The ShanghAI Lectures

人工智能

上海授课

Video clips

passive dynamic walker

Denise

The ShanghAI Lectures by the University of Zurich
An experiment in global teaching

Today from the University of Zurich

29 November 2012

欢迎您参与

“来自上海的人工智能系列讲座”

Lecture 8

Where is human memory?

29 November 2012

University of Zurich

robotics Swiss National Centre of Competence in Research

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The ShanghAI Lectures

Today's schedule

09.00 - 09.05 Intro, preliminary comments

09.05 - 10.00 Where is human memory?

10.00 Break

10.05 - 10.30 Guest lecture by Prof. Vera Zabotkina (RSUH, Moscow, Russia)

10.35 - 11.00 Guest lecture by Prof. José del Millán (EPFL, Lausanne, Switzerland)

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Calling on

- ISRI, SKKU, Korea: Differences between human memory and computer memory
- NYU, Abu Dhabi: more differences between human memory and computer memory
- Karlsruhe: More differences between human memory and computer memory
- Chiba University, Japan: difference episodic-semantic memory?
- Shanghai Jiao Tong University: Structure of water fountain - where is it stored?
- Osaka University: Where is the memory of DAC?
- Xi’an: Examples of scaffolding?
- HITLab, UTAS: Which design principle(s) in scaffolding?
- Zurich: memory for walking in Passive Dynamic Walker?

Lecture 8: Guest speaker

from RSUH, Russian State University for the Humanities

Prof. Dr. Vera Zabotkina,
"Cognitive modeling in linguistics: conceptual metaphors"

10.00h Zurich time (13.00 Moscow time)

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Lecture 8: Guest speaker

from EPFL, Switzerland

Prof. Dr. José del Millán
"Brain-machine interfacing"

10.30h Zurich time

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Today’s topics

- Where is human memory?
- Memory concepts
- The “storehouse metaphor” and its problems
- Embodied notions of memory
- Summary and conclusions

Differences in memory computer — human

Careful: FOR — performance differences, and differences in mechanisms
- accuracy
- speed
- generalization
- categorization
- embeddedness (human memory: embedded into complete organism)
- variations in performance (large for human memory)
- many different types of memory (human); also: related to sensory modalities
- capacity
- addressability (location vs. content-addressability)
- storage and retrieval mechanisms
- retention (short/long-term memory)
- “expert paradox”: the more you know, the faster the retrieval (in contrast to computer memory
- data base)
- organization

Differences in memory computer — human

differences?
—> ISRI, SKKU, Seoul Korea

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Differences in memory computer — human

