Cognitive Ecology

Distributed Cognition

Cogs 102A * Christine Johnson * UCSD

The Great Wave

Hokusai, 1830

The Great Wave

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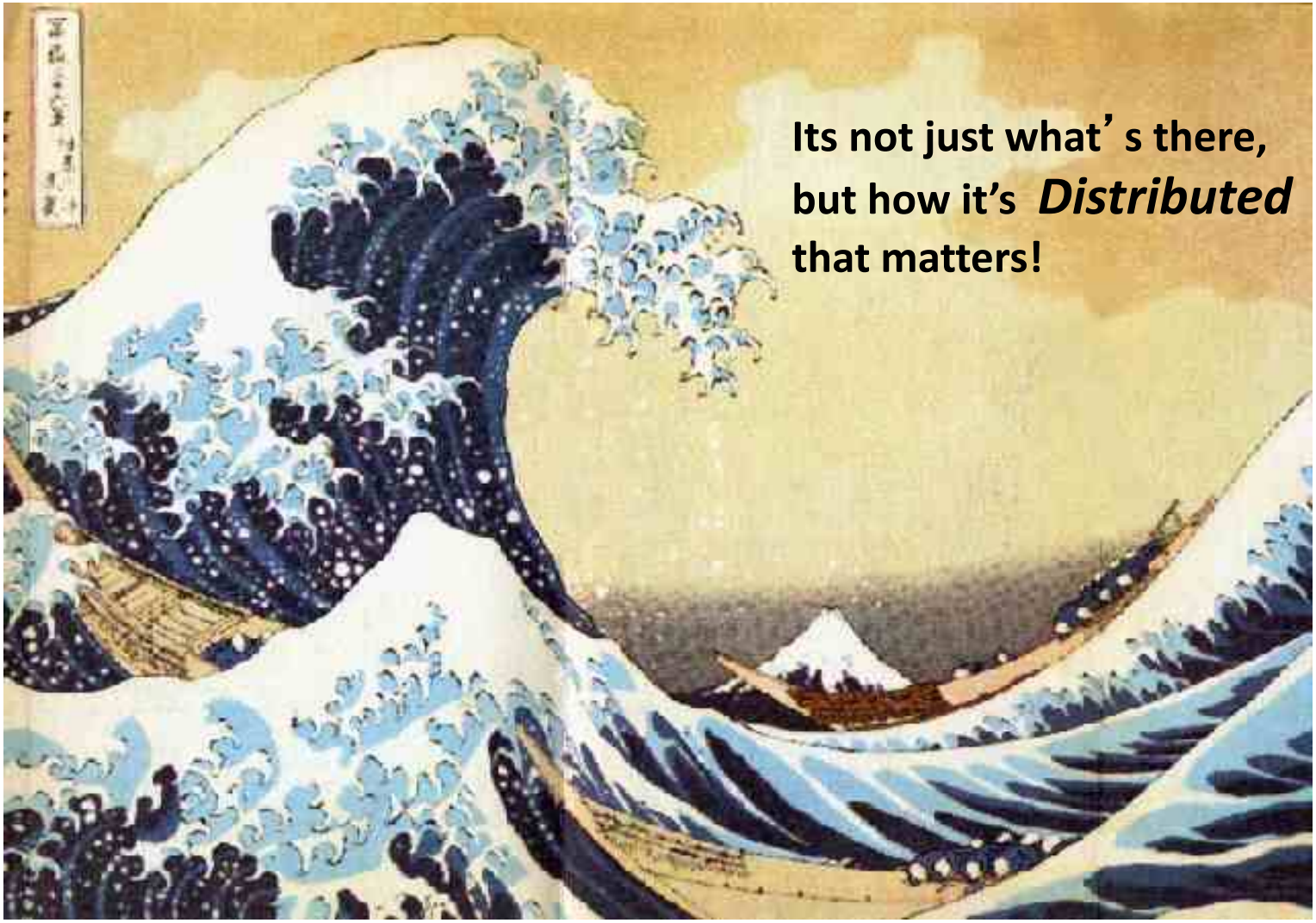
Hokusai, 1830

The Great Wave



Hokusai, 1830

Distributed Cognition

requires

changing our perspective –

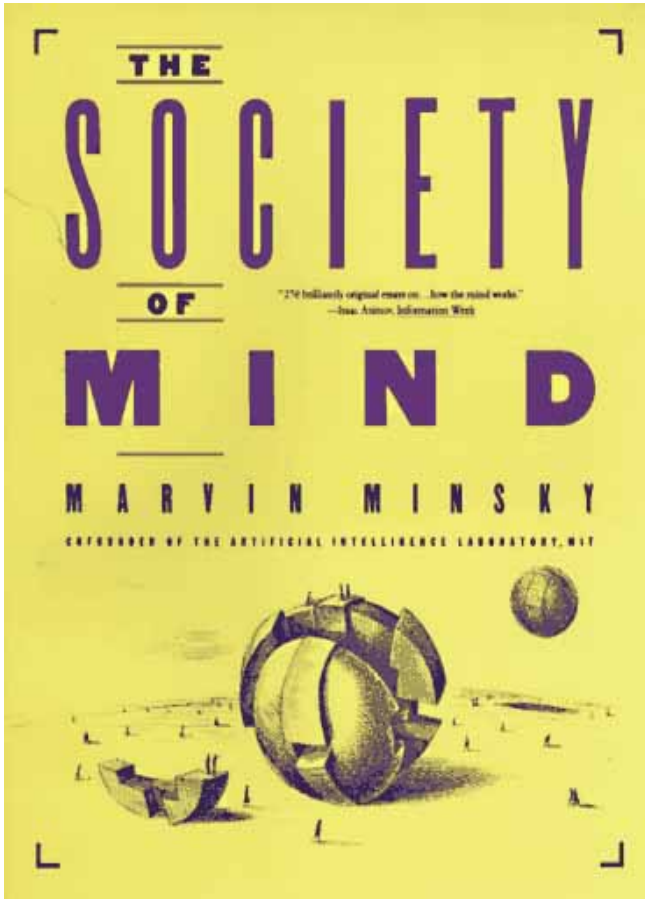
See cognition as a ***SYSTEM!***

Approaching Cognition as a *SYSTEM*

- **The Brain** – one type of "Cognitive System"
  - **Minsky**: "Society of Mind"

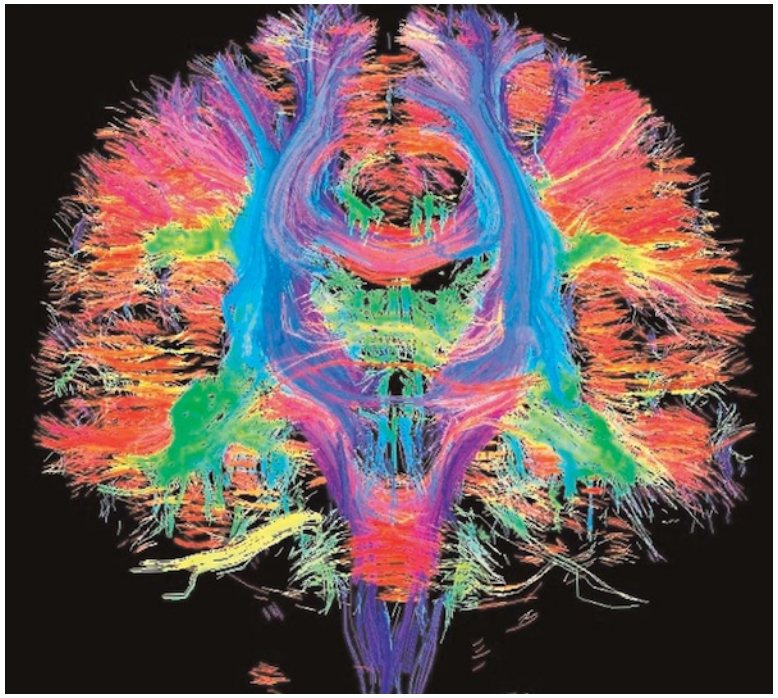
Approaching Cognition as a *SYSTEM*

- **The Brain** – one type of "Cognitive System"
  - **Minsky**: "Society of Mind"
  - "…each brain contains hundreds of different types of machines, interconnected in specific ways which predestine that brain to become a large, diverse society…" (Minsky, 1988)



Approaching Cognition as a *SYSTEM*

- **The Brain** – one type of "Cognitive System"
  - **Minsky**: "Society of Mind"
  - Neuroscience also adopting this...
    - e.g. White matter
      - Connections between cells
      - Your brain has >150,000 km of myelinated axons
      - Est. up to 66% of brain volume!
    - It is not just the cells, but their connections that matter!

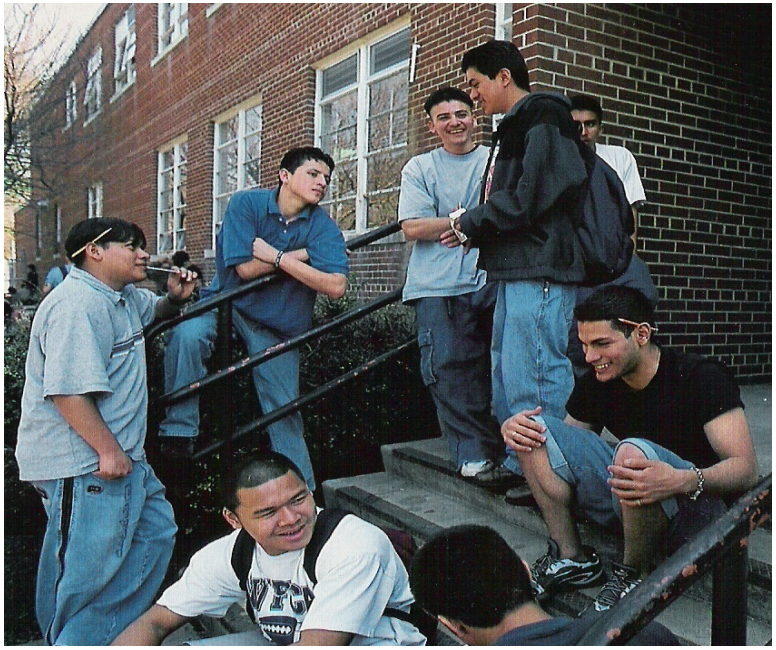


Tshibanda et al. (2009) *Progress in Brain Research,* 177:215-229.

Approaching Cognition as a *SYSTEM*

Another type of "Cognitive System"...

- **Human Engagement with the World**
  - Humans+Artifacts, Humans+Humans, Both
  - It is not just the elements,
    but their connections that matter!



