Introduction to Neuroscience – Behavioral Neuroscience

Animal Behavior & Neuroethology

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Outline

What is behavior?

What are the different aspects in the study of behavior?

Types of behavior

Neuroethology
Ethology = Ethos + logia
(from greek) (Character) (Study)

Study of animal behavior as it interacts with other animals and with the external environment
Ethology = Ethos + logia
(from greek) (Character) (Study)

Study of animal behavior as it interacts with other animals and with the external environment

Neuroethology

Study of neural mechanisms underlying animal behaviour
Behavior

Interaction of an animal with its environment

Interaction with social environment (e.g. - communication)

Interaction with physical environment (e.g. - foraging)

Karl von Frisch
Behavior

What the animal **uses** for this interaction – defines its **Umwelt**

Jacob von Uexkull

**Sensory ("perceptor")**

How a fly might perceive a village

How we might perceive a village
Behavior

What the animal uses for this interaction – defines its Umwelt

How we might think this painting was made

Motor ("effector")

How this painting was actually made
Ethology

Understanding behavior by speaking to an animal in its own language
(and ideally also in its own environment)

Visible Light  UV Light
Ethology

Understanding behavior by thinking how the world looks through the animal’s senses, and “speaking to an animal in its own language” (and ideally also within its own environment)

Visible Light  UV Light

VR for animals
How do we understand behavior?

What is happening?

How does it work?

How did it develop?

How did it evolve?

What is it for?

Nikolaas Tinbergen
What is happening?

*Chicken crossed the road.*

How does it work?

How did it develop?

How did it evolve?

What is it for?
What is happening?

*Chicken crossed the road.*

How does it work?

*Hens get out of their cages and walk across to the other side.*

How did it develop?

How did it evolve?

What is it for?
What is happening?
*Chicken crossed the road.*

How does it work?
*Hens get out of their cages and walk across to the other side.*

How did it develop?
*They saw their older sisters do it earlier.*

How did it evolve?

What is it for?
What is happening?
*Chicken crossed the road.*

How does it work?
*Hens get out of their cages and walk across to the other side.*

How did it develop?
*They saw their older sisters do it earlier.*

How did it evolve?
*The farmers put the roosters on the other side of the road.*

What is it for?
What is happening?
*Chicken crossed the road.*

How does it work?
*Hens get out of their cages and walk across to the other side.*

How did it develop?
*They saw their older sisters do it earlier.*

How did it evolve?
*The farmers put the roosters on the other side of the road.*

What is it for?
*To mate and reproduce.*
<table>
<thead>
<tr>
<th>Question</th>
<th>Short-term</th>
<th>Long-term</th>
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<tbody>
<tr>
<td>How?</td>
<td>Mechanism</td>
<td>Development</td>
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<tr>
<td>Why?</td>
<td>Function</td>
<td>Evolution</td>
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<tr>
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<td><strong>How?</strong></td>
<td>\textit{Mechanism} \newline (Aristotle – Efficient cause; Tinbergen – Causation; Marr – Circuit + Algorithm)</td>
<td>\textit{Development} \newline (Aristotle – Material cause; Tinbergen – Ontogeny)</td>
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<tr>
<td>\textit{(Proximate)}</td>
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<tr>
<td><strong>Why?</strong></td>
<td>\textit{Function} \newline (Aristotle – Final cause; Tinbergen – Survival value; Marr – Function)</td>
<td>\textit{Evolution} \newline (Aristotle – Formal cause; Tinbergen – Phylogeny)</td>
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<tr>
<td>How?</td>
<td>Walked across road</td>
<td>Saw older hens do it.</td>
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<tr>
<td>Why?</td>
<td>Mate/Reproduce</td>
<td>Roosters on other side.</td>
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Bird Migration

Spring migration of birds

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<th>Bird migration</th>
<th>Short-term</th>
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<tbody>
<tr>
<td><strong>How?</strong></td>
<td>Temperature + daylight</td>
<td></td>
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<tr>
<td><strong>Why?</strong></td>
<td>Fitness – food requirement; Selection – Better breeding chance</td>
<td>Too early – winter storms, Too late – can only find place in outskirts of colony</td>
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Lion Intimidation

