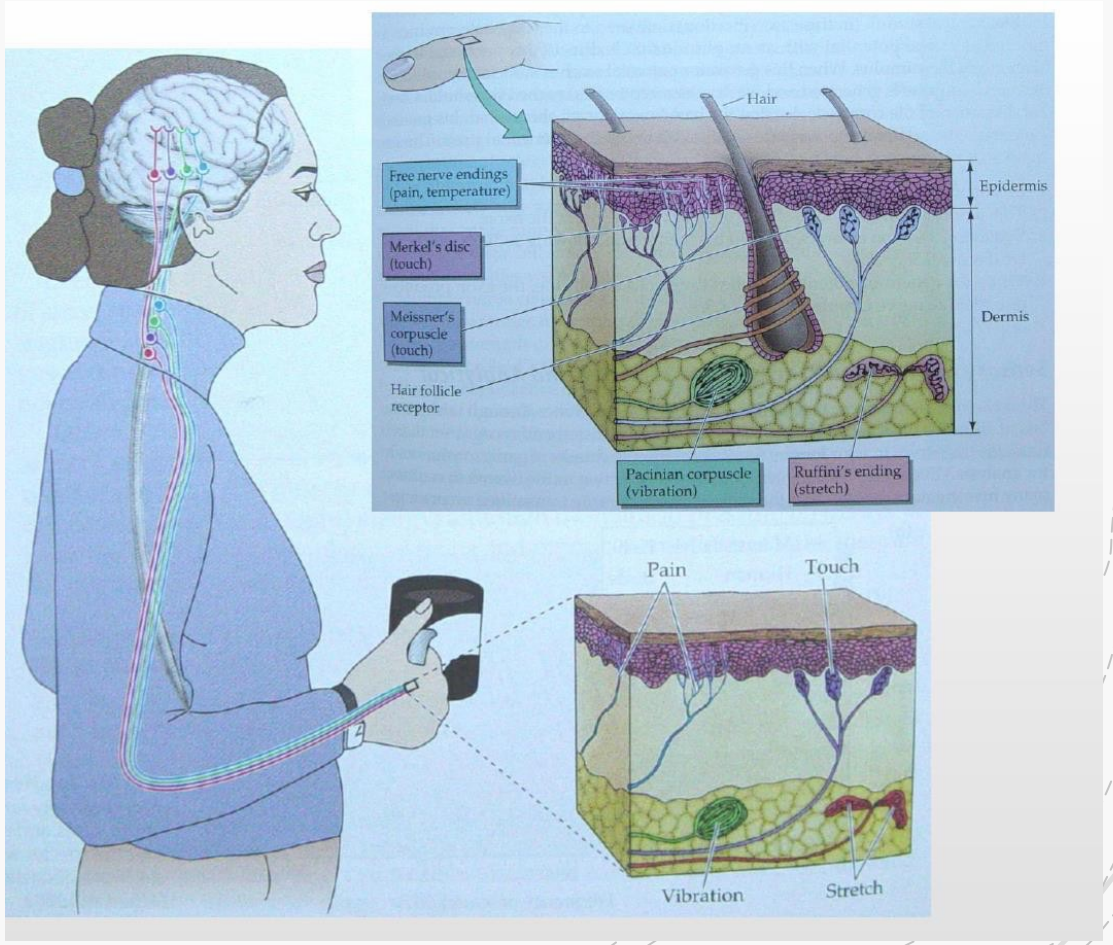
- Position
- Orientation
- Force

Tactile

- Contact location
- Pressure
- Slip and shear
- Vibration
- Temperature

CUTANEOUS SYSTEM

- Skin – heaviest organ in the body
- Epidermis outer layer, dead skin cells
- Dermis inner layer, with four kinds of mechanoreceptors

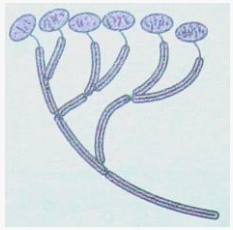
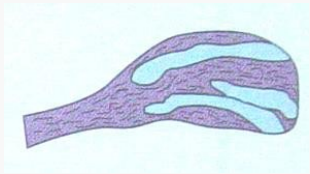
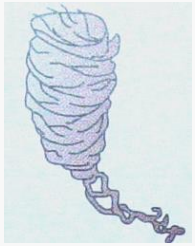
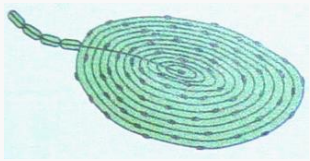
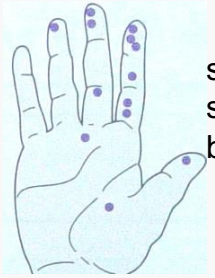
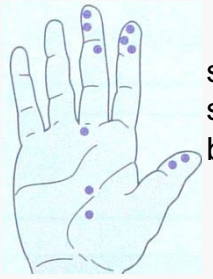
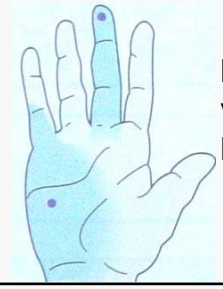
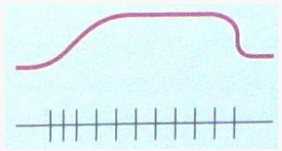
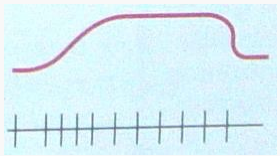
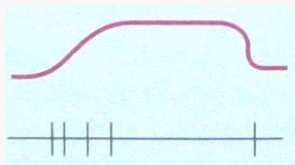
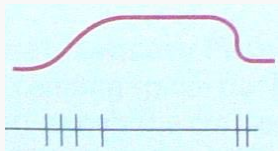


MECHANORECEPTORS

- Cells that respond to pressure, stretching, and vibration
- Slow Acting (SA), Rapidly Acting (RA)
- Type I at surface – light discriminate touch
- Type II deep in dermis – heavy and continuous touch

Receptor Type	Rate of Acting	Stimulus Frequency	Receptive Field	Detection Function
Merkel Discs	SA-I	0 – 10 Hz	Small, well defined	Edges, intensity
Ruffini corpuscles	SA-II	0 – 10 Hz	Large, indistinct	Static force, skin stretch
Meissner corpuscles	RA-I	20 – 50 Hz	Small, well defined	Velocity, edges
Pacinian corpuscles	RA-II	100 – 300 Hz	Large, indistinct	Acceleration, vibration

PROPERTIES OF SKIN RECEPTORS RELATED TO TOUCH

Receptors	 Merkel's Disks	 Ruffini's Ending	 Meissner's Corpuscle	 Pacinian Corpuscle
Function	Edges, Indentation	Skin stretch	Velocity, Edges	Vibration
Receptive Field	 small, sharp borders	 large, vague borders	 small, sharp borders	 large, vague borders
Stimulus Response	 Slow Adaptation I	 Slow Adaptation II	 Rapid Adaptation I	 Rapid Adaptation II

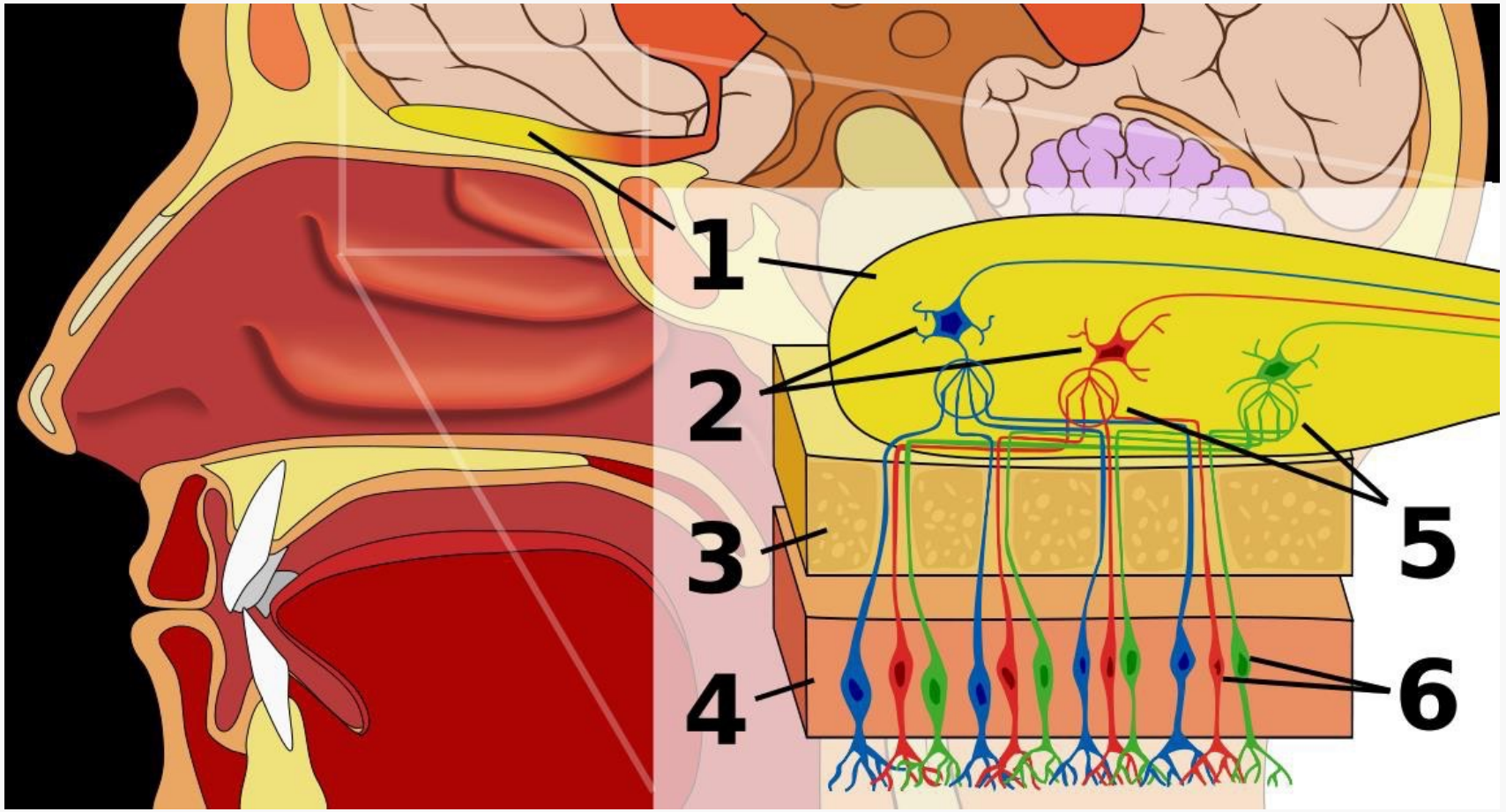
Olfaction

Smell

HOW THE NOSE WORKS

- https://www.youtube.com/watch?v=zaHR2MAxywg

OLFACTORY SYSTEM



Human olfactory system. 1: Olfactory bulb; 2: Mitral cells; 3: Bone
4: Nasal epithelium; 5: Glomerulus; 6: Olfactory receptor neurons

