Introduction to Neuroscience: Behavioral Neuroscience

Lecture 1: Introduction to Animal Behavior

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Processing & integration of sensory information is crucial for survival and successful breeding.

Defending territory

Predator avoidance

Food finding

Mate finding
“Umwelt” is the organism’s model of the world: the perceived things in the world, the signals emitted by both the subject and things, and the actions that are performed by each species.

- These information is perceived by set of sensory channels that are specially adapted to the species survival needs and its niche (biotic and abiotic components).

Von Uexküll (1921) intended his idea of the umwelt to apply principally to physical stimuli (i.e. it can be water, food, shelter, potential threats, or points of reference for navigation).

Lorenz (1935) extended this concept by recognizing that animals also have a social umwelt since signals from other individuals can have important influences on their behavior.

**ANIMAL BEHAVIOR**
What is Animal Behavior?

The study of *how* and *why* animals interact with each other (both within and among species) and their environment.

**Proximate perspective**
- How is that...?
- What is that...?

**Ultimate perspective**
- Why is it that...?

**BEHAVIOR**

Studying the mechanisms responsible for interactions (behavioral act)

How these interactions influence an individual's survival and reproduction
Darwin’s theory of natural selection of behavior (ultimate prespective)

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.
Darwin realized that some (behavioral) traits directly relate to mate acquisition and mate choice.

He termed this evolutionary process “sexual selection”.

Sexual Selection “...depends on the success of certain individuals over others of the same sex, in relation to propagation of the species...”

Charles Darwin 1871
Example: Sexual selection of behavior
The Lyrebird courtship behavior
Founders of animal behavior study in the natural habitats (Ethologist)

Niko Tinbergen (1907-1988)

Konrad Lorenz (1903-1989)

Karl von Frisch (1886-1982)

The Nobel Prize in Physiology or Medicine 1973
"for their discoveries concerning organization and elicitation of individual and social behavior patterns"
Two ways to study animal behavior

It's a rather interesting phenomenon. Every time I press this lever, that post-graduate student breathes a sigh of relief.
Karl von Frisch

• Pioneered studies in bee communication and foraging.

• Demonstrated that honey bees use a dance language to communicate the location of food resources to other bees.

• The waggle dance uses for communicate the position of a distance food source.

• This dance communicates both the distance and direction using the sun, the hive, and the food source as reference points.
Honey bee waggle dance
"It takes a very long period of observing to become really familiar with an animal and to attain a deeper understanding of its behaviour; and without love for the animal itself, no observer, however patient, could ever look at it long enough to make valuable observations on its behaviour."

Konrad Z. Lorenz, 1960
Imprinting

• Early recognition of the same group (morphology and behavioral pattern).
• Include both learning & innate components, and generally irreversible.
• Has a sensitive period (i.e. acquired during a limited critical period right after birth).
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 preferred humans for the rest of their lives and even tried to mate with humans.

Conclusions: Greylags 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.
Fixed Action Pattern (FAP) and Instinct behavior:

• In response to an external sign stimulus (a releaser) the organisms will initiate a fixed (unchangeable) responses which once begun must be carried to completion.

• FAP is innate (instinct) behaviour and highly stereotypically performed.

• In some cases, aspects of the FAP need to be learned (trained) in order to master the behavioral repertoire.
Nest finding behavior in wasp

How does the wasp find its way back to the nest after returning from a hunting trip?

• Tinbergen noticed that a wasp circle its nest in exactly the same way each time it flew away to hunt.

• He suggests that this fixed action pattern is used to gather visual cues that will be used later to locate the position of its nest.
Tinbergen's Experiment: fixed action pattern in wasp nest finding behavior
Fixed Action Patterns:
Egg-rolling behavior of the greylag goose

Fig. 69. Grey lag goose retrieving egg. After Lorenz and Tinbergen, 1938.

Fig. 70. Grey lag goose attempting to retrieve giant egg. After Lorenz and Tinbergen, 1938.
• 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.
FAP social behavior in three-spined stickleback
(Key visual sign stimulus releasing)
Fixed action pattern in three-spined stickleback

- Will attack as long as red spot present on the ventral body part.

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

Proximate perspective

How is that...?
What is that...?

Ultimate perspective

Why is it that...?

Studying the mechanisms responsible for interactions

How these interactions influence an individual's survival and reproduction
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 his 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.
Learned Behavior

- Often affects even innately programmed behaviors, e.g. Fixed Action Patterns.

