

**INTERESTING FACTS ABOUT HOW  
DOGS “SEE / SENSE” THE WORLD  
SEE, HEAR, SMELL, FEEL...**

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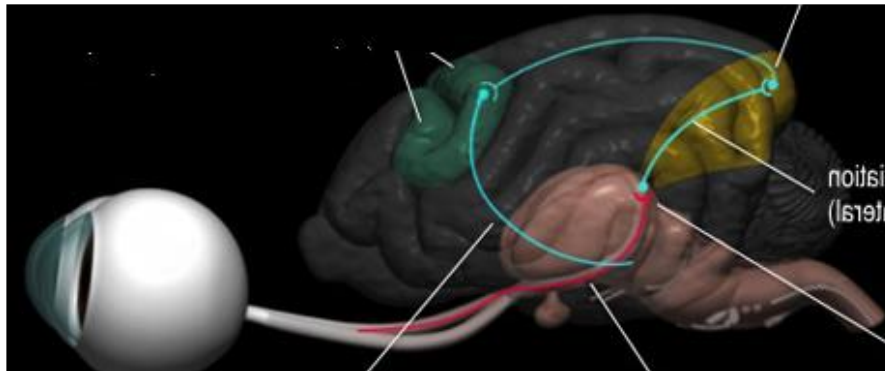
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# WHAT IS PERCEPTION?

*Detecting, processing and transform external (environmental) stimuli into meaningful messages using sensory organs and the nervous system*

stimulus → message → representation → behavior



# WHY IS IT IMPORTANT?

*Understanding the perceptual world of dogs improves our understanding of their behavior*



1. There is a weird object on the ground, the dog is scared of it

2. There is a heating bitch nearby, the dog is processing smell

3. The dog hears a growl nearby and gets frustrated



# EVOLUTIONARY APPROACH

*Perception tightly coupled to the survival of the species  
in its environment (niche).*

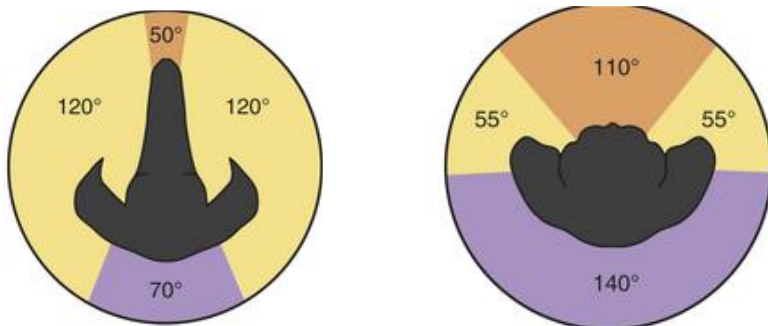


# DOGS ARE SPECIAL!

Huge morphological differences  
between breeds!



Different perceptual abilities  
within the species!



Huge differences in the  
environment during  
development!



Individual  
differences!