Repercussions of this shift - - -

- Traditionally, cognition has been considered to be bounded by the skull…

Repercussions of this shift - - -

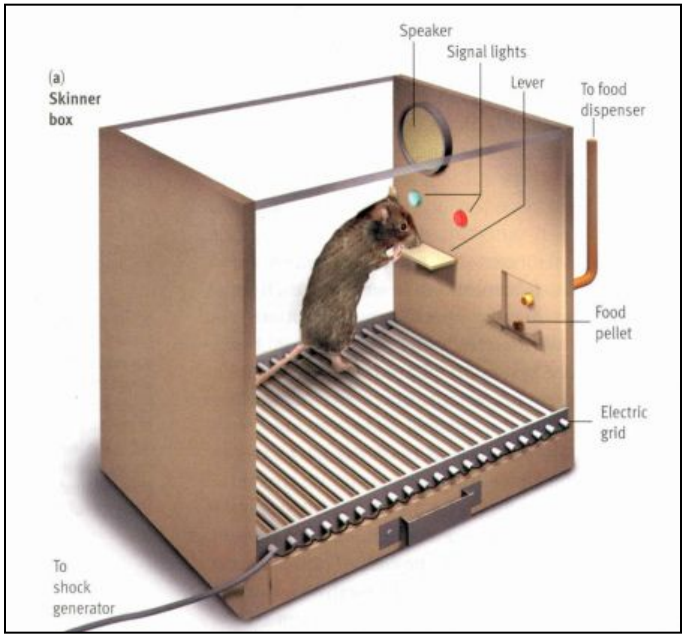
- Traditionally, cognition has been considered to be bounded by the skull…
- In this class, we will privilege a different boundary…

...to include participants, objects & cultural settings as aspects of this cognitive system.

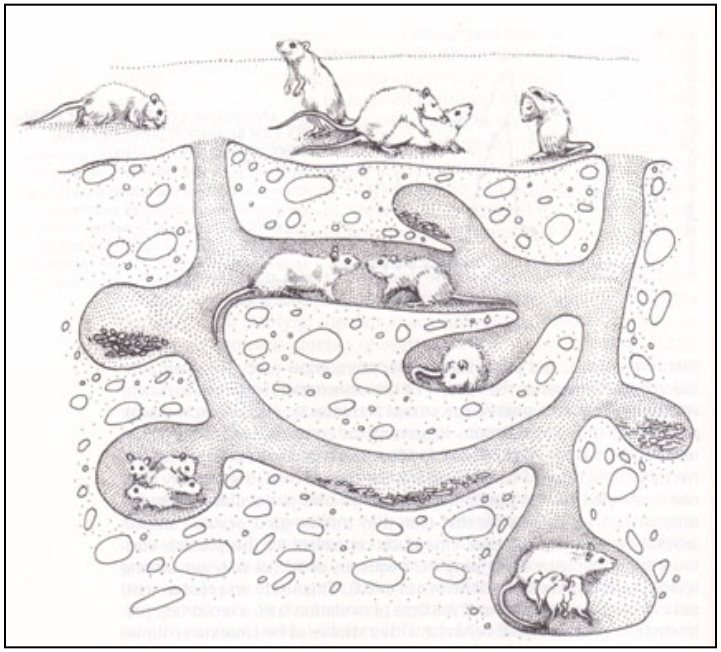
Repercussions of this shift - - -

Changes targets of research

Research will **not** focus on this



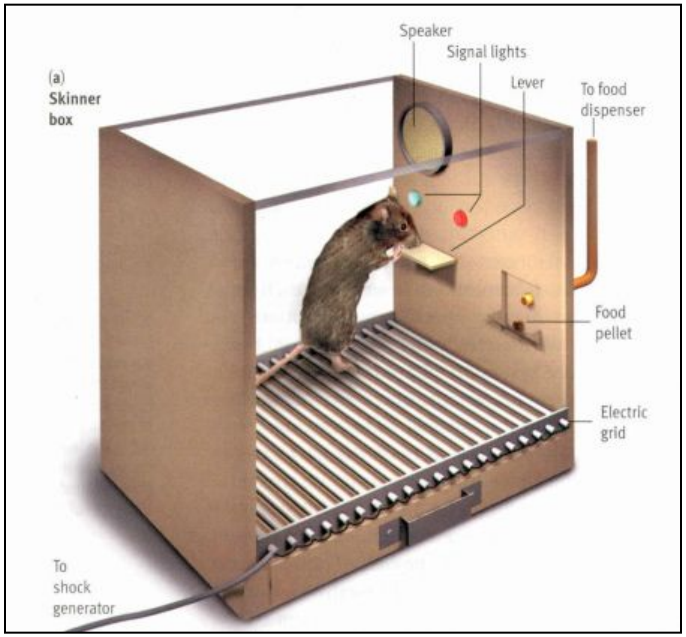
Research **will** focus on this!



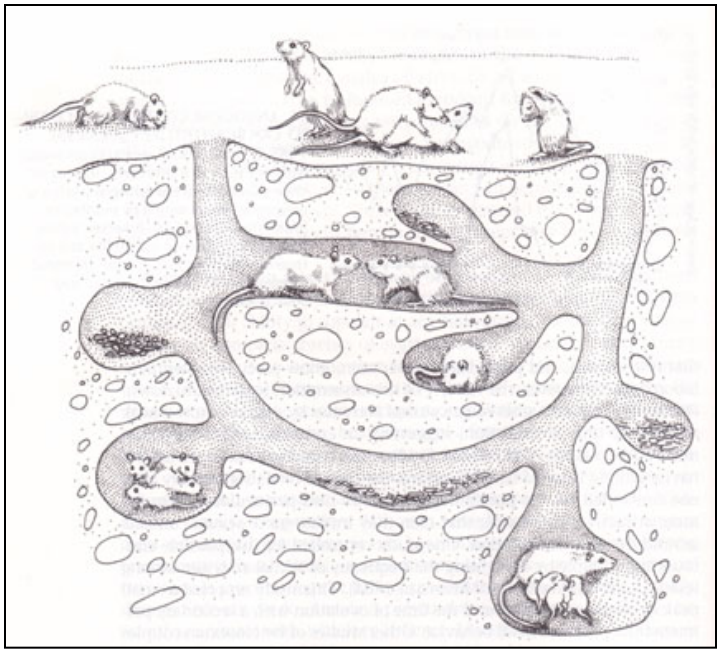
Changes the <u>questions</u> we ask, and the <u>interpretations</u> we give.

Repercussions of this shift - - -

ASK:
Can subject learn association
(form a mental representation)
of light + lever?



ASK:
How does engagement proceed?
What are the constraints on
information flow in this system?



~~Cognition is something you HAVE.~~

Cognition is something you DO.

Changes the questions we ask, and the interpretations we give.

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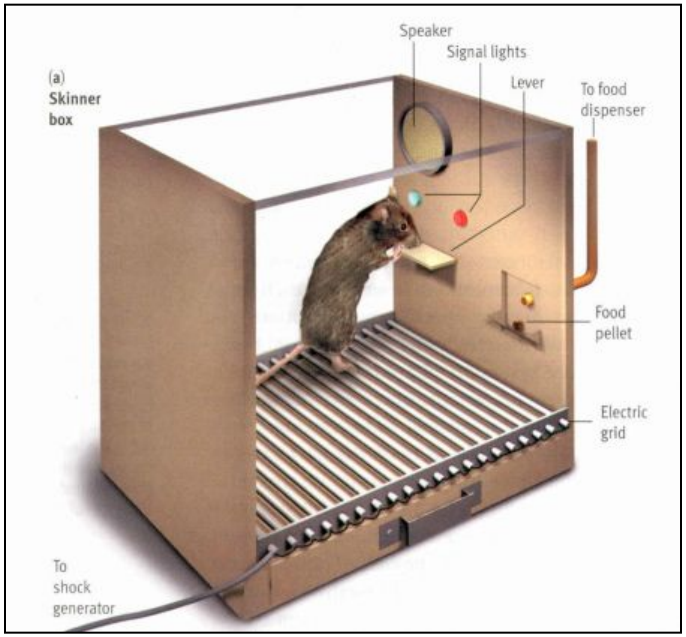

DATA:
lever presses under condition A
(red light) vs. B (blue light),
while "control" (hold constant)
all other variables

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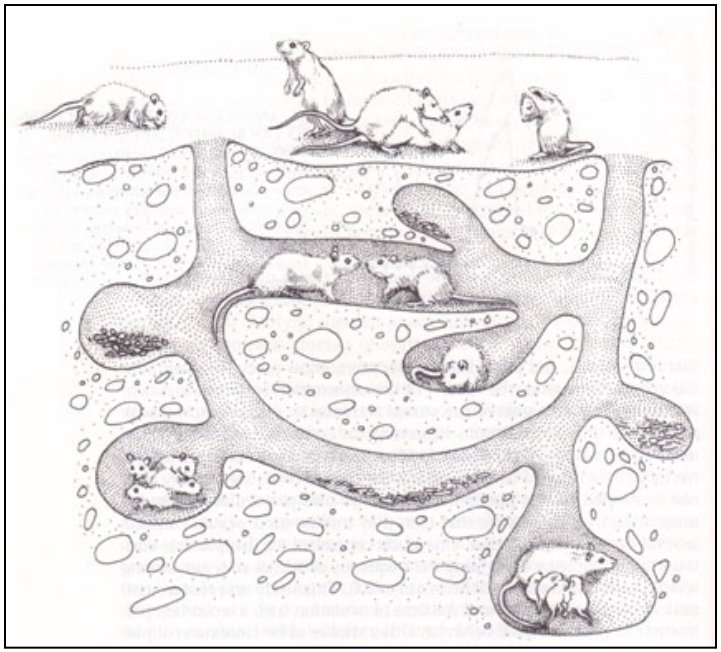


DATA:
Multi-modal (smell, hearing, sight, etc.)
Multi-party (roles, relationships, signals etc)
Multi-scalar (moment-to-moment, daily,
seasonal, evolutionary)

Repercussions of this shift - - -

So, for now at least…

- We will NOT be interested in this type of cognition…

Repercussions of this shift - - -

So, for now at least…

- To help us think ecologically, we will …
  - Avoid using the terms "ability", "skill", or "mental representation"
  - When temped to use above, instead, stop and ask…
    - What can we *SEE* happening?
    - How are participants engaged?
    - How do they co-constrain one another?

- i.e. Focus not on Product, but on ***Process!***

  Not on Contemplation, but on ***Situated Practice!***

WHY?

- Why make this difficult, confusing, laborious shift???

