

9.20 M.I.T. 2013

Lecture #12

Early evolution of behavior.
Genetics, learning and plasticity.
Navigation and migration.

Notes on Evolution and the Organization of Behavior

1. What are the most basic multipurpose movement abilities of animals from protozoa to primate?

Earliest evolution of behavior: Single-celled organisms

- *Elementary life-support*
 - *Intracellular movements and transport across cell membrane*
- **Multipurpose movement abilities**
 - 1) **Locomotion**
 - Approach movements: Foraging, feeding
 - Avoidance/escape movements: Anti-predator
 - 2) **Orienting** movements
 - Responses to sensory inputs
 - 3) **Grasping** movements
- **Special purpose movements** for consummatory behavior

Is this different for multicellular animals?

Multicellular animals

- Note that **all of the behaviors listed** for single-celled organisms apply.
- In vertebrates, outputs of the midbrain control each of the types of multipurpose movements.
 - The ASPs depend more on the forebrain, especially on the hypothalamus.
- Next, we try to summarize
 - A. Basic support systems** (expressed in general terms)
 - B. Regulators and controllers of behavior**
 - These have evolved in the vertebrates, supporting or governing the multipurpose and special purpose motor patterns.
 - They are the mechanisms of motivational states (drives).

Notes on Evolution and the Organization of Behavior

2. What are the three types of basic support underlying all behavior?

They were called the three stabilities by the neuroanatomist Walle Nauta.

You should be able to give examples of each for vertebrates.

Here we are talking, initially, about internal automatisms and the mantle of reflexes

Basic supports of behavior:

internal automatisms and the mantle of reflexes

1. Stability of the internal milieu: “vital functions”

- Respiration: breathing *via* reflex actions and endogenous brain mechanisms
- Circulation of blood *via* heartbeat, with reflex regulation
- Regulation of chemical environment (blood, lymph, extracellular fluids): *via* reflexes and feedback control systems.
- Temperature regulation *via* reflex actions and by FAPs

2. Stability in space

- Postural supports *via* reflex actions
- Maintenance of balance and direction during locomotion

3. Stability in time

- Temporal organization of the day-night cycle: Circadian rhythms and entrainment by natural light cycle
- Longer and shorter rhythms
- Motivational persistence

Notes on Evolution and the Organization of Behavior

Above the level of reflexes and internal automatisms, the basic supports of behavior are extended by brain evolution.

For which of the three is the forebrain most important?

#3

Notes on Evolution and the Organization of Behavior

3. Above the basic supports are specific regulators of behavior [“B” in slide 4] – the basic controllers we call drives or motivational systems.

List the most basic groups of drives/controllers, found in all vertebrates. (Most of these, if not all, are also found in invertebrates.)

[The list is an outline for an ethogram of a species.]

Regulators of behavior: the basic drives (“controllers”)

- 1) Ingestion drives (motivations)
- 2) Related but distinct drives, e.g., foraging, predation
- 3) Defense: anti-predator motivations
- 4) Defense: social motivations
- 5) Reproduction: various drives
- 6) Exploration of novelty; various roles of novelty detection
- 7) Other motivations (many!): e.g.,
 - For elimination
 - For shelter/ nest construction
 - For sleeping
 - For play
 - Various social motivations
 - Learned motivations

Regulators of behavior: the basic drives (“controllers”)

1) Ingestion drives

- Hunger
- Thirst

2) Related but distinct drives

- Foraging
- Predatory attack in cats and other predators
- Prying in starlings
- Poking with a spine in cactus finches
- Etc.

Continued on the following three slides.

Regulators of behavior: the basic drives (“controllers”)

3) Defense: anti-predator motivations

- Escape
- Avoidance

4) Defense: social motivations

- Territorial
- Position in hierarchy: achieving, maintaining, improving it

Regulators of behavior: the basic drives (“controllers”)

5) Reproduction: essential drives

- Pairing
 - Roaming (searching)
 - Advertising
 - Selecting or responding (mate selection)
- Mating
- Brood tending (parental behavior)

Regulators of behavior: the basic drives (“controllers”)

- 6) Exploration of novelty: Various roles of novelty detection and its effects
 - Security; defense
 - Arrest of current actions; orienting
 - Exploration to correct and expand the “cognitive map”
 - Ingestion functions (e.g., neophobia, neophilia)
 - Sexuality functions
- 7) Other motivations (many): e.g., for elimination, for shelter/nest construction, for sleeping, for play, other social motivations, learned motivations...

Scott, ch 4: Genes and behavior, pp 57-66

4. Variations in a single gene can result in variations in behavior. What kind of effect on the body must such a gene have?