more differences?
—> NYU, Abu Dhabi

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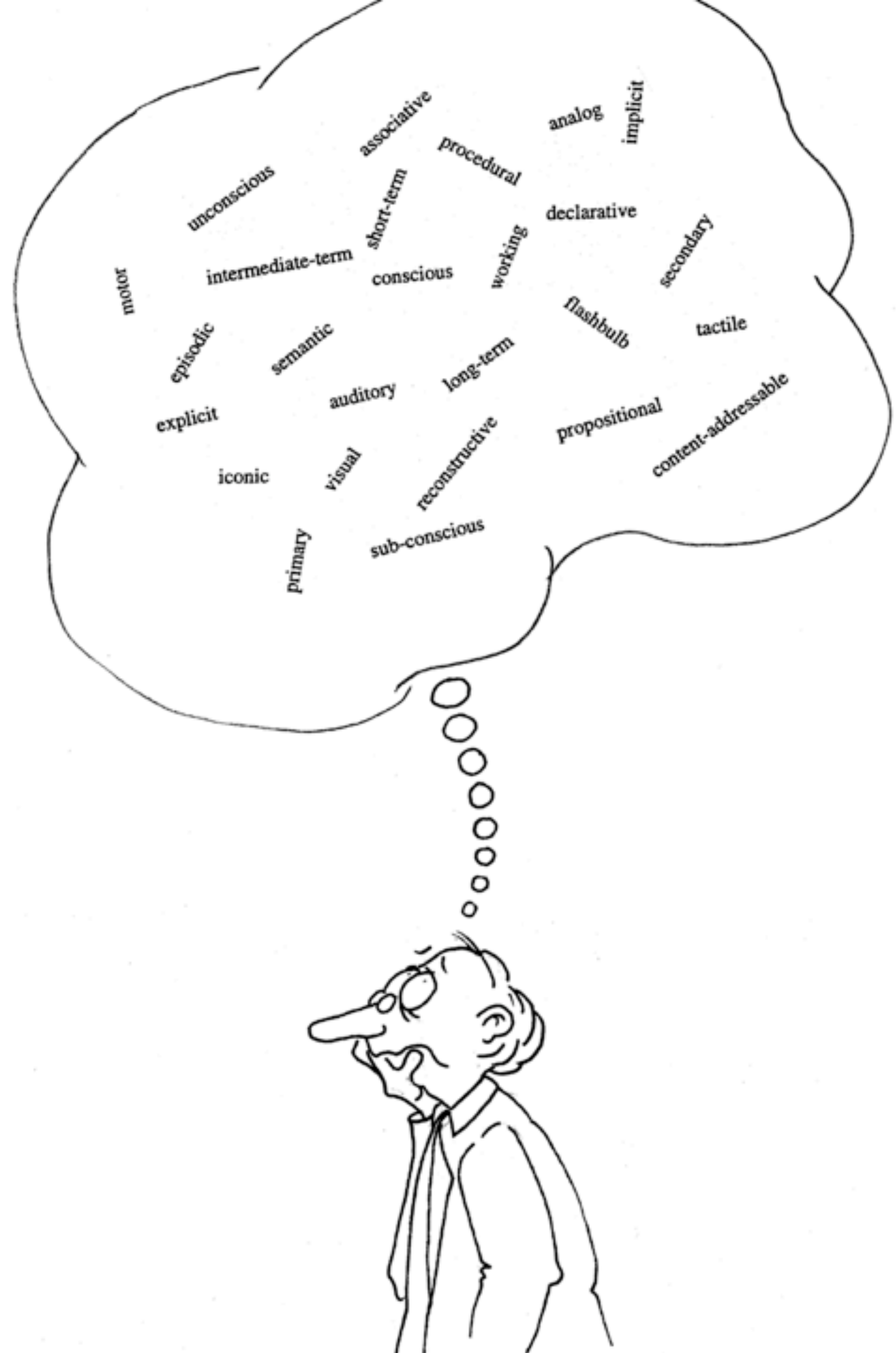
Many memory concepts

researcher puzzled by the many different notions of human memory



cartoon: Isabelle Follath, Zurich

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Many classifications exist:
- temporal characteristics
- modalities
- accessability
- context: relating to time-line, semantic, etc.

Types of memory

- short-term/primary
- long-term/secondary
- working
- episodic
- semantic
- propositional
- sensory buffers
- iconic
- visual
- acoustic
- flashbulb
- autobiographical
- auditory/echoic
- olfactory
- declarative
- procedural
- sensory-motor
- explicit
- implicit
- conscious
- unconscious
- eidetic
- etc.

Semantic vs. episodic memory

Brief explanation:
semantic vs. episodic memory?
—> Chiba

- episodic memory: concerning specific events (experience of sight and sound of tram in Zurich)
- semantic memory: concept of "Tokyo Subway"

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- etc.

Classical notions of memory
The storehouse metaphor

memories stored in particular locations from where they are later retrieved

“a system for storing and retrieving information” (Baddeley, 1997, p. 9)

“a system for storing and retrieving information” (Baddeley, 1997, p. 9)

… and its problems

- "memory as stored structures" (Clancey, 1997)
- unfamiliar rendition of piece of music (Bursen, 1978)
- "stored mental image"? (Rosenfield, 1988)
- every stroke in tennis unique (Bartlett, 1932)
- homunculus problem — inspecting the memory contents (Gregory, 1987)
- storehouse metaphor: entails problems of classical AI (e.g. symbol grounding, frame, etc.)

Clancey: Situated cognition
Bursen: Dismantling the memory machine
Bartlett: Remembering
Rosenfield: The invention of memory
When we speak of a stored mental image of a friend, which image or images are we referring to? The friend doing what, when and where? (Rosenfield, 1988, p. 163).
Gregory: The Oxford companion to the mind

… and its problems

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Clancey: Situated cognition. Example: Water fountain.
Bursen: Dismantling the memory machine
Bartlett: Remembering
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Water fountain
Where is the memory for shape?

clear structure visible

underlying mechanism?