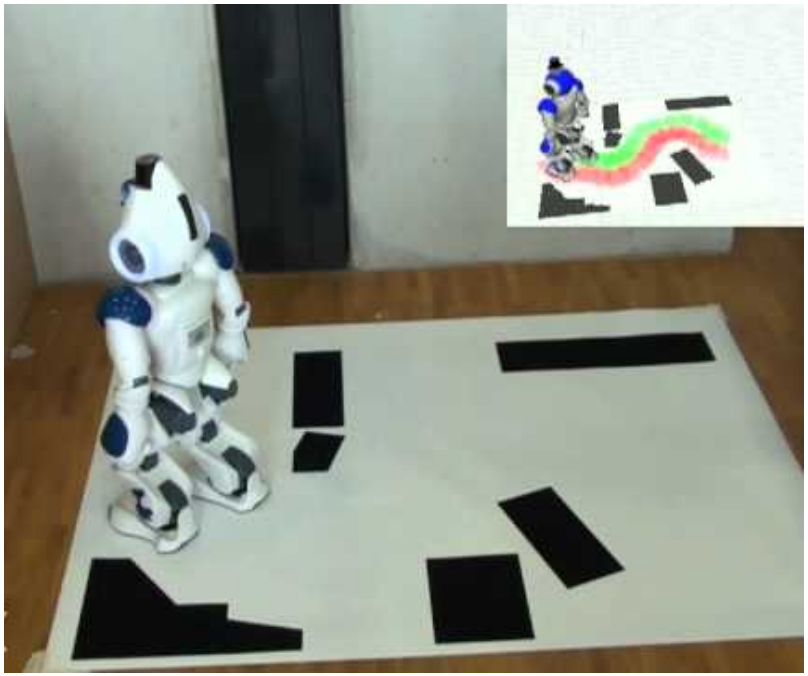
Ecological Validity

Research should be designed to investigate the real-world challenges that cognizers face

WHY?

Ecological Validity

- Cognition evolved as a situated response to complex environmental challenges
  - e.g. Navigate, Forage (seek & process resources), Socialize, etc.
  - e.g. Go around obstacles, move toward resources, from threats, etc.



WHY?

Ecological Validity

- Cognition evolved as a situated response to complex environmental challenges
  - e.g. Navigate, Forage (seek & process resources), Socialize, etc.
  - e.g. Go around obstacles, move toward resources, from threats, etc.
- Since we evolved to cogitate in real-world, <u>our adaptations match real-world affordances</u>
  - e.g. Since communication, in the real world, involves vision & audition, language interpretation requires integration of visible gestures & facial expressions with vocal output
  - Artificial conditions of lab (e.g. only words) do not pose same challenges, so will not reveal natural processes
  - By focusing on one element at a time, we will MISS critical role played by other modalities, people, objects, and environment!

WHY?

System-Level Properties

These properties can have consequences, and can be missed if focus on elements alone

WHY?

System-level properties differ from properties of elements

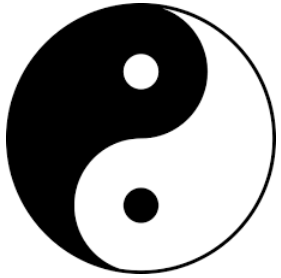
- e.g. Flock shape not = bird shape
  - This has consequences
    - e.g. **V** can be seen from farther away than individual birds can
- Some examples of system properties:
  - Synchrony:
  - Sequence: AAABBBCCC vs. ABCABCABC
  - Groupings: AB AB AB vs. ABA BAB
  - Positive and negative feedback loops
- Cannot be investigated by looking only at elements

Whole not = sum of parts !

WHY?

"Emergent Properties"

through dialectic engagement



- When multiple elements come into coordination, shaping options & actions, such coordination is an emergent property of that system

- e.g. Ant Trails (see NetLogo LAB1)
  - A function of # of ants, diffusion and evaporation of chemical
  - Trails are a colony-level property, *not* programmed into individuals

Cognition: A Definition

- From this view, we will define Cognition as

adaptive engagement with the world

- Cognition is Situated Practice, a range of activities-in-context, not a set of abilities

- "Adaptive" not necessarily = "optimal" or even "successful", but "relevant" to task or situation

Basic Assumptions of Distributed Cognition

- Cognition is Embodied
- Cognition is Distributed
- Cognition is Situated

Cognition is Embodied

- Cognizers, and thus many cognitive resources, are embodied
  - e.g. Species-specific sensori-motor constraints
    - Gulls see UV, we Primates are handy
    - Dolphins hear high, Elephants hear low freqs

Cognition is Embodied

GIBSON's "Affordances"

- "Ecological Perception" includes
  perceiving ***how*** one can interact w/world

  - e.g. For humans, chair affords sitting, pen affords gripping,
    floor (not cliff) affords walking, etc.

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  perceiving ***how*** one can interact w/world

  - e.g. For humans, chair affords sitting, pen affords gripping,
    floor (not cliff) affords walking, etc.

  - Note: "Canonical Cells" in parietal & prefrontal cortex
    found to respond to affordances of objects

Affordances depend on object AND your anatomy!

Cognition is Embodied

Multi-Modal coordination, within and between individuals

- e.g. Hand-Eye coordination involves organization of visual + proprioceptive + tactile + motor information

- e.g. Conversation involves relative timing of vocalizations, facial expressions, gestures, etc. across interlocutors

Cognition is Embodied

Multi-Body

Communicative activity (gestures, words) afford certain kinds of engagement

- Pointing affords co-attention to target

- Naming affords collaborative discussion

Cognition is Distributed

- Multi-party, including participants, artifacts, & cultural norms

- **<u>Problems are solved by system</u>**, not by any one element
  - Like your joint-accomplishment of **Maze!**

- If examine elements in isolation, one is likely to miss data critical to system operation

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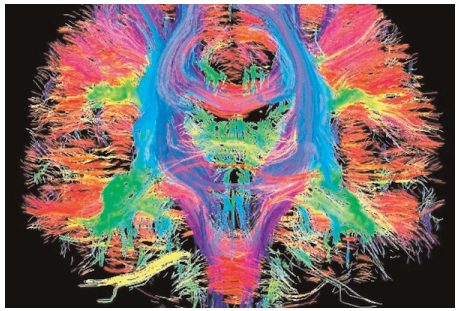
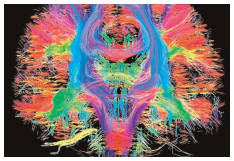
Consider the following examples from

Cognitive System: <u>Brain</u>



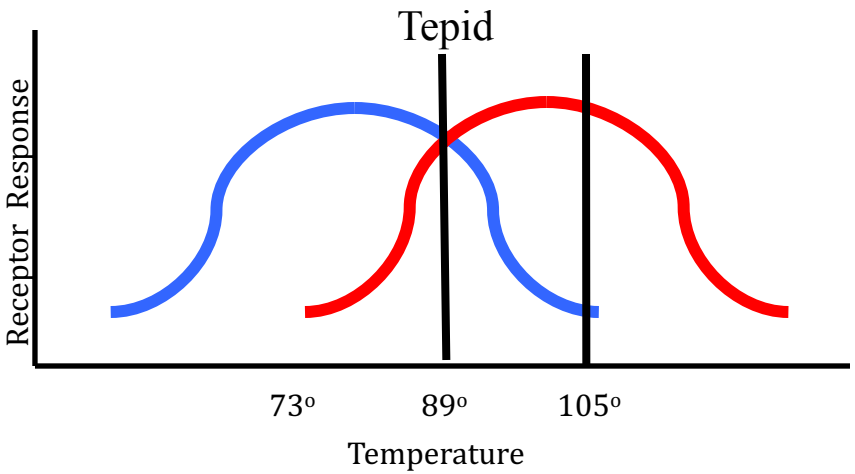
and

Cognitive System: <u>Social</u>



Cognition is Distributed

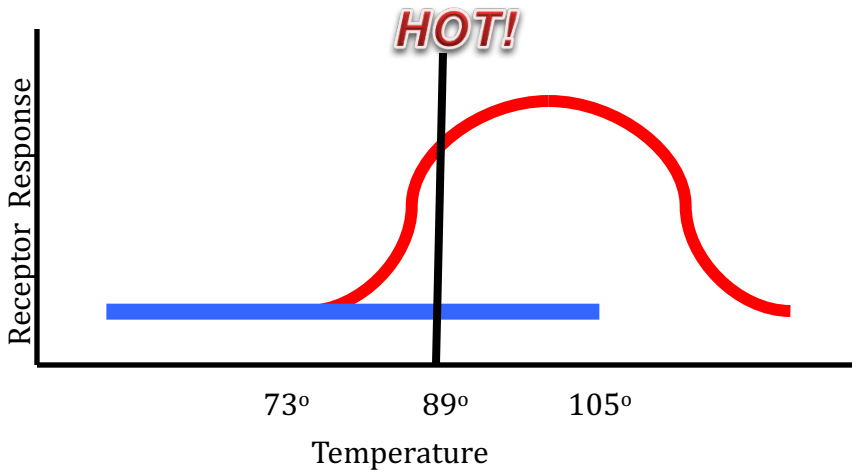
- **“Across-Fiber Coding”**



Cool-Best
Warm-Best

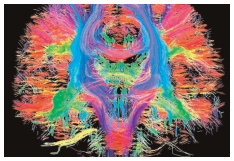
Normal conditions:

- 89º coded as WB=CB
- 105º coded as **WB>CB**



After adapt to ice water:

- 89º coded as **WB>CB**
- So, it *feels* like 105º !



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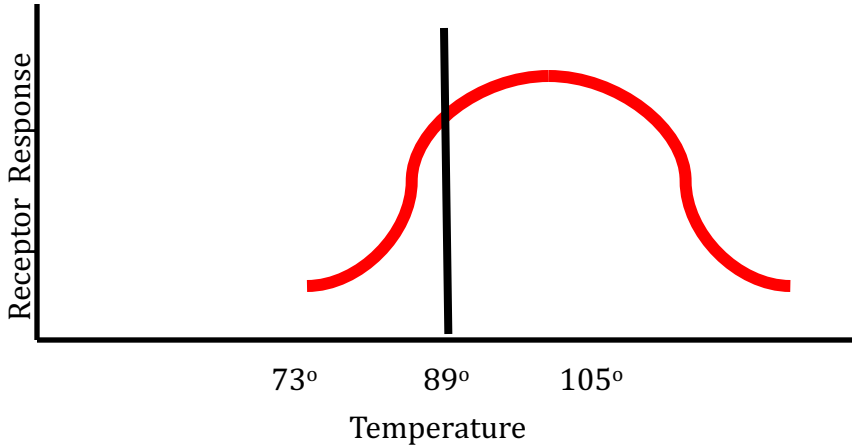
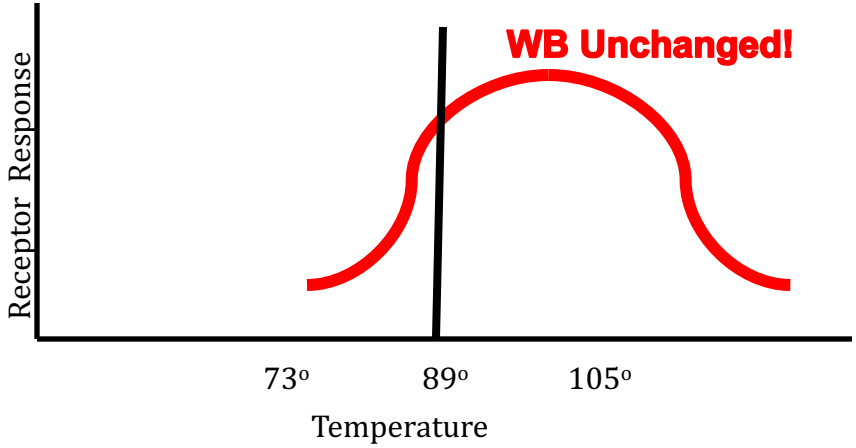
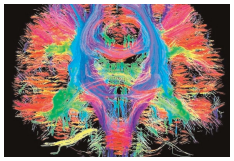




Cool-Best
Warm-Best

NOTE!