# TYPES OF SENSES

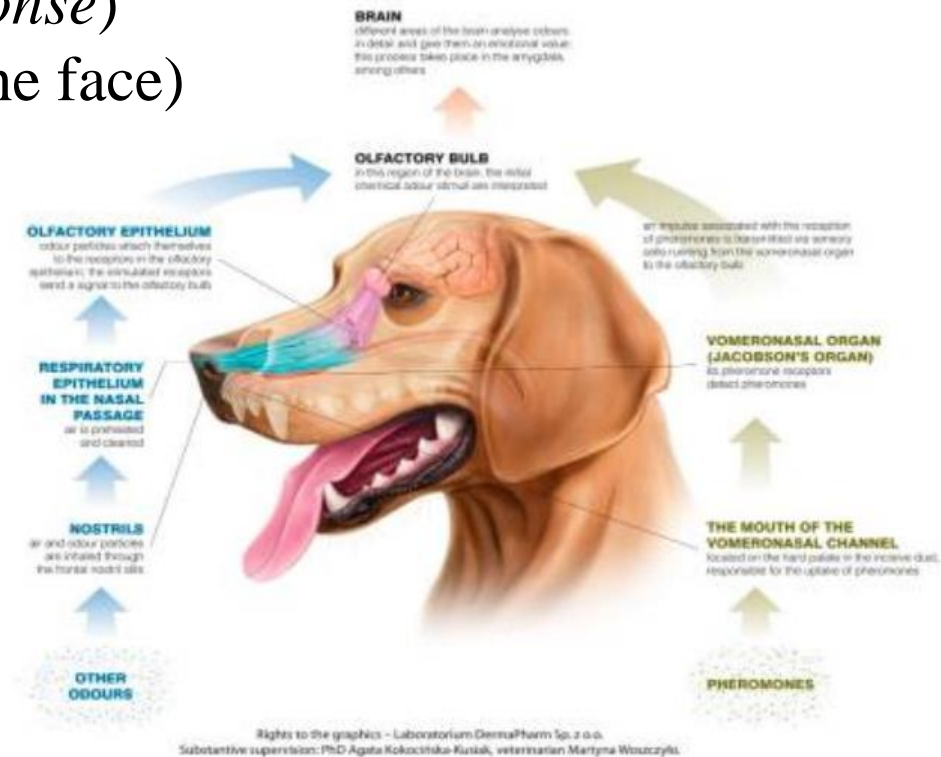


**OLFACTION, HEARING, VISION, TASTING, TOUCHING**



# OLFACTION

1. Olfactory system (most odour molecules: main olfactory epithelium/ORC → olfactory nerves → olfactory cortex)
2. Vomeronasal (Jacobson) organ – (non-volatile molecules-feromones: between nasal-oral cavity → accessory olfactory bulb → hypothalamus (*flehmen response*))
3. Trigeminal nerve (innervating the face)

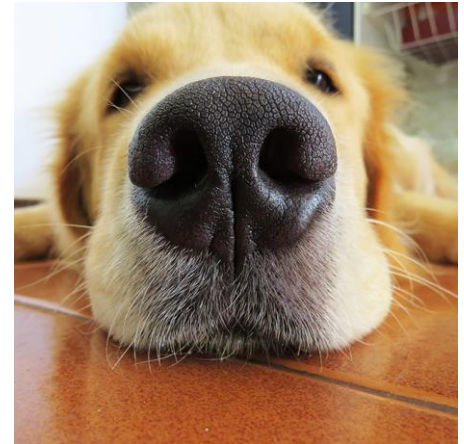


# OLFACTION

Olfactory capability ~ number of OR genes ~ number of ORC in the olfactory epithelium/mm<sup>3</sup>

Olfactory acuity (lowest concentration) ~ sensitivity of the ORs

Species	OR genes
Humans	350 (560 pseudogenes)
Mice	1000 – 1300
Other Mammals	4000
Cow	2129
Dog	1100
Macaque	606
Rat	1767
Mice	1391



Breed differences: inconsistent results...high level of OR gene polymorphism behind bad & good sniffer breeds (trainability motivation, etc.)





# OLFACTION

„Important odours” for dogs

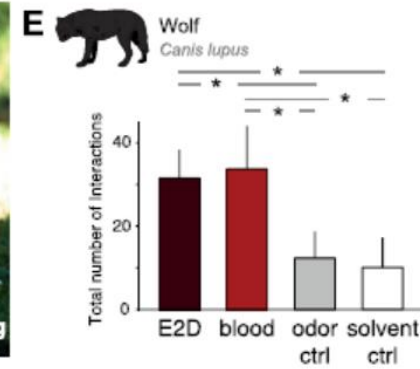
„Smell of a heating bitch”: complex of volatile and non-volatile molecules (methyl-p-hydroxibenzoate, estradiol, from urine, faces, vagina, anal sac)

„Appeasing pheromone”: mixture of fatty acids, glands located in the intermammary sulcus, calming effect → firework, veterinary visits

„Smell of blood”: oxygenated aldehyde molecule with metallic aroma, different behavioral responses from predators and preys!



Goodwin et al. 1979, Dunbar et al. 1980  
Sheppard & Mills 2003, Arshamian et al. 2007,



# OLFACTION

Applied „benefits”

1. Drugs, money, explosives, etc.
2. Diseases (COVID, cancer, seizure prediction, etc.)
3. SAR, mantrailing (body particules-odour sample and/or body temperature)



# OLFACTION

## Underlying mechanisms

### Matching of two stimuli:

Human scent identification: unique smell of the individual from an odour sample

Particular diseases: from exhaled air (concrete molecules are unknown), family dogs can be easily trained with clicker

Melanoma (85%), Breast cancer (88%), Lung cancer (99%), Ovary cancer (100%)

MACHINE (60-70%) < DOGS (90%)



