Basic Concepts in Animal Behavior and Neuroethology

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April, 2024

Outline

Why study animal behavior?

What is behavior?

What are the different aspects in the research of behavior?

Types of behavior

Neuroethology- definition and examples

Why should we care of animal behavior?

~~Human survival~~

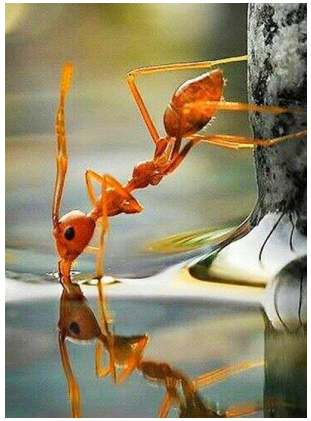
Understanding conserved behavioral principals and the their mechanisms

Understanding neuropsychiatric diseases:
-Autism
-Anxiety disorder
-Depression and Mood disorders

What is animal behavior?

The study of how animals interact with their environment, other animals, and themselves; Everything the animals do.

Environment

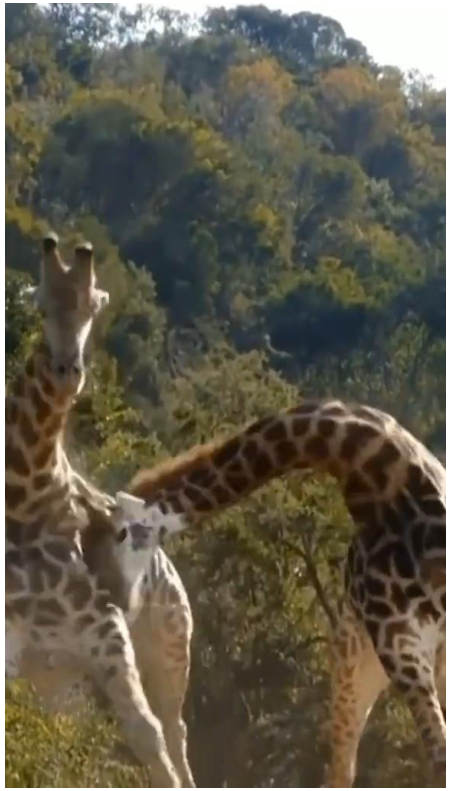


Other animal

Themselves

What behavior is used for ?

All aspects of life including: finding food, finding shelter, avoiding predator, communication, reproductive behaviors (courtship, mating, nursing)



Evolutionary causes of behavior

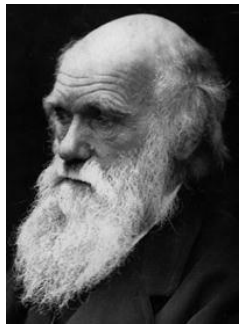
In nature animals behave in ways that maximize their fitness

Fitness = the ability to survive and reproduce

Beneficial behavior

Not-beneficial behavior

How does behavior evolve? Natural selection



Charles Darwin
(1809-1882)

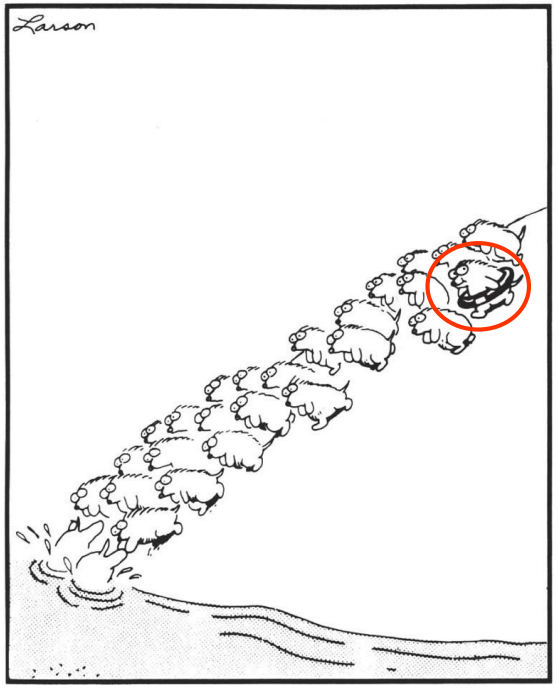
Behavior (as other character) is shaped by natural selection.

1. Variations also exist in behavioral traits

2. Some of these behavioral variations are heritable

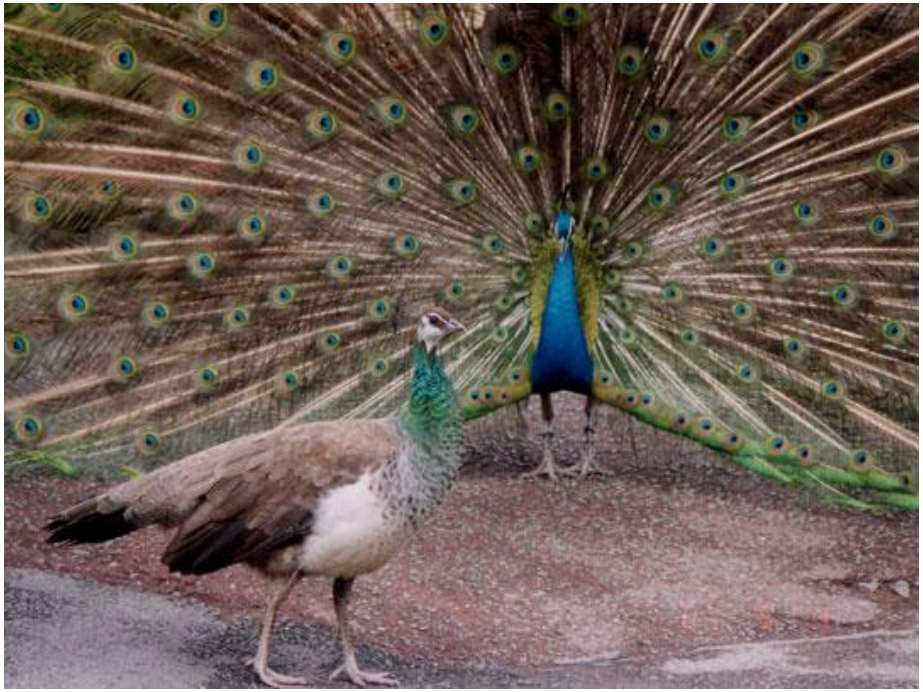
3. Certain behavioral variations make individuals better adapted to their environment

4. These individuals have the chance to survive longer and leave more offspring than those with less successful behavioral traits



Sexual selection of behavior

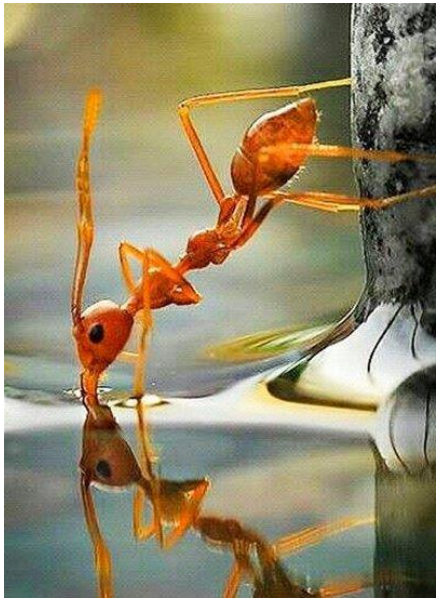
- Darwin realized that some behavioral traits directly relate to mate acquisition and mate choice.
- These traits developed to increase reproductive success
- He termed this evolutionary process “**sexual selection**”.



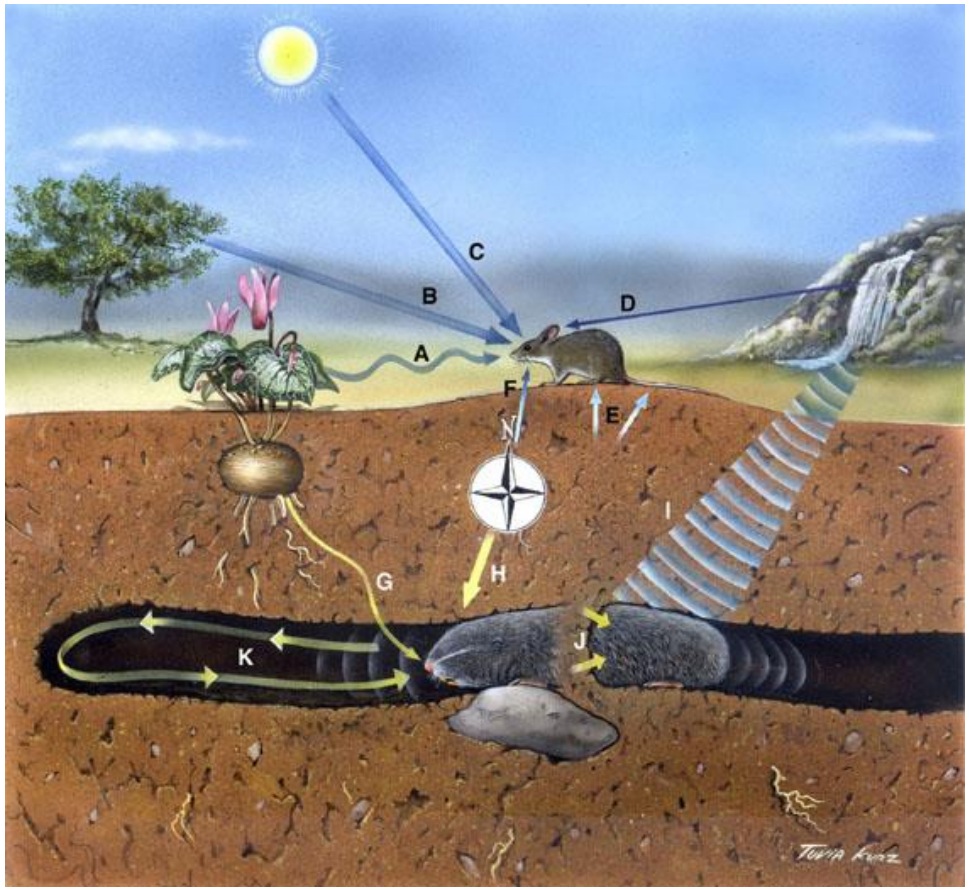
Male courtship behavior

Immediate causes of behavior

Animals behave as a response to a **stimulus**- an external (e.g. odor, sound) or/and internal (e.g. hormone) cue

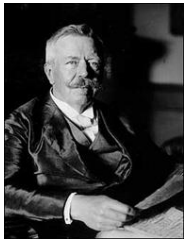


Different external stimuli present to a mouse vs a subterranean mole rat



Species-specific sensory systems adapted to the specific environmental and social conditions

The animal “Umwelt”



Jakob von Uexküll
(1864-1944)

Umwelt = The organism's model of the world

How the animal perceives things in the world and the actions (behaviors) that are performed by each species.

Our vision: 400-780 nm in length

Bee vision: 300 and 560 nm in length

Ethology

The study of naturalistic animal behavior and its relationship to its evolutionary origins

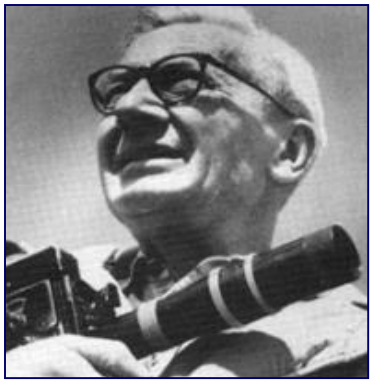
An ethological research starts with field observations

Ethologist: observe the natural animal behavior and choose the appropriate animal model for the research question

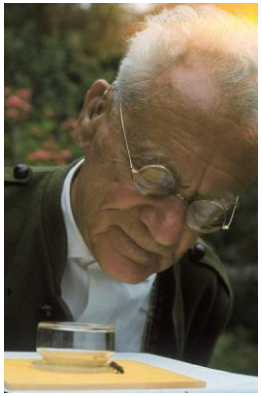
Three pioneer observes of animal behavior (Ethology)

1973 the Nobel Prize for Physiology or Medicine

Konrad Lorenz
(1903-1989)



Nikolaas (Niko) Tinbergen
(1907-1988)

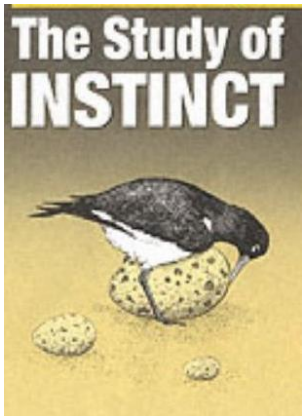


Karl von Frisch
(1886-1982)

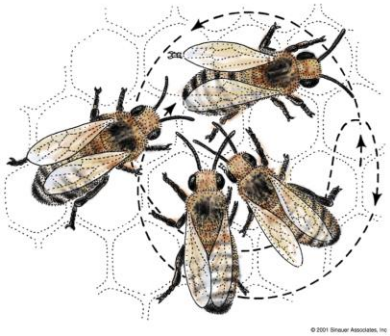
Experts in animal behavior who, through extensive field observation and experience, exposed fundamental patterns and motivations in the behavior of animals

Three pioneer observes of animal behavior (Ethology)

Konrad Lorenz:
Imprinting



Niko Tinbergen:
Fixed action pattern



Karl von Frisch:
Honeybee communication

Their main discoveries were made on insects, fishes and birds, but the basal principles have proved to be applicable to all mammals

How we study and understand animal behavior?

Asking *how* and *why* animals interact with each other and their environment

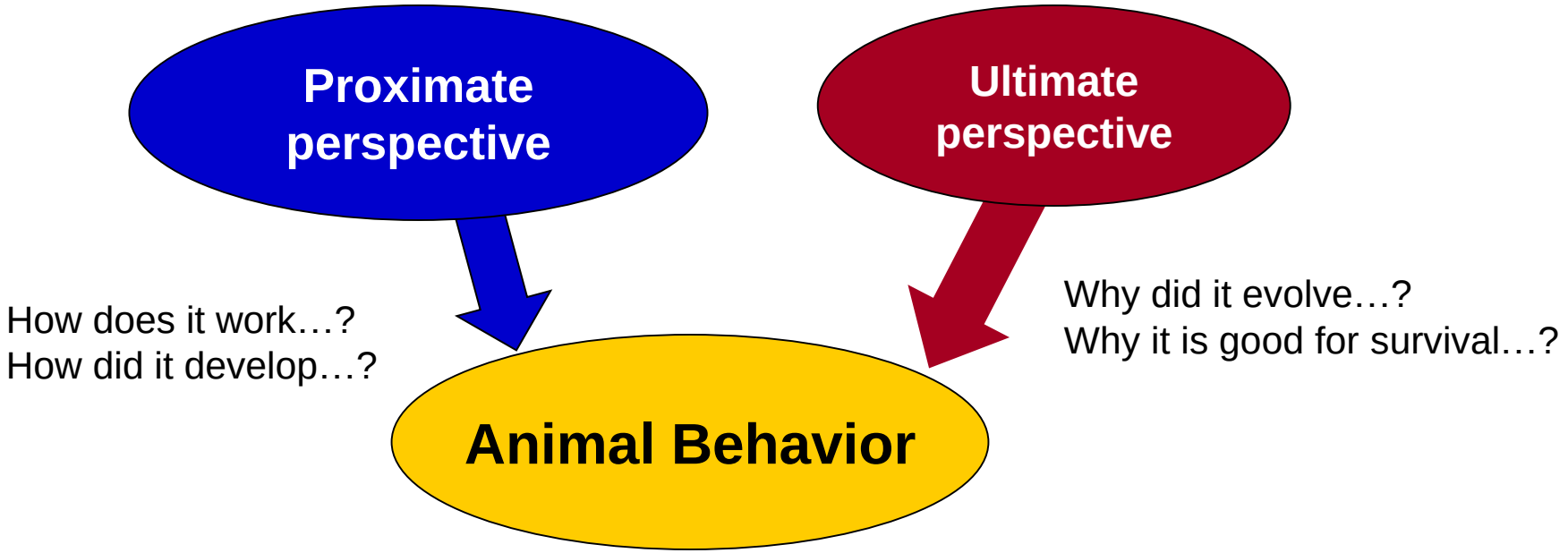
How does it work?