Water fountain
Where is the memory for shape?

clear structure visible

underlying mechanism?

Where is the "structure" stored?
—> Shanghai Jiao Tong University

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shape can be described as structure — just as a memory structure; most like dynamically generated in interaction with environment (the situated, embodied nature of memory)
shape of water emergent from:
- shape and direction of jets
- pressure at exit
- water surface tension
- gravity

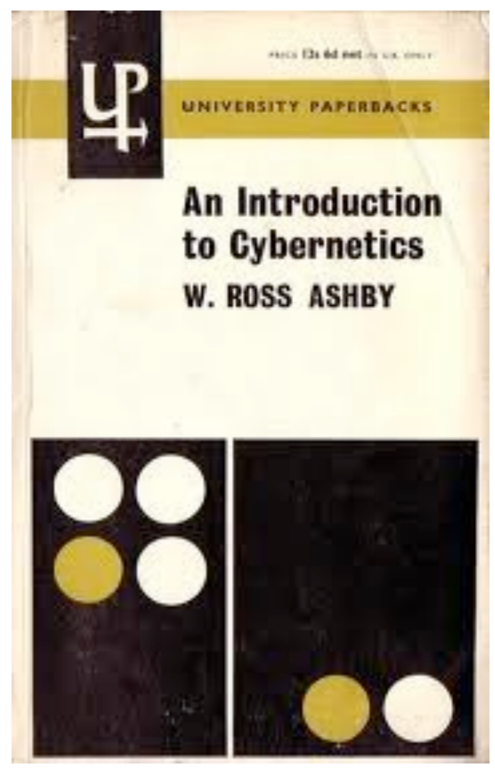
… and its problems

- “memory as stored structures” (Clancey, 1997)
- **unfamiliar rendition of piece of music (Bursen, 1978)**
- **“stored mental image”? (Rosenfield, 1988)**
- **every stroke in tennis unique (Bartlett, 1932)**
- **homunculus problem — inspecting the memory contents (Gregory, 1987)**
- **storehouse metaphor: entails problems of classical AI (e.g. symbol grounding, frame, etc.)**

When we speak of a stored mental image of a friend, which image or images are we referring to? The friend doing what, when and where? (Rosenfield, 1988, p. 163).
Clancey: Situated cognition
Bursen: Dismantling the memory machine
Bartlett: Remembering. “It is with remembering as it is with the stroke in a skilled game. We may fancy that we are repeating a series of movements learned a long time before from a text-book or from a teacher. But motion study shows that in fact we build up the stroke afresh on the basis of the immediately preceding balance of postures and the momentary needs of the game. Every time we make it it has its own characteristics (Bartlett, 1932, p. 204).
Rosenfield: The invention of memory (unfamiliar rendition of piece of music)
Gregory: The Oxford companion to the mind. “Homunculus” inspecting the memory contents. Who tells the homunculus what to do?, etc.

Towards a new conception of memory

W. Ross Ashby, the great cybernetician



Originally: Cybernetics or Control and Communication in the Animal and the Machine (1948). Norbert Wiener

Ashby’s concept of “memory as a theoretical construct”

W. Ross Ashby (1956). An introduction to cybernetics.

a. b.

Ashby’s notion of memory

Suppose I am in a friend’s house and, as a car goes past outside, his dog rushes to a corner of the room and cringes. To me the behaviour is causeless and inexplicable. Then my friend says, “He was run over by a car six months ago.” The behavior is now accounted for by reference to an event of six months ago. If we say that the dog shows “memory” we refer to much the same fact—that his behavior can be explained, not by reference to his state now but to what his state was six months ago. If one is not careful one says that the dog “has” memory, and then thinks of the dog as having something, as he might have a patch of black hair. One may then be tempted to start looking for the thing; and one may discover that this “thing” has some very curious properties. Clearly, “memory” is not an objective something that a system either does or does not possess; it is a concept that the observer invokes to fill in the gap caused when part of the system is unobservable. (1956, p. 117)

