

**9.20 M.I.T. 2013**

**Lecture #8**

More about innate behavior & motivation

Key concepts from Lorenz on fundamentals of  
ethology:

The “fixed action pattern”

# Why do animals sleep?

A question with multiple levels of meaning:

- **Adaptive pressures** (the functions that have increased survival to the age of reproduction)
- Sleep instinct (Fixed Action Pattern)
- Action of neuromodulator systems in the CNS

# Adaptive pressures: why it evolved

- Need for rest and recuperation
- Need to conserve energy stores
- Need to avoid predators
- Role in the ontogeny of neural circuits:  
promoted by organized activity during dream  
sleep
- Memory consolidation; memory editing

# Why do animals sleep?

A question with multiple levels of meaning:

- Adaptive pressures
- **Sleep instinct (FAP) triggered by a biological clock entrained by the light-dark cycle**
- **Action of neuromodulator systems:**
  - Axons with widespread axonal connections: serotonin, norepinephrine, acetylcholine
  - Chemicals in the cerebrospinal fluid (another type of neuromodulator)

# Addendum: Sleep schedules

- **Biphasic sleep in humans**

- Before electric lights: the frequent practice of “first sleep” and “second sleep”
- More common when daylight is  $< 10$  hr
- More common in absence of electric lighting

- **Polyphasic sleep**

- “Siesta” in humans (which may be another biphasic sleep pattern)
- Very common in animals
  - In hamsters: Shorter cycles of activity are superimposed on a daily schedule of overall intensity of activity divided into active and inactive portions.
  - During inactive periods, the animals are not always sleeping.

# Addendum: Sleep schedules (continued)

**Arctic animals:** reindeer in northern Norway (70 degrees N) and in the high arctic archipelago of Svalbard (78 degrees N)

“Circadian organization in reindeer”, *Science* 2005 (6 authors)

Daily rhythms abandoned in summer (continuous light) for both groups; abandoned also in winter (continuous dark) by the Svalbard group.

## **Goldfish: variability & complexity**

- Activity rhythms and feeding rhythms can be out of phase under normal day-night lighting
  - Activity is higher during daytime, and feeding higher during nighttime,
  - or vice-versa in some cases
- Activity of some fish may be more diurnal, others more nocturnal
- Free-running rhythms under constant lighting conditions can have different periods for locomotor activity and for feeding.

## **Addendum: Sleep schedules (continued)**

- Various studies of total sleep need in humans (of interest to military organizations and others)
  - Experiments on increasing efficiency of activities
  - Greatly varying results, many failures
  - One thing is certain: Individuals vary greatly in sleep patterns and sleep needs
    - However, they all have a biological clock – actually, more than one.

# Energy regulation and circadian clock mechanisms

- Abnormalities, or deletions, of the Clock (CLK) gene in mice result in abnormal regulation of feeding and metabolism
  - Homozygous mutants: hyperphagic and obese with symptoms of adult diabetes, high leptin levels in blood, and abnormal fat storage in liver cells
  - Heterozygous animals also show some abnormalities of energy regulation and in feeding cycles.

Lorenz, K.Z. (1981) *The Foundations of Ethology*

1. In early writings and discussions concerning fixed motor patterns (fixed action patterns, or FAPs), the concept embraced **three** physiologically different functions. What are they? (Section 1)