- The Warm-Best receptor acts the *SAME* way in both cases!



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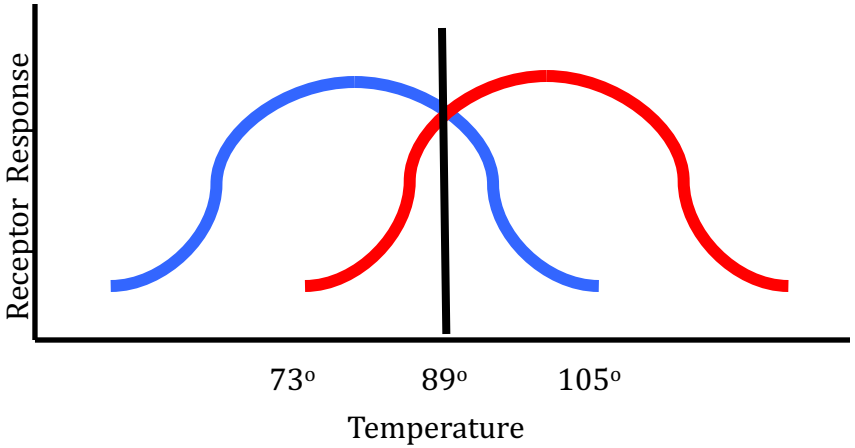
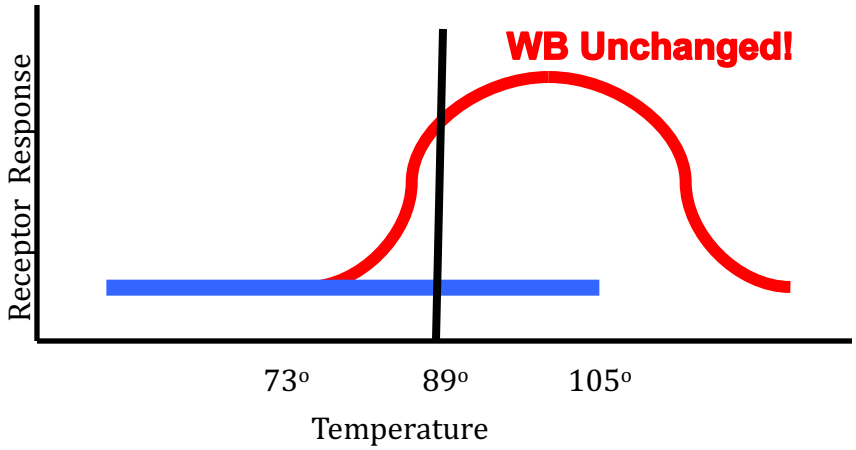




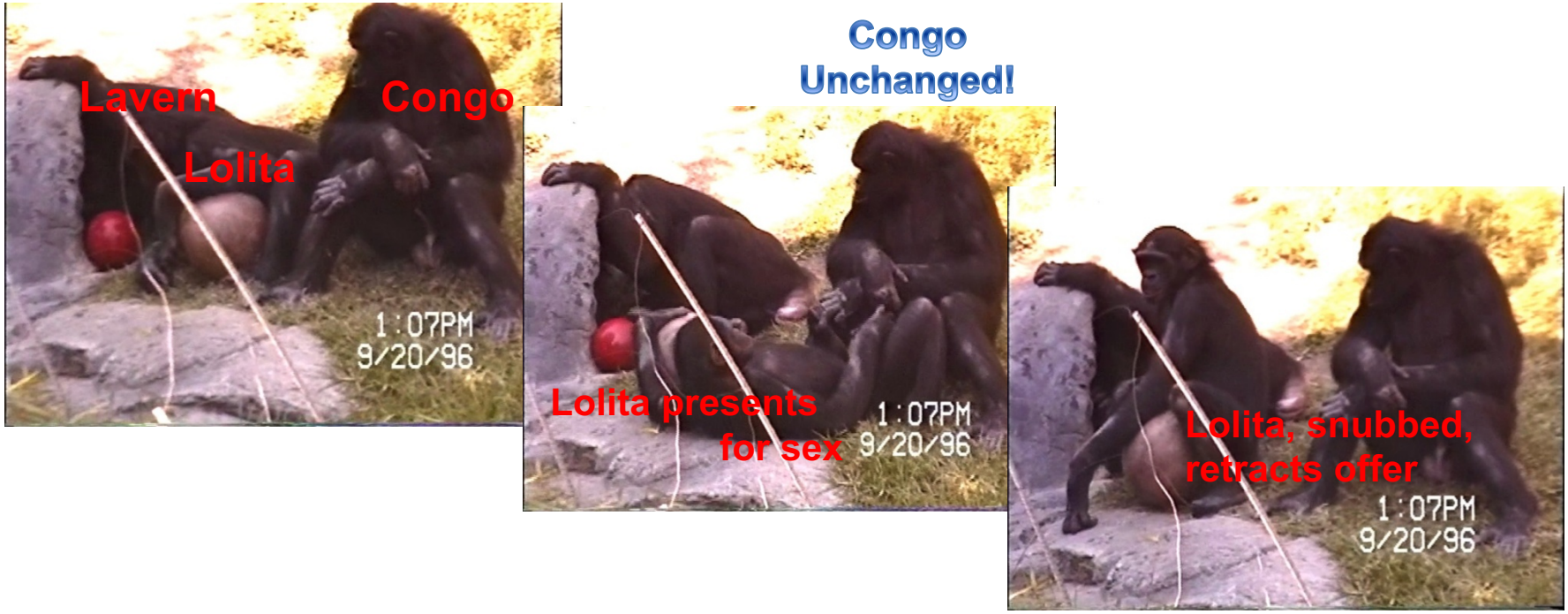
Cool-Best
Warm-Best

NOTE!

- The Warm-Best receptor acts the *SAME* way in both cases!
- It is its ***INTERACTION*** with the Cool-Best receptor that determines the perception.
- So, not the act of individual cell, but the interaction of cells that is informative…

Cognition is Distributed

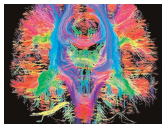
- Same principle applies to social system… e.g. **"Snub"**



- Congo keeps his head averted despite solicitous efforts by Lolita.

- Not reacting to a solicitation is a reaction!

"Nothing never happens!"

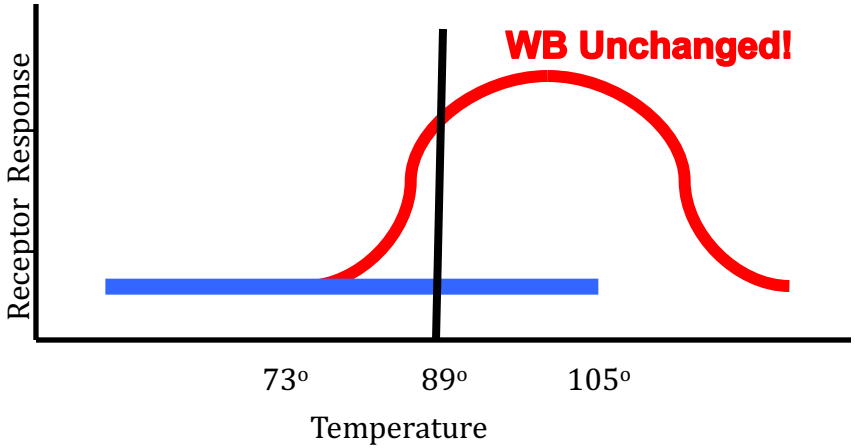


Cognition is Distributed

Even tho Warm Best receptors & “snubber” Congo did not change their behavior,

their constancy, under the circumstances,

did change the information available in their systems.



- We can say “**Meaning**” of Snubber’s non-movement, or of WB's response, has changed, wherein…

Meaning, Informativeness = **Relevance = role of event in larger system**

Cognition is Situated

- <u>Social, physical & cultural resources</u> shape cognitive activity
  - The world is a critical source of resources & constraints

<u>All</u> cognition is

"Cultural Cognition"

Cognition is Situated

- Vygotsky 1978:

  "Zone of Proximal Development"

  - **Learning as apprenticeship**

    - Novice + Expert engage until Novice can play all parts

Cognition is Situated

- Vygotsky 1978:

  "Zone of Proximal Development"

  - **Learning as apprenticeship**

    - Novice + Expert engage until Novice can play all parts

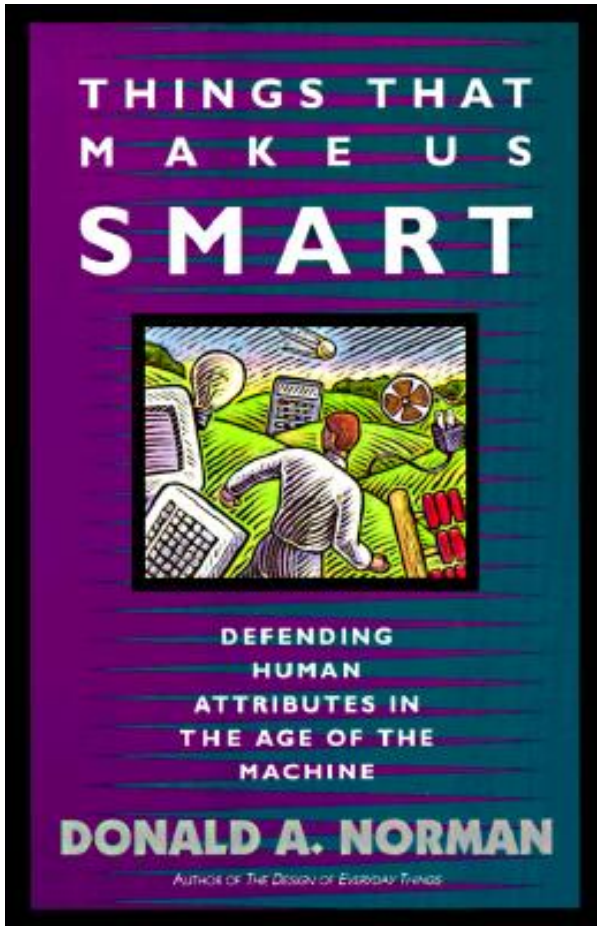
- Cognition is first inter-personal, only later intra-personal

- So, whatever "internal resources" player brings (perception, memory, inference) will be based on (& largely visible in) its embodied, polyadic, and situated experience

Cognition is Situated

- **Norman 1994**
  - "Things that make us smart"
- Cognitive artifacts task us
  - By constraining our practices w/their physical and informational affordances
- And, if well designed, these constraints will facilitate accomplishing task

Or not!