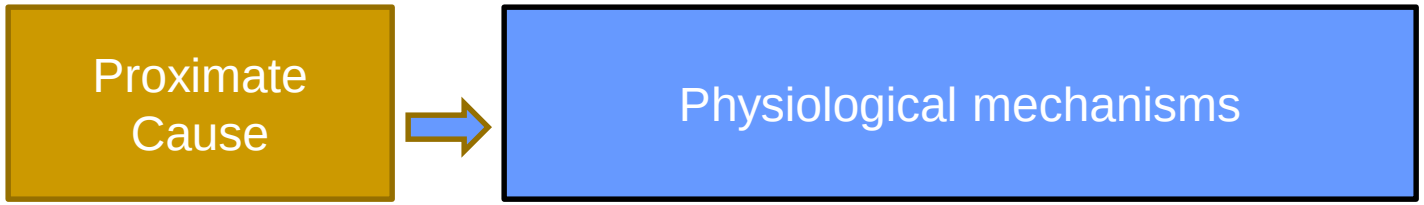
How did it develop?

Why did it evolve?

Why it is good for survival?

How we study and understand animal behavior?





Studying the mechanisms of the immediate causation and development of the behavior

Studying what is the adaptive significance and evolution for survival and reproduction

The 4 questions asked in behavior (Tinbergen Niko, 1963)

	Short-term	Long-term
How?	Mechanism	Development
Why?	Function	Evolution

Proximate

Mechanism: Reactions or reflex to immediate stimulus (immediate causation)

Development: The lifespan of the organism in its environment (genetics, experience)

Ultimate

Function: What is the behavior good for (the value of the behavior to the animal)?

Evolution: The ancestral history of the organism

Lion Intimidation

Young lions have to leave their pride and take over other prides

Lion intimidation	*Short-term*	*Long-term*
How?	Big, dark manes	More testosterone
Why?	Indicates more strength – better chances of survival	Females found more attractive – selection of dark maned lions

	Short-term	Long-term
How?	Mechanism	Development
Why?	Function	Evolution

Proximate and ultimate perspectives on aggressive behavior by male sticklebacks

BEHAVIOR: A male stickleback fish attacks other male sticklebacks that invade its nesting territory

PROXIMATE CAUSE:

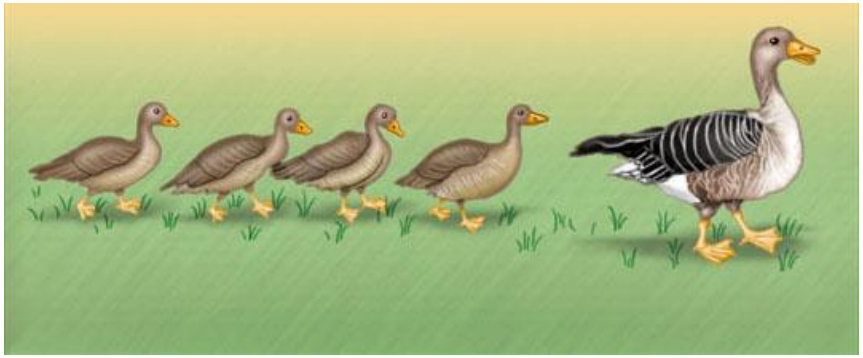
The red belly of the intruding male acts as a sign stimulus that releases aggression in a male stickleback

ULTIMATE CAUSE:

By chasing away other male sticklebacks, a male decreases the chance that eggs laid in its nesting territory will be fertilized by another male

Proximate and ultimate perspectives on imprinting in graylag geese

BEHAVIOR: Young geese follow and imprint on their mother



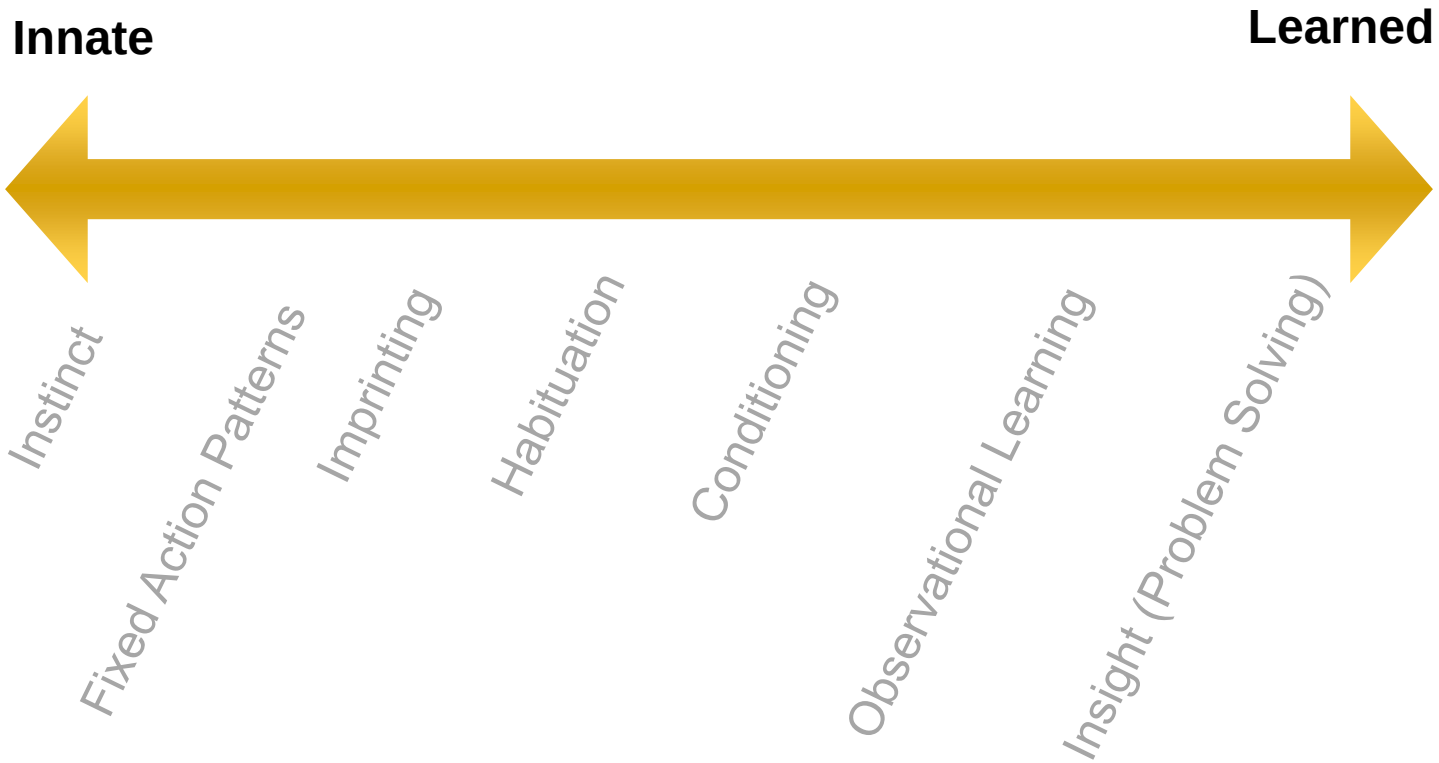
PROXIMATE CAUSE:

During an early, critical developmental stage, the young geese observe their mother moving away from them and calling

ULTIMATE CAUSE:

On average, geese that follow and imprint on their mother receive more care and learn necessary skills, and thus have a greater chance of surviving than those that do not follow their mother

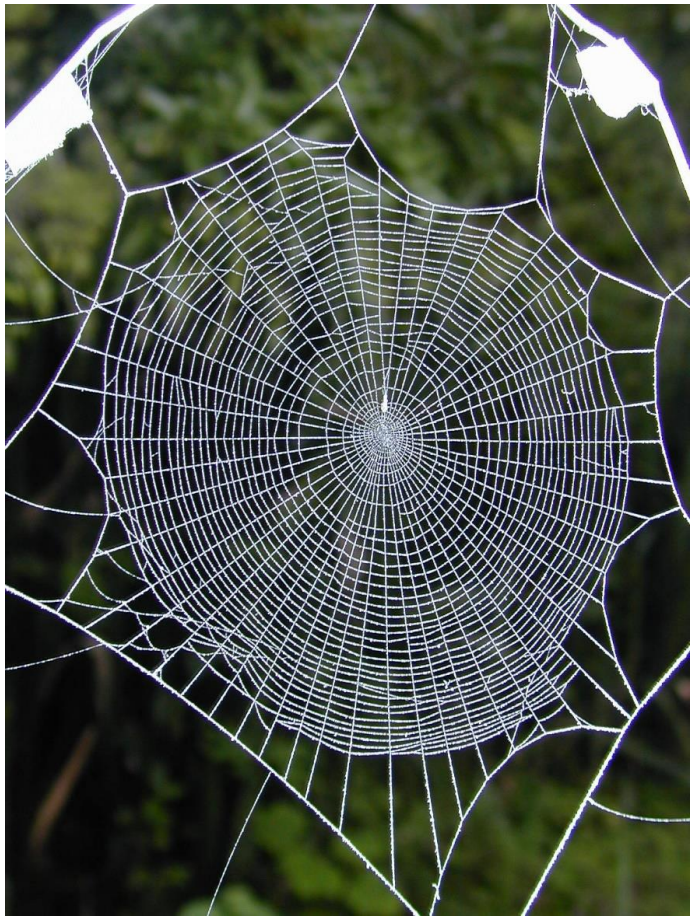
Types of behaviors

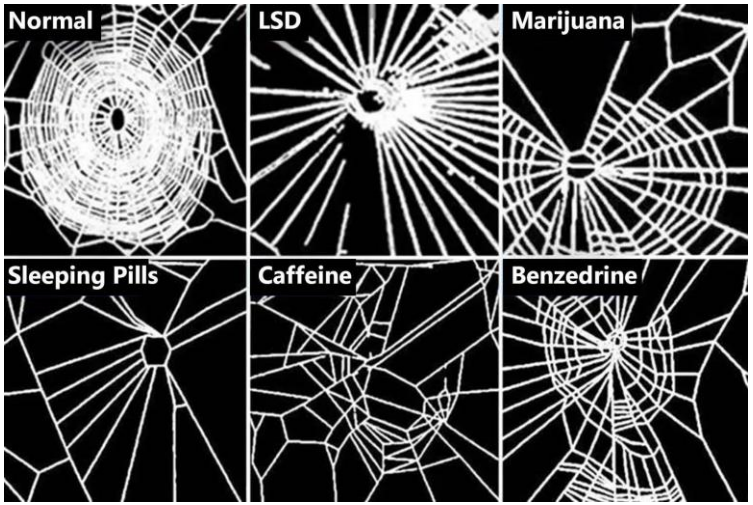


Innate Behavior

- First time performance is completely functional
- Animals don’t have to witness the behavior (inborn)
- Uniform, stereotyped
- Triggered by a simple sign stimulus (sensory releaser)
- Has a strong genetic (inherited) basis: controled by pre-programmed fixed neural circuitries

Innate behavior





https://rarehistoricalphotos.com/nasa-spiders-drugs-experiment/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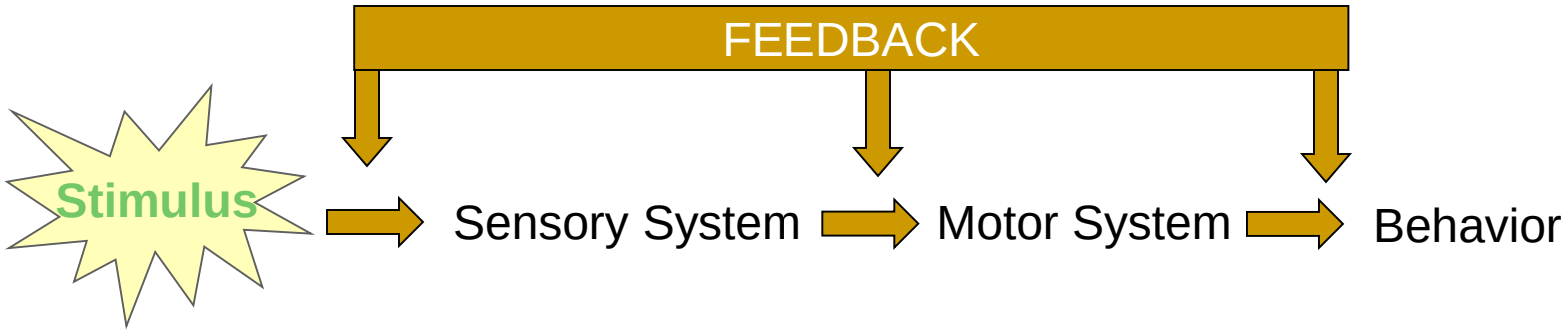
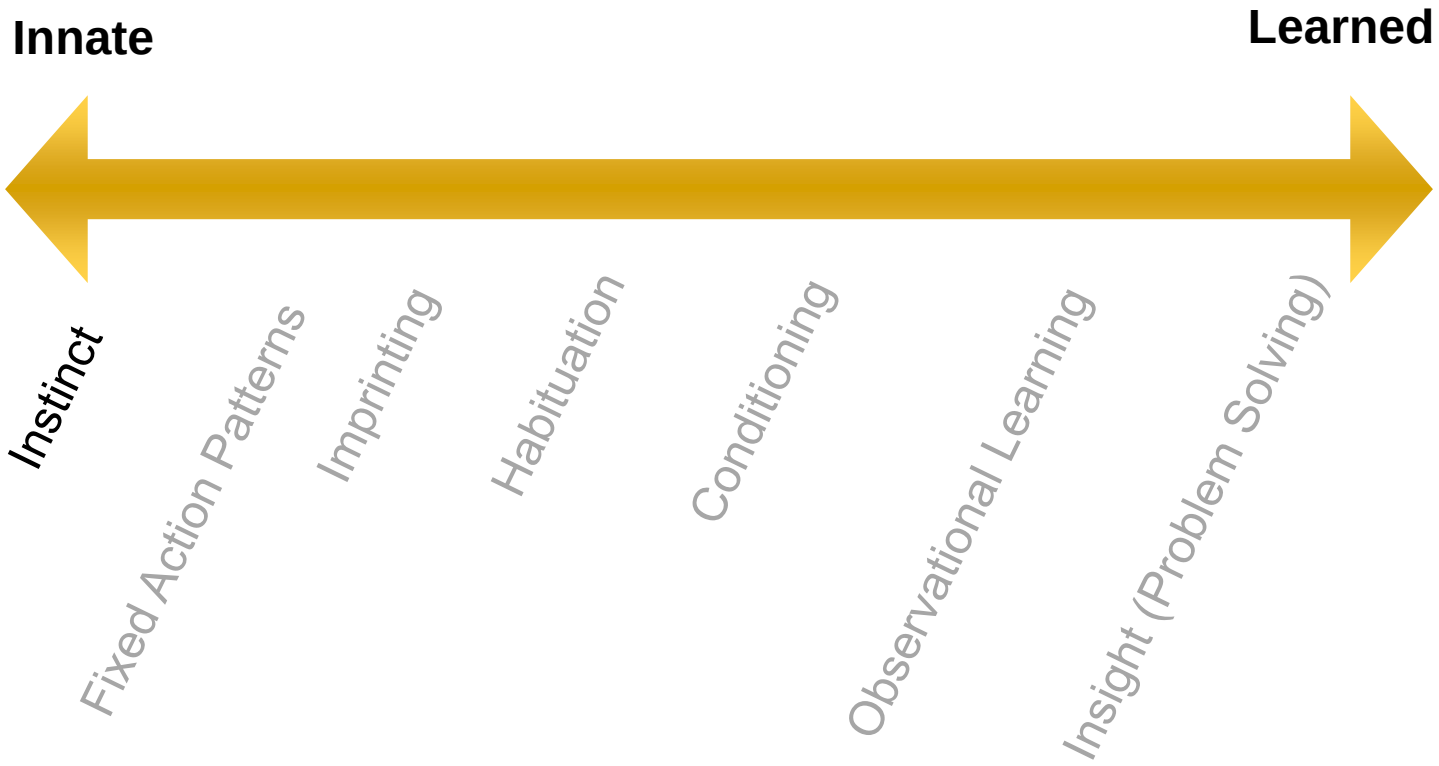
Learned behavior