Memory experiment

Learning phase

intermediate task

test phase
- **recall**
- **recognition**

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Learning phase

WMS-III		
List A		List B
Target		Diamond
Finger		Garden
Sunset		Court
Crocodile		Hero
Dollar		Sand
Yard		Kitten
Student		Branch
Traffic		Kitchen
Broom		Daisy
Ocean		Lake
Wing		Gorilla
Giant		Jail

test phase
- **recall**
- **recognition**

Recognition List		
Magazine	Village	Student
Dollar	Finger	Breakfast
Carpet	Market	Feather
Nest	Giant	Crocodile
Traffic	Smile	Yard
Doctor	Ocean	Shoelace
Target	House	Sunset
Broom	Wing	Hotel

from WMS-III, the Wechsler Memory Scale test
Behavioral characterization: subjects are able to reproduce the list of words later because of some kind of memory --> perfectly OK. Problem: inferring that the *underlying mechanism* is also based on a stored list --> flawed.
Clancey: it;s like modeling a camera's mechanism by describing the photographs it produces (1991).

Ashby’s notion of memory

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see also: Ashby’s “Design for a brain”
—> design principles

Embodied notions of memory

- Arthur Glenberg, Laboratory for Embodied Cognition, University of Wisconsin-Madison: "What memory is for" (Glenberg, 1997)
- Koriat and Goldsmith: "… the growing interest in embodiment phenomena … brings action to the forefront of cognitive theory" (Koriat and Perlman-Avnion, 2003)
- interaction with environment: central (perhaps counter-intuitive)

memory has not evolved to learn list of words, but it is in the service of behavior, of perception and action.

Arthur Glenberg: Embodiment as a unifying concept in psychology. Wire's Cognitive Science, volume 1, 2010, 586-596.

—> paradigm shift is taking place

Three-Constituents and Complete Agent Principles

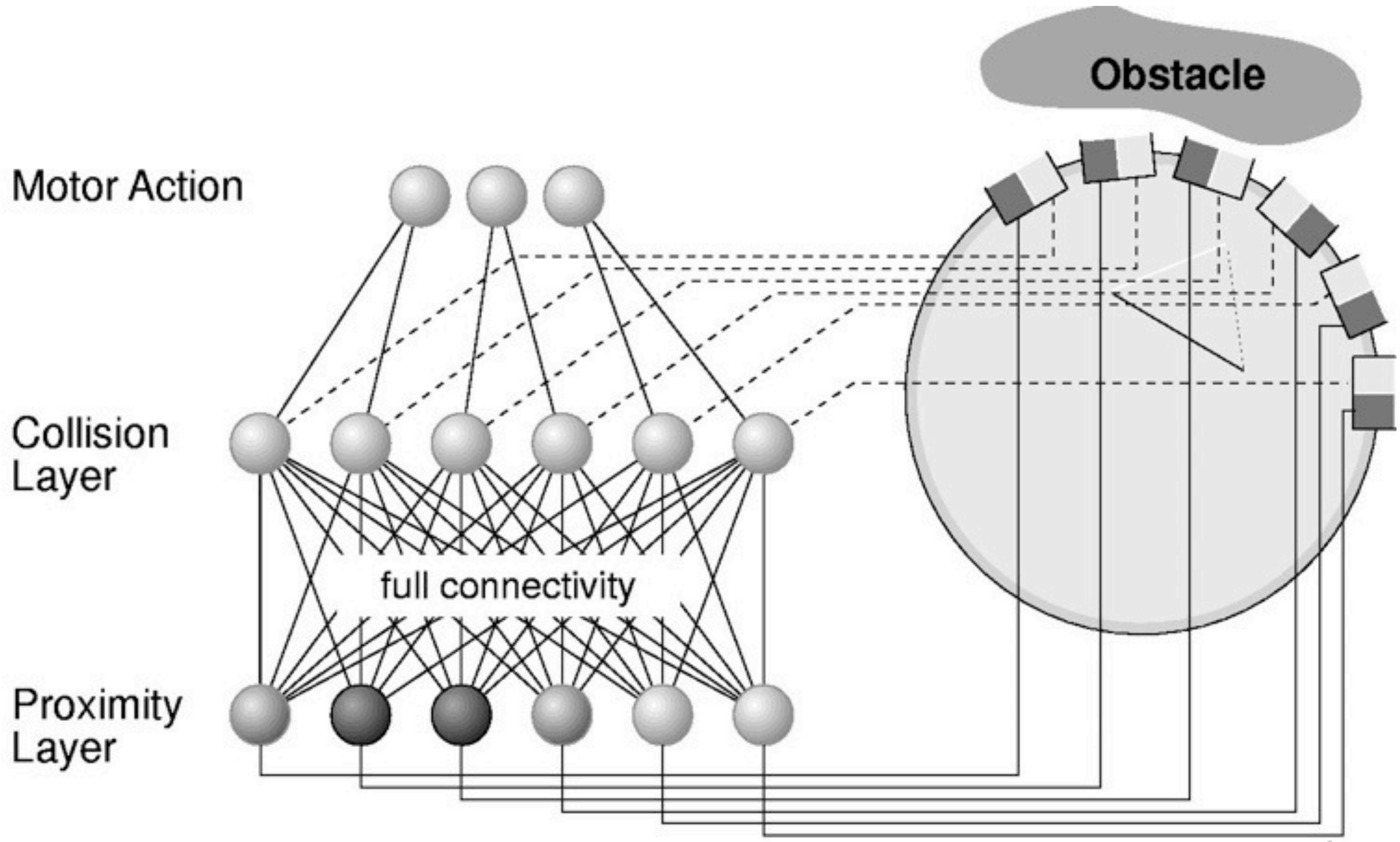
- classical memory experiments: precisely controlling environmental condition to establish “pure memory function”
- ecological approach: memory in real-life situations (e.g. eyewitness testimony)
- sensitivity to context, motivation — importance clear from complete agent perspective: storehouse not plausible
- manifestation of memory: through changes in behavior (Craik, 1983)