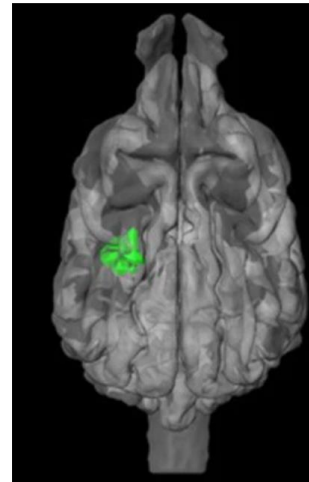
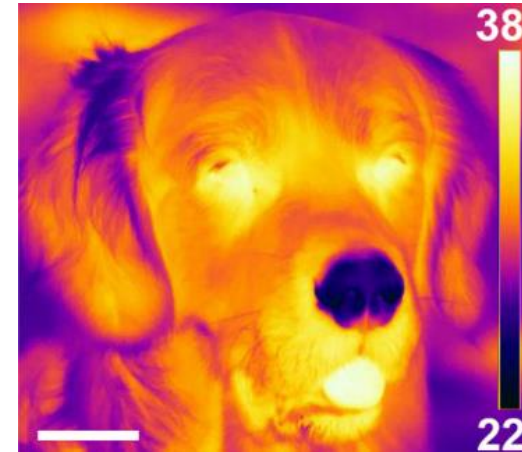
# THERMAL RADIATION

Sensing warm body temperature („snake sense”)

Organ: nose tip (rhinarium) → cooler in heat, warmer in cold – richly innervated (vagus trigeminus)

Training & behavioral test + non-invasive fMRI

- Dogs are able to distinguish between two identical objects with 10 degrees difference
- The warm stimulus elicited increased neural response in the left somatosensory association cortex





# HEARING

Mechanosensation: sound waves -outer ear → amplified via the middle ear → transduced into nerve impulses (electrical signals) –inner ear→ auditory nerve →temporal lobe

Audible frequency range (audiogram)

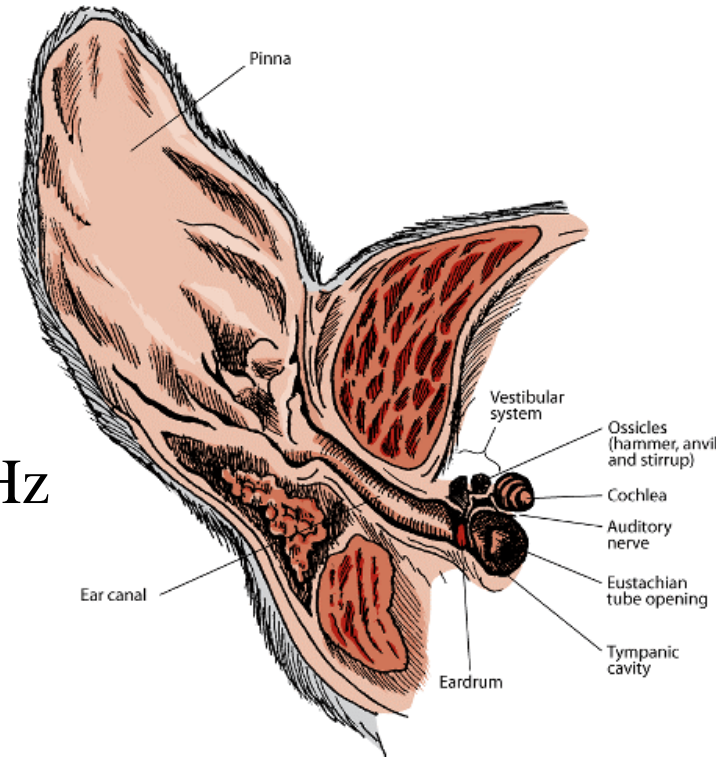
Human: (infra) 60 Hz-20.000 Hz (ultra)

Dog: 67 Hz- 45.000 Hz

Distance: humans 90 m, dogs 400 m

Localization : humans  $1,3^\circ$ , dogs  $8^\circ$

Discrimination: humans 3 Hz, dogs 8-10 Hz





# HEARING

Ear flaps (Pinnae): erect, semi-erect, dropped

Large erect pinnae → better localization

Ability to control the orientation of pinnae → improve hearing sensitivity (28 dB)