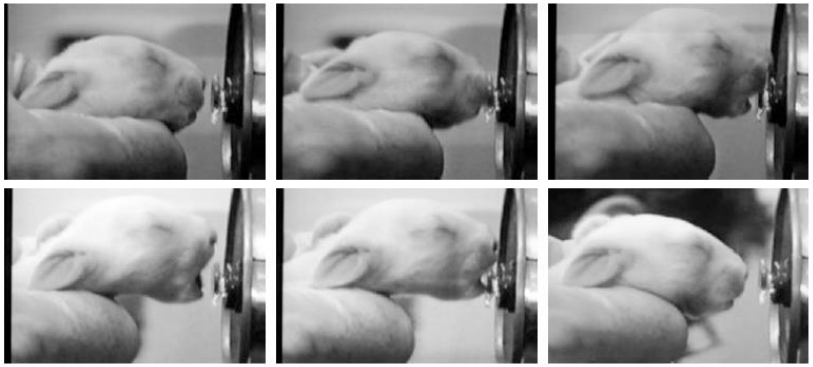
- Behavior that is modified by experience (trial-and-error pattern)
- Flexible. Phenotype is changing with time/experience
- Often affects even innately programmed behaviors



Types of behaviors



Reflex behavior- sucking



Schaal et al 2003

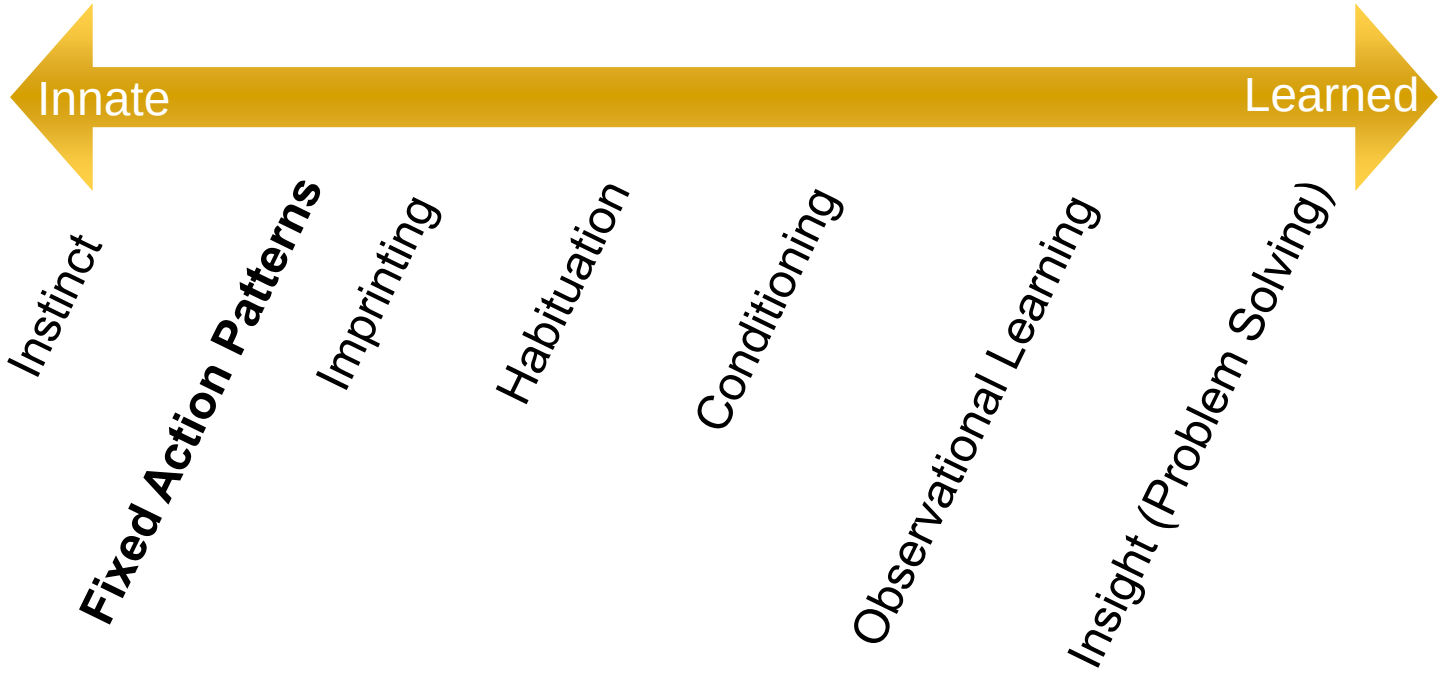
Babies tend to suck on anything that touches the roof of their mouth

Reflex behavior- Grasping

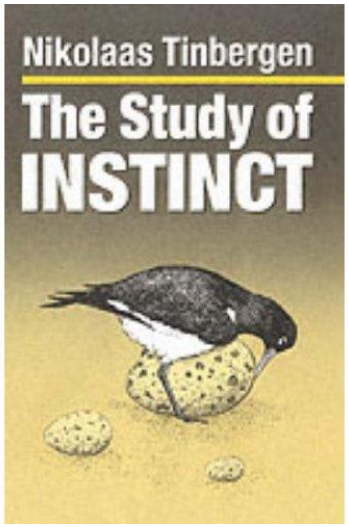
Involuntary grasping motion of the hand in newborn

Instinct behaviors: Freeze or flee in mice

Types of behaviors

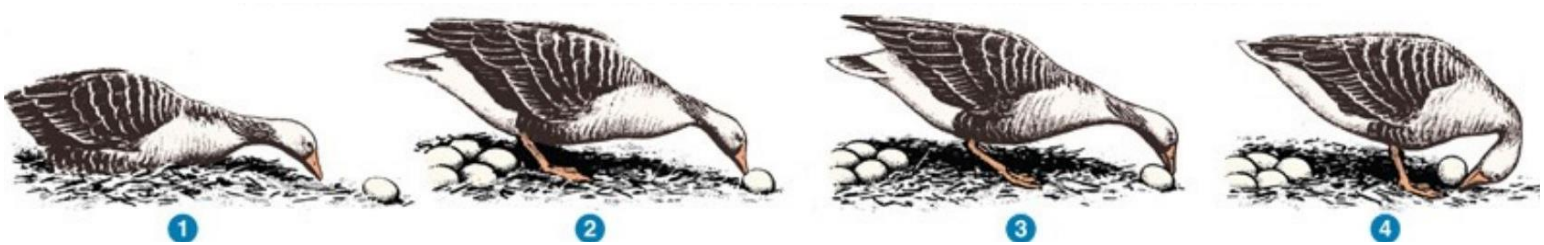


Fixed Action Pattern (FAP)



- Highly stereotypic behavior
- Triggered by a sign stimulus (external stimuli)
- Once begun, the behavior will continue to completion

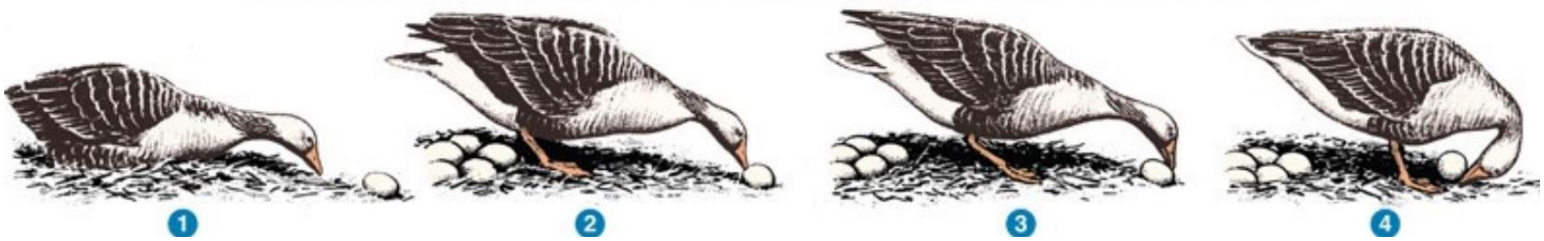
Fixed Action Patterns:
Egg-rolling behavior in greylag goose



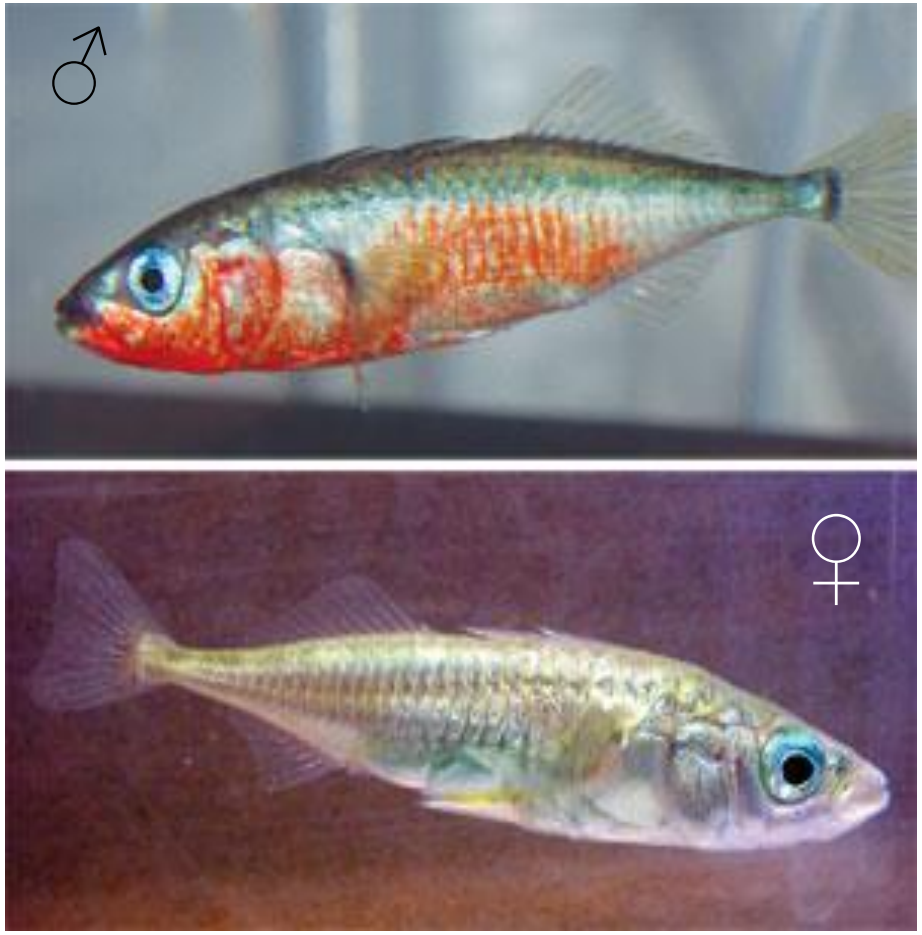
• The goose will roll an egg that is outside the nest back into the nest in the same manner every time.

• The goose will do this with any round object placed outside the nest.

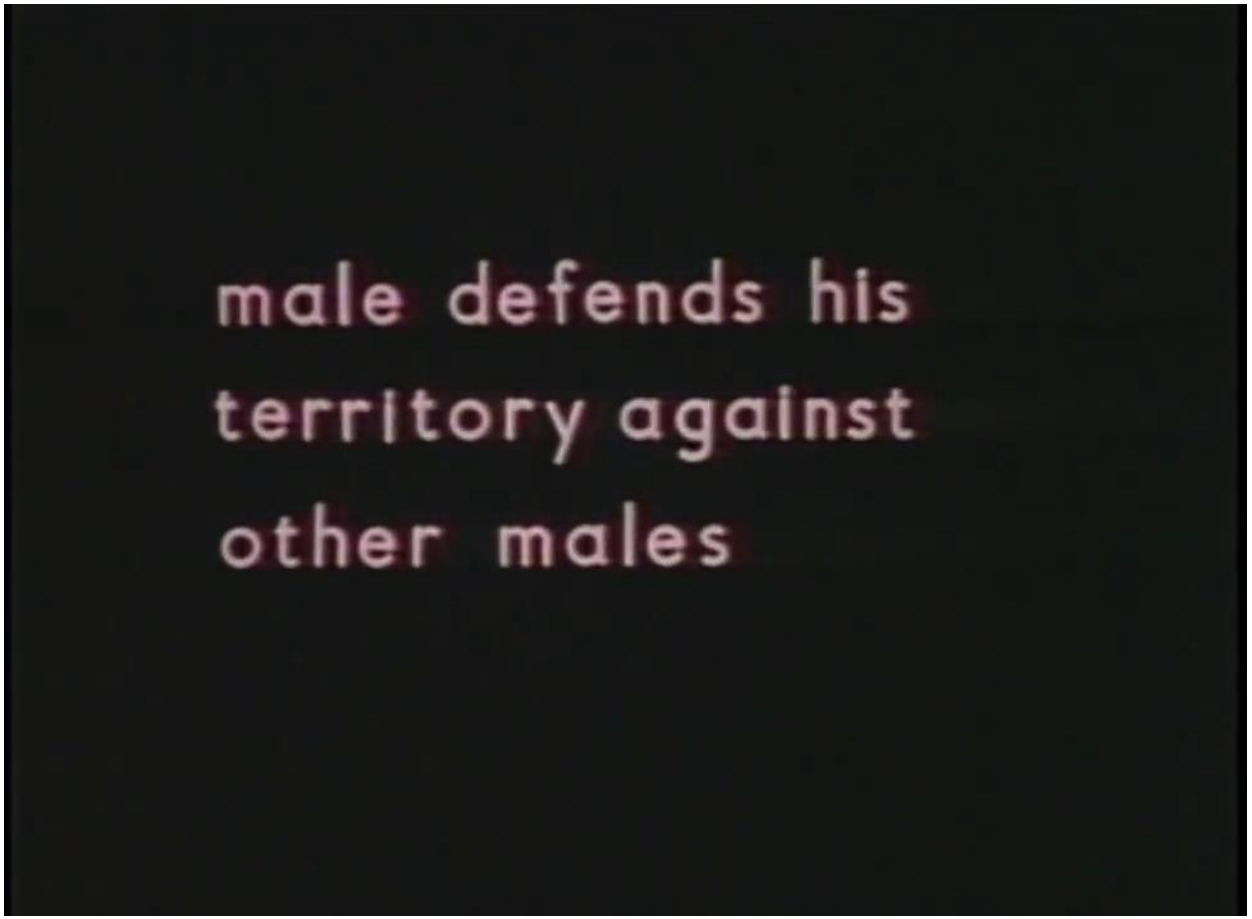
• Each time this action pattern is initiated, it is carried through to completion.