How to Study a System?

- We can learn about studying systems from the other sciences
  - "Systems Thinking" becoming widespread
    - Nonlinear Mathematics: Dynamical systems
    - Physics: Chaos theory
    - Economics & Game Theory : e.g. "A Beautiful Mind"
    - Evolutionary Biology
    - Behavioral Ecology

How to Study a Cognitive Ecology

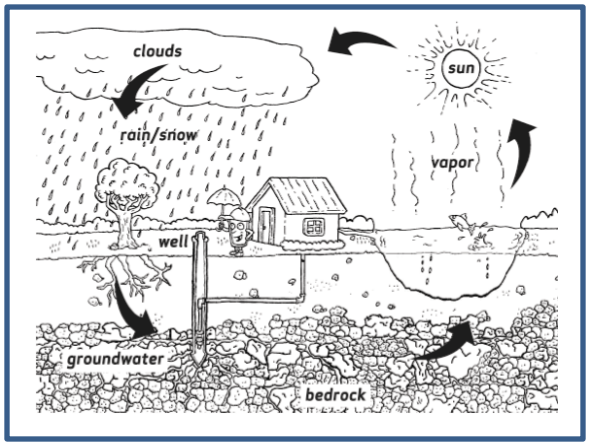
- Ecologies are complex!
- Difficult to study!
- Require collecting a rich, multi-faceted database
    - Time is an integral part
- Consider lessons from Biology…

Ecology

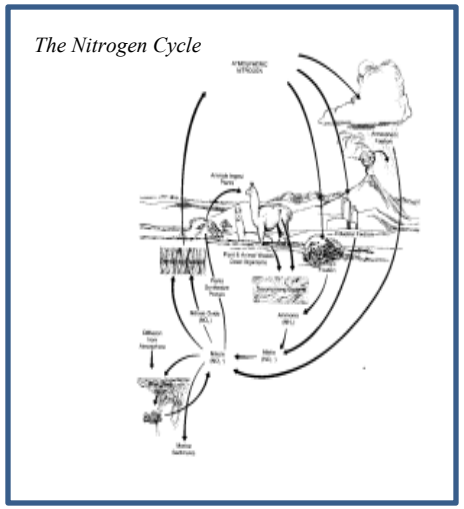
An ecology is a WEB of interactions . . .

Illustration by Barry Small

How to Study an Ecology

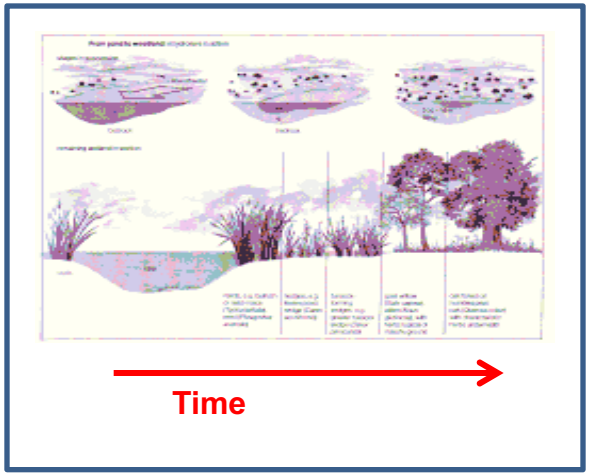


- Track transformations

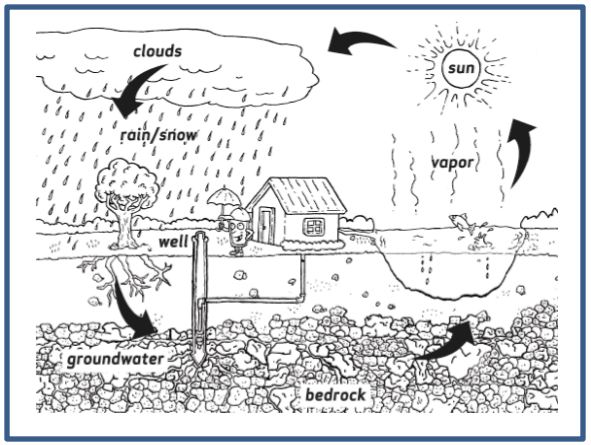


- Examine co-constraints

- Observe change over time



Also How to Study a ***Cognitive*** Ecology!



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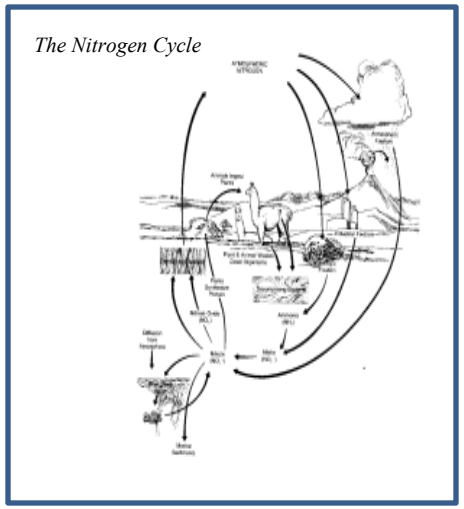

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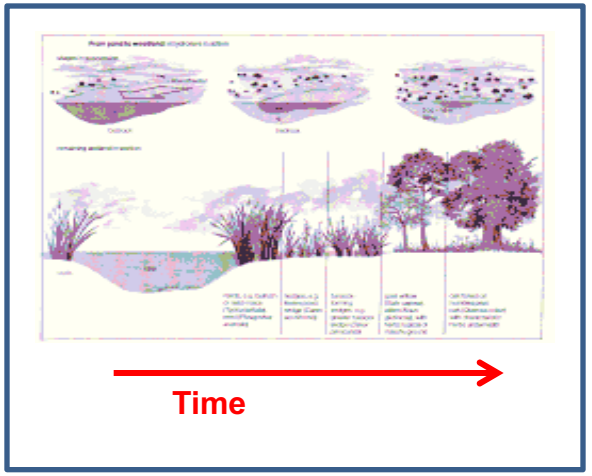
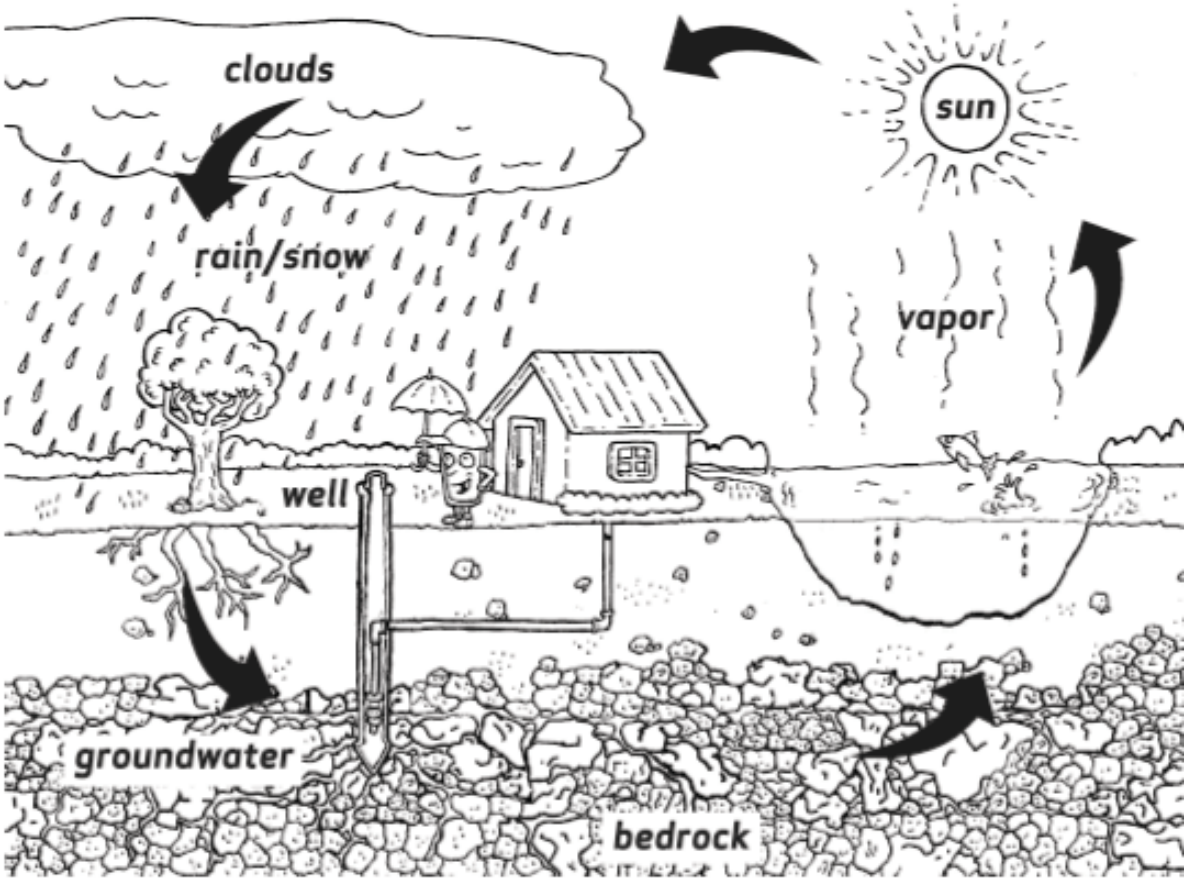


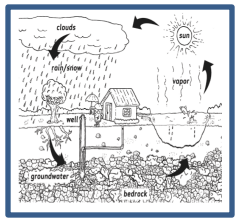
How to Study a *Cognitive* Ecology

- Tracking transformations …



http://www.arthursclipart.org/ecology/

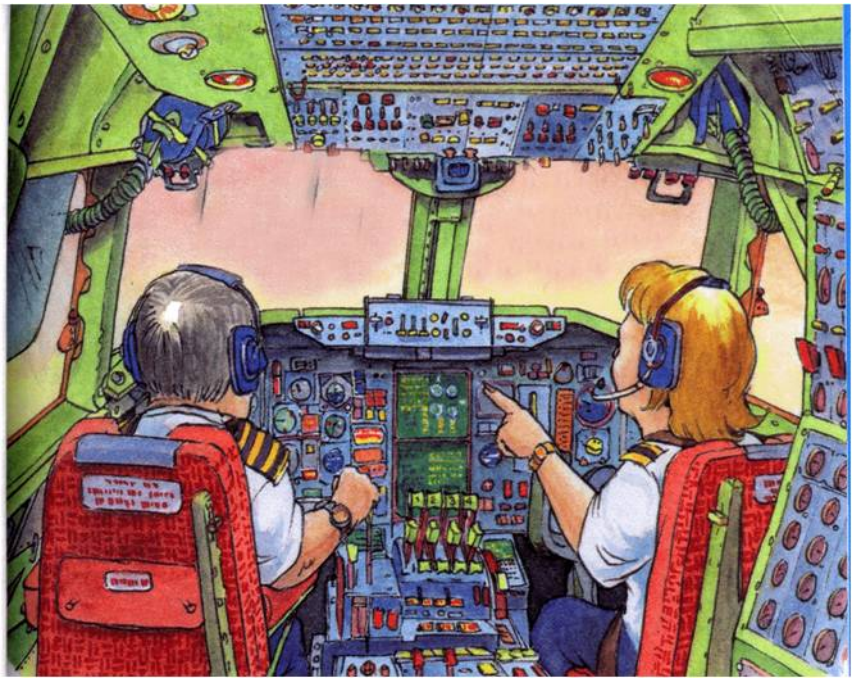
How to Study a *Cognitive* Ecology



Tracking Transformations of Information

ASK: What information goes where, when, in what form?