SMELL

Smells are sensed by olfactory sensory neurons in the olfactory epithelium

- 10 cm2 with hundreds of different types of olfactory receptors
- Human's can detect at least 10,000 different odors
- Some researchers say trillions of odors

Sense of smell closely related to taste

- Both use chemo-receptors
- Olfaction + taste contribute to flavour

The olfactory system is the only sense that bypasses the thalamus and connects directly to the forebrain

Smells in interactive design

Scentee Machina

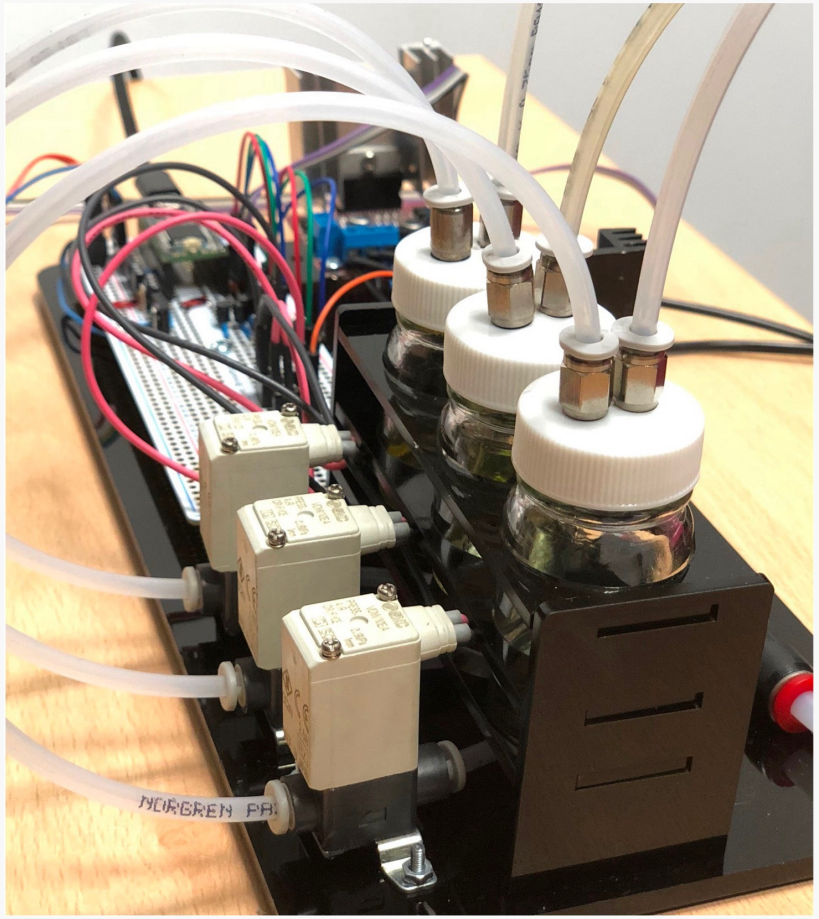
Smells in interactive design

oPhone DUO

Smells in interactive design

Aroma Shooter

OWidgets



Gustation

Taste

TASTE

- https://www.youtube.com/watch?v=FSHGucgnvLU

BASIC TASTES

- Salty
- Sweet
- Sour
- Bitter
- Umami

Salty

- Sodium chloride (Na^+ Cl^-)
- Needed for electrolyte balance
- Na-channels

Sweet - Sugar

- Needed for energy
- Many types of sugar:
  - Glucose
  - Fructose
  - Galactose
  - Sucrose (fructose + glucose)
  - Maltose
  - Lactose
- Receptors: T1R2 + T1R3

Sour

- Acids (H^+)
- E.g. Citric acid - palatability of oranges.
- Acid-sensing channel - the PKD2L1 channel, gated by pH (H^+ ion concentration)

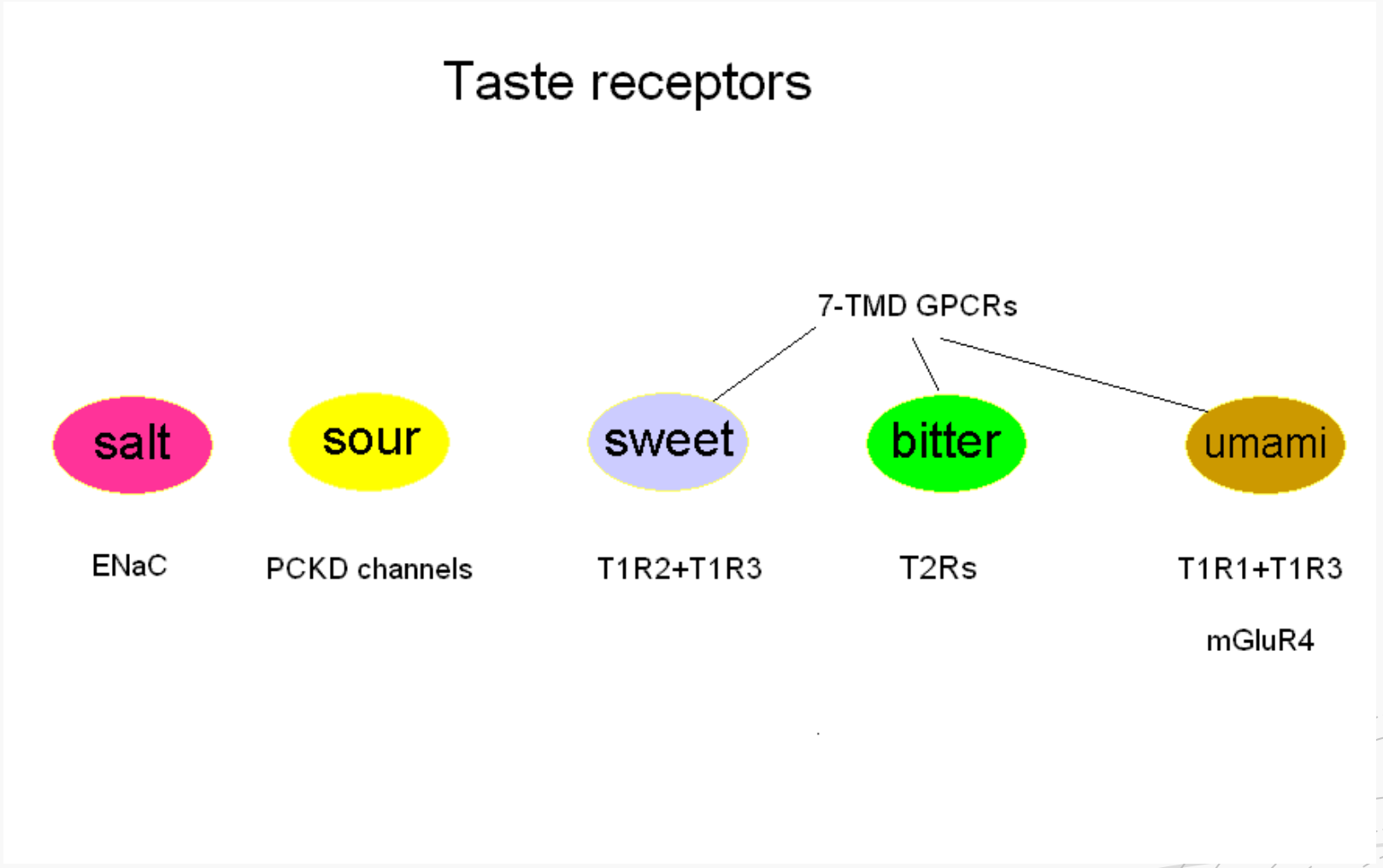
Bitter

- Indicate foods that may be poisonous
- T2R receptors activating the G-protein
- Supertasters: has heightened sense of the taste of bitterness

Umami

- Taste of essential amino acids (e.g. glutamate) needed for protein synthesis.
- Meaning: **savoury taste**
- First identified by Kikunae Ikeda in 1909.
- Receptors: T1R1 + T1R3 + mGluR4

