Chapter 4

The Control of Behavior

Water toad (Bufo stejnegeri)

Bull frog (Japanese)
4.2 A simple rule of thumb governs this beetle’s mating behavior
Fixed Action Patterns (FAP)

- Innate or genetically programmed behavior
- Once initiated, will continue until completed
- Needs sign stimuli (or releasers) to be initiated
Fixed Action Patterns

1. Female goose extends her neck toward egg.
2. Goose gets up from nest and approaches egg.
3. Goose places her neck above the egg.
4. Goose rolls egg back to nest with her beak and neck.

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4.4 Begging behavior by a gull chick
4.5 Effectiveness of different visual stimuli in triggering the begging behavior of herring gull chicks
4.6 Instinct theory

Releaser

Innate releasing mechanism
Practical application of FAP: Evolving to deceive each other
An example of a self-referential, stereotypical behavior pattern triggered in the absence of its appropriate external stimulus. In a small pond, a cardinal feeds minnows, which rose to the surface looking for food. Over several weeks the bird fed them, probably because her nest had been destroyed. Having lost her nestlings, the bird was most likely responding inappropriately to a dominant parental instinct, that is, the sight of stimuli similar to her nestling (small open mouths) elicited an inborn and stereotypic behavior (known as a “fixed action pattern,” or FAP; see chapter 7). This behavior is genetically determined and presents a complex interaction with environmental stimuli. The Dutch ethologist Niko Tinbergen was one of the first to study such behaviors in vertebrates. (From N. Tinbergen, *Animal Behavior*. New York: Time Inc., 1966.)
4.3 Pioneers in the study of animal behavior

How about man?
Practical application of FAP

Olfactory releases
A Game with releaser chemicals

- Release secretions which feed red ants
- Red ants protect the caterpillar against predatory insects
- Wasp releases pheromone which trigger ants fight each other & laying eggs into the caterpillar
- Ants eventually take care the babies of wasp

Normal reaction to Intruder of red ants: volatile hydrocarbons → aggressive behaviors
4.9 Complex code breaking by a wasp (Part 2)

(B)  

- **Run toward**
- **Investigate**
- **Attack**

Ratio of ant responses relative to controls:

- **Flee from**
- **Attack fellow worker ants**

Chemical:

- Mixed
- Z-9-C20-ol
- Z-9-C24-ol
- Z-9-C2-ol
- Z-9-C24-ol

4.10 The eyestalks of a fiddler crab point straight up

**Escaping behaviors**

**Approaching or ignorance**
Echolocations between Bats and Moths

Lazzaro Spallinzani (1794): bats avoid objects in flight, even if blinded.

1795: Swiss surgeon, Spallinzani (1795) : bats fail if ears plugged or if mouth covered.

Griffin (1933)

1) Dark room $\rightarrow$ no effect on bat’s predation
2) High frequency jamming $\rightarrow$ effects
3) Low frequency jamming $\rightarrow$ no effects
Echolocations between Bats and Moths
Escaping behaviors from approaching Bats

By Kenneth Roeder

(A) Noctuid moth ears

Brain
Thoracic ganglia
Ear with auditory receptors

(B) Mehanosensory receptors

Tympanum
Air sac
Air sac
Air sac

A1 Receptor cells
A2
4.12 Neural networks of moth

Neural signaling mechanism

Mechanosensory receptors

Releases glutamates
Firings of A1 neurons are proportional to the intensity of 30~50 Hz sound

No difference between 30 and 50 Hz

Do not respond to low frequency sound
More responsive to pulses of ultrasound not to continuous one
4.15 How moths might locate bats in space (Part 1)

(A) A bat approaching to left side

Pulses of sound

Left

A1 cell activity

Right

A1 cell activity
4.15 How moths might locate bats in space (Part 2)

(B) **A Bat approaching to the back of moth**

- A1 cell activity
- Pulses of sound
- A1 cell activity
4.15 How moths might locate bats in space (Part 3)

A Bat is above the moth

Wings up

Wings down

A1 cell activity

Sound stimulus
Evasive behaviors of moths

1) When a bat come closer → Turning the direction of flying
2) When a bat attacks → Diving Erratically downward

*Ultra sound from bat is the information to control those behaviors
Lower intensity → 1)
Higher intensity → 2*)
4.16 Bat ultrasonic cries trigger evasive behavior in a number of insects

The normal flying of mantis

Diving when bat's approaching
A hypothesis by suggested Roeder:
A2 cells are involved in the fall-down
4.17 Is the A2 cell necessary for anti-interception behavior by moths? (Part 2)

A2 cell firings seems not to be critical
Sound avoidance and preference in crickets

(A) Silent
(B) 5 kHz
(C) 40 kHz

Tethered cricket
Male sounds
Bat’s sound
Firing rats of int-1 neurons

![Graph showing intensity threshold (dB) for response versus sound frequency (kHz).](image_url)
4.19 How to turn away from a bat—quickly

By Mike May

(A)

Beating of right wing to be slowed

(B)

The right hind leg is lifted

(C)