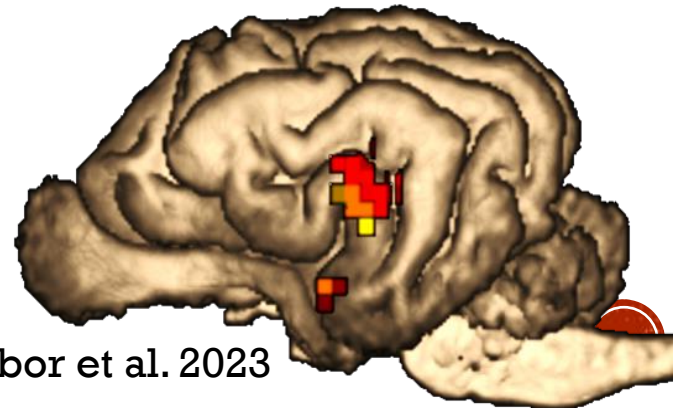
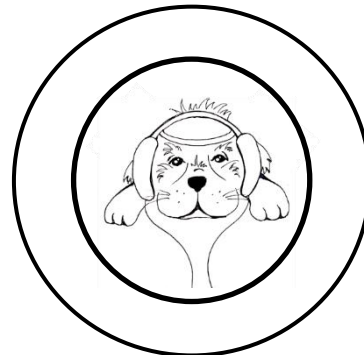
# HEARING

Important sounds:

- Conspecific vocalizations (80-8000 Hz): growls (80-800 Hz), barks (120-1600 Hz), howls (200-2000 Hz), whines (300-2300 Hz), whimpers (400-8000 Hz)

Higher pitch → more attention (distress, alarm calls, chorus howling)

- Human speech (90-300 Hz): adult-directed (90-120 Hz), infant- and dog-directed (100-250 Hz) → preference for female dog-directed prosody in non-primary auditory cortices



# (COLOR)VISION

Ability to perceive differences between light composed of different frequencies

1. Number of cone receptor cell types (iopsin):  
Monochromacy, Dichromacy, Trichromacy,  
Tetrachromacy, Pentachromacy

2. Iopsin sensitivity:  
human: 380-740 nm (trichromats)  
dogs: 429-555 nm (dichromats)



Only 3% of the receptors in retina are cones...



# VISUAL ACUITY



Night vision: 97% are rods (rhodopsin-506-610 nm → low light condition adaptation!)

tapetum lucidum (light reflecting layer)– reflects visible light back through the retina!

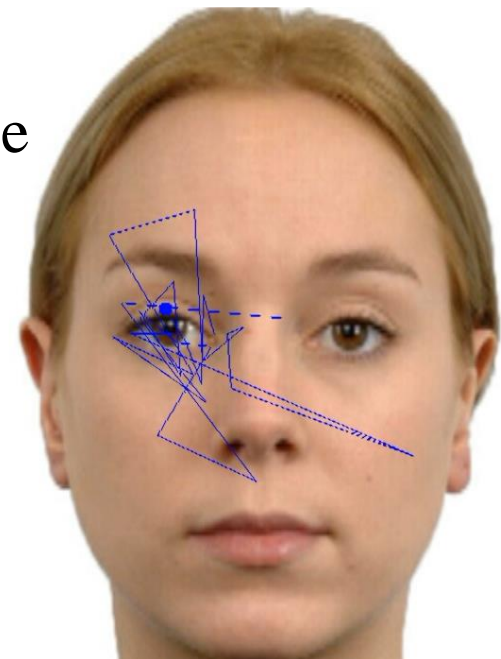
Accommodation-Focus: humans 7-10 cm, dogs 33-50 cm!!!

Visual acuity: how many cones are connected to one single ganglion cell → primates: 1:1; dogs 4:1

Distribution is elongated („visual streak”) →

Sensitivity to horizontal plane (scanning for prey)

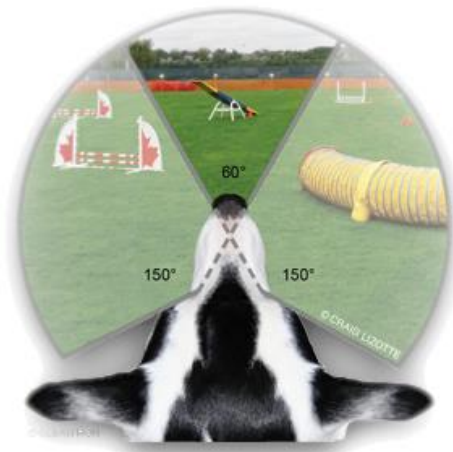
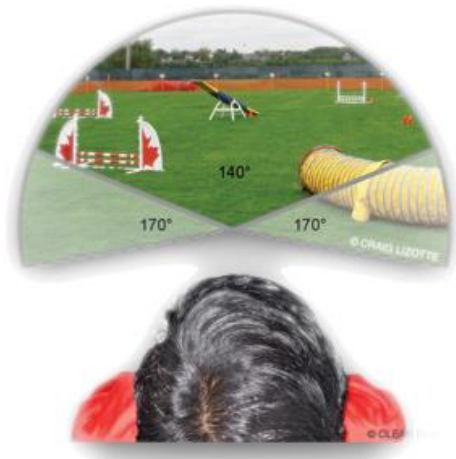
Fast saccadic eye-movements unlike humans!