eyewitness testimony extremely sensitive to context (system-environment interaction): some examples
Eleonor Rosch’s experiments. Video of traffic accident. Question: How fast was the car when he drove over the stop sign? There was in fact no stop sign, but when the subjects were later asked about the presense of a stop sign, they tended to give a positive reply.

Manifestation of memory

"Clearly something in the system must change as a result of experience, but the changes may be diffuse and widespread modifications of the whole cognitive system so that the system now interacts with aspects of the environment in a different way, rather than events being recorded specifically and discretely like events on a video recorder." (Craik, 1983, p. 356)

Environment of DAC robot: Arena with obstacles



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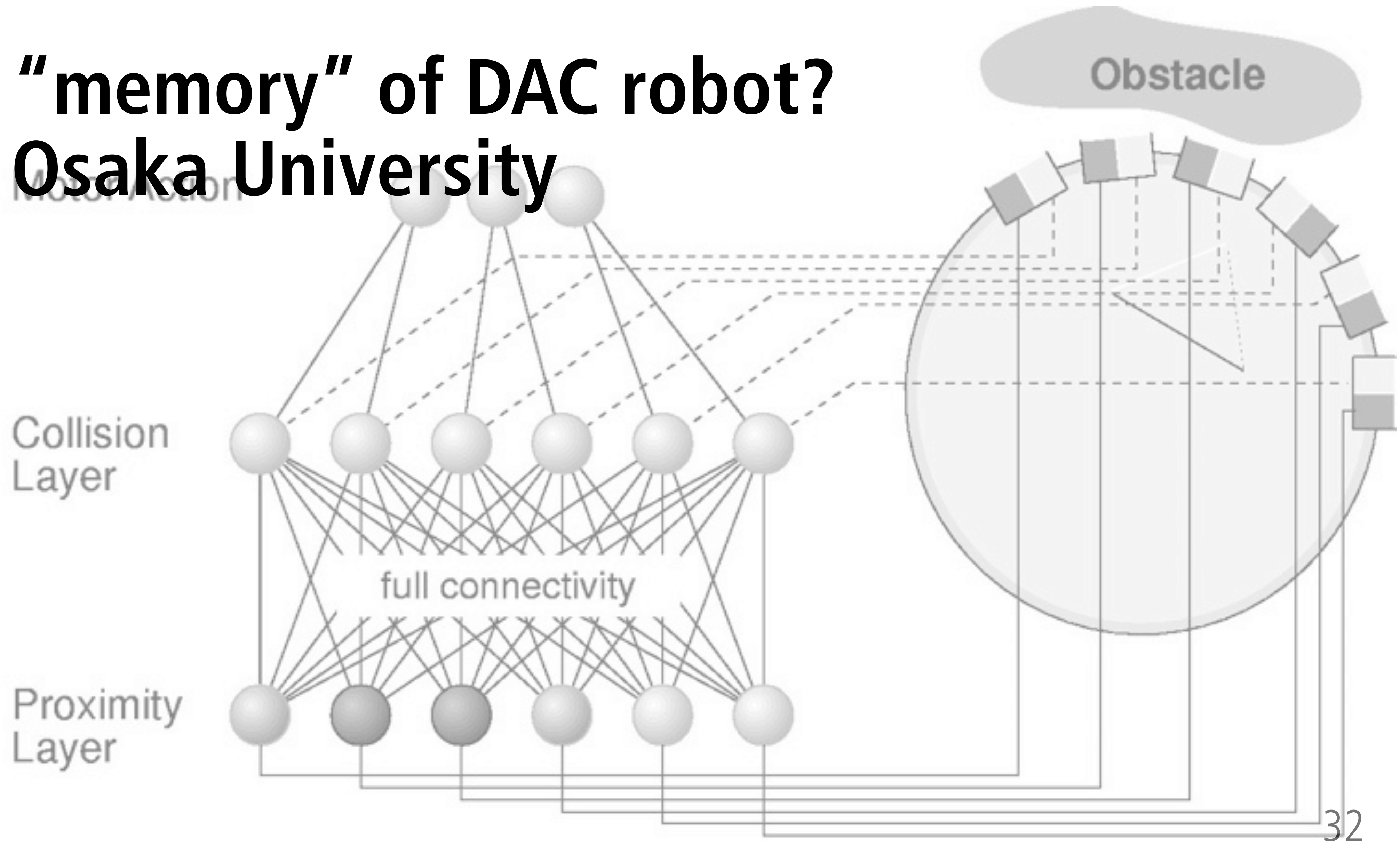
Remember: Distributed Adaptive Control (DAC). What the robot learns is reflected in changes in the weight matrix. The weights only make sense if embedded into a robot in an environment with obstacles in which the robot has to avoid running into them.