Left int-1 neurons are fired

USV
4.19 How to turn away from a bat—quickly

Locating of enemy by wind perception

Motor neurons
To contracts leg muscles

Pairs of sensory organ for wind perception
Locating preys by using neural networks
Superior olive

Medial superior olivary nucleus (MSO): The coincidence detector

Temporal summation → Synaptic summation
Central pattern generators

Active rhythmic D/V contractions

Escaping of a sea slug from a sea star
Two motor neurons are alternatively fired
4.22 The central pattern generator of *Tritonia* in relation to the dorsal ramp interneurons
Central pattern generators for walking
Central pattern generators for fish song

- Sonic muscles
- Fin
- Swim bladder
4.24 Neural control of the sonic muscles in the plainfin midshipman fish
Adaptive aspects of stimulus filtering
The proximate basis of stimulus filtering

Stimulus filtering

Proximate causes
A1 receptors are only activated by acoustic stimuli
A1 receptors are sensitive to high frequency sound

Ultimate cause
The detection of predators

Biologically Relevant signals $\rightarrow$ Stimulus filtering $\rightarrow$ Locating predator
Locating male or female
Locating host or prey
Ormia ochracea flies lay eggs in male crickets

Female flies located the victim by his song

Female flies are coming to the speaker which generate male cricket song
4.25 Tuning curves of a parasitoid fly
4.26 Tuning curves of a katydid killer
Insectivores
The star-nosed mole’s nose differs greatly from those of its relatives.
4.28 A special tactile apparatus (Part 1)

- Nose
- Nostril
- Nose appendages
- Mouth
Cortical magnification

(A) Somatopic map
By Katania and Caas

(B)
4.29  The cortical sensory map of the star-nosed mole (Part 2)

Cortical magnification

Mole’s brain is more interested in

(C)

Average area of cortex per input fiber ($\mu m^2$)

Appendage number
Cortical magnification
Adaptive sensory bias

Cortical magnification occurs in all mammals. The drawings in Figure 4.31 of the textbook are cortical maps based on the amount of brain tissue devoted to tactile inputs from different parts of the bodies of human beings and of the naked mole-rat (see Figure 13.34 of the textbook), a strange, nearly hairless mammal that uses its large front teeth to dig a vast network of underground tunnels while also excavating and processing tuberous roots for food. In what ways do these two maps support the argument that animal brains exhibit adaptive sensory biases?
4.32 Ultraviolet-reflecting patterns have great biological significance for some species.

Many bees can see UV which helps the bees find the nectar source within a flower.

Only male sulfur butterfly has UV-reflecting patch.
A bird that can sense ultraviolet light

UV-reflecting patch
What is the meaning of UV signals to females?

- Older male has more UV-reflecting feathers
- Old age indirectly prove the capacity for longer survival
- Able to pass survival-enhancing genes to their offspring
Bythograea thermydron

Adaptive visual metamorphosis in a deep-sea hydrothermal vent crab
(Nature, 2002)

Living place
1000m

2500m

At the bottom

Linkage between sensory receptor development and habitat
Mcgurk effects

Interactions between visual and auditory pathways
Superior temporal sulcus → active during talking

- Mouth movement
- Body movement
- Eye gaze
- Hand movement
The face recognition center

Fusiform gyrus

Independent from object recognition
Stimulus-filtering circuits of human brain

Human brain is biased toward gathering information from social environment
Hemispheric lateralization for seeing words
fMRI imaging during virtual navigation
The hippocampus is essential for navigation by humans (Part 2)
The hippocampus is essential for navigation by humans (Part 3)
Tuesday, 14 March, 2000, 15:51 GMT

**Taxi drivers' brains 'grow' on the job**

The hippocampus is essential for navigation by humans (Part 2)

Rear portion of the hippocampus

Front

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time
The ability to navigate unfamiliar terrain requires a compass sense and map sense (Part 1).

**‘Compass sense’ vs. ‘Map sense’**

- Knowing in what direction to move
- Knowing the location of a goal

4000 km wandering

Coming back via the short-cut
4.40 The ability to navigate unfamiliar terrain requires a compass sense and map sense (Part 2)
Homing of Honey bees

If the bee works three hours, she compensate 45° when coming back home.
Is their internal clock?

Pigeon experiment

Shifting clock 6 hours earlier
Quiz

We put a homing pigeon on an experimental light–dark cycle in which the lights come on at noon (12 pm) and go off at midnight (12 am) at a time of the year when actual sunrise is at roughly 6:00 a.m. and sunset is at 6:00 p.m. After several weeks on this schedule, we release the pigeon at noon on a clear day in unfamiliar territory due east of its home loft.

First, in what direction should the pigeon fly?

Second, are you surprised to learn that on a completely overcast day, the pigeon would fly directly home? What does this finding suggest about the homing mechanism(s) of this bird?
The fall migration route of monarch butterflies takes some butterflies from Canada to Mexico on a 3600 km journey. Also use sun as a compass.
Manipulation of the biological clock changes the orientation of migrating monarchs.

Lights on 7:00 a.m.

The time lights on?
What wave length of sun light is critical? → UV

They use the polarized light information?
2000 km journey at night...

They use the magnetic field of the earth
Experimental manipulation of the magnetic field affects the orientation of green sea turtles.