See p 108

# The “fixed action pattern”:

## Three distinct processes, normally integrated:

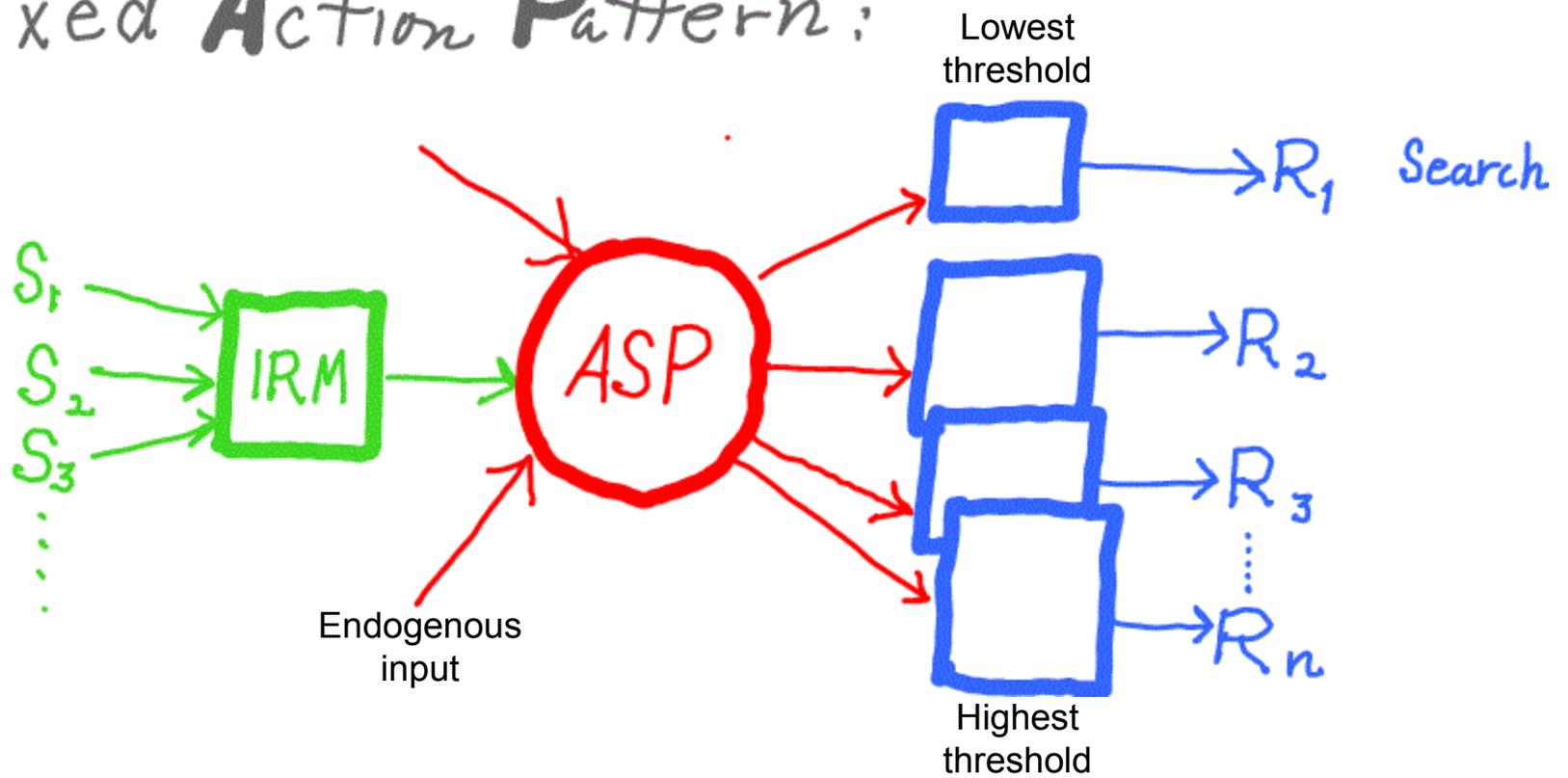
1. The motivation—or “**drive**”—to search for a certain stimulus situation.
  - Lorenz’ term: the action-specific potential (ASP)
2. The selective response to it: its “**innate recognition**” *via* the innate releasing mechanism (IRM)
3. The discharge of an innate motor activity coping with the situation: the **fixed motor pattern**

Try drawing simple information-flow models of  
a) a reflex, and b) a fixed action pattern

Reflex:



Fixed Action Pattern:



Lorenz, K.Z. (1981) *The Foundations of Ethology*

2. What are “intention movements” in relation to fixed action patterns? Give an example from animal behavior. Also describe human intention movements with at least one example. (Section 2)

See p 110-111

Movements made prior to a full fixed motor pattern, that give away the intention of the animal (or person) to carry out the movement.

# On the evolution of social signals:

- Intention movements can evolve “on their own” if they come to serve as important social signals.  
They have evolved into elaborate courtship rituals in some bird species.
- Ritualized aggression among conspecifics must have arisen this way.

Remember the jackdaws and the kittiwakes

Lorenz, K.Z. (1981) *The Foundations of Ethology*

3. In the case of complex FAPs involving a series of different movements, how can we be sure that we are dealing with a single FAP rather than a series of different ones? Give two or three of Lorenz' arguments. (Section 4; see p 113-115)

# Lorenz on the unity of motivation

1. Consistent predictability: The experienced ethologist can reliably predict the next movement in a series, e.g., Seitz' demonstrations of cichlid fighting behavior.
2. As intensity increases, there may occur quick switches between two patterns, but the sequence is always clear. Intention movements anticipating the next stage can mix with the actions of the previous stage.
3. One stage moves smoothly to the next without the inertia normally shown in switching between FAPs.
4. The same stimulus configuration elicits all the motor patterns. (Also, in brain stimulation studies, the whole sequence can be elicited from the same locus.)      The same “mood” is behind all of the movements.
5. The organism's readiness to perform any one part of the sequence of movements fluctuates in parallel with its readiness to perform any other. One never sees a higher intensity movement immediately followed by one of lower intensity. If a strong stimulus can elicit only the earlier, weaker movements, no stimulus will be able to elicit the later, higher intensity patterns.

The unity may not be present early in development; it may increase with experience. 15

# Lorenz, K.Z. (1981) *The Foundations of Ethology*

4. Summarize **Seitz' method of dual quantification, used to assess the effectiveness of a dummy stimulus**. Seitz used this method in studies of fighting behavior of one species of male fish, and it has been used for other studies as well.  
*(Section 5, p 115-117)*

The key to his method is that there are two variables in any experiment using dummy stimuli: a readiness (the ASP) which decreases with every performance, and a varying efficacy of different stimulus configurations.

Assuming these two variable, what was his method?