Environment of DAC robot: Arena with obstacles

Where is the "memory" of DAC robot?
—> Osaka University



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Complete agents, SMC, situated nature of memory

- overhearing snatch of song, humming, reproducing entire song
- Josh (Bongard) walking down ramp —> memories from childhood
- memory as re-categorization (Edelman, 1987)

Memory as re-categorization: each interaction with environment (e.g. each time we see a specific friend), the category of this specific friend will be somewhat modified (re-categorized).

Cheap design, ecological balance and scaffolding

- **Josh: partial off-loading of task into system-environment interaction**
- **Scaffolding: “Our brains make the world smart so that we can be dumb in peace! Or to look at it another way, it is the human brain plus these chunks of external scaffolding that finally constitutes the smart, rational inference engine that we call mind.” (Clark, 1997, p. 180).**
- **Generally, recognition easier than recall: exploiting interaction with environment; off-loading “storage” into environment (reminder - Brooks: “The world is its own best model”).**

Cheap design, ecological balance and scaffolding

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- Generally, recognition easier than recall

examples of scaffolding?

—> Xi'an

- putting signs into environment (Beijing, Wuhan, …)
- GPS
- building roads
- taking notes
- maintaining an electronic calendar

Cheap design, ecological balance and scaffolding

Which design principles?

—> HITLab Univ. of Tasmania

- Josh: partial off-loading of task into system-environment interaction

- Scaffolding: "Our brains make the world smart so that we can be dumb in peace! Or to look at it another way, it is the human brain plus these chunks of external scaffolding that finally constitutes the smart, rational inference engine that we call mind." (Clark, 1997, p. 180).

- Generally, recognition easier than recall: exploiting interaction with environment; off-loading "storage" into environment (reminder - Brooks: "The world is its own best representation").