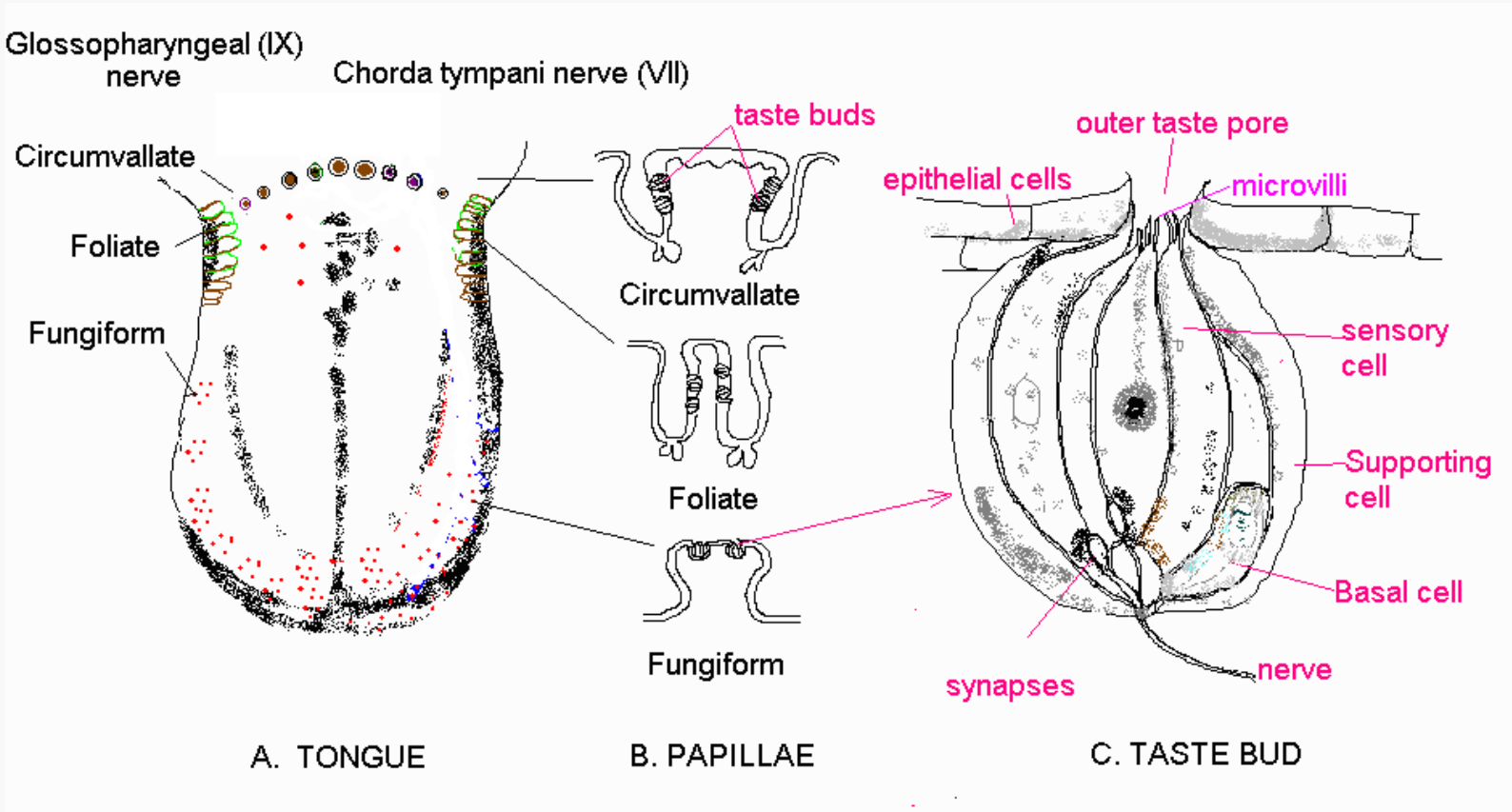
Basic tastes



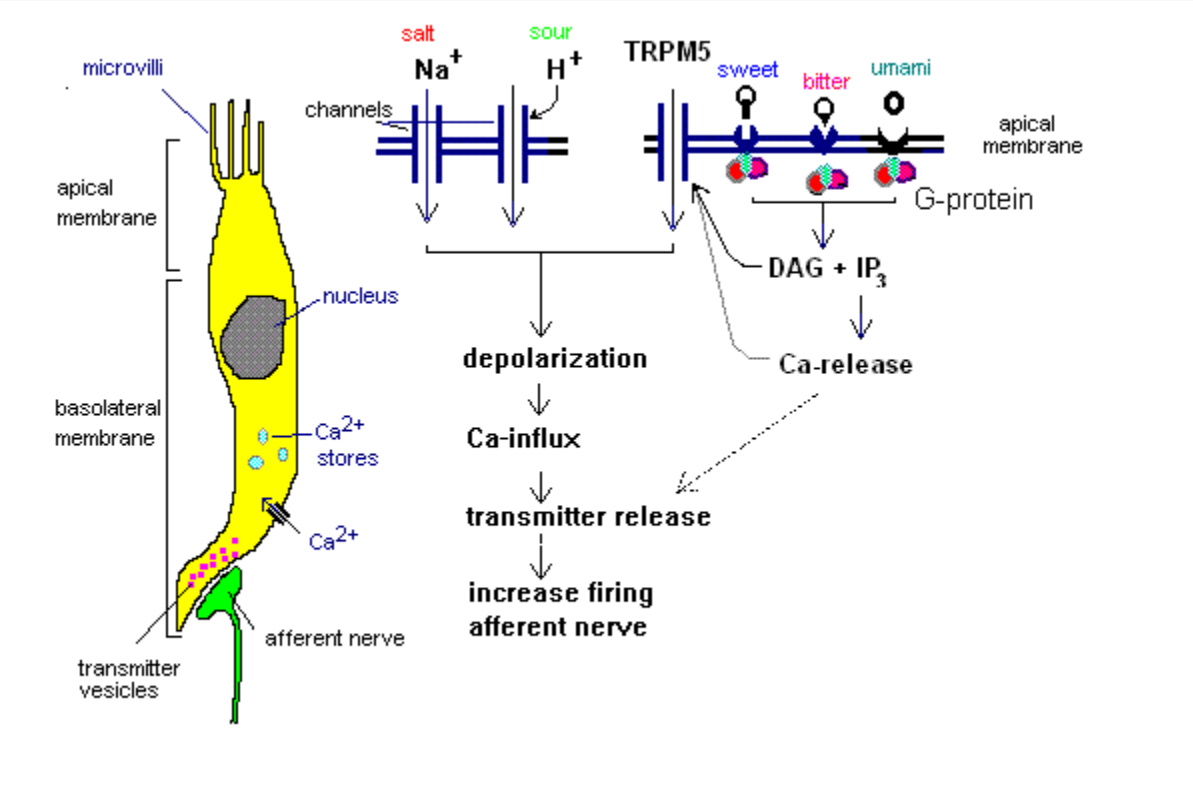
Other possible tastes

- Starch (recently confirmed)
- Calcium
- Tannin
- Metals
- Fat

Papillae and taste buds



A taste receptor cell



Taste vs. flavour

- Flavour is the combination of taste, smell, and trigeminal sensations (sensation in the face).
- “It tastes great” == “It has a great flavour”

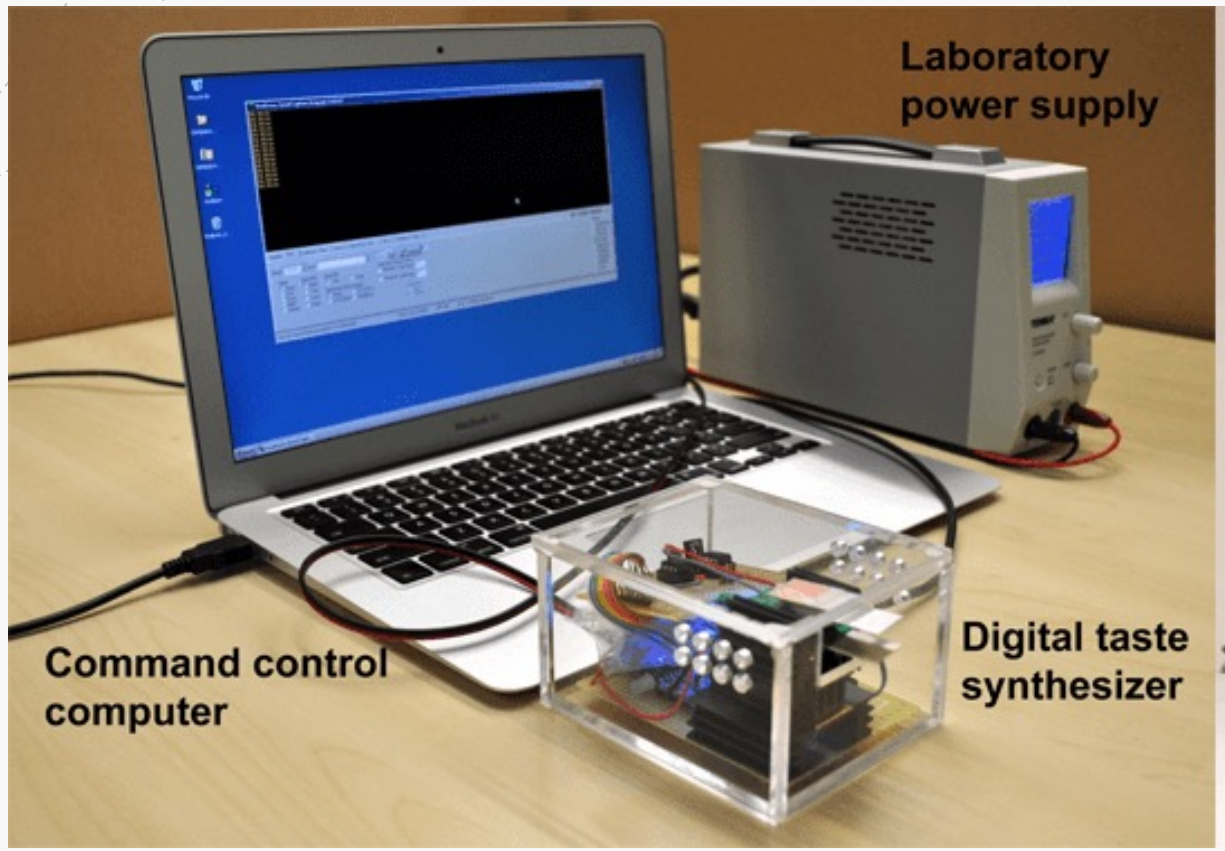
Tastes in interactive design

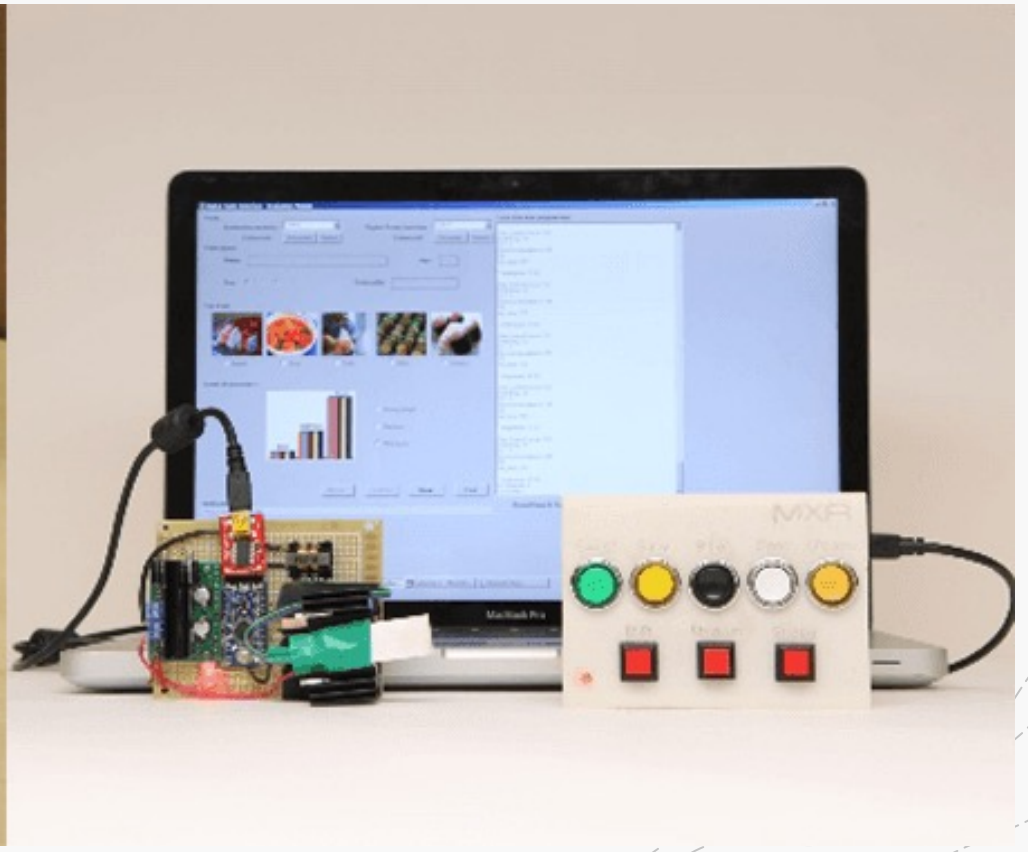
- Stimulate taste

Tastes in interactive design

Ranasinghe, N., Cheok, A., Nakatsu, R., & Do, E. Y. L. (2013, October). Simulating the sensation of taste for immersive experiences. In *Proceedings of the 2013 ACM international workshop on Immersive media experiences* (pp. 29-34). ACM.