1
2
3
4

FAP: social behavior in three-spined stickleback



Stickleback – Aggressive behavior; field observation



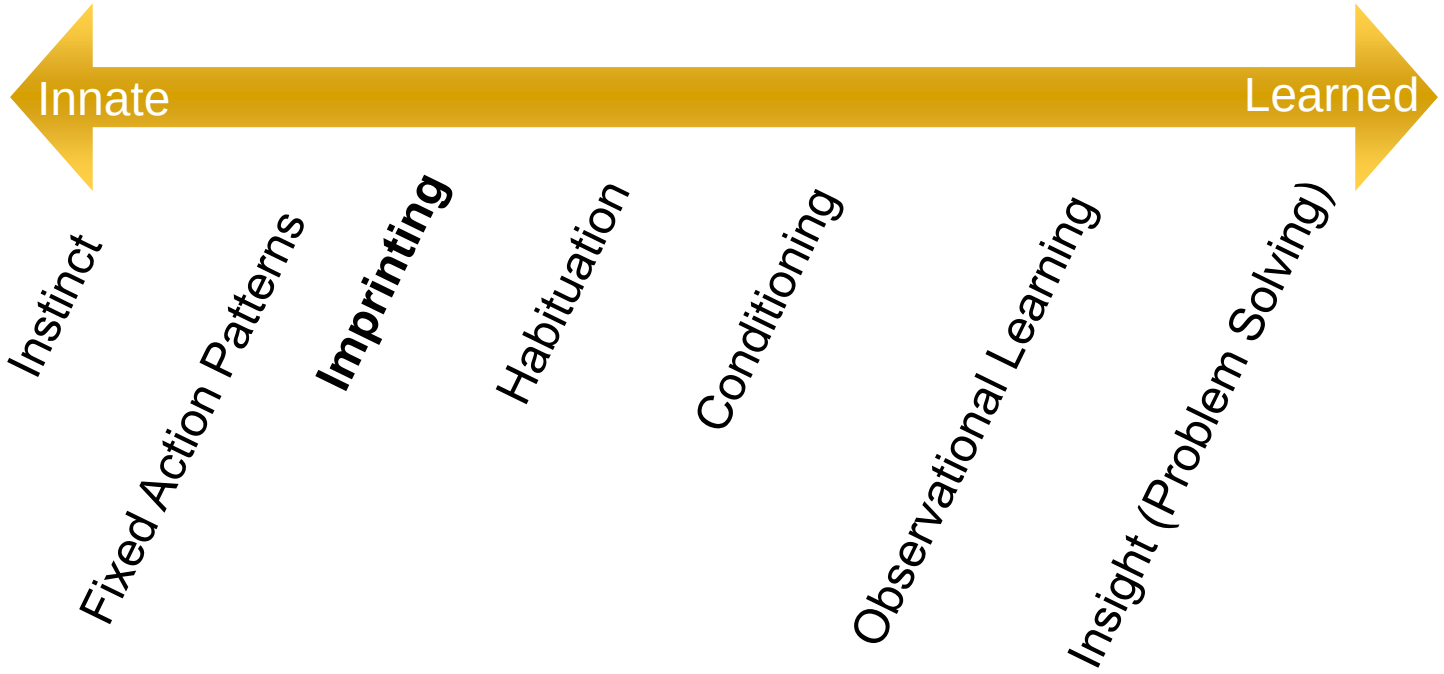
Stickleback – FAP; lab experiment with models

Fixed action pattern in stickleback- eperiments conclusions

- Will attack: as long as a red spot is present on the ventral part of the body (shape is not important)

- Will court if: white swollen belly (i.e. a pregnant female)

Types of behaviors



Learning who is your mother- Imprinting behavior

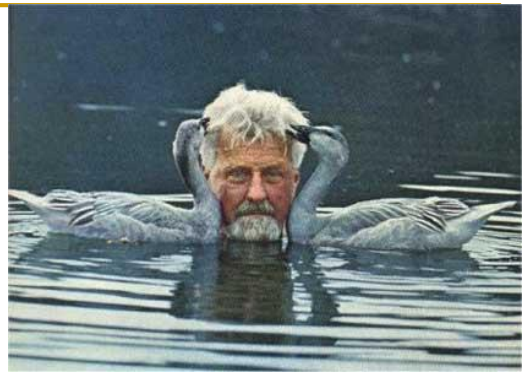
Imprinting- Konrad Lorenz

- A learned behavioral pattern that is dependent on innate mechanisms
- Learning that occurs during a critical period in the early life of an individual
- Irreversible

Imprinting field observation

- Behavioral observation: Geese hatchlings closely follow their mother
- Explanation: Mother-offspring bonding in animals is crucial to safety & development of the offspring
- Hypothesis: Geese hatchlings follow the first thing they see moving

Lorenz's imprinting experiment



Experiment: A clutch of goose eggs was divided between the mother goose and an incubator (treated by Lorentz).

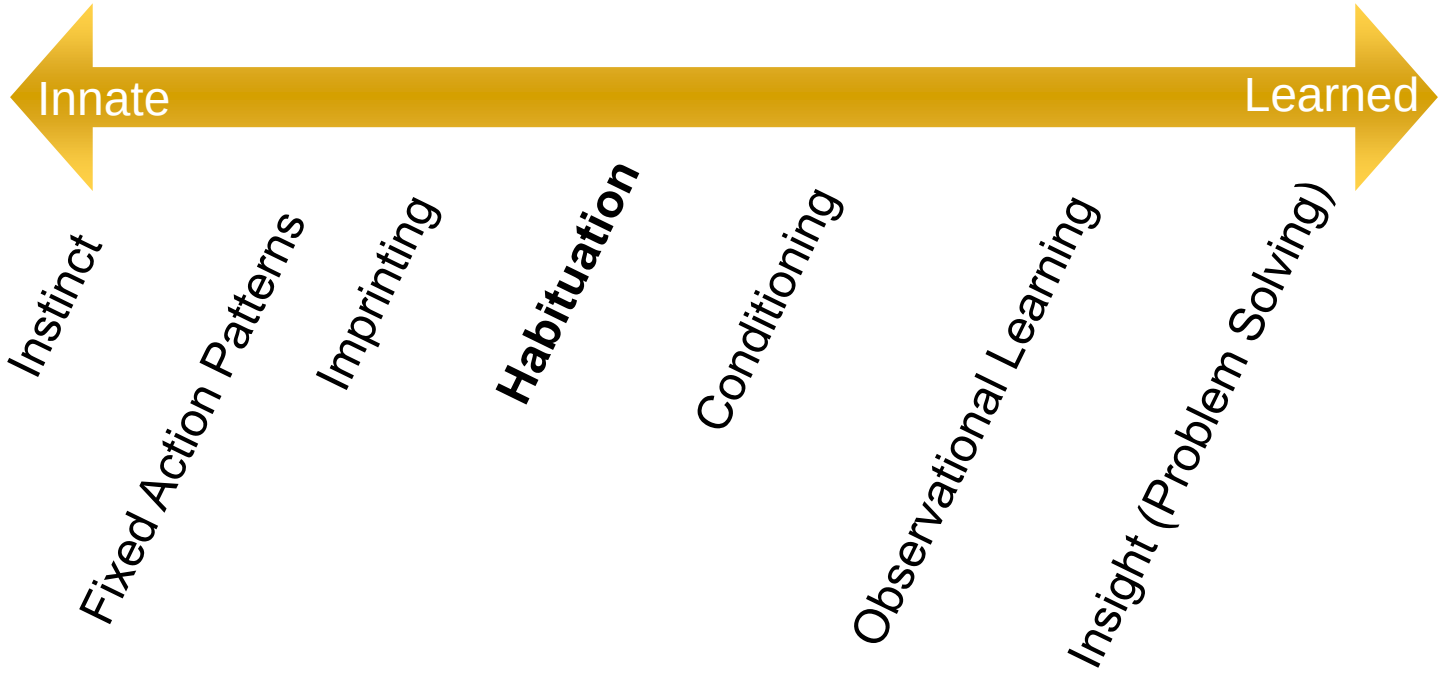
Results: Goslings reared by the mother behaved normally and mated with other geese.
-Goslings that spent their first hours of life with Lorenz followed him and even tried to mate with humans.

Conclusions: Goose have no innate sense of "mother" or "gooseness".
-They identify with and respond to the first object with certain characteristics they encounter.
-The ability or tendency to respond is innate.

Imprinting for conservation

Conservation biologists have taken advantage of imprinting by young whooping cranes as a mean to teach the birds a migration route.