Scott, ch 4: Genes and behavior, pp 57-66

4. Variations in a single gene can result in variations in behavior. What kind of effect on the body must such a gene have?

It must have effects on the Central Nervous System.

Besides a heritable change in central axonal connections, the CNS can be altered by heritable changes in hormones, by changes in sensory inputs, etc.

Scott, ch 4: Genes and behavior, pp 57-66

5. What are “hygienic bees”? Why do bee colonies (hives) need them?

- See figure 4.2 (p 62) concerning the genetics.
- See pp 64-66 concerning interactions with environmental conditions.

From:

H. S. ARATHI & M. SPIVAK (2001) Influence of colony genotypic composition on the performance of hygienic behaviour in the honeybee, *Apis mellifera* L. *Animal Behaviour*, **62**, 57–66

Their four colonies contained different proportions of hygienic bees: 25%, 50%, 100%, 0%.

Table 1. Colony composition and performance of hygienic behaviour in the four different observation colonies

Colony	Number of bees hygienic (nonhygienic)	Number of bees performing hygienic behaviour (%)	
		Hygienic	Nonhygienic
25H	400 (1200)	315 (78.75%)	75 (6.25%)
50H	800 (800)	317 (39.62%)	81 (10.13%)
100H	1600 (0)	307 (19.18%)	—
100N	0 (1600)	—	190 (11.87%)

A paper published the same year in the Journal of Comparative Physiology was entitled: “Olfactory and behavioral response thresholds to odors of diseased brood differ between hygienic and non-hygienic honey bees (*Apis mellifera L.*)”

Results indicated that there is a genetically based **difference in sensory thresholds for detection of diseased larvae by hygienic and non-hygienic bees**. Non-hygienic bees show higher olfactory thresholds, and may not be able to detect diseased broods easily.

This may explain why “non-hygienic” bees sometimes do clean out a cell of a dead larva (see table).

It does not explain the separation of uncapping and removal behaviors.

6. How is it possible for an individual who has no offspring to have greater “**inclusive fitness**” than an individual who has offspring?

Answer by describing an example.

- First, what is “fitness” here?
- How is the term “inclusive fitness” defined?
- See the box on pp 64-65.

6. How is it possible for an individual who has no offspring to have greater “**inclusive fitness**” than an individual who has offspring?

Answer by describing an example.

- A major issue for Charles Darwin: How could sterile workers evolve in social insects?
- Modern answer: Because their work for the colony promotes the survival and increase in their genes which they share with their mother, the queen.

This topic will become a major one when we discuss sociobiology later in the term.

Scott, ch 4: C. Learning, pp 66-75

7. Write definitions for “habituation” and “sensory adaptation”. The textbook describes briefly only the former. You must find the rest elsewhere.

8. Give examples of habituation from your own experience. Can we habituate to complex stimuli as well as to simple stimuli? Answer with your examples.

Scott, ch 4: C. Learning, pp 66-75

7. Write definitions for “habituation” and “sensory adaptation”. The textbook describes briefly only the former. You must find the rest elsewhere.
 - **In both cases, there is a decreased response with repeated exposure to the same stimulus.**
 - **Habituation: change is more central, and closer to the motor side. Level of response depends on degree of novelty.**
 - **Sensory adaptation: shorter term (does not last so long); change is in the sensory neurons, often the primary sensory neurons—a short-term “fatigue”**

Scott, ch 4: C. Learning, pp 66-75

8. Give examples of habituation from your own experience. Can we habituate to complex stimuli as well as to simple stimuli? Answer with your examples.
- **We habituate to complex stimuli, even to temporal aspects of a stimulus.**
 - ***E.g.*, with repetitive stimuli we will respond to the sudden absence of a stimulus as well as to the sudden introduction of a stimulus—i.e., any detection of novelty.**

Responses to Novel Stimuli

(Terms: Arousal response; orienting response; orienting reflex; curiosity)

- Autonomic
 - Arousal of sympathetic nervous system, with heart rate increase, altered breathing, increased muscle tension, vasodilation in head, vasoconstriction in limbs
- Behavioral
 - Alerting, orienting of head, eyes, ears
 - Exploratory behavior: approach & manipulation
- Also, there is motivation to **seek** novelty
 - Especially in higher vertebrates there is exploratory behavior caused by a motivation to seek novelty
 - We call this “curiosity.”

* These are all components of the orienting response (orienting reflex, novelty response)

- A novel stimulus results in a **conflict** between expected input and perceived input.
- The autonomic changes are the same as measured by a lie detector: Lies cause a different kind of conflict.

Scott, ch 4: C. Learning, pp 66-75

9. Why have scientists often chosen to study learning in animals like sea slugs and snails and certain insects? Give more than one reason.

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