Tastes in interactive design



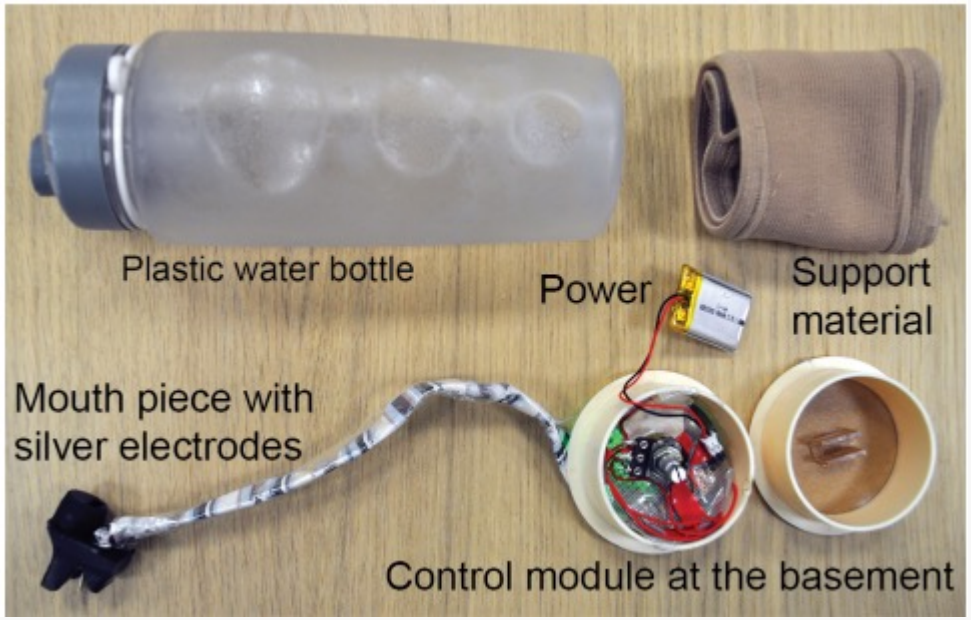


Ranasinghe, N., Cheok, A., Nakatsu, R., & Do, E. Y. L. (2013, October). Simulating the sensation of taste for immersive experiences. In *Proceedings of the 2013 ACM international workshop on Immersive media experiences* (pp. 29-34). ACM.

NewScientist

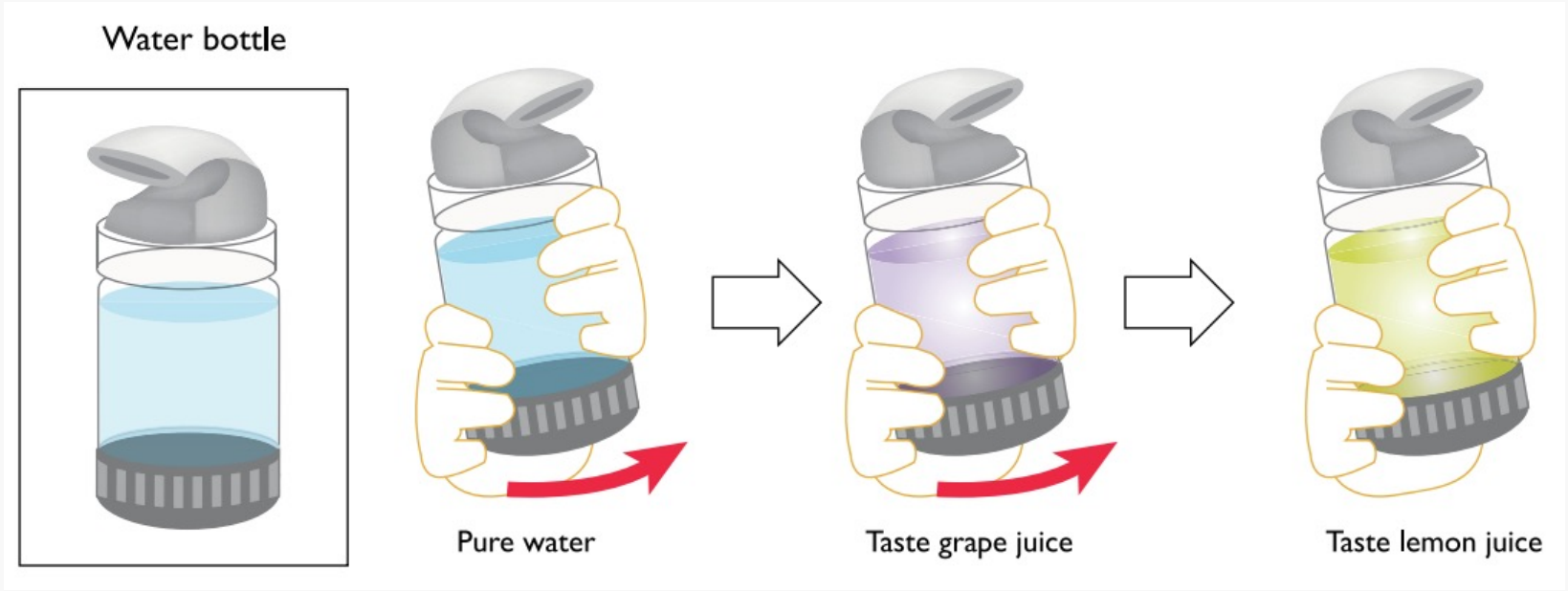
Taste simulator lets you sample virtual food