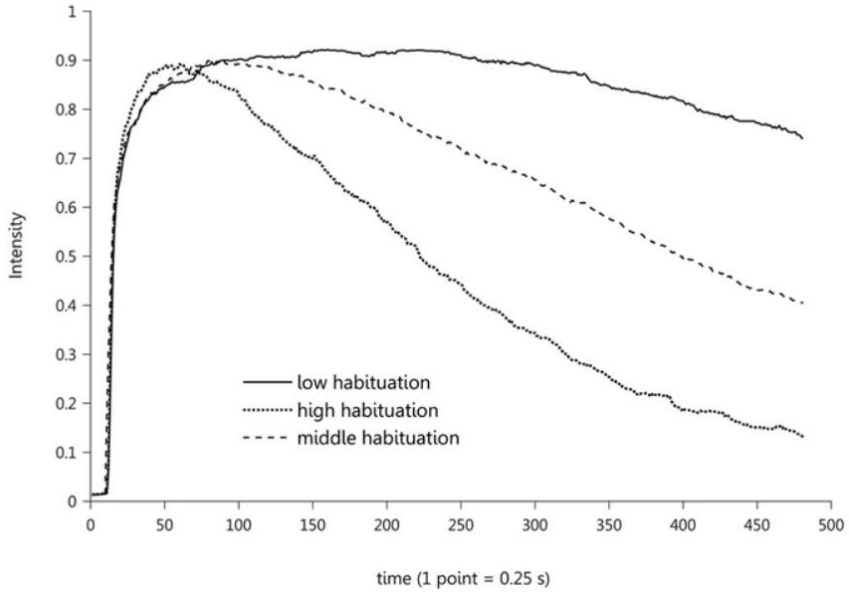
Types of behaviors

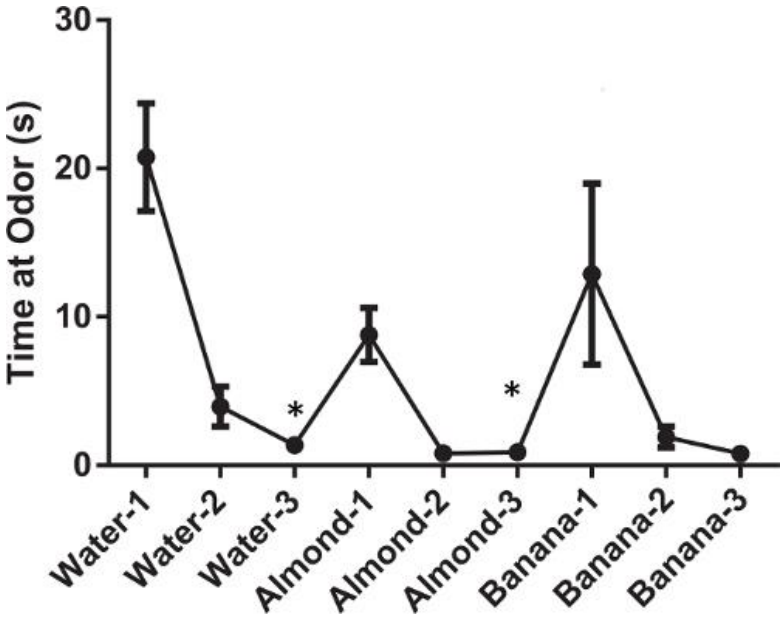


Habituation – Reduction of innate responses

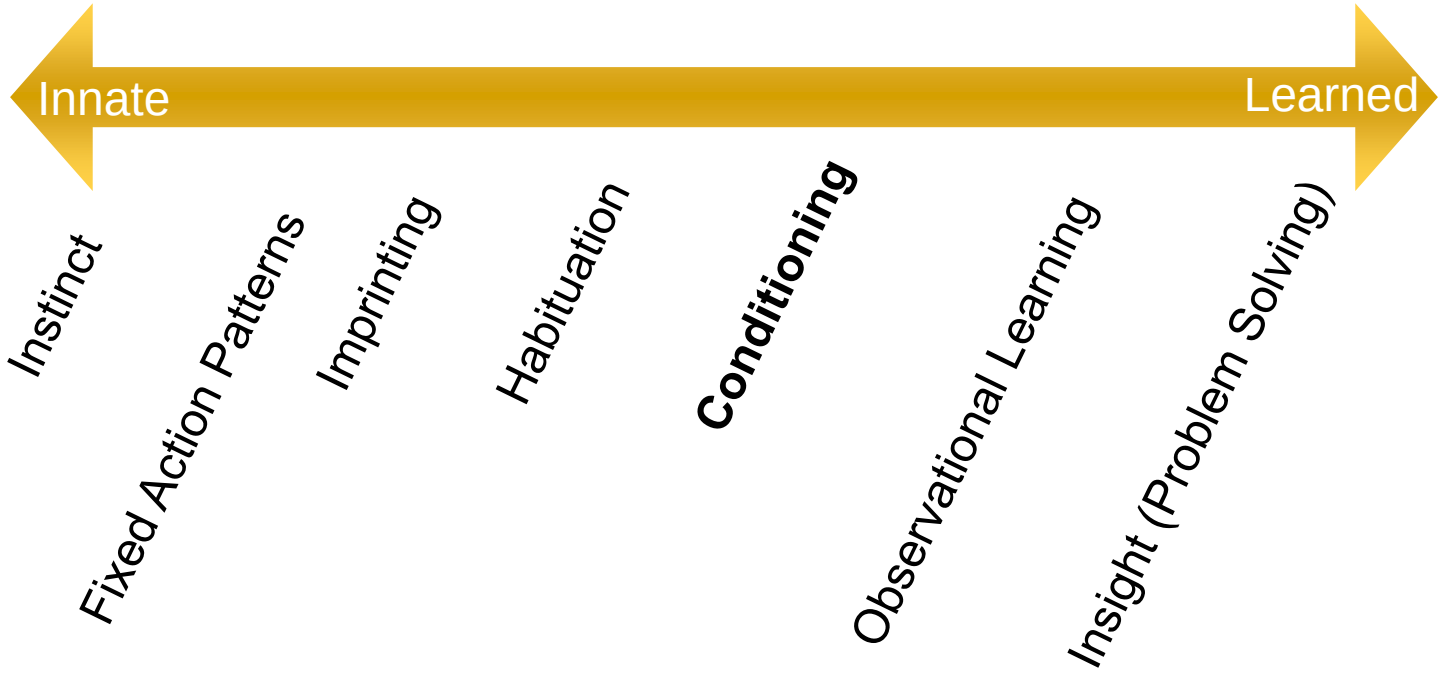
Prolonged exposure to scarecrow

Habituation to odors

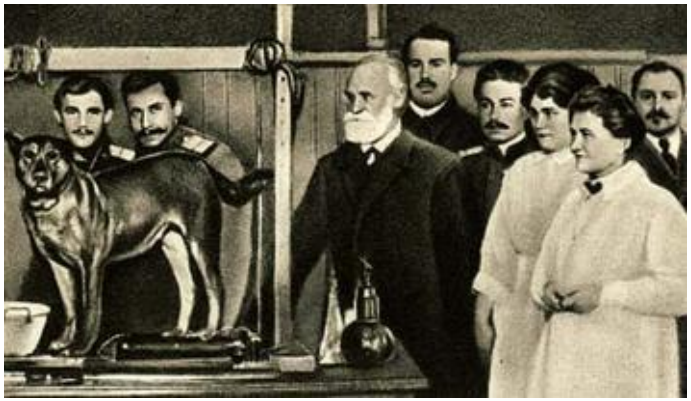




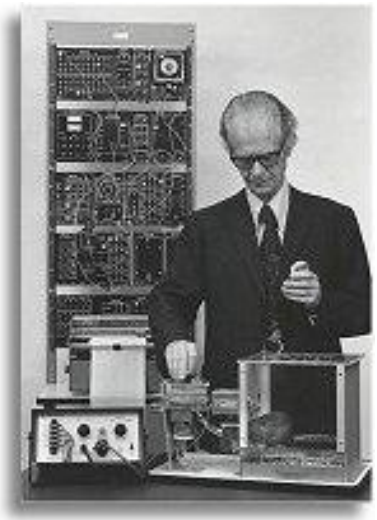
Types of behaviors



Experimental studies of conditioned behavior in the laboratory



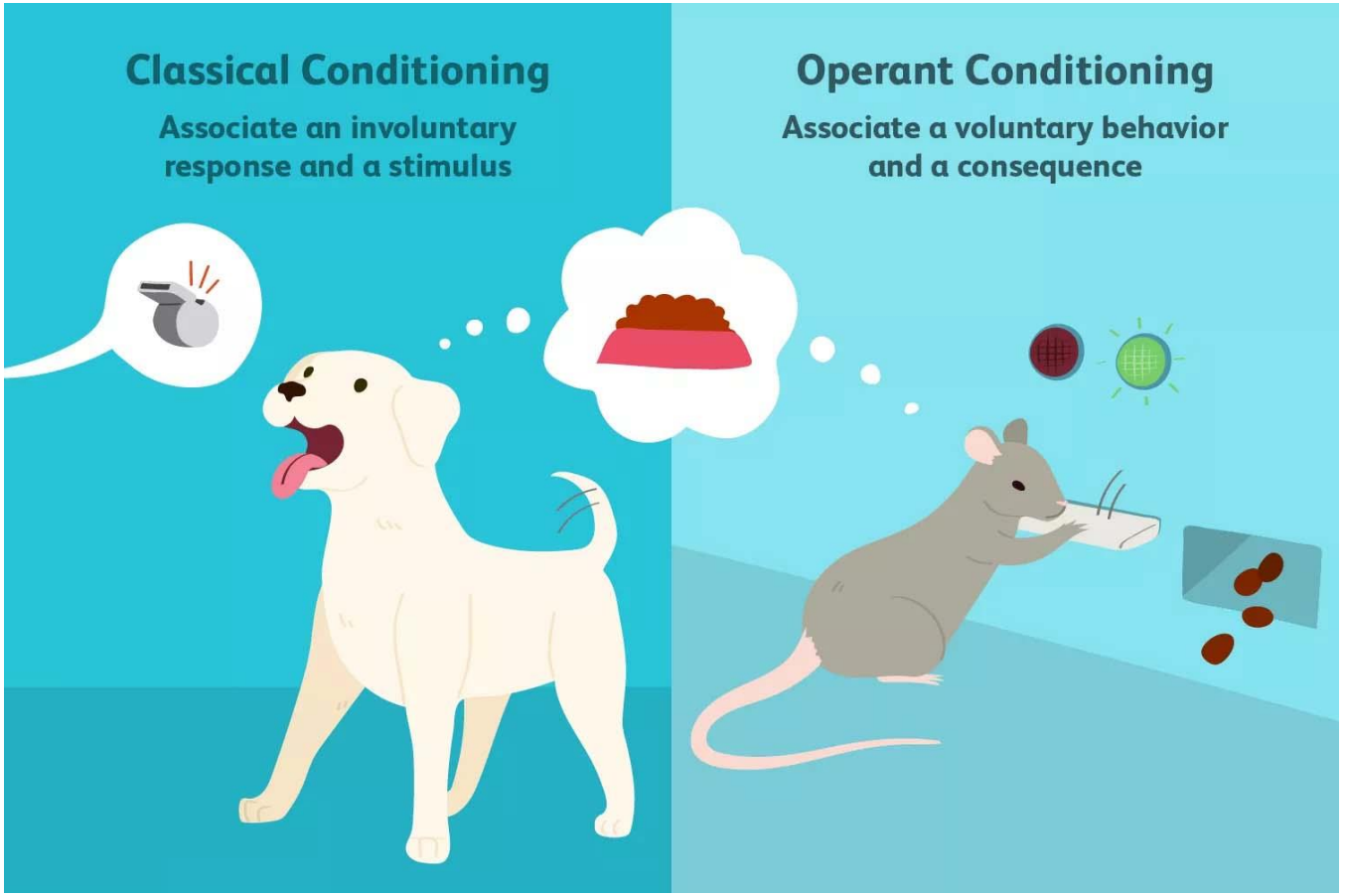
Ivan Pavlov (1849-1936)



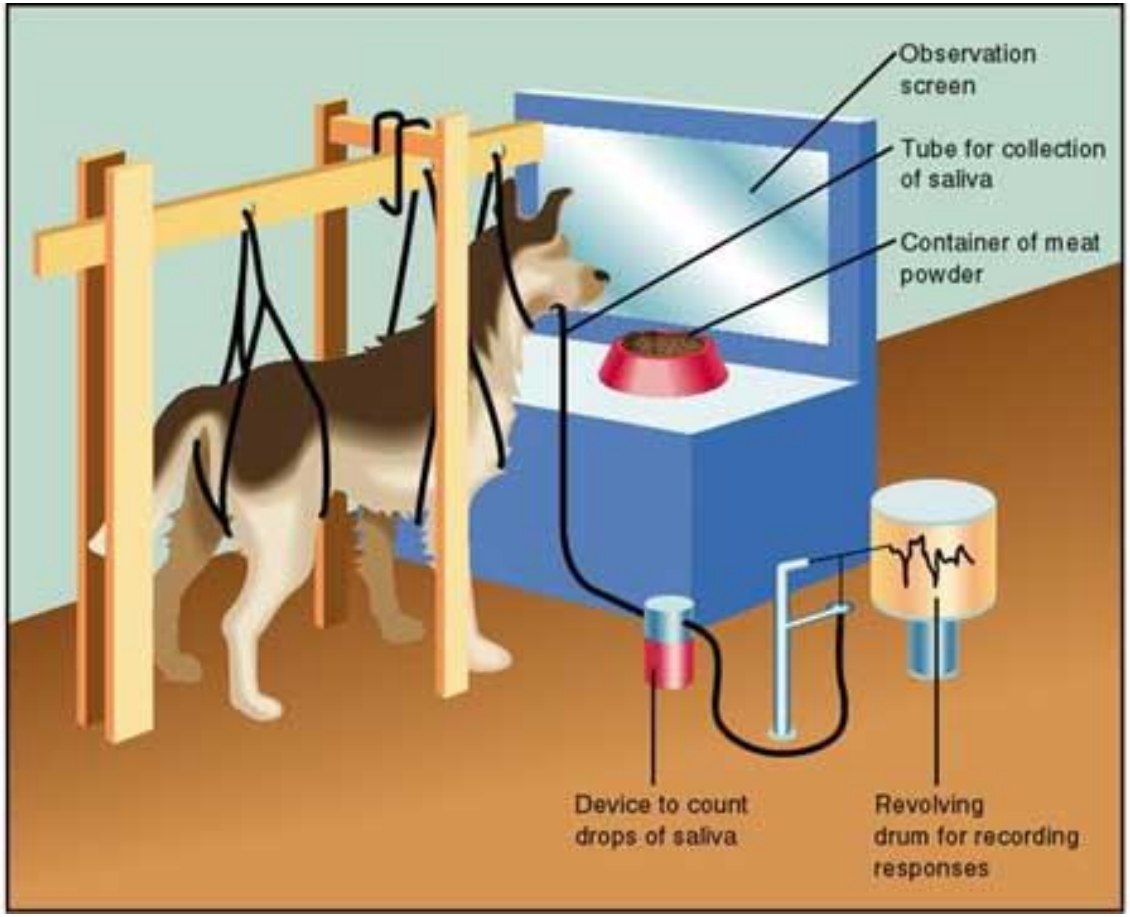
Burrhus Frederic Skinner (1904-1990)

Pavlov

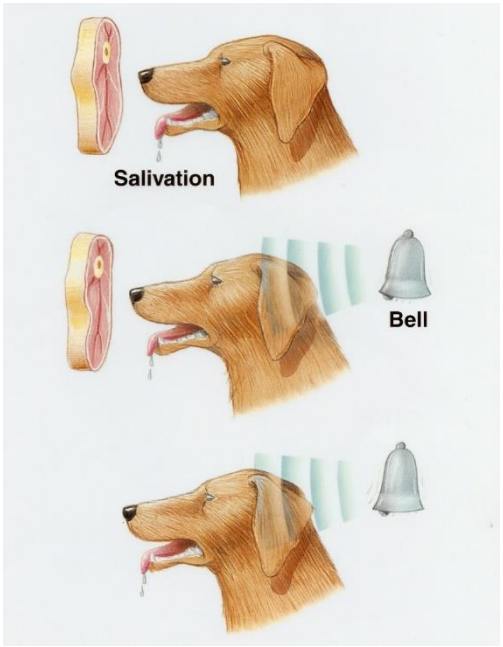
Skinner

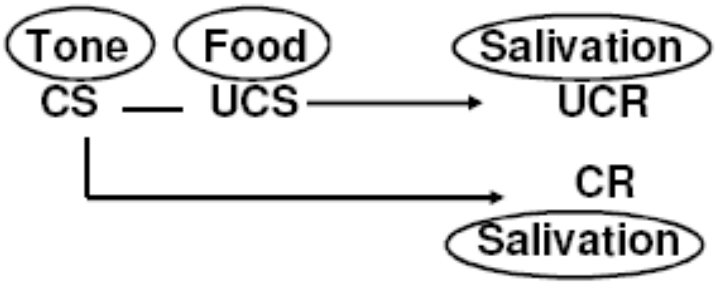


Pavlov's classical conditioning experimental setup



Pavlov's Classical Conditioning





Before Training/Conditioning

Food → Salivation

Tone → ???? (nothing)