- e.g. Hutchins (1995) "How a cockpit remembers its speed"
  Cognitive Science, 19, 265-288

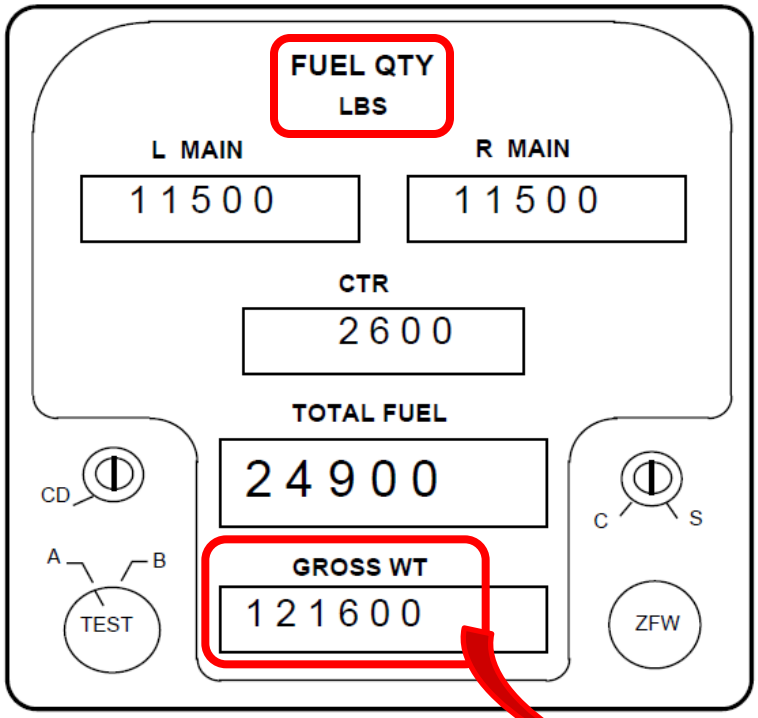


How to Study

Tracking Transformations of Information

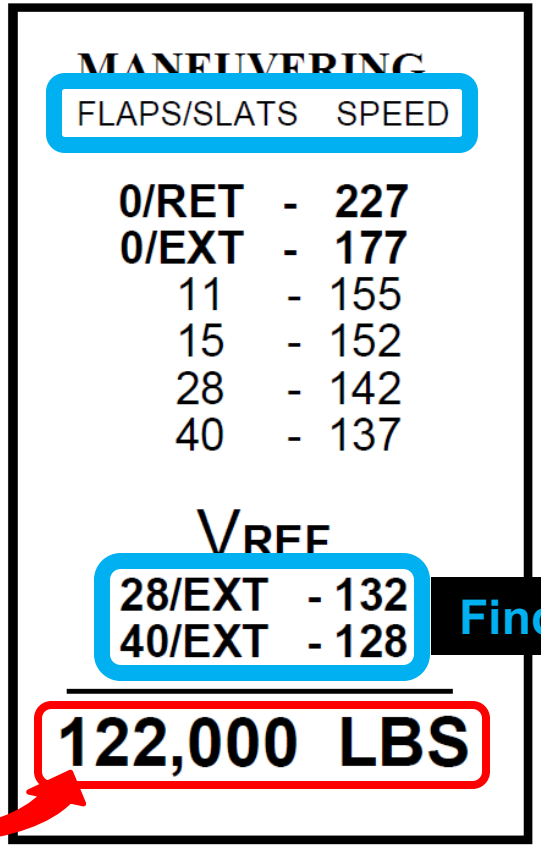
- TASK: Pilots must adjust flaps for descent for landing

Control panel



Find fuel weight on control panel

Speed card



Find VREF info

Find card from booklet that matches current fuel weight

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing

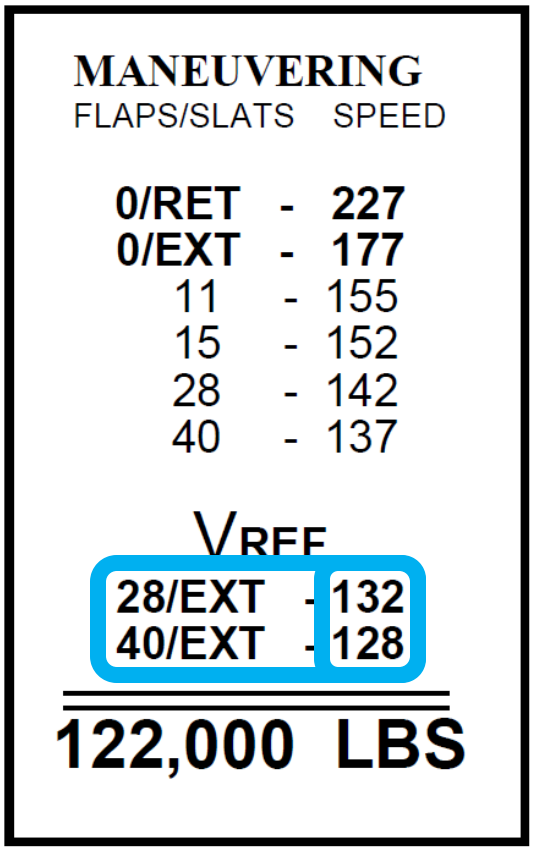
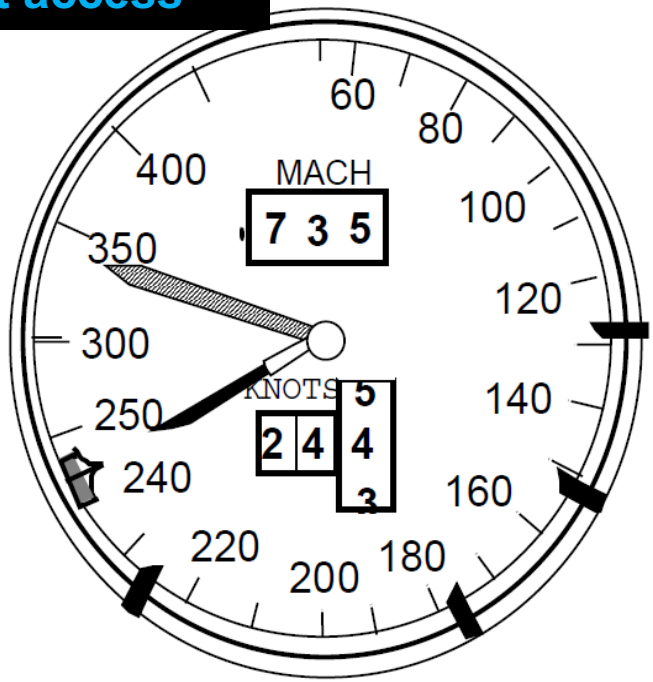


Figure 1. A speed card from an MD-80 speed card booklet.

Position card for joint access



Narrow focus to speed (in knots)

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing

MANEUVERING
FLAPS/SLATS SPEED

0/RET	-	**227**
0/EXT	-	**177**
11	-	155
15	-	152
28	-	142
40	-	137

VREF

28/EXT	-	**132**
40/EXT	-	**128**

122,000 LBS

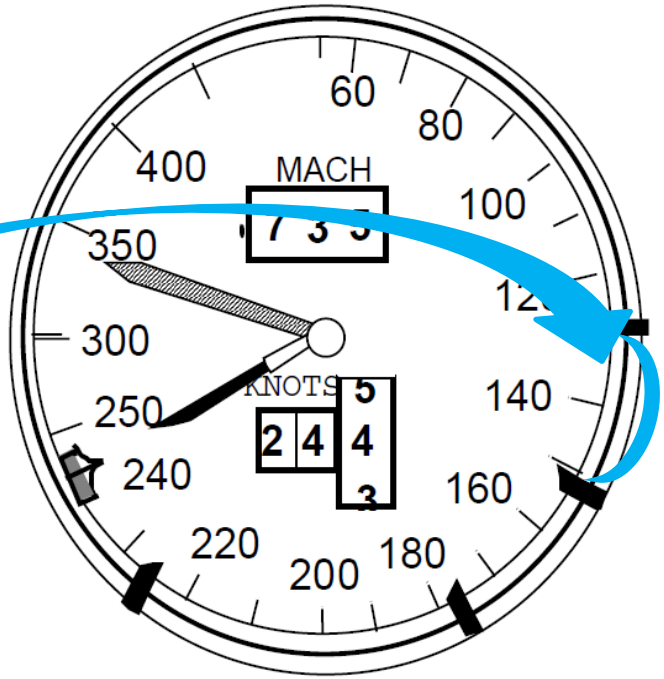


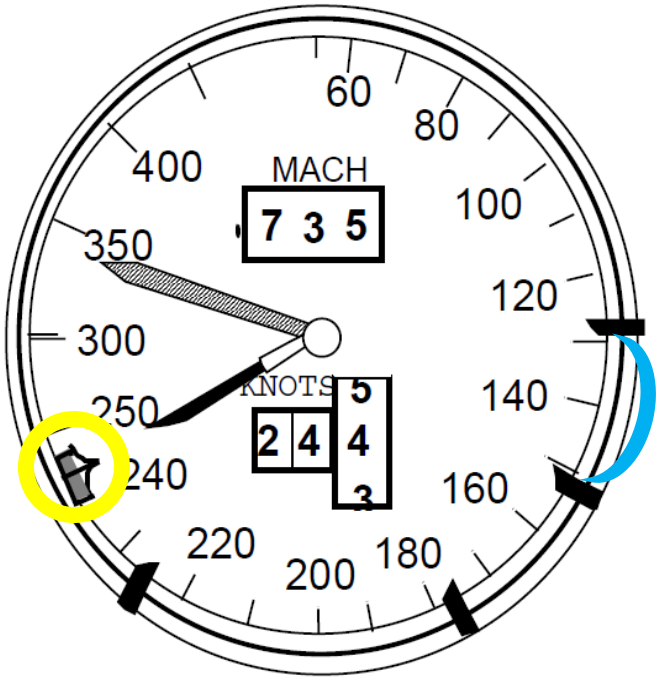
Figure 1. A speed card from an MD-80 speed card booklet.