Tastes in interactive design

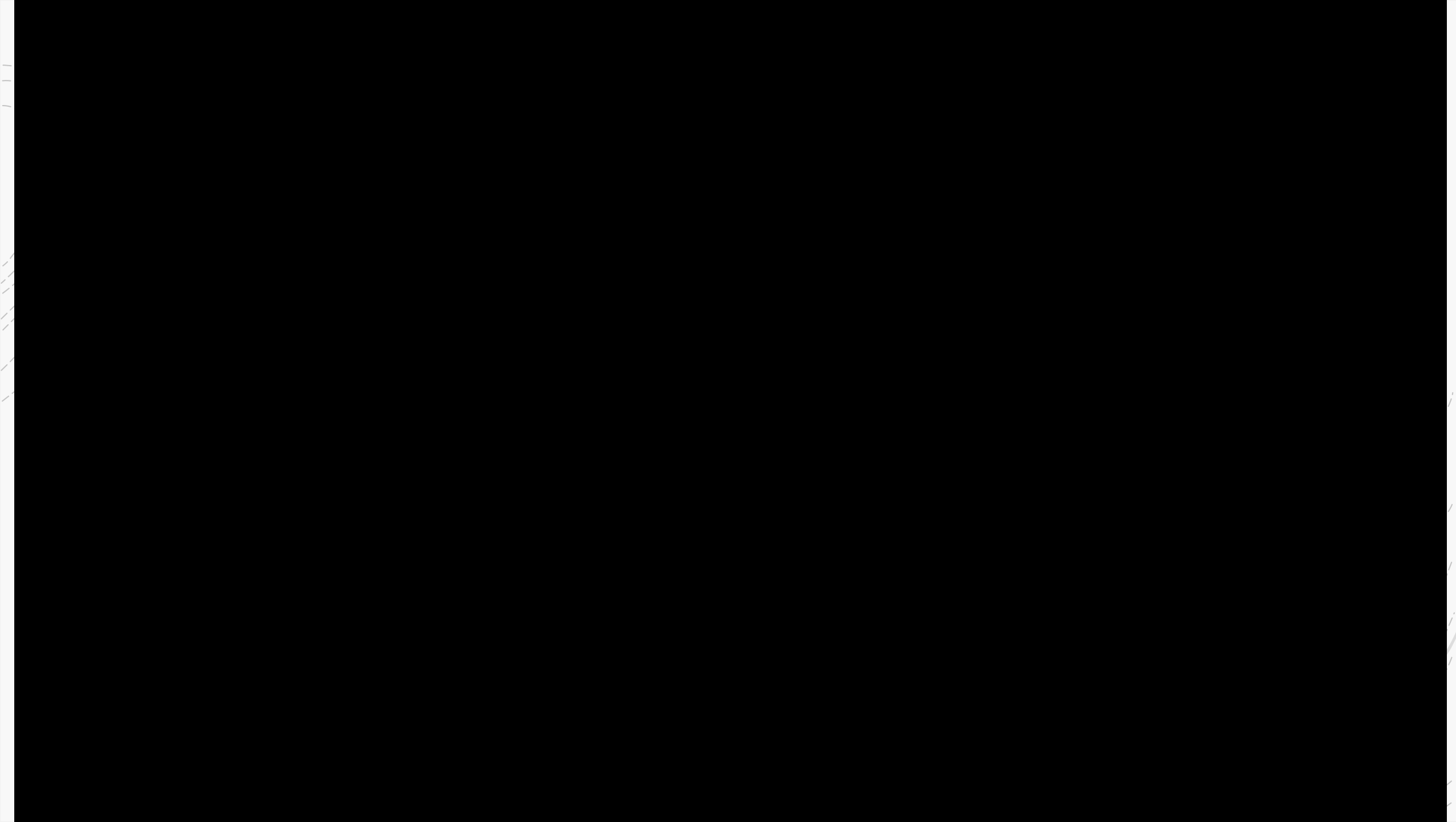


Taste+: The Sensation of Taste in the Future of Immersive Media

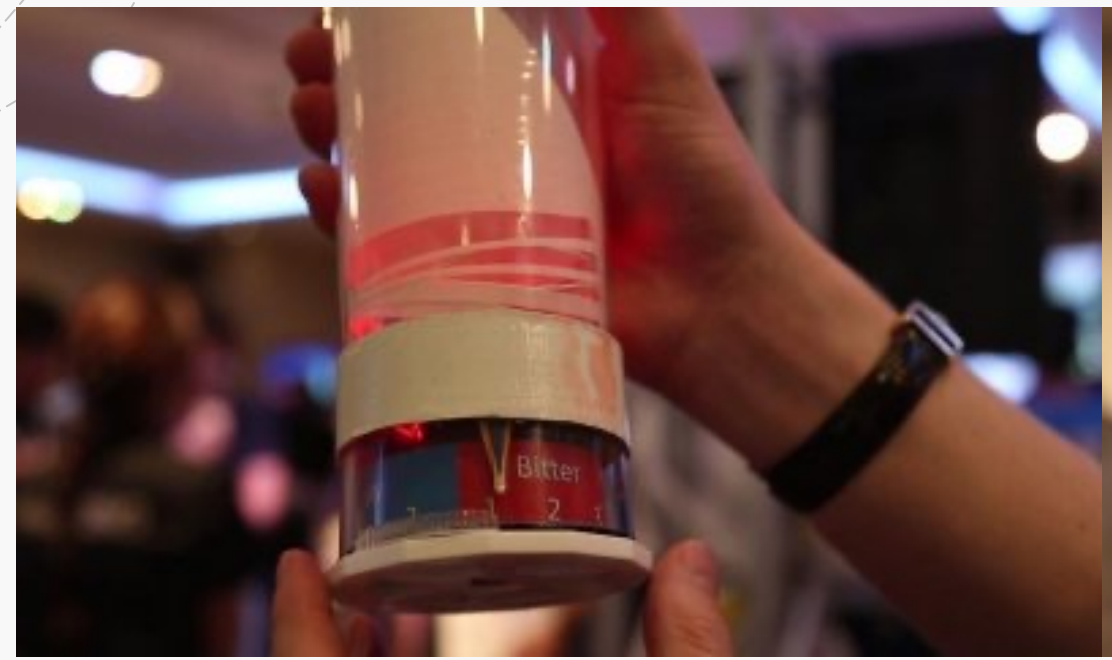
Tastes in interactive design



Taste+: The Sensation of Taste in the Future of Immersive Media

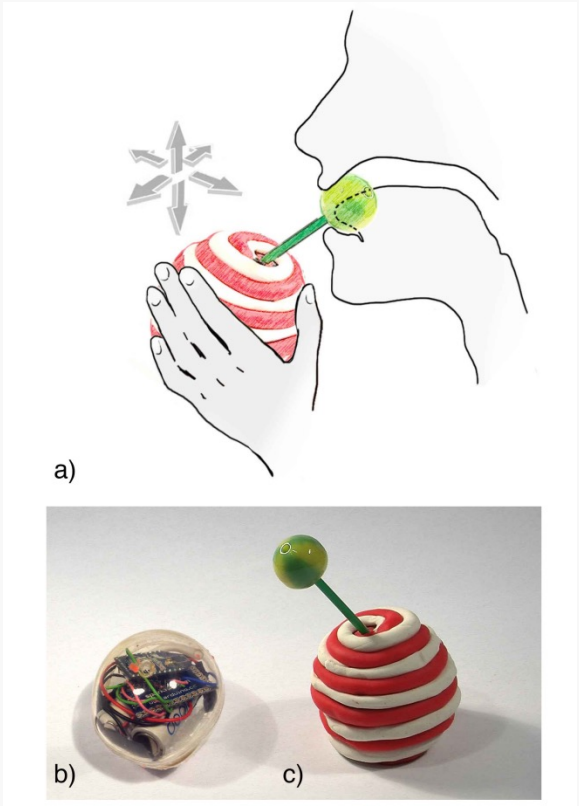


Tastes in interactive design



Taste+: The Sensation of Taste in the Future of Immersive Media

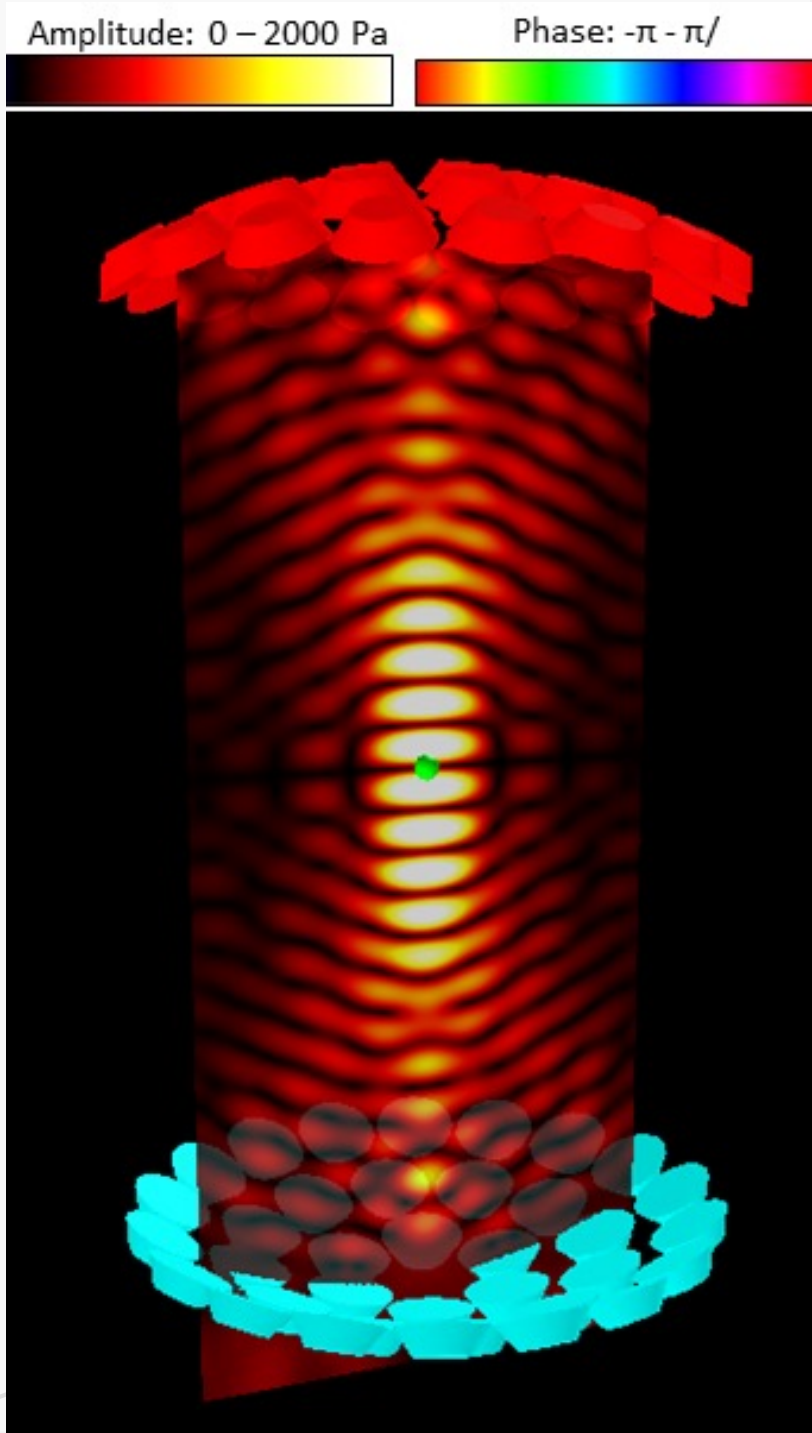
Tastes in interactive design

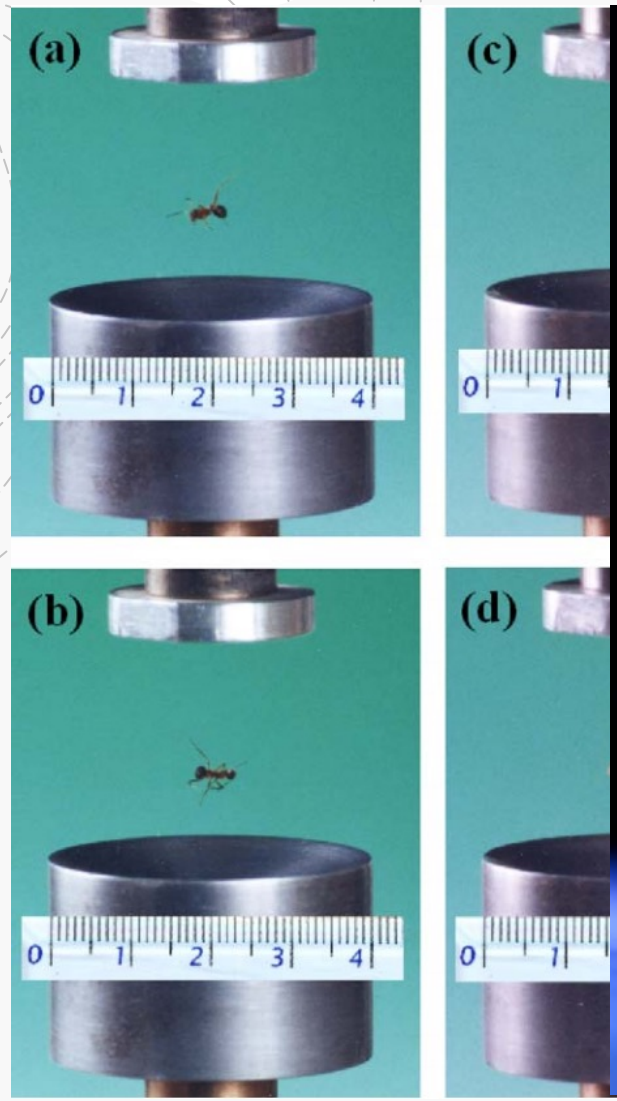


LOLLio: exploring taste as playful modality

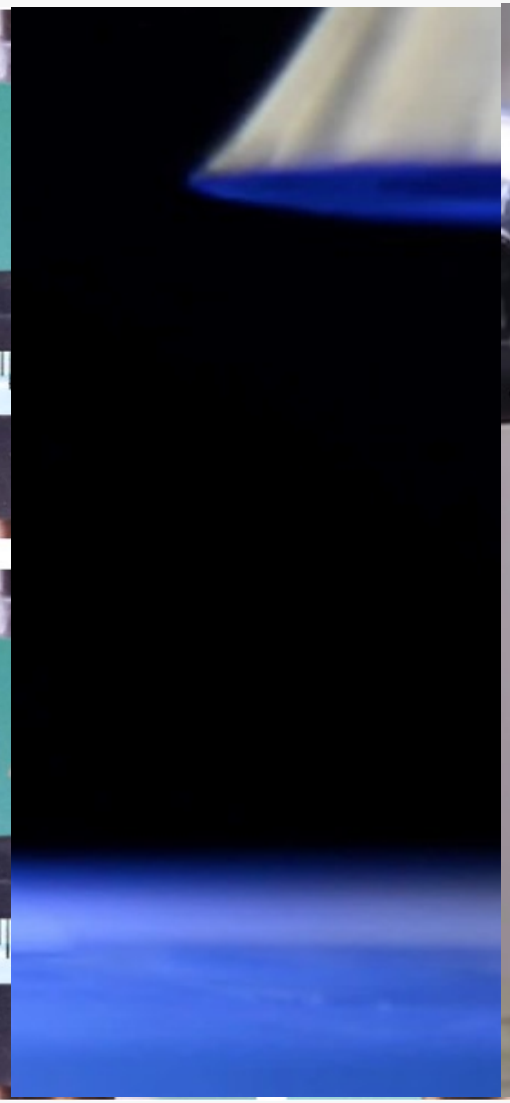
Taste & Acoustic Levitation

- Hold and move an object in mid-air using sound
- **A simple setup:**
  - Emitter of high frequency waves
  - Reflector to reflex the waves back
  - Create standing waves with nodes and antinodes