During Training/Conditioning

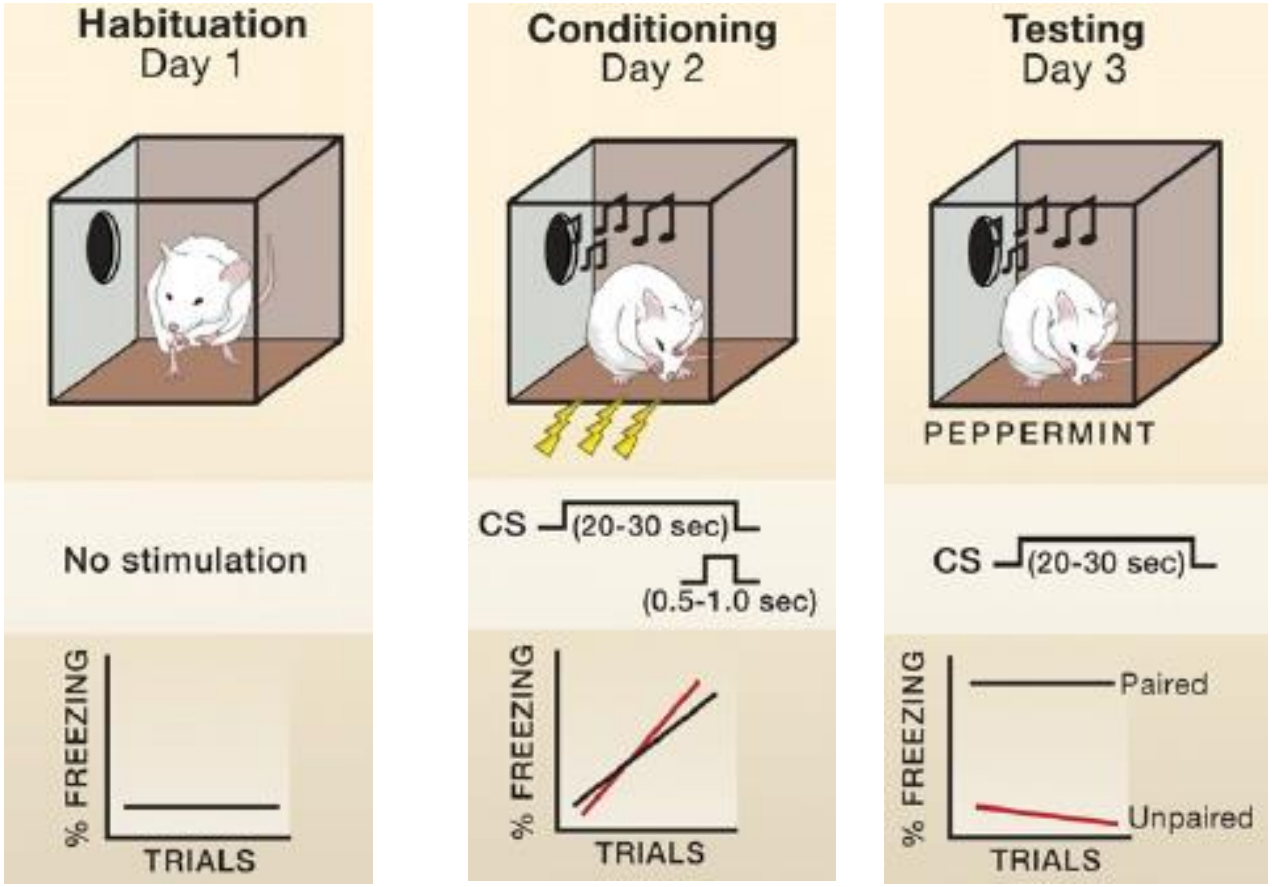
Tone — Food → Salivation

After Training/Conditioning

Tone — Food → Salivation

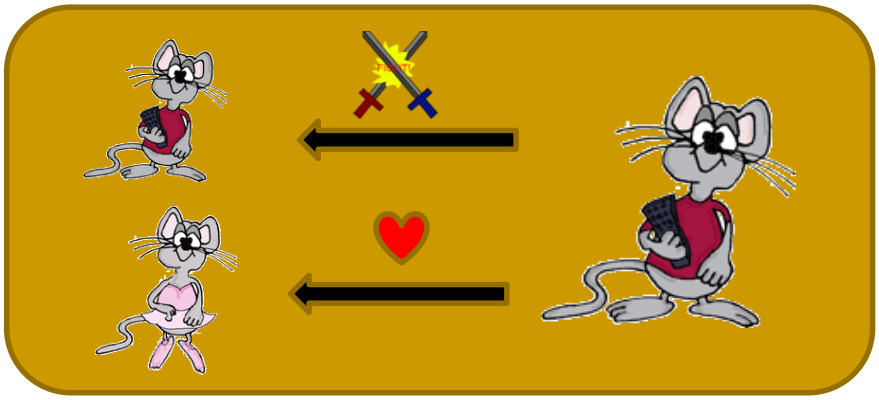
Salivation

Negative Classical Conditioning



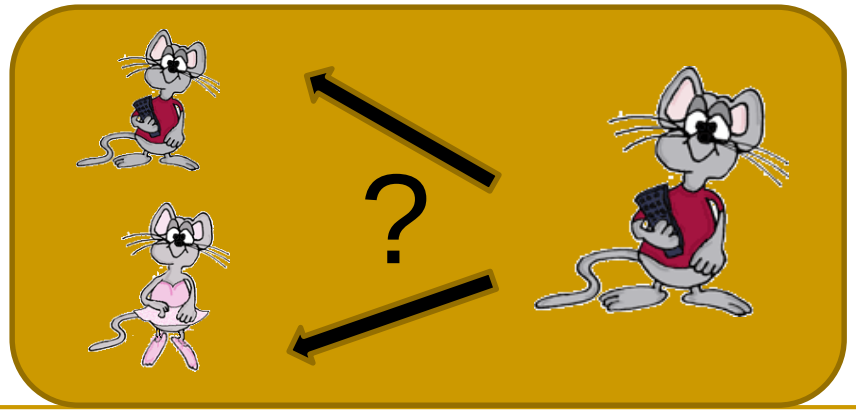
Jonathan et al 2011; Cell

Classical conditioning on innate social behavior



Conditional sex-specific pheromonal aversion

Associating female odor to a mild stomach ache /nausea

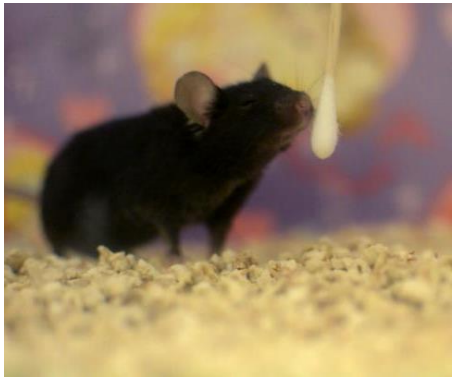


Conditioned taste aversion

LiCl injection

Conditioned odor (pheromone) aversion

Exposure to female pheromones



LiCl injection

Sexual behavior assay

Negative conditioning altered innate sexual preference/behavior in males

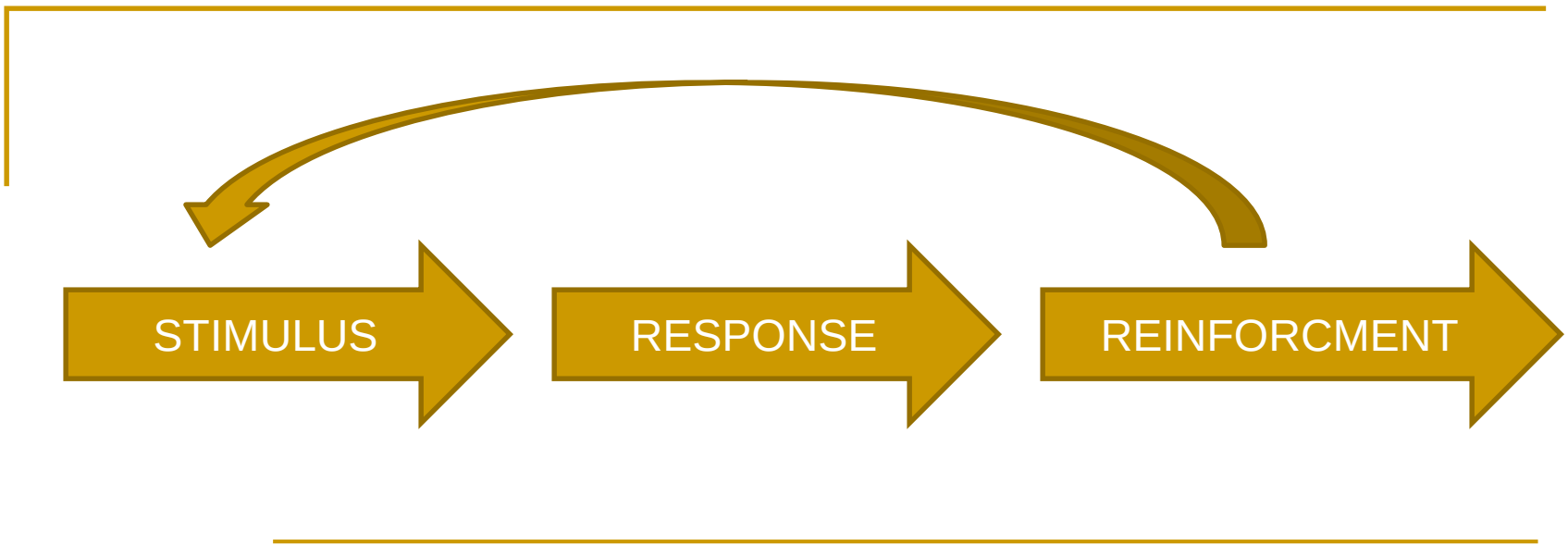
Operant Conditioning

"Everything we do and are is determined by our history of rewards and punishments."-BF Skinner

•A process where an animal learns to associate one of its behaviors with a reward or punishment and then tends to repeat or avoid that behavior

•In contrast to classical conditioning the response is voluntary (it is NOT a reflex) and the animal must do something to gain a reward (or avoid punishment)

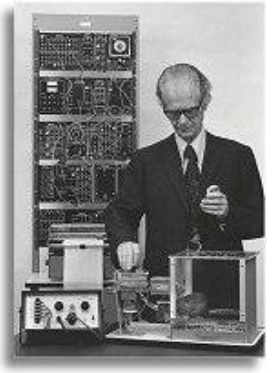
Skiner's Operant Conditioning

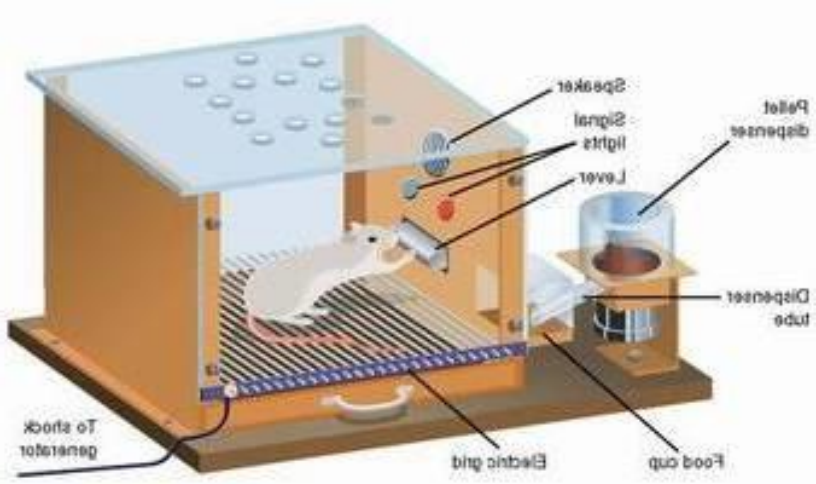


If your behavior is followed by a positive consequence, you are more likely to repeat the act in the future.

If it is followed by a negative consequence, you are less likely to repeat it.

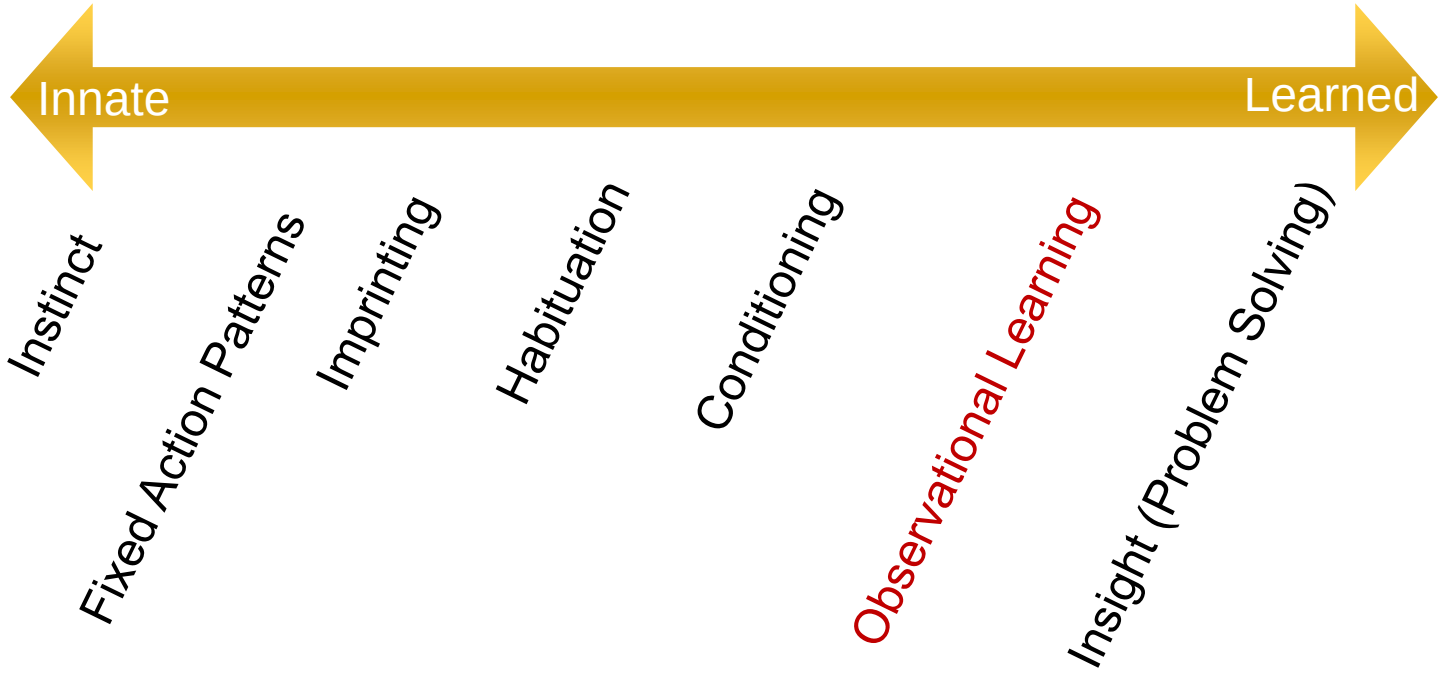
Operant Conditioning: The Skinner Box





Positive operant conditioning in pigeons

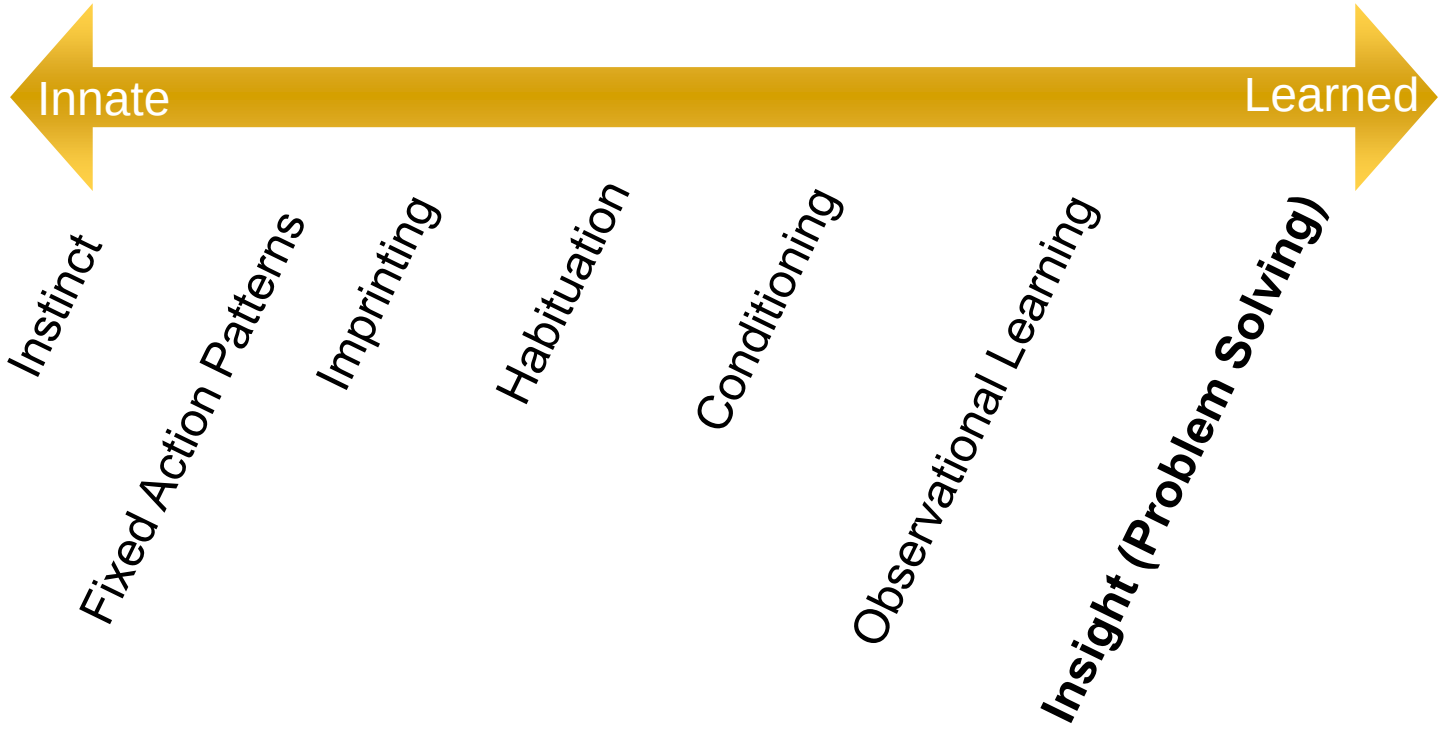
Types of behaviors



Observational Learning – Cultural transmission

Some Japanese monkeys learned to wash food before eating in 1950s, the effect still persists in the group

Types of behaviors



Insight (problem solving)- Chimpanzees use boxes to reach food

Insight – Chimpanzee build tools- field observation

Jane Goodall

Insight – Caledonian crow tool building in nature

From Ethology to Neuroethology

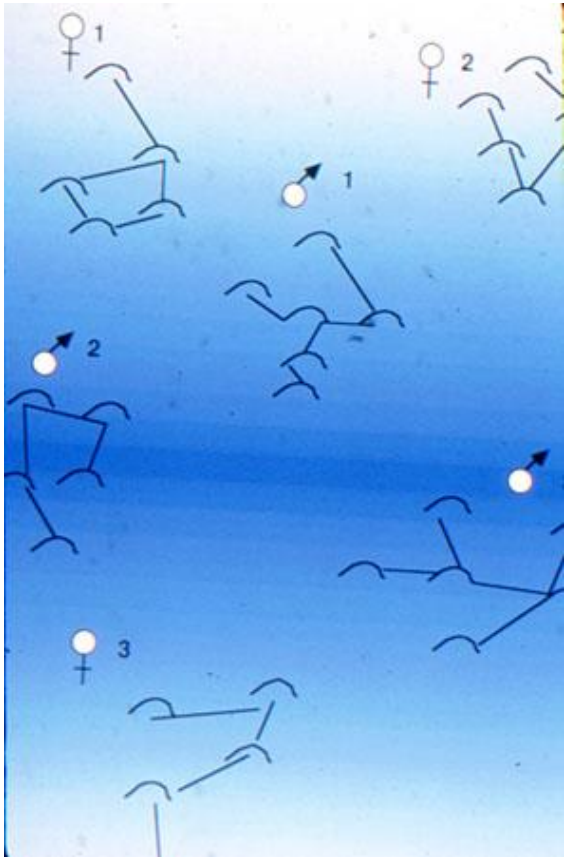
A discipline that combines the study of animal behavior and study of neuroscience, to inquire how the brain controls behavior in wild-derived animals, using lab conditions mimicking the natural environment.

The neural basis for seismic social communication

The blind mole rat (*Spalax ehrenbergi*)

Sensory adaption to the underground niche

How do blind mole rats communicate with each other (find their mate/ avoid aggressive)?