Innate versus Learned behavior

- Behavior is modified by experience (trial and error pattern).
- Flexible- Phenotypic is changing with time/experience
- Often affects even innately programmed behaviors, e.g. Fixed Action Patterns.
Learned behavior
Learned behavior

A young chimpanzee learning to crack oil palm nuts by observing an experienced elder.
Instinct (innate) Behavior

- First time performance is completely functional
- Animals don’t have to witness the behavior (inborn)
- Uniform, stereotyped
- Triggered by simple sign stimulus (sensory releaser)
- It has a strong genetic (inherited) basis: control by pre-programmed fixed neurological circuitries
Innate behavior
Innate behavior of the Cuckoo bird
Innate behavior of the Egyptian Vulture
More animal behavior videos?
Innate or learned behavior?
Two ways to study animal behavior

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Experimental studies of animal behavior in laboratory conditions

Ivan Pavlov (1849-1936)

Burrhus Frederic Skinner (1904-1990)
Ivan Pavlov

The Nobel Prize in Physiology or Medicine 1904
For his research in temperament, conditioning and involuntary reflex actions of the digestive glands

Pavlov's experiment:
The original and most famous example of classical conditioning involved the salivary conditioning reflex of Pavlov's dogs.
Pavlov’s Classical Conditioning

Before Training/Conditioning
Food → Salivation
Tone → ??? (nothing)

During Training/Conditioning
Tone → Food → Salivation

After Training/Conditioning
Tone → Food → Salivation
Unconditioned Response (UCR): That unlearned reaction/response to an UCS without previous conditioning.

Conditioned Stimulus (CS): Is a previously neutral stimulus that, through pairing with the UCS, also eventually elicits a response.

Conditioned Response (CR): That reaction/response that occurs to the CS.
Pavlov’s Classical Conditioning
Skiner’s Operant Conditioning

The study of how behavior is affected by its consequence.

• 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 different to classical conditioning the response is voluntary (it is NOT a reflex).
Operant Conditioning: The Skinner Box

ABC
- Antecedent (previous event)
- Behavioral action
- Consequence
Neuroethology: Neural Basis of Behavior

Diagram showing the neural basis of behavior with the following components:
- Environment
- Sensors
- Motor Control
- Neural Integration
- Brain
- Body
- Effectors
- Organism

The diagram illustrates the interactions between these components, highlighting the integration of sensory processing and motor control within the organism's body.
Mole rat - side view
Mole rat - Front view
Two patterns of mole rat mounds in Israel
Burrows excavations is both costly and difficult

- High energy cost: up to 3400 times more than moving on surface
- High CO₂ pressure (~13.5%) and low O₂ pressure (~5.5%)
- High risk of body overheating (unventilated niche)
- High risk of losing water and consequent dehydration (food is the only water source)
Mole rat sensory perception
How does the blind mole rat orient underground (avoid obstacles)?
Type of bypass for different obstacles

*Naturwissenschaften; Animal Behaviour*
Mole rats are able to assess:

The dimensions and density (air vs. stone) of underground obstacles and their relative distance from the obstacle boundaries.
Do mole rats use seismic echolocation for spatial orientation?
Seismic signals produced by mole-rats during bypass burrowing

Kimchi, Reshef and Terkel, 2005. *Journal of Experimental Biology*
Computer seismic simulator modeling

Seismic signals produced by mole-rats during bypass burrowing

Synthesized seismic source wavelet

Underground obstacle

Mole-rat’s underground habitat (soil density of 1.1 gr/cm³)

300 Hz seismic pulse

Reflection
How does the blind mole rat communicate with each other (find their mate/ avoid aggressive males)?
Airborne Sound is Quickly Attenuated in Soil

![Graph showing the attenuation of total sound level (L_{Aeq}) with distance from the source. The graph includes three curves representing minimum, mean, and maximum attenuation. The x-axis represents distance from the source in meters, and the y-axis represents total attenuation in dB.]
Middle latency response (MLR) MLR is thought to represent the synchronous firing of neurones in the primary auditory cortex to an acoustic stimulus.
Middle latency response (MLR)
Middle latency response (MLR)

Jaw is barely touching the tube

Jaw is laying on the tube

Jaw is firmly pressed against the tube surface
Middle latency response (MLR)
Effect of bilateral deafening on the mole-rat head-drumming behavior

(A) Drumming mole rats (% of total)

(B) Head drumming bursts

Post-deafening time (weeks)
Vibration frequency

Rate: 0.5/s

Rate: 7/s

Middle latency response (MLR)

Single cell recording in the auditory cortex
Animal Communication