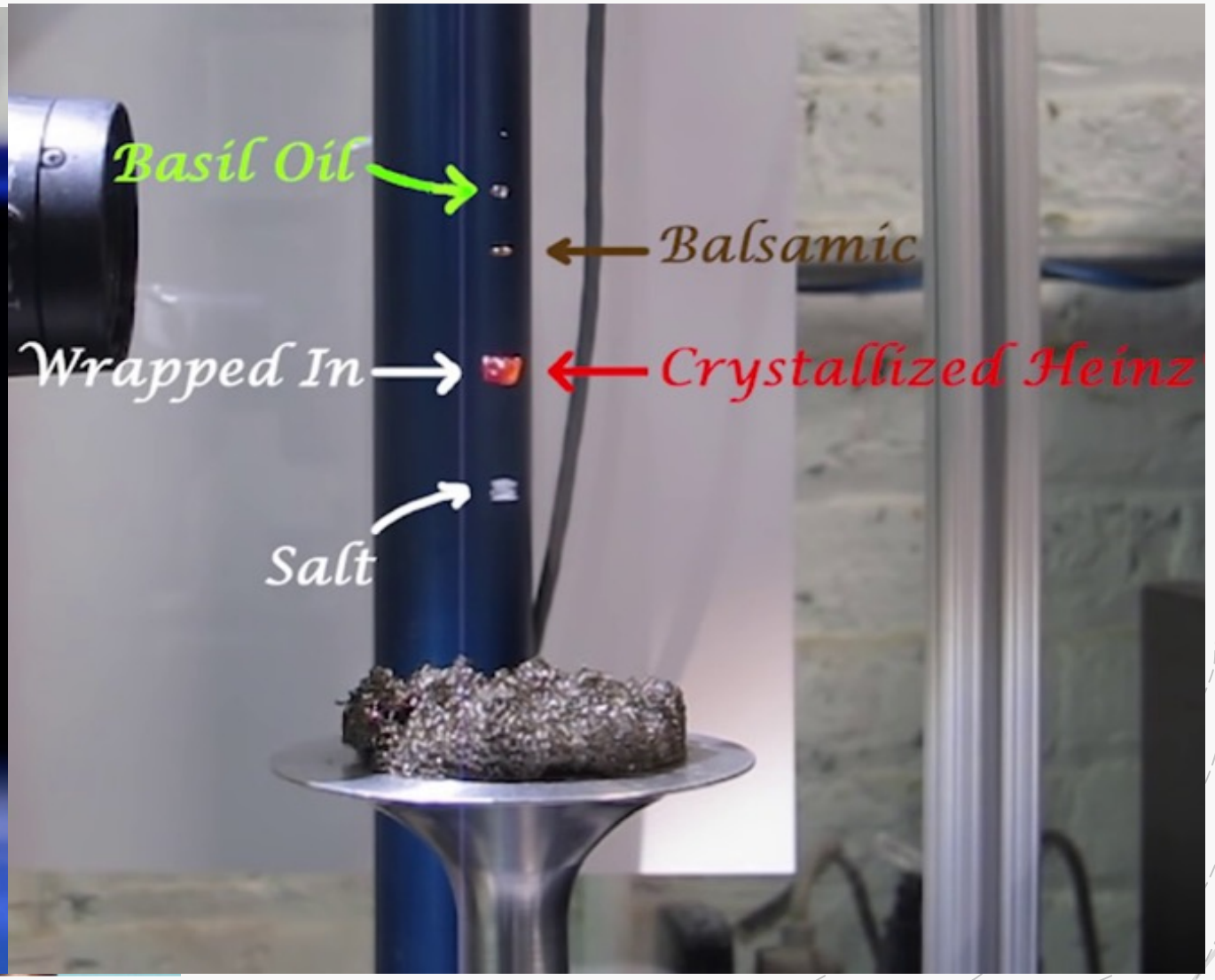




Xie et al. Appl. Phys. Lett. 89, 214102 (2006)



The Levitron. https://goo.gl/ibNyhs



World's First Levitating Food: Heinz Caprese Salad and Acoustic Levitation. https://goo.gl/7AMCrC

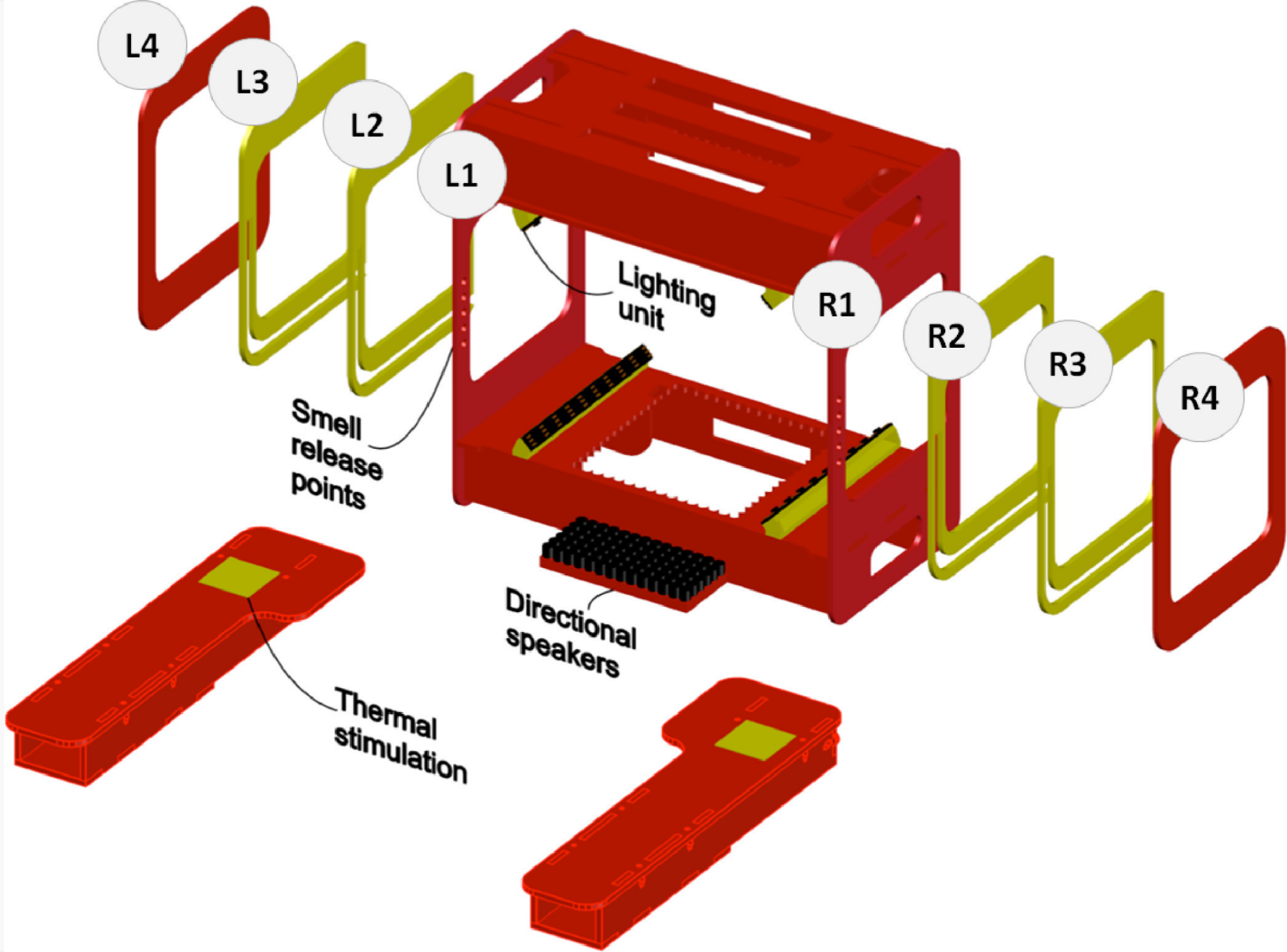

BBC

Preliminary findings

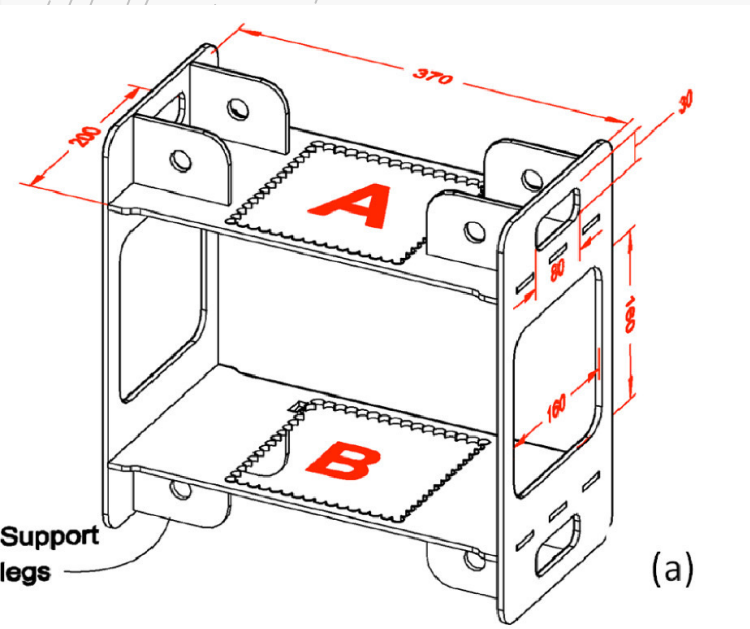
Recognition rates	• Sweet (86.36%), Umami (70.41%), Bitter (45.56%)
Intensity	• Levitation > Pipette
Pleasantness	• Levitated bitter is more pleasant
Satisfaction	• Sweet is slightly satisfying • Bitter and Umami are slightly unsatisfying