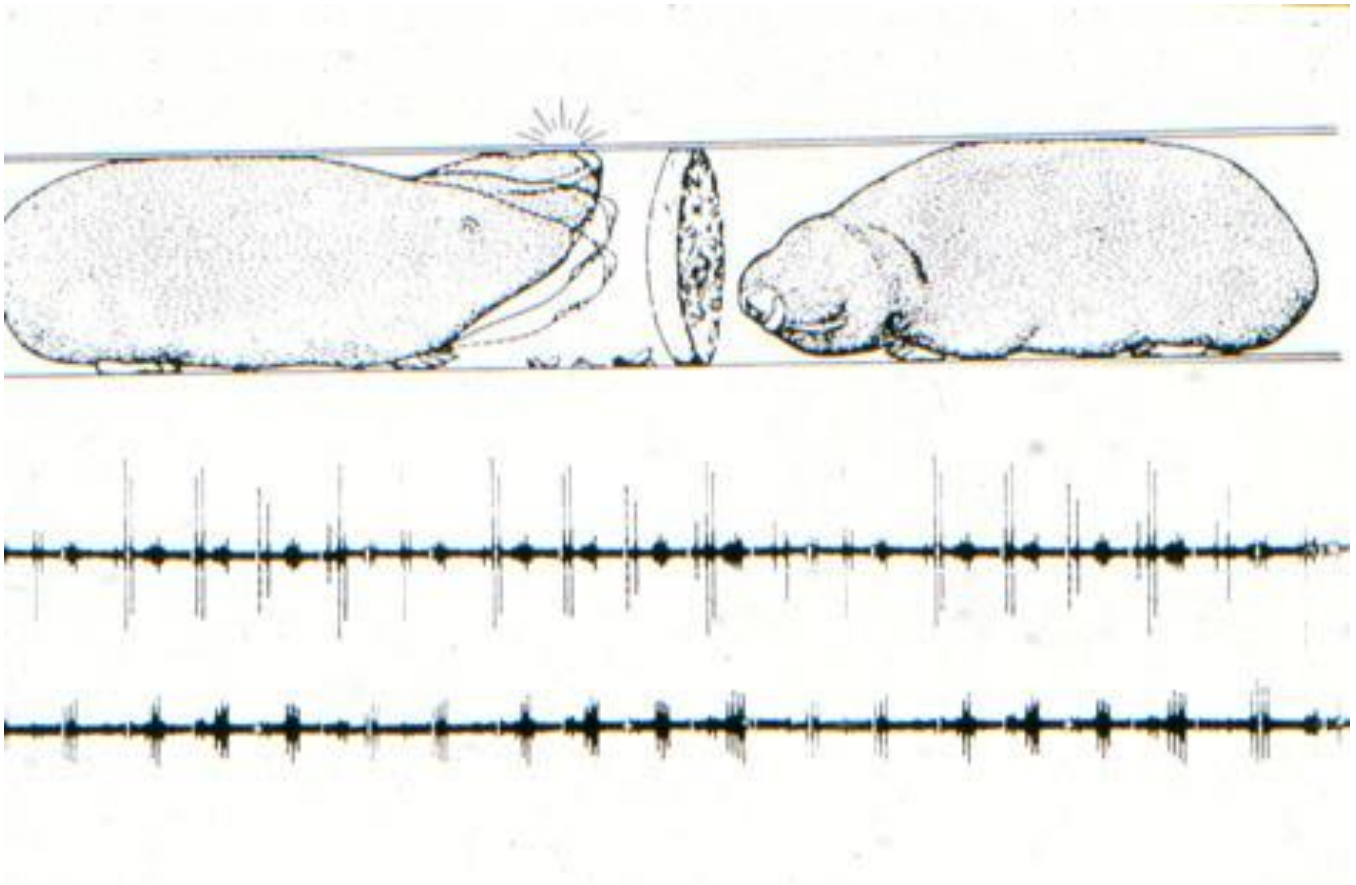
Behavioral observations:

Mole rats produce head drumming
Mole rats often press their lower jaw to the tunnel side

Hypothesis:

Mole rats communicate using soil-borne vibrations

Social communication in the blind mole rat



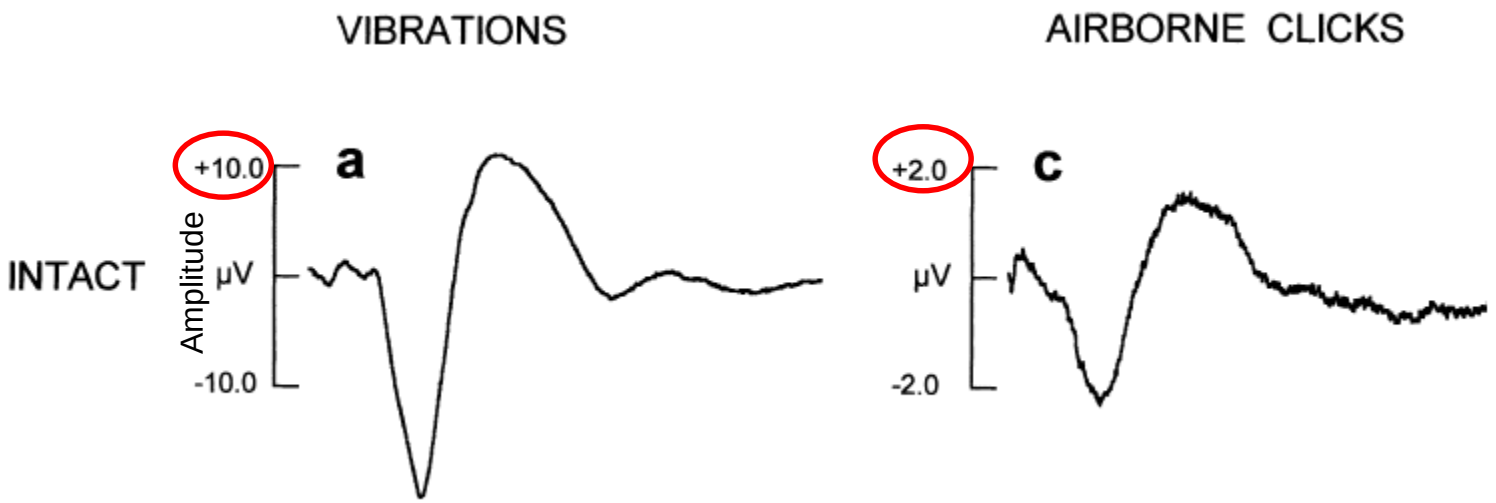
Seismic social communication in blind mole rats

Lab experiments in the blind mole rat

Does head drumming perceive by the mole rat as air borne sounds or seismic signals?

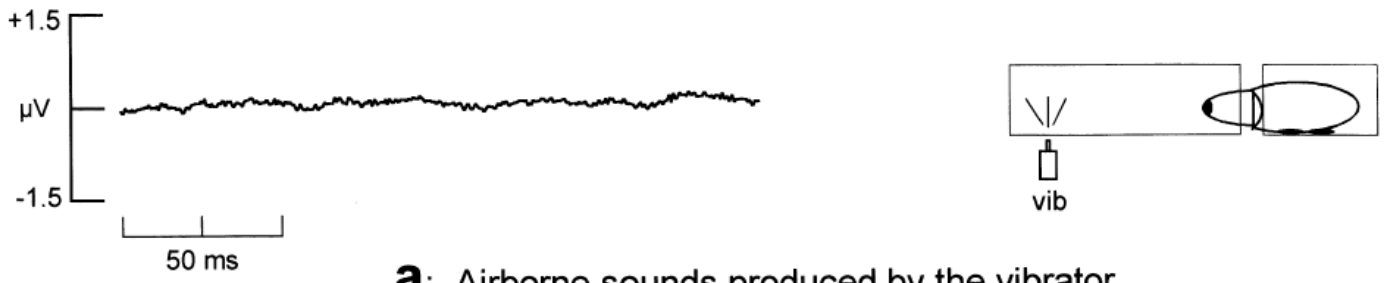
Rado, R (1998); J Comp Physiol

Recording the response of the auditory system (the MLR) in mole rat following auditory and seismic signals

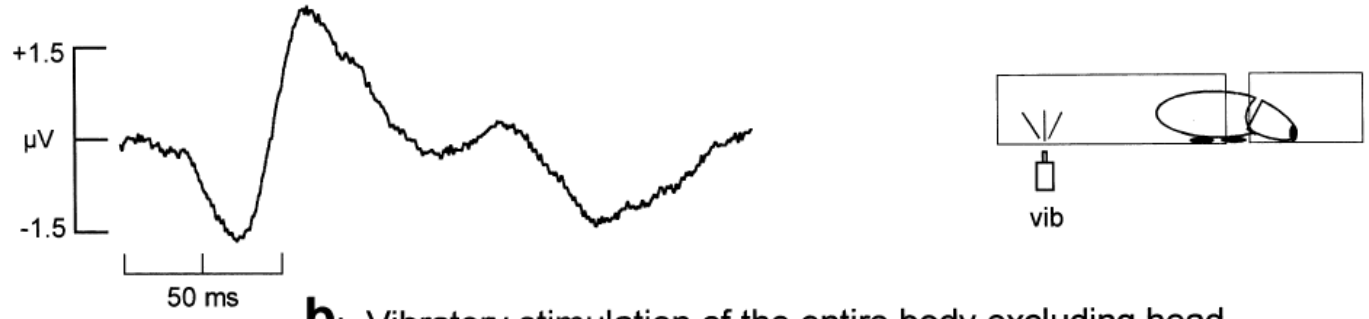


Middle latency response (MLR):
response of the auditory pathway occurring 20±70 ms after an auditory stimulus

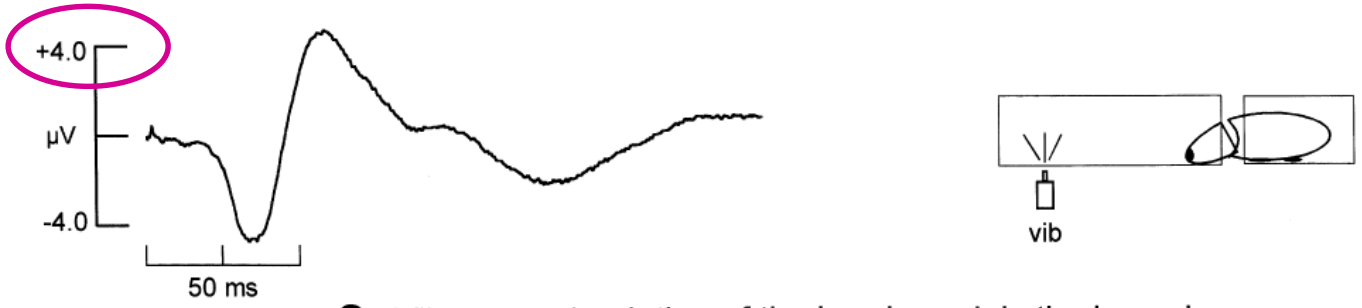
Rado, R (1998); J Comp Physiol



a: Airborne sounds produced by the vibrator

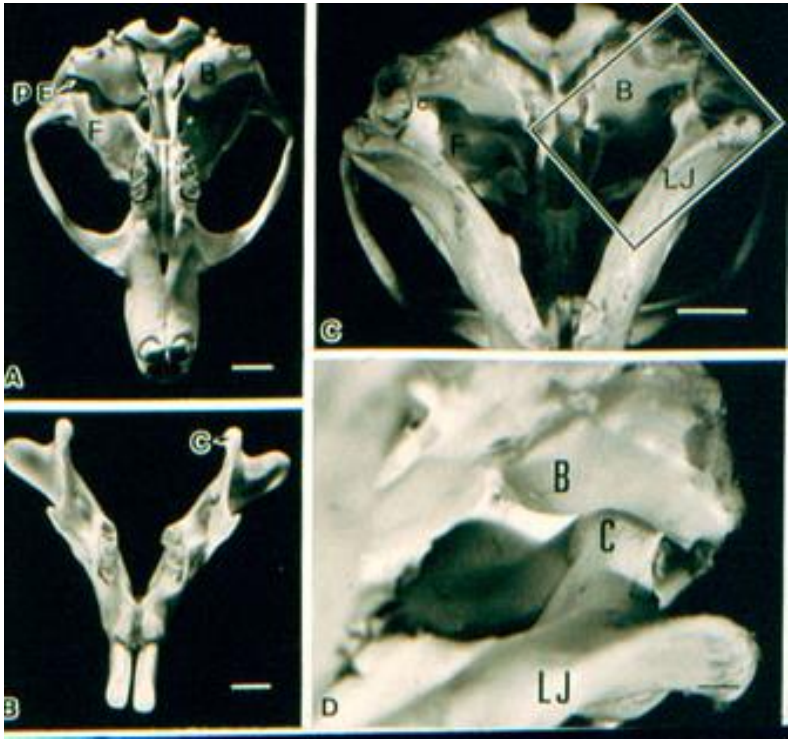


b: Vibratory stimulation of the entire body excluding head



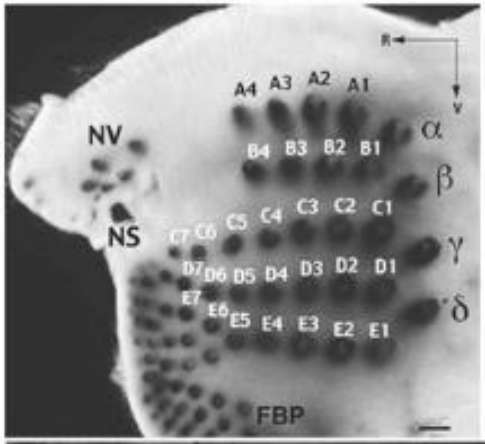
c: Vibratory stimulation of the head - mainly the lower jaw

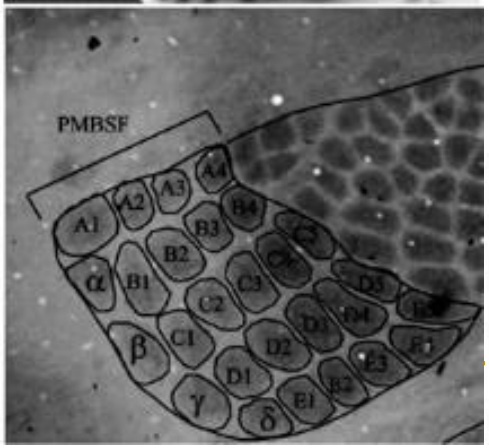
Seismic signals are detected via bone conduction, through the lower jaw

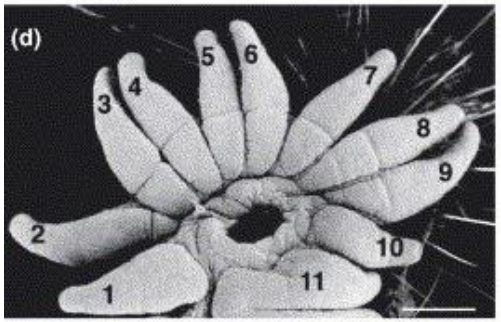


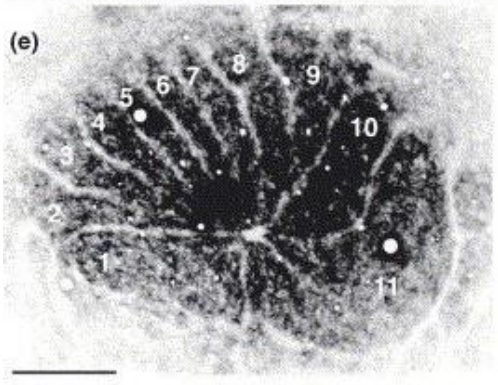
Neuroethology – Brain structure

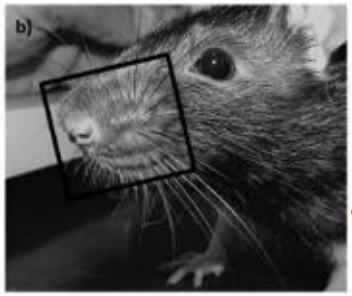
Umwelt of animals
and their brain
(Somatosensory cortex)