Transform #s on card to area on speed dial

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing

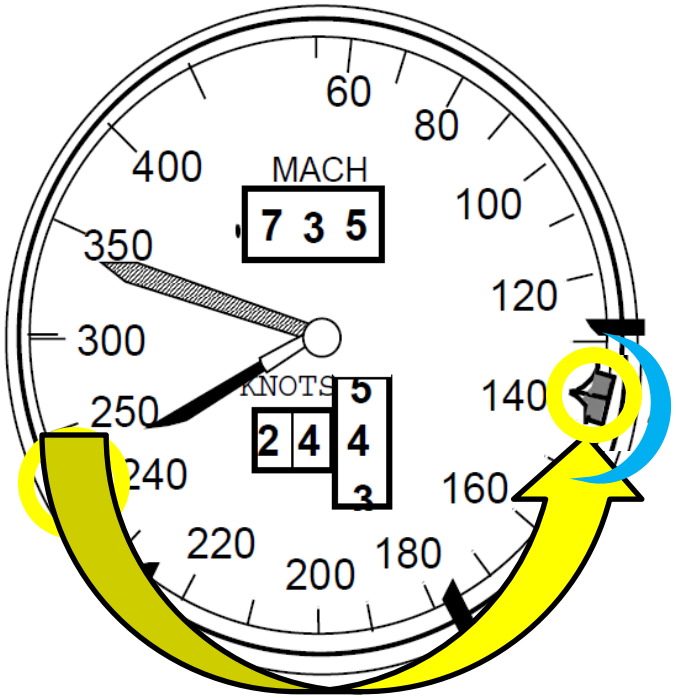


Locate “bug” on dial

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing

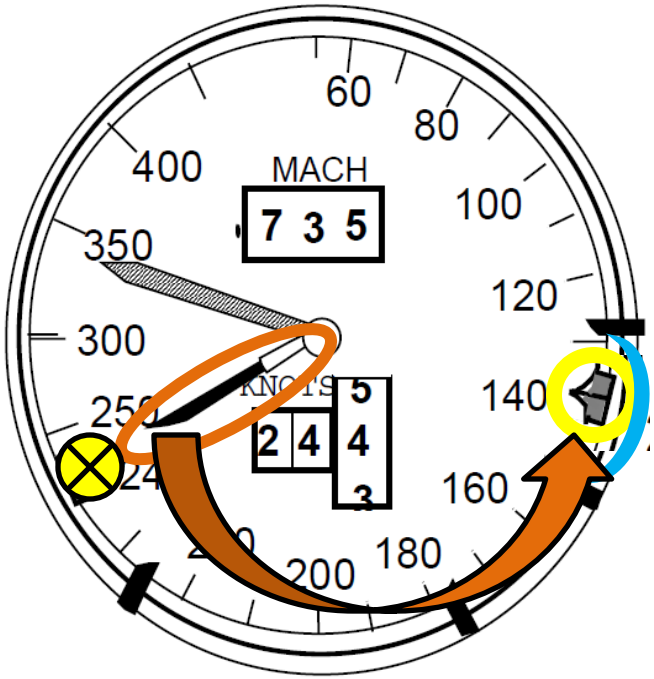


Move “bug” into area of concern

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing



Track spatial juxtaposition of needle and “bug”

How to Study

Tracking Transformations of Information

- TASK: Pilots must adjust flaps for descent for landing

MANEUVERING
FLAPS/SLATS SPEED

0/RET	-	**227**
0/EXT	-	**177**
11	-	155
15	-	152
28	-	142
40	-	137

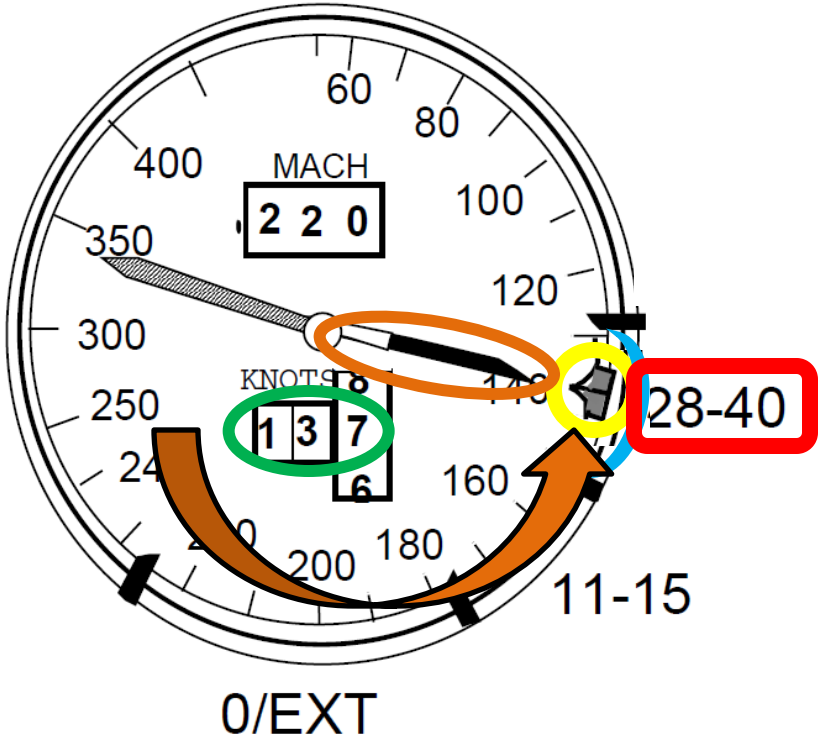
VREF

28/EXT	**132**
40/EXT	**128**

122,000 LBS

Figure 1. A speed card from an MD-80 speed card booklet.

Make sure flaps are extended to proper range (per VREF) by now!

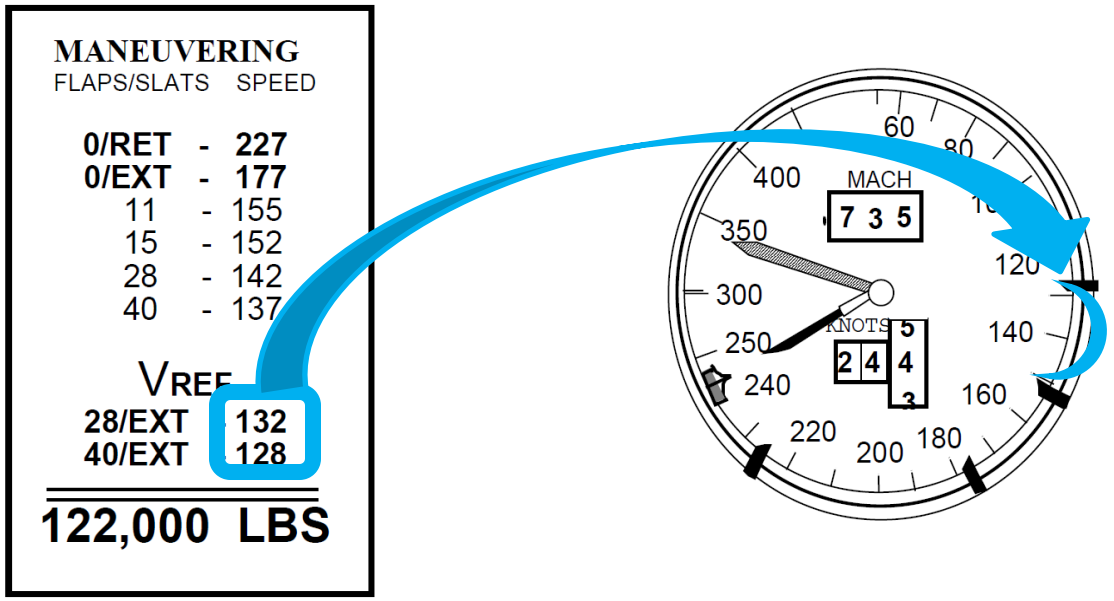


OK to land!

Tracking Transformations of Information

NOTE: When the transformation changes a task to one that is less computationally demanding . . .

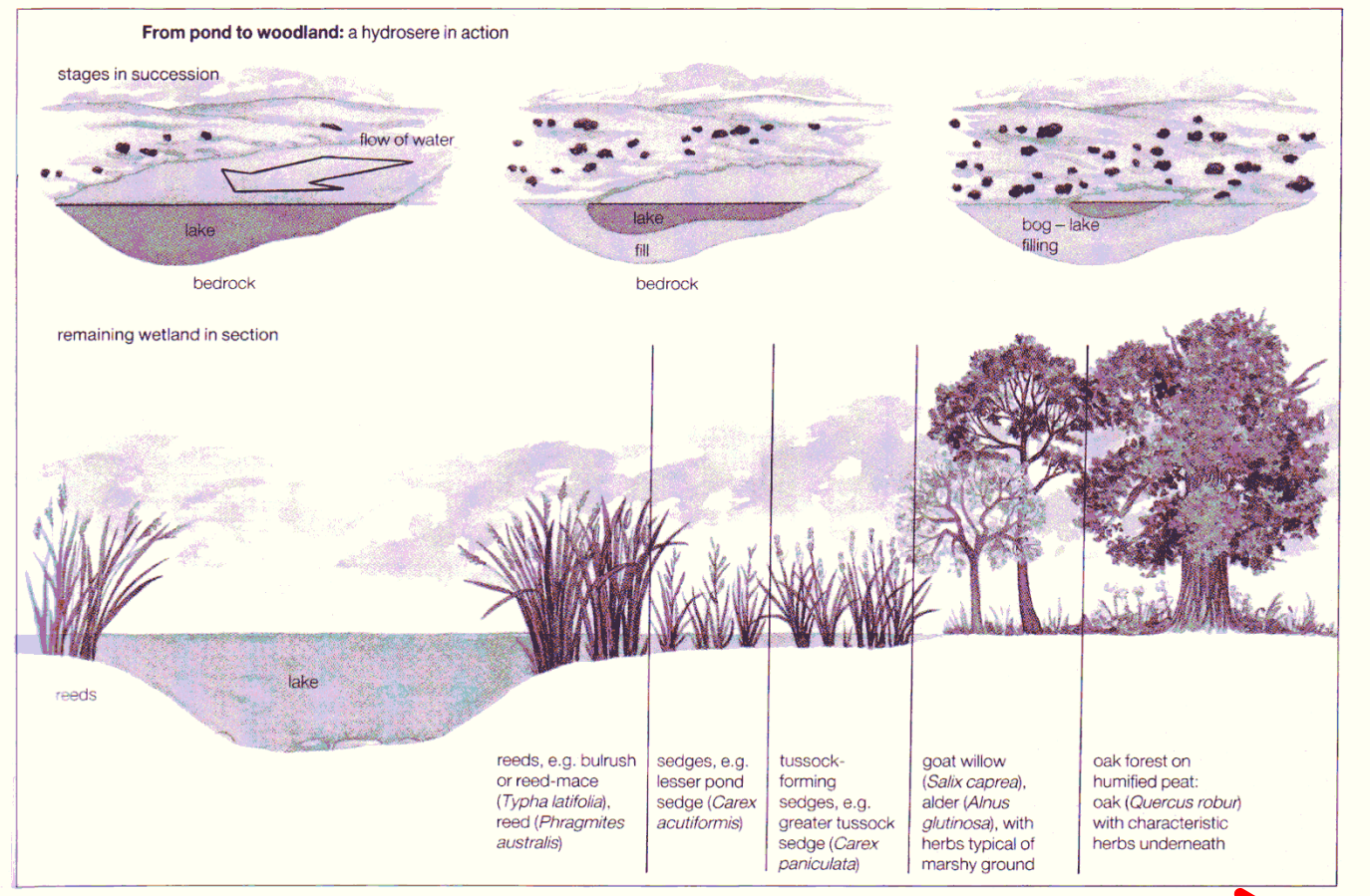
- KIRSH (1995): **"Epistemic Action"**
  - "Epistemic" action changes informational environment