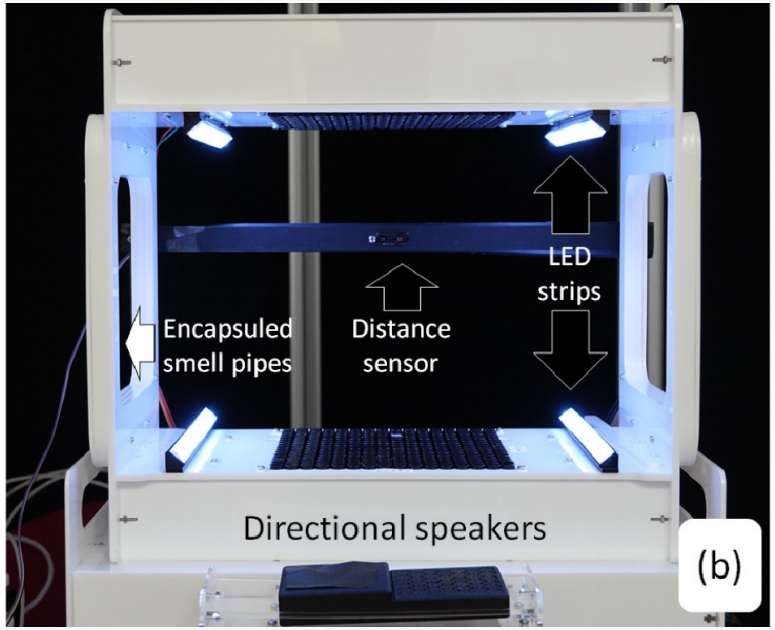
LeviSense

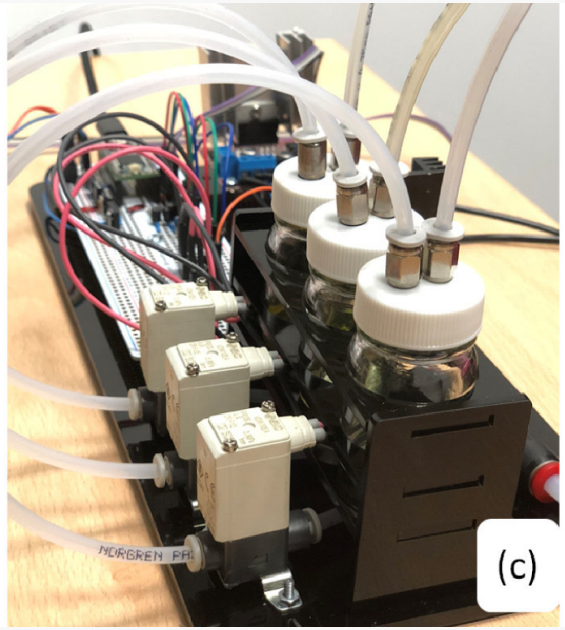
- Smell
- Taste
- Visual
- Touch
- Audio

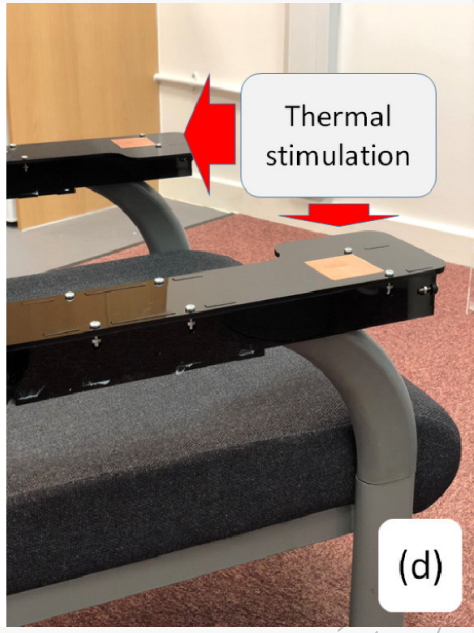


LeviSense


370
200
A
B
Support
legs
(a)


Encapsuled
smell pipes
Distance
sensor
LED
strips
Directional speakers
(b)


(c)


Thermal
stimulation
(d)


3M
PELTOR
OPTIME III
A


B


C

Research Question: using/ stimulate taste to have an effect?

- Tastes can trigger user experiences:
  - Temporal
  - Affective
  - Embodiment

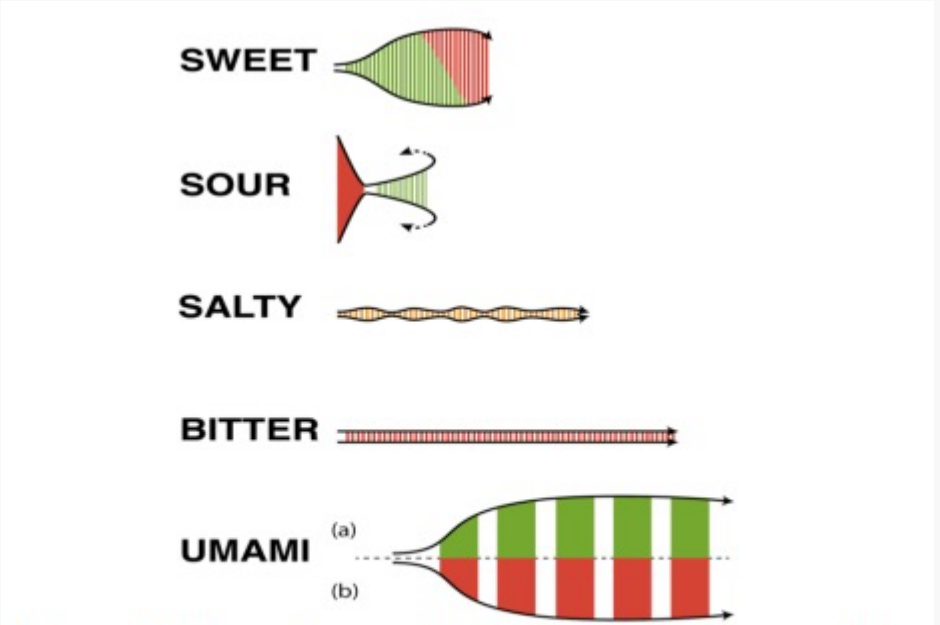
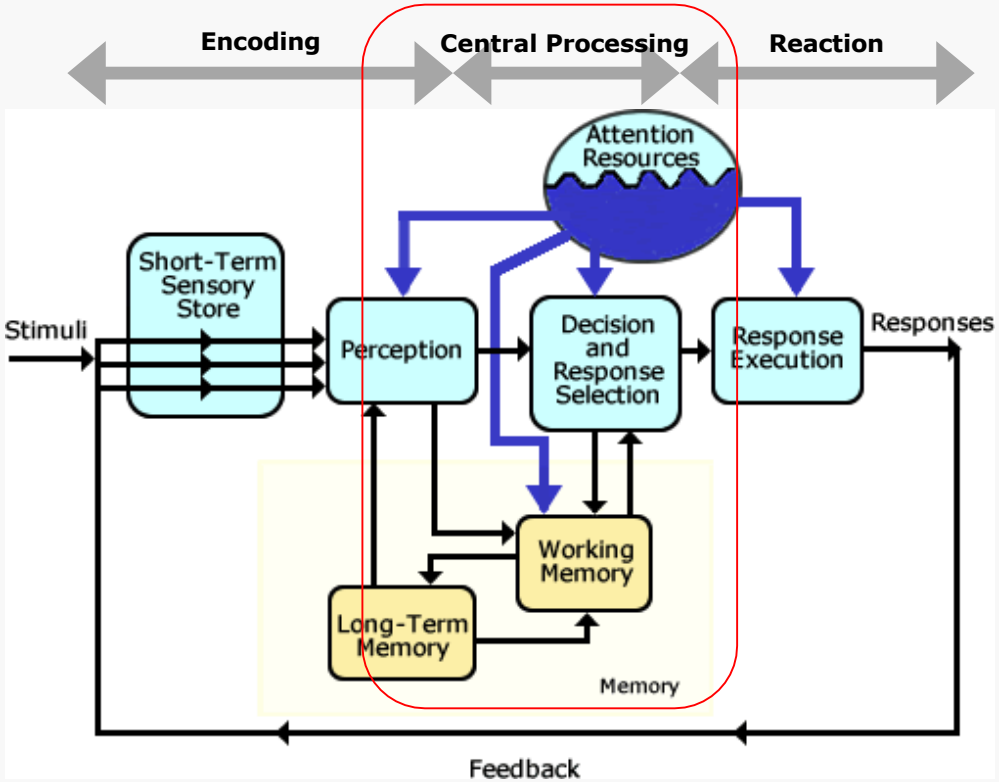


Figure 5. All taste characteristics combined: the temporality shown through its length; affective reactions through the color (green pleasant, red unpleasant, orange neutral experience); and the embodiment through its form (mouth feeling).

Obrist et al. Temporal, affective, and embodied characteristics of taste experiences: a framework for design. CHI '14. ACM, New York, NY, USA, 2853-2862.