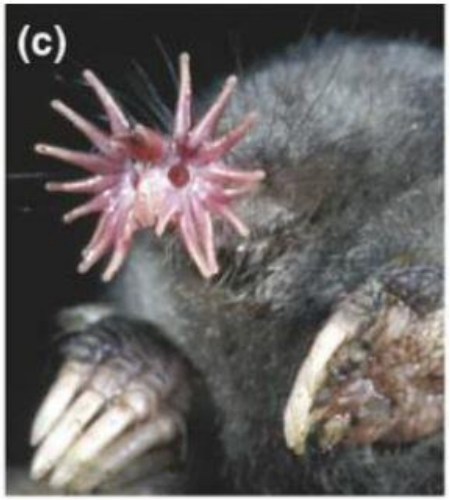


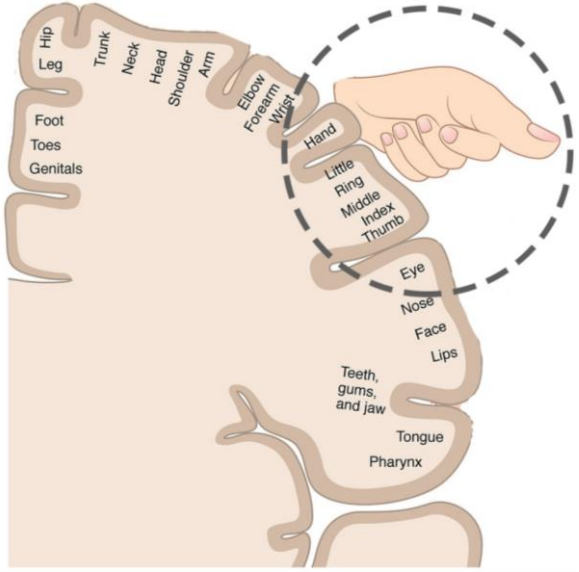






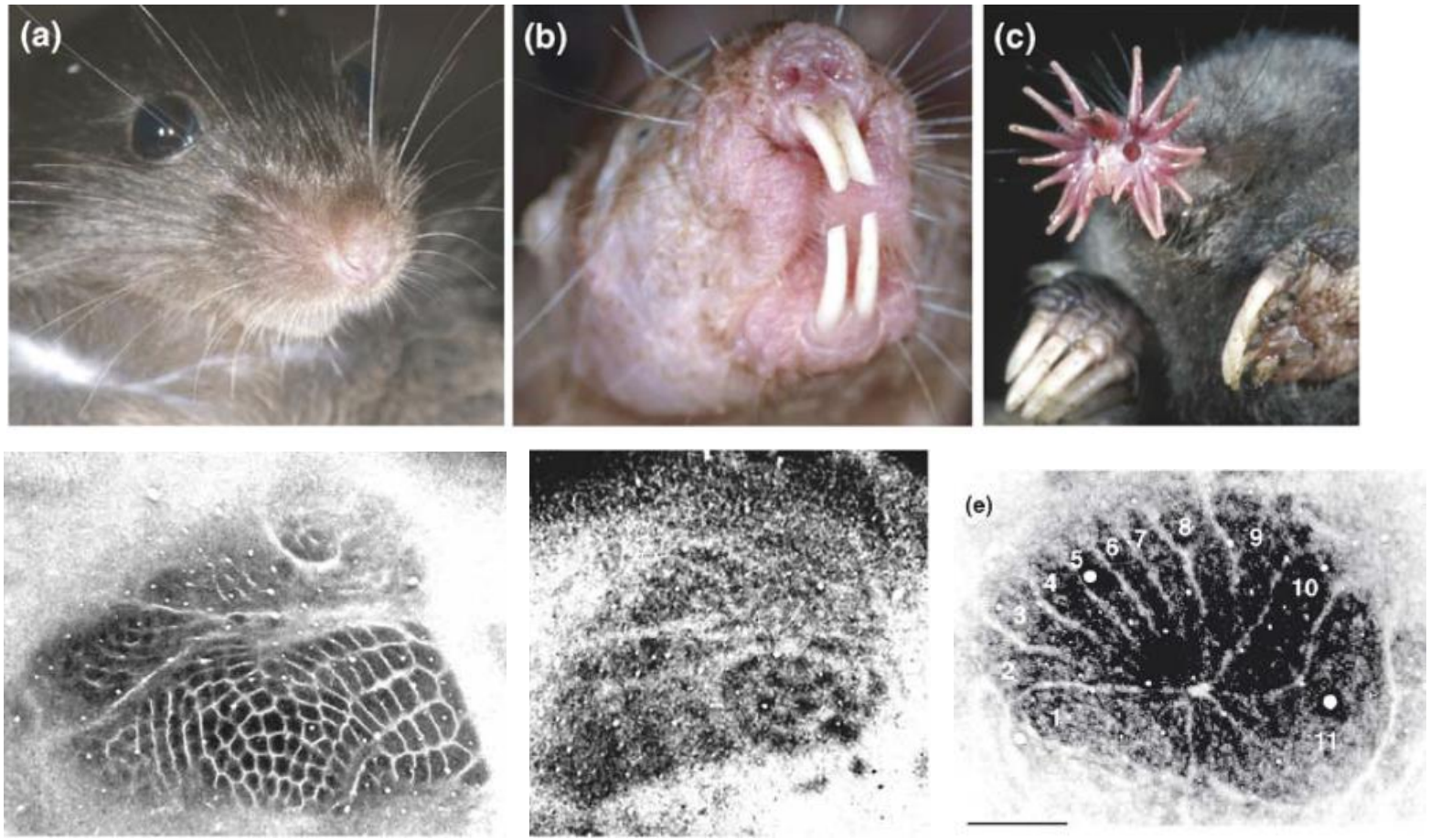






Species-specific somatosensory map in the cortex

Mouse | Naked mole rat | Star mole



Catania and Henry 2006, Curr Opin Neurobiol

The neuronal basis of pair bonding in voles

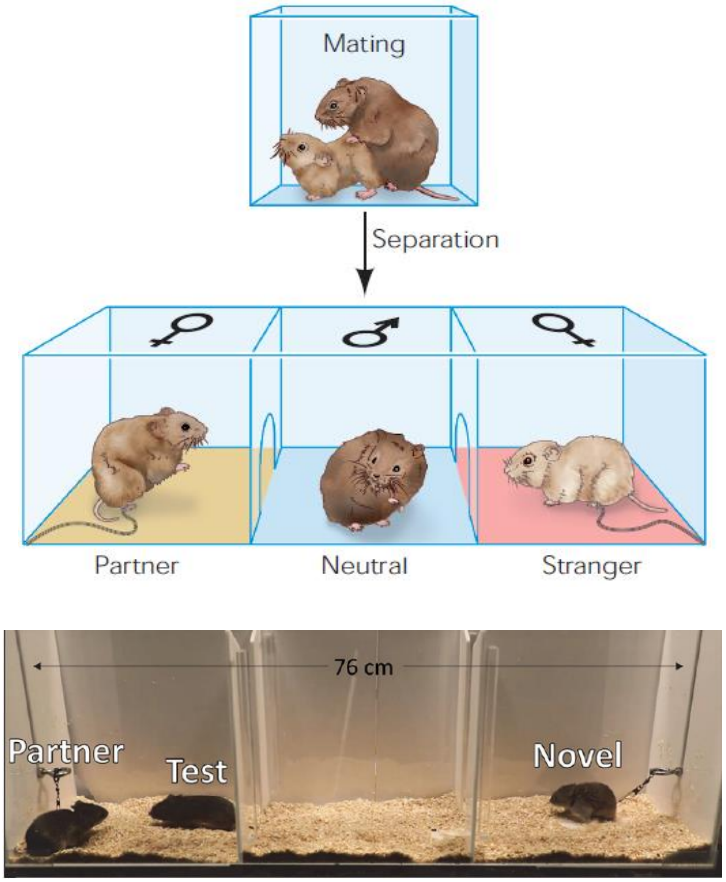
Pair bonding and social behavior in voles

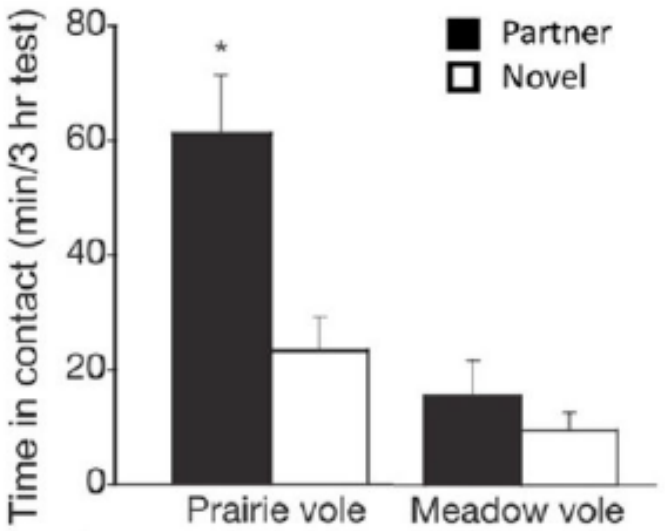
Prairie voles

- Highly social
- Monogamous
- Spend most of their time in social interaction

Montane/Meadow voles

- Avoid social contact except for the purpose of mating
- Polygamous
- Spend ~5% of their time in social interaction





Hemanth et al 2006

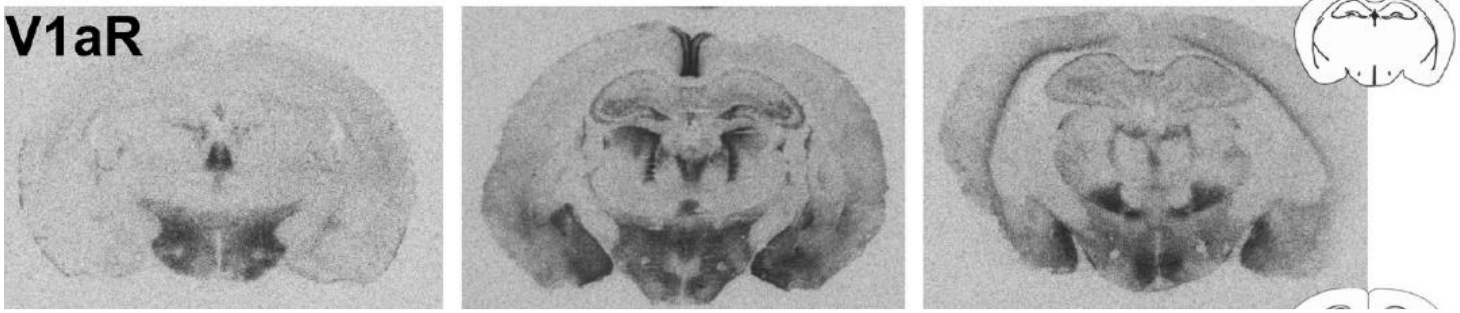
Sadino and Donaldson, 2018

Diversity in V1aR expression in across rodent species

Mouse (Mus)

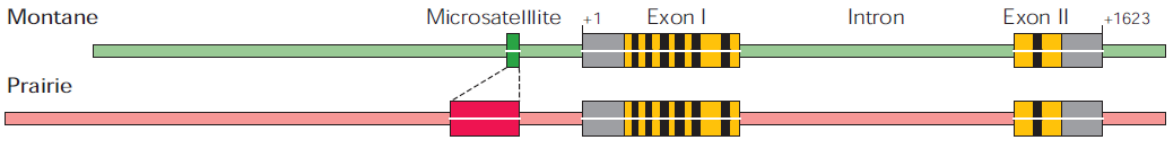
Prairie vole

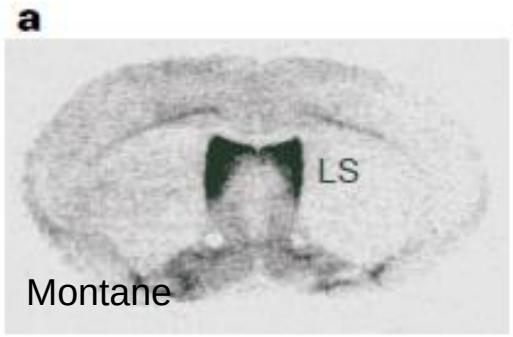
Meadow vole

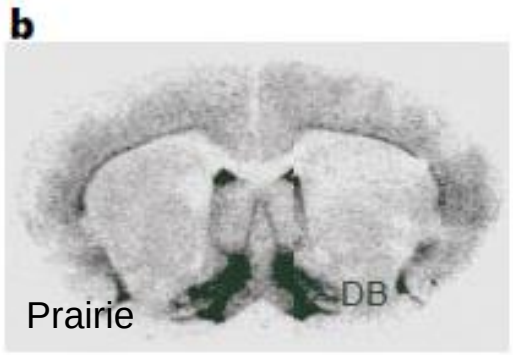


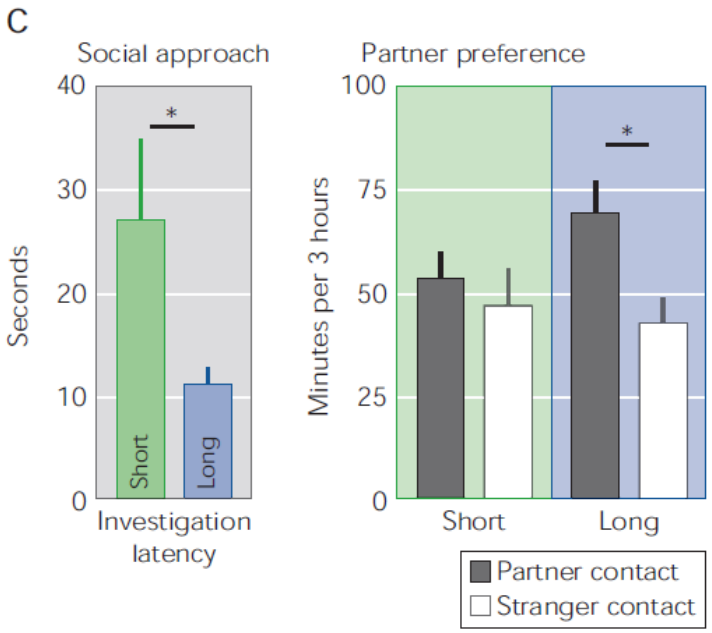
Sadino and Donaldson, 2018

Polymorphism in V1aR microsatellites generate differences in the brain and in social behavior





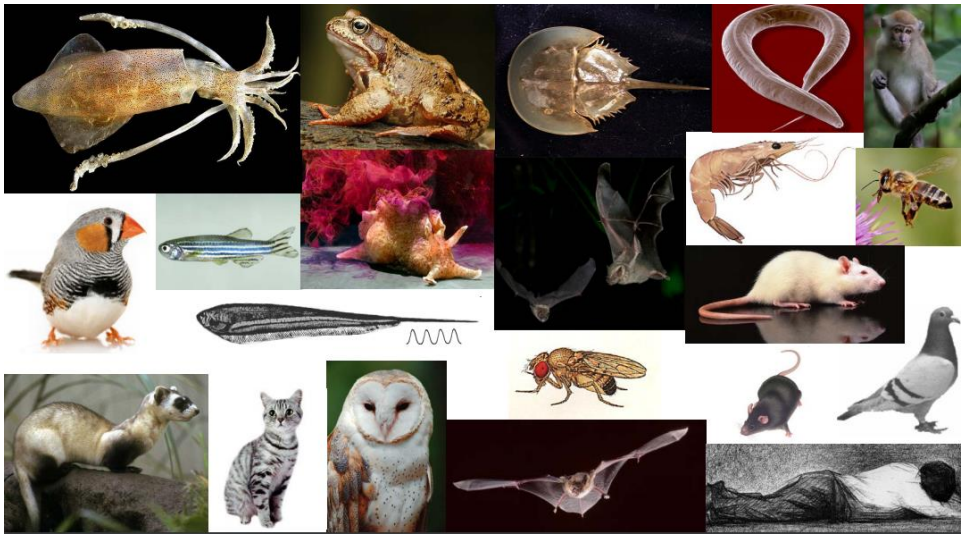




Hammock & Young, 2005 *Science*

Neuroethology- working guide

- Choice of suitable animal model
- Use experimental paradigms suitable to the animal sensory perceptions and natural conditions
- Use naturalist settings adapted to animal umwelt



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