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

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<tr>
<td><strong>How?</strong></td>
<td>Big, dark manes</td>
<td>More testosterone</td>
</tr>
<tr>
<td><strong>Why?</strong></td>
<td>Indicates more strength – better chances of survival</td>
<td>Females found more attractive – selection of dark maned lions</td>
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**Fitness** – Traits which allow you to survive and pass on your genes

**Sexual Selection** – Traits which make you a more attractive mate and pass on your genes

Darwin
10 min break – followed by Questions
Innate behaviours

- Instinct (reflex)
- Fixed Action Patterns

Learned behaviours

- Imprinting
- Habituation
- Conditioning
- Observational Learning
- Insight (Problem Solving)

Neuroethology
Innate Learning Neuroethology

Habituation

Imprinting

Conditioning

Observational Learning

Insight (Problem Solving)

Instinct

Fixed Action Patterns

Instinct - Fleeing

Mouse Tracking

Stimulus Display
Innate Learning

Neuroethology

Instinct - Fleeing

Fixed Action Patterns  Habituation  Observational Learning
Imprinting  Conditioning  Insight (Problem Solving)

Instinct

Innate  Learned
Innate Learning

Neuroethology

Habituation

Fixed Action Patterns

Imprinting

Conditioning

Observational Learning

Instinct

Insight (Problem Solving)

Instinct - Freezing + Fleeing
**Innate Learning**

- **Neuroethology**

- **Habituation**
- **Fixed Action Patterns**
- **Imprinting**
- **Conditioning**
- **Observational Learning**
- **Insight (Problem Solving)**

**Instinct**

- **Cruising Predator**
  - Visual sweep
  - Freeze

- **Approaching Predator**
  - Visual loom
  - Flight
Innate Learning

Neuroethology

Habituation

Fixed Action Patterns

Imprinting

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Instinct

- Freezing + Fleeing

Insight (Problem Solving)
Innate Learning

Neuroethology

Habituation

Fixed Action Patterns

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Insight (Problem Solving)

Instinct

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

Instinct – Humans sucking reflex
Fixed Action Patterns
Instinct
Imprinting
Habituation
Observational Learning
Conditioning
Insight (Problem Solving)

Nikolaas Tinbergen
The Study of INSTINCT

Innate
Neuroethology
Learned
Greylag Goose Egg Rolling

1. Nikolaas Tinbergen
2. Konrad Lorenz

- Fixed Action Patterns
- Habituation
- Observational Learning
- Insight (Problem Solving)

Innate Neuroethology Learned
Releaser (stimulus that causes fixed action pattern) – Small convex object
Stickleback – Aggressive behavior

Fixed Action Patterns
- Instinct
- Imprinting
- Conditioned

Innate Neuroethology Learned

Habituation Observational Learning Insight (Problem Solving)
Stickleback – Aggressive behavior

male defends his territory against other males
Innate Learning

Neuroethology

Fixed Action Patterns
Instinct
Imprinting

Experiments with models

Stickleback – Fixed action pattern (releaser – red color)
Stickleback – Courtship behavior

Fixed Action Patterns  
- Instinct
- Imprinting
- Habituation
- Conditioning
- Observational Learning
- Insight (Problem Solving)

Innate  Neuroethology  Learned
Stickleback – Courtship behavior

Fixed Action Patterns

- Instinct
- Imprinting
- Conditioning

Habituation
Observational Learning
Insight (Problem Solving)

Innate Neuroethology Learned
Stickleback – Courtship (releaser – fat object)
10 min break – followed by Questions
Habituation – Reduction of innate response
Recognition Test / Memory Test

- Fixed Action Patterns
- Imprinting
- Conditioning
- Observational Learning
- Insight (Problem Solving)

Habituation: Spends less time with habituated object
Innate Learning

Neuroethology

Fixed Action Patterns
Imprinting
Habituation
Observational Learning
Insight (Problem Solving)

Classical Conditioning
Operant Conditioning

Ivan Pavlov
BF Skinner

Classical Conditioning
Operant Conditioning
Innate Learning and Neuroethology:

- Fixed Action Patterns
- Instinct
- Observational Learning
- Insight (Problem Solving)
- Conditioning
- Habituation
- Imprinting
- Classical Conditioning
  Associate an involuntary response and a stimulus
- Operant Conditioning
  Associate a voluntary behavior and a consequence

Illustration:

- A dog is associated with Classical Conditioning, indicating an involuntary response and stimulus.
- A rat is associated with Operant Conditioning, indicating a voluntary behavior and consequence.
Classical Conditioning

Fixed Action Patterns
Imprinting
Instinct

Habituation
Observational Learning
Insight (Problem Solving)

Conditioning

Innate
Neuroethology
Learned
Operant Conditioning

Fixed Action Patterns
Habituation
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Insight (Problem Solving)

Instinct
Imprinting
Conditioning

Innate Neuroethology Learned
Operant Conditioning – Reinforcement theory

“...responses that produce a satisfying effect in a particular situation become more likely to occur again in that situation, and responses that produce a discomforting effect become less likely to occur again in that situation.” – Thorndike, 1898

Positive reinforcement

Negative reinforcement
Innate

Neuroethology

Learned

Fixed Action Patterns  Habituation  Observational Learning

Imprinting  Conditioning  Insight (Problem Solving)

Instinct
Innate Learning

Neuroethology

Fixed Action Patterns  Habituation  Observational Learning
Imprinting  Conditioning  Insight (Problem Solving)
Instinct
Innate Learning

Neuroethology

Fixed Action Patterns
Imprinting
Habituation
Observational Learning
Insight (Problem Solving)
Conditioning
Observational Learning - Songbirds

Young males learn courtship songs from their fathers
Young males learn courtship songs from their fathers.
Observational Learning - Songbirds

Can learn through a speaker

Can learn some aspects of other species’ song

Fixed Action Patterns
Instinct

Imprinting

Habituation

Conditioning

Insight (Problem Solving)

Observational Learning

Innate  Neuroethology  Learned
Observational Learning – Cultural transmission

Use of sponge to protect snout in group of Australian bottlenose dolphins when foraging

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

Kohler, circa 1920

Fixed Action Patterns  Habituation  Observational Learning
Instinct  Imprinting  Conditioning

Innate  Neuroethology  Learned
Innate Learning:

- Fixed Action Patterns
- Instinct

Learned Learning:

- Insight (Problem Solving)
- Observational Learning
- Conditioning
- Habituation
- Imprinting

Neuroethology:

- Insight – Crow tool building and use
Weaver ants use silk from larvae, and cooperatively build nests.
Problem – Can’t fold it over

They first try to pull it as usual.
Insight – Weaver ants

Insight – Get leaf piece back in place and join it

Innate

Neuroethology

Learned

Fixed Action Patterns

Habituation

Observational Learning

Insight

Instinct

Imprinting

Conditioning

Insight (Problem Solving)
Innate behaviours

- Instinct (reflex)
- Fixed Action Patterns
- Imprinting
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Learned behaviours

- Observational Learning
- Insight (Problem Solving)

Neuroethology
Innate behaviours

- Instinct (reflex)
- Fixed Action Patterns
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- Conditioning
- Observational Learning
- Insight (Problem Solving)

Learned behaviours

- Neuroethology

Approximate percentages:

- Innate: ~20%
- Learned: ~80%

Neuroscience today: ~0%
Neuroethology – Brain structure

Umwelt of animals and their brain (Somatosensory cortex)
Neuroethology – Toad hunting worms
Neuroethology – Toad responds to horizontal moving segment
Neuroethology – Neuronal response in the toad brain

Neuron in the optic tectum (homologous to superior colliculus)
Fish generally turn to face a current and swim against it, so that they are not swept away.
Fish follow visual bars – impression of staying in same place
(Here water is still and bars are moving, but in the normal world, the water will be
moving and the markings on the river bed would be still)
Neuroethology – Rheotaxis in zebrafish larvae
Neuroethology – Social Transmission of Food Preference
Neuroethology – Social Transmission of Food Preference

Olfactory Bulb → Piriform Cortex → mPFC → NAc → Hypothalamus → Piriform Cortex

Rats with cheese silhouettes
**Summary**

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- **Visible Light**
- **UV Light**

**Innate behaviours**  
**Learned behaviours**

**Neuroethology**
Questions