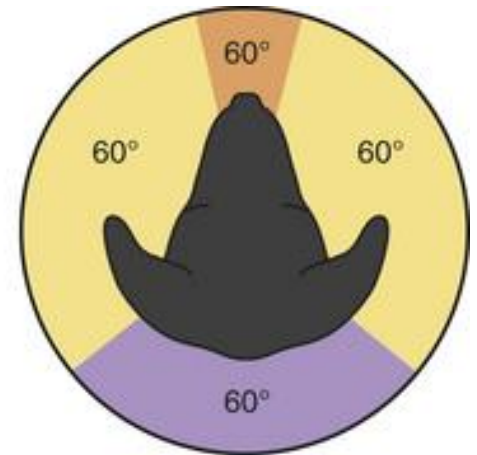
# BREED DIFFERENCES

Visual field and skull shape:

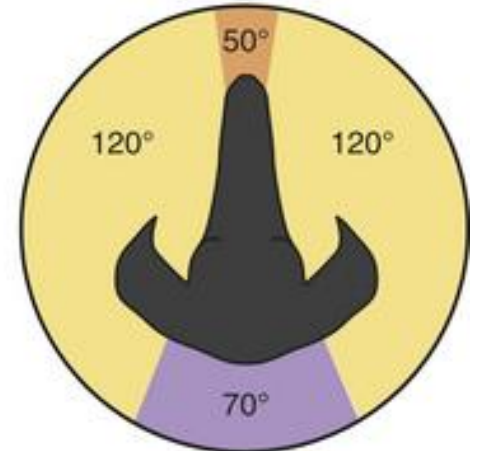
Mesocephalic, doliocephalic,  
brachycephalic



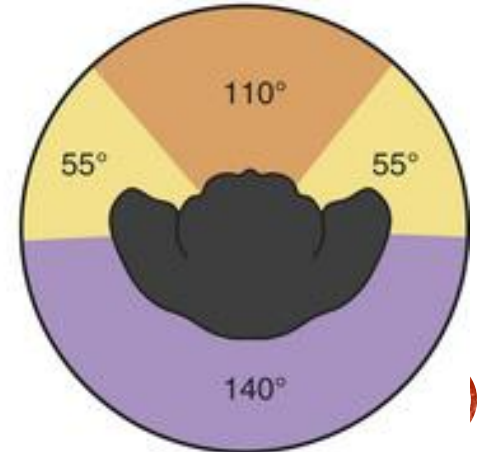
Average dog



Borzoi



Pekingese





# TACTILE SENSATION

Newborn puppies are blind and deaf! Licking → defecation stimulus

Deprivation from early tactile stimulation has great impact...

Conspecific communication: mouthing, pawing, grooming

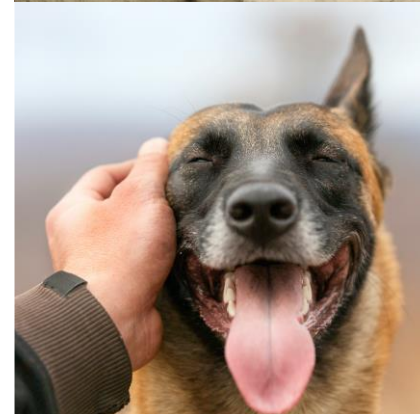
Human-dog interaction (petting)

- attenuate stress responses in humans

- increase peripheral oxytocin levels in both species

- polymorphisms in the oxytocin receptor gene → friendliness, need for petting

- familiarity and preferences → huge individual differences



# TAKE HOME MESSAGES

1. Dogs are greater sniffers than humans (3x times better)
2. Dogs and humans both can sense the smell of blood, but we behave like preys, dogs behave like predators
3. Dogs are able to detect weak thermal radiation (we do not)
4. Dogs can hear at higher frequencies and from larger distances  
BUT we can locate and discriminate sounds better
5. Dogs are dichromats, humans are trichromats
6. Dogs can see better in dim light but our visual acuity is 4 times better.
7. Breed and individual differences are large in dogs!



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# THANK YOU FOR YOUR ATTENTION!