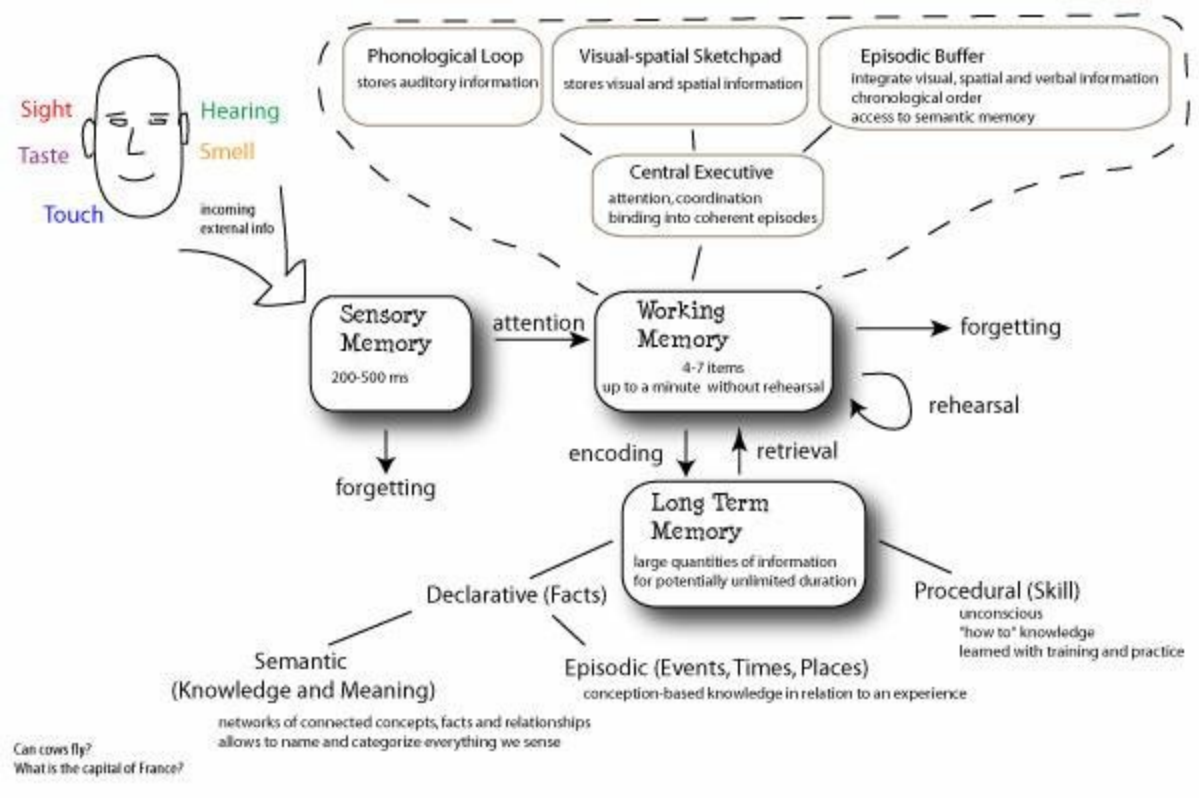
COGNITION


Encoding
Central Processing
Reaction
Attention Resources
Short-Term Sensory Store
Stimuli
Perception
Decision and Response Selection
Response Execution
Responses
Working Memory
Long-Term Memory
Memory
Feedback

COGNITION

- Merely serves to connect inputs from the perceptual system to the right outputs of the motor system
- A group of mental processes that includes attention, memory, producing and understanding language, learning, reasoning, problem solving, and decision making
- Usually refers to an information processing view of an individual's psychological functions

HUMAN MEMORY SYSTEM



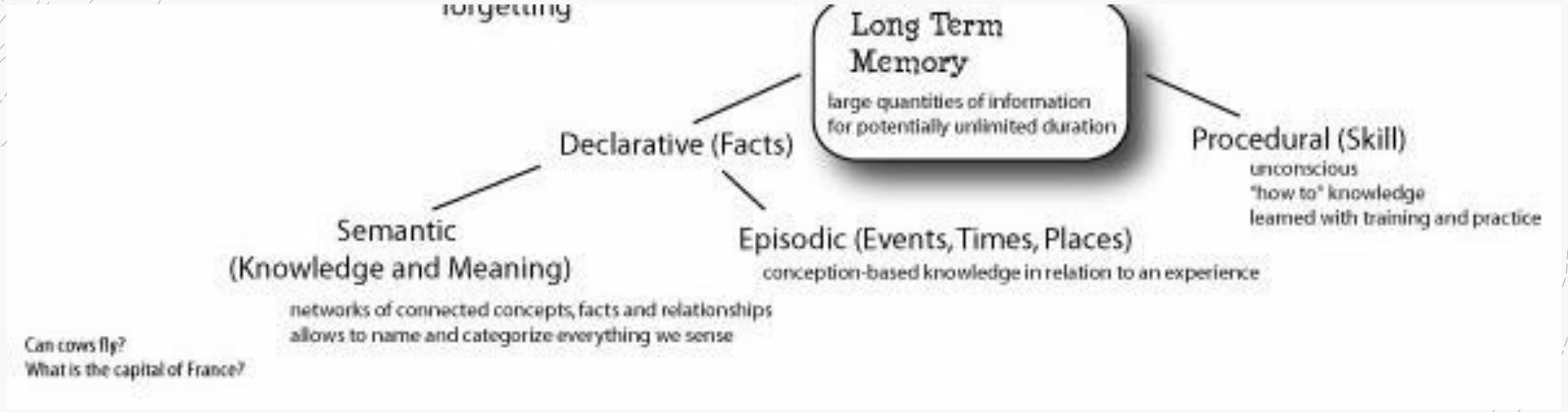
WORKING MEMORY

- To hold the intermediate products of thinking and the presentations produced by the perceptual system
- rapid access ~ 70ms
- rapid decay ~ 200ms
- limited capacity - 7± 2 chunks

LONG-TERM MEMORY

- To store knowledge for the future
- A network of related chunks, accessed associatively from the contents of the working memory
- slow access ~ 1/10 second
- slow decay, if any
- huge or unlimited capacity

TYPES OF MEMORY



LONG-TERM MEMORY (CONT.)

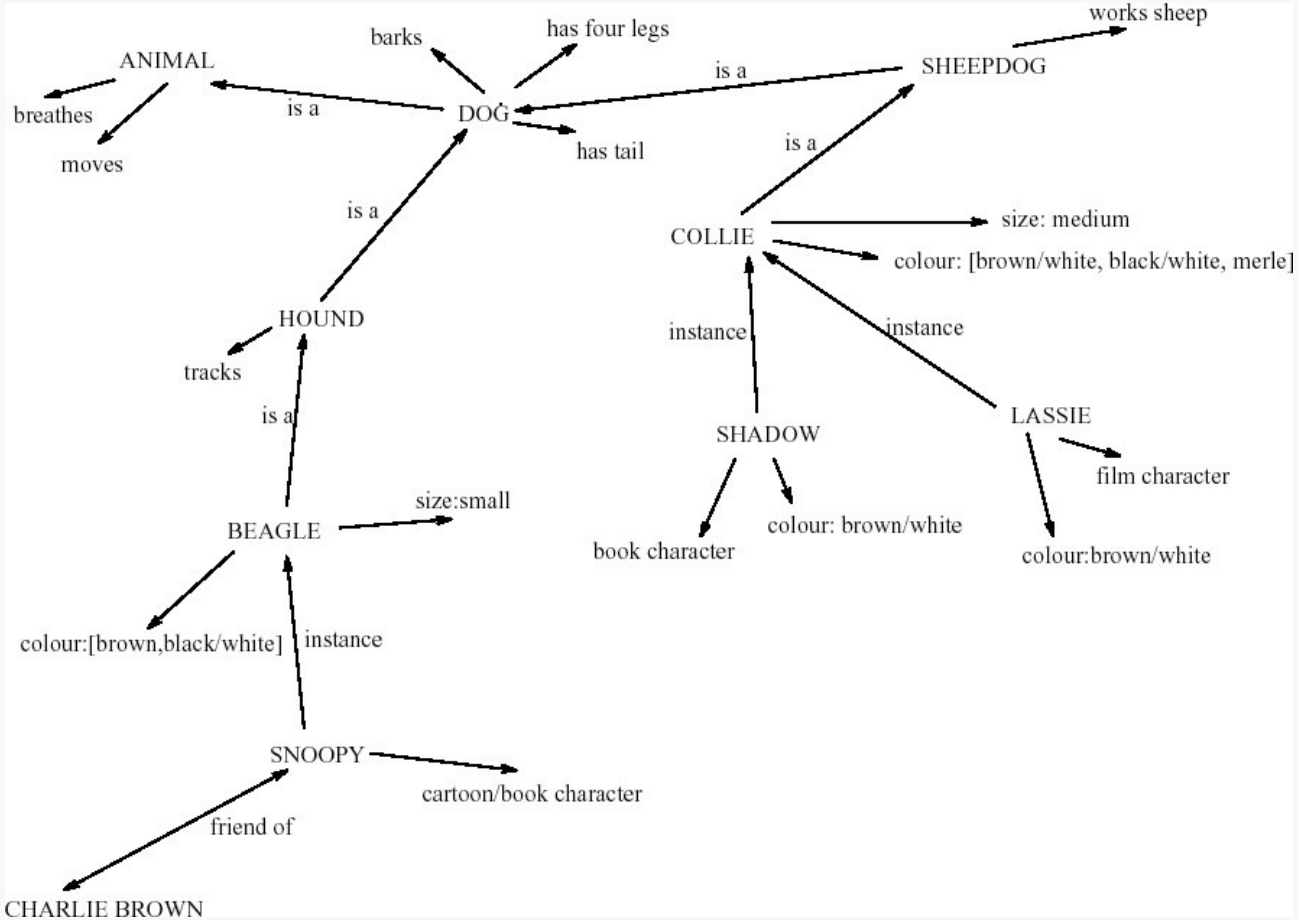
Semantic memory structure

- provides access to information
- represents relationships between bits of information supports inference

Model: semantic network

- inheritance – child nodes inherit properties of parent nodes relationships between bits of information explicit
- supports inference through inheritance

LTM – SEMANTIC NETWORK



ENCODE, STORE, AND RECALL

- Memory has the ability to encode, store and retrieve information
- Encode: conversion of stimuli into a construct that can be stored within the brain (long-term memory)
- Store: the retention of information in the brain for a prolonged period of time until it is accessed through recall
- Recall: the retrieval of events or information from the past

ENCODING AND STORING

Encoding in different memory types

- Sensory and working memory: raw signal
- Long-term memory: only selective info. from working memory goes to here after encoding of the raw signal

Encoding types

- Visual encoding: visuo-spatial sketchpad
- Elaborative encoding: relating new information to knowledge that is already in memory
- Semantic encoding: mapping to a meaning

ENCODING STRATEGIES

- Rote Rehearsal, e.g., verbal repetition of someone's name
- Chunking, i.e., categorizing
- Mnemonic devices: linking new to already known, e.g., mental picture, reword (verbal), method of loci (locational), acronym
- Self-referencing
- Spacing, e.g., five hours study in a row < one hour for five days

RETRIEVAL

- Recognition: association of an event or physical object with one previously experienced or encountered
- Recall: remembering a fact, event or object that is not currently physically present
  - Free recall: without any hint, only contextual overlap
  - Cued recall: recall with given hint, contextual + conceptual overlap
- Recognition, cued recall is easier than free recall. Thus, try to convert free recall to recognition in interaction

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THANK YOU

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