- Cognitive Artifacts (including tools, language, other cultural practices) are often designed to promote such simplifying transforms

How to Study an Ecology

- Observe change over time …



http://www.arthursclipart.org/ecology/

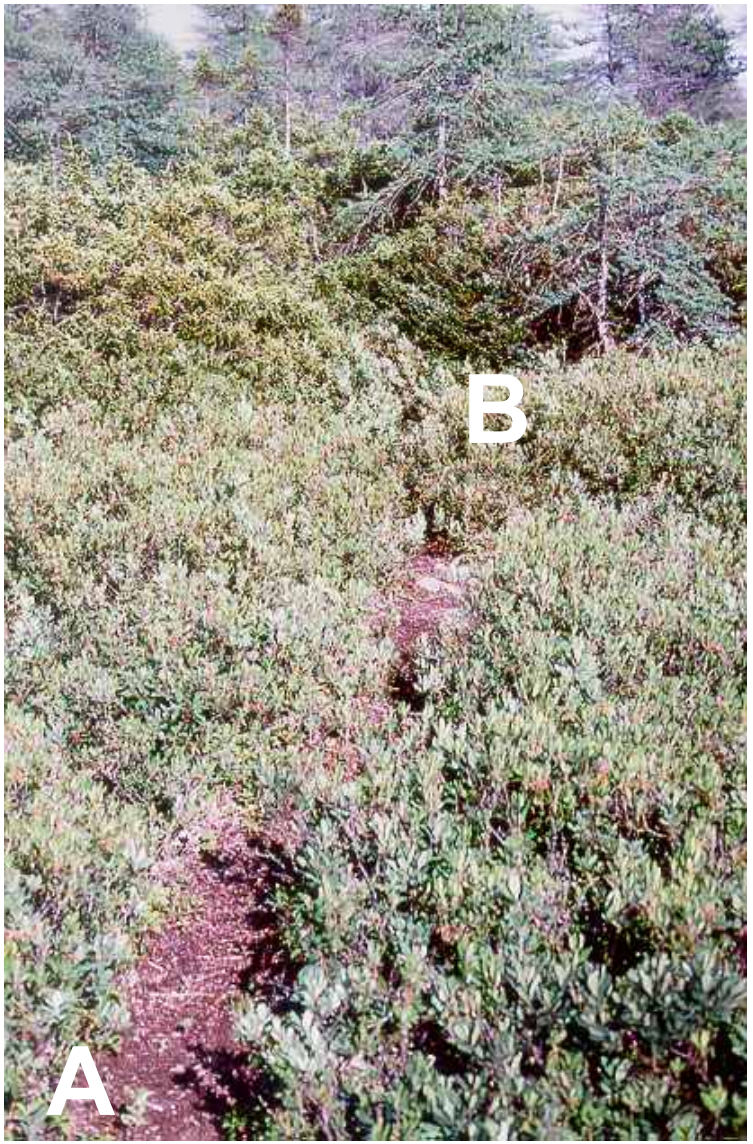
How to Study

Observing Change over Time

- ASK:
- How does <u>cumulative change</u> affect system function?

e.g. Animal Trails

- A type of "cognitive artifact"
- Problem-solving processes build up solutions over time



How to Study

Observing Change over Time

- ASK: How does <u>cumulative change</u> affect system function?

  e.g. Animal Trails

  - They change the task of getting around . . .

Photo by Mark Paulson

How to Study

Observing Change over Time

- ASK: How does cumulative change affect system function?

  e.g. Animal Trails

  - They change the task of getting around . . .
  - And create opportunities for new practices
    - Like scent marking . . .

How to Study

Observing Change over Time

- ASK: How does <u>cumulative change</u> affect system function?

  e.g. Animal Trails

  - They change the task of getting around . . .
  - And create opportunities for new practices
    - Or easier predation . . .

How to Study

Observing Change over Time

- ASK: How does cumulative change affect system function?

Humans, especially, perform such "**Cognitive Niche Construction**"

- Create, share, use many cognitive artifacts

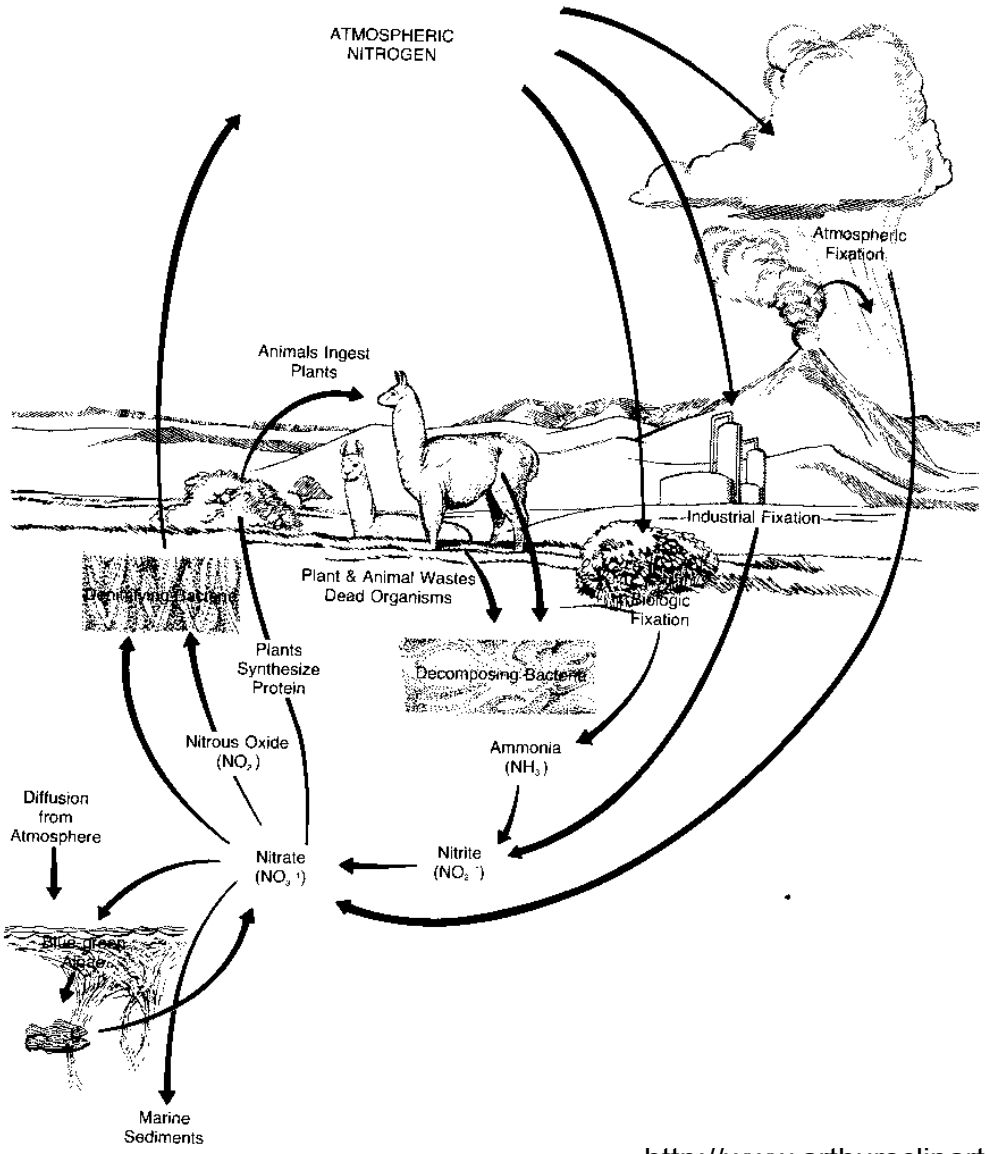
- Tools as cultural "crystallization of partial solutions to common problems"

- Includes symbols, language, other conventions

How to Study an Ecology

- Examine co-constraints…

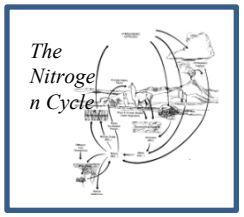
The Nitrogen Cycle



http://www.arthursclipart.org/ecology/

How to Study

Examine Co-Constraints



ASK: How do constraints on activity in this system <u>interact</u>?

- **Thelen & Smith, 1994**
  Locomotor development as a Dynamical System

How to Study

Examine Co-Constraints

- e.g. Seems that infant does not "have ability"
  to crawl until 8 months,
  or to walk until 1 year.

- But, younger infant makes proper moves if immersed in water, just can't support weight

- Locomotor tasks involve dynamic coupling of multiple factors!
  - i.e. Walking is an emergent property of this system!

Let’s examine a cognitive system,

and how its elements co-constrain one another,

generating its emergent properties . . .

Team Evaluations

Each week there is a lab, you will be emailed a link

- Confidential evaluation form
- Rate each of of your teammates (by name)
  - After you have turned in your lab in secion
  - Based on participation in that week's lab
  - 0 = no participation 10 = full participation

- This will impact on 25% of your score on that lab
  - Your average rating X 25% of the possible 100 pts
  - e.g. If you team earns 100/100 and your rating is…
    - Avg rating = 10 Your score = 100
    - Avg rating = 5 Your score = 75 + (25 * .5) = 87.5
  - e.g. If your team earns 80/100 and your rating is…
    - Avg rating = 5 Your score = 60 + (20 * .5) = 70