**The method allows one to test for effectiveness of dummy stimuli using animals with various levels of internal readiness (drive, ASP level)**

# Seitz' method of dual quantification

- Present the dummy stimulus; observe the response.
- Then, present a stimulus known to be maximally effective.  
How much drive is left?
  - “The greater the effect of the dummy, the weaker was the subsequent response to the maximum stimulation”
- Note that the same actions could be produced by
  - a strong internal readiness (ASP) and a weak external stimulation,
  - a weaker ASP and a stronger stimulus.

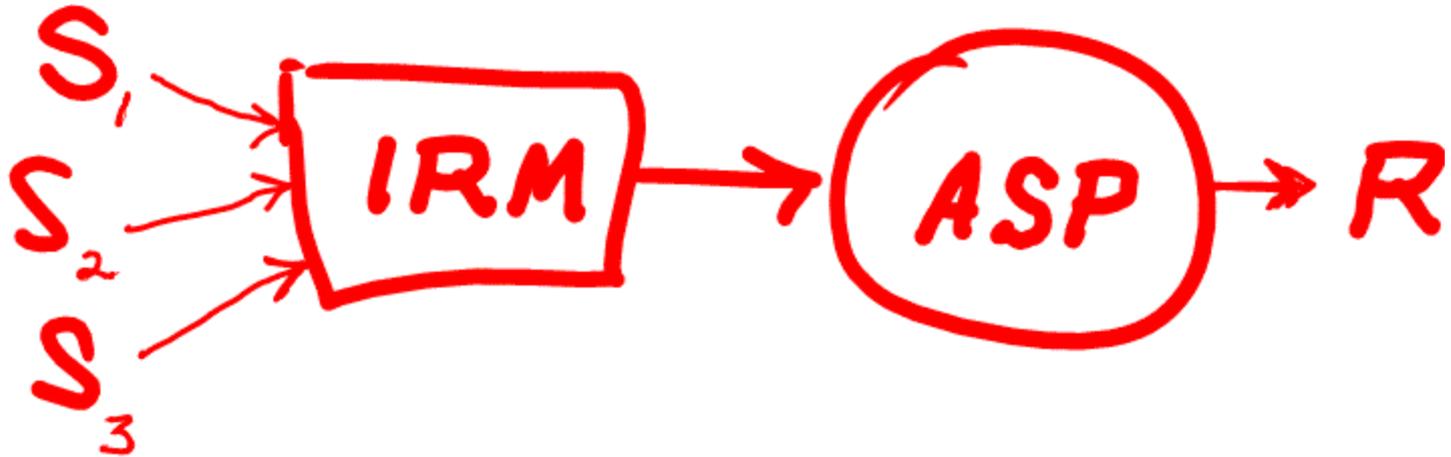
Required: extensive knowledge of the FAP, so that some level of quantification of drive intensity level is possible

Lorenz, K.Z. (1981) *The Foundations of Ethology*

5. One of Seitz' findings was the “**law of heterogenous summation**”. What does this phrase mean?

*(p 117; see also p 116 on innate recognition of another animal of the same species.)*

# Seitz' law of heterogenous summation



*Key stimuli*

Effectiveness of the stimulus is the linear sum of the effectiveness of the three key stimuli (or another number) acting separately

Lorenz, K.Z. (1981) *The Foundations of Ethology*

6. Contrast “action specific fatigue” and “habituation”.  
(Section 6)

This was demonstrated particularly clearly by Precht (1949) in studies of the releasing of the gaping movements of young chaffinches (*p 119*).

**In each case, there is a decrease in the response with repeated presentations of a stimulus.**

Lorenz, K.Z. (1981) *The Foundations of Ethology*

Prechtl showed that “fatigue” occurs not only on the “motor side” with performance of the FAP, but also on the receptor side.

**Each part of the stimulus configuration that can elicit gaping could be separately habituated.** (Habituation occurs closer to the input side.)

Later in the book, beginning on p 265 when he is dealing with learning, Lorenz reviews habituation.

# “Action-specific fatigue”

- "Fatigue" is not the best term for what Lorenz is discussing. He means the decrease in motivational level (ASP) that occurs each time the FAP is performed. It can appear to be "fatigue."

# Habituation: examples

- **Selectivity of habituation demonstrated by Syrian hamster behavior**
  - Orienting of head & eyes toward novel visual, auditory and whisker stimuli—when the movement does not lead to reward.
  - Escape into tunnel in response to novel sounds.
- **In each case, there is a progressive decrease in response intensity (or the probability of a response) with decreasing novelty (with repeated presentations of the stimulus).**
  - A stimulus that can trigger the FAP can become less and less effective with repetitions, while a separate key stimulus remains fully effective. There is habituation to that first stimulus; this habituation is lost over time.
- The response is also strongly affected by the modality and the specific situation.

Lorenz, K.Z. (1981) *The Foundations of Ethology*

7. What are “tool activities” as defined by Lorenz.  
Give examples.

How is their underlying motivation – their ASP –  
different? (*p 122-123*)

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