Case study: The “Passive Dynamic Walker”

VIDEO: Passive Dynamic Walker

Design and construction: Ruina, Wisse, Collins: Cornell University, Ithaca, New York

The “brainless” robot”: walking without control

Case study: The "Passive Dynamic Walker"

VIDEO: Passive Dynamic Walker

self-stabilization

Design and construction: Ruina, Wisse, Collins: Cornell University, Ithaca, New York

The "brainless" robot": walking without control

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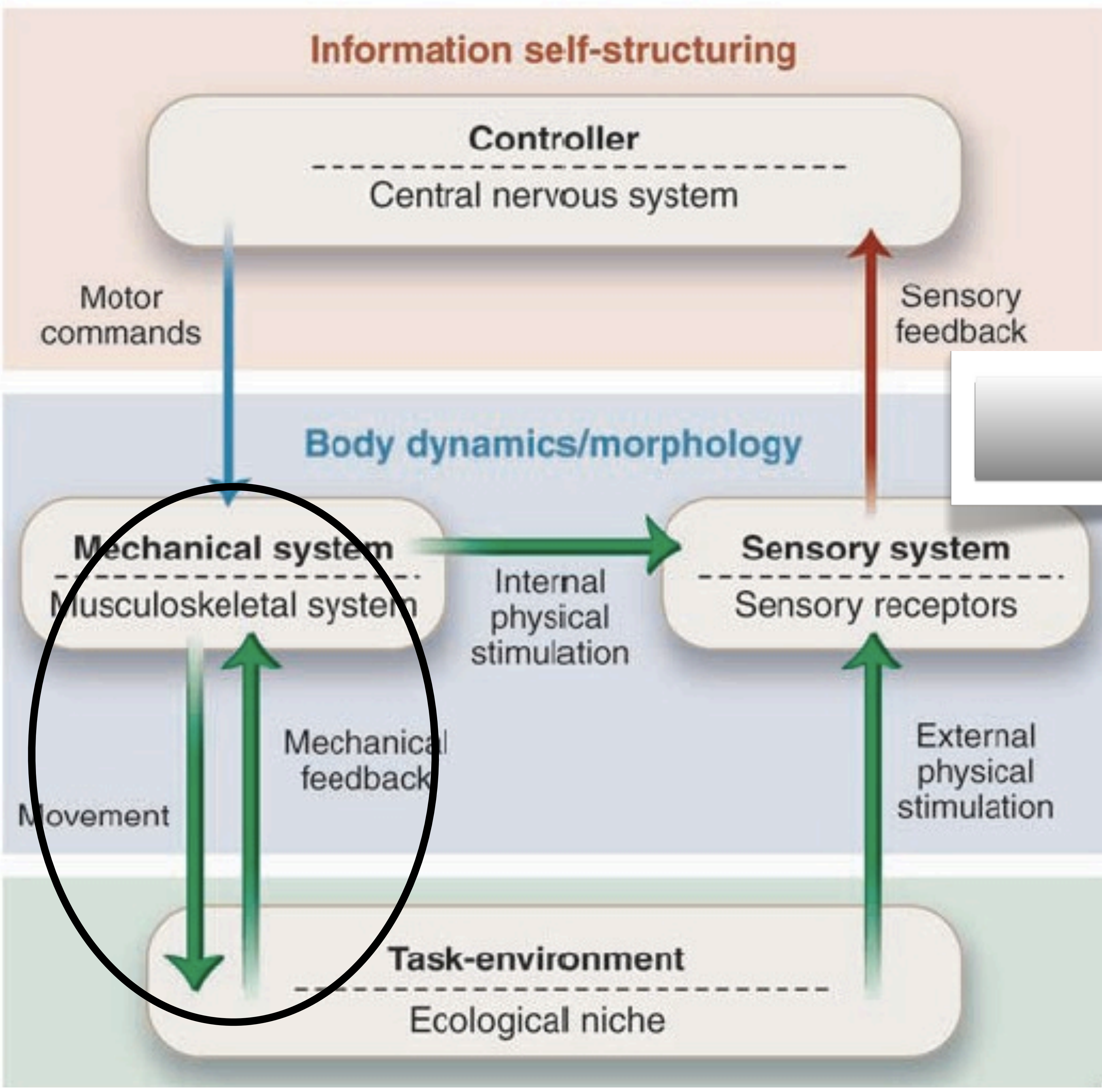
Overall scheme: Self-stabilization in the Passive Dynamic Walker



self-stabilization

Pfeifer et al.,Science, 16 Nov. 2007

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Circle in lower left corner: responsible for self-stabilization.
The fact that the passive dynamic walker has no sensors for the mechanical feedback does not imply that it's not there!

Remember: Short question

memory for walking?

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Remember: Short question

memory for walking?

—> Zurich

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Extending the ecological niche: Denise's memory

VIDEO: Denise

Design and construction: Martijn Wisse, Delft University

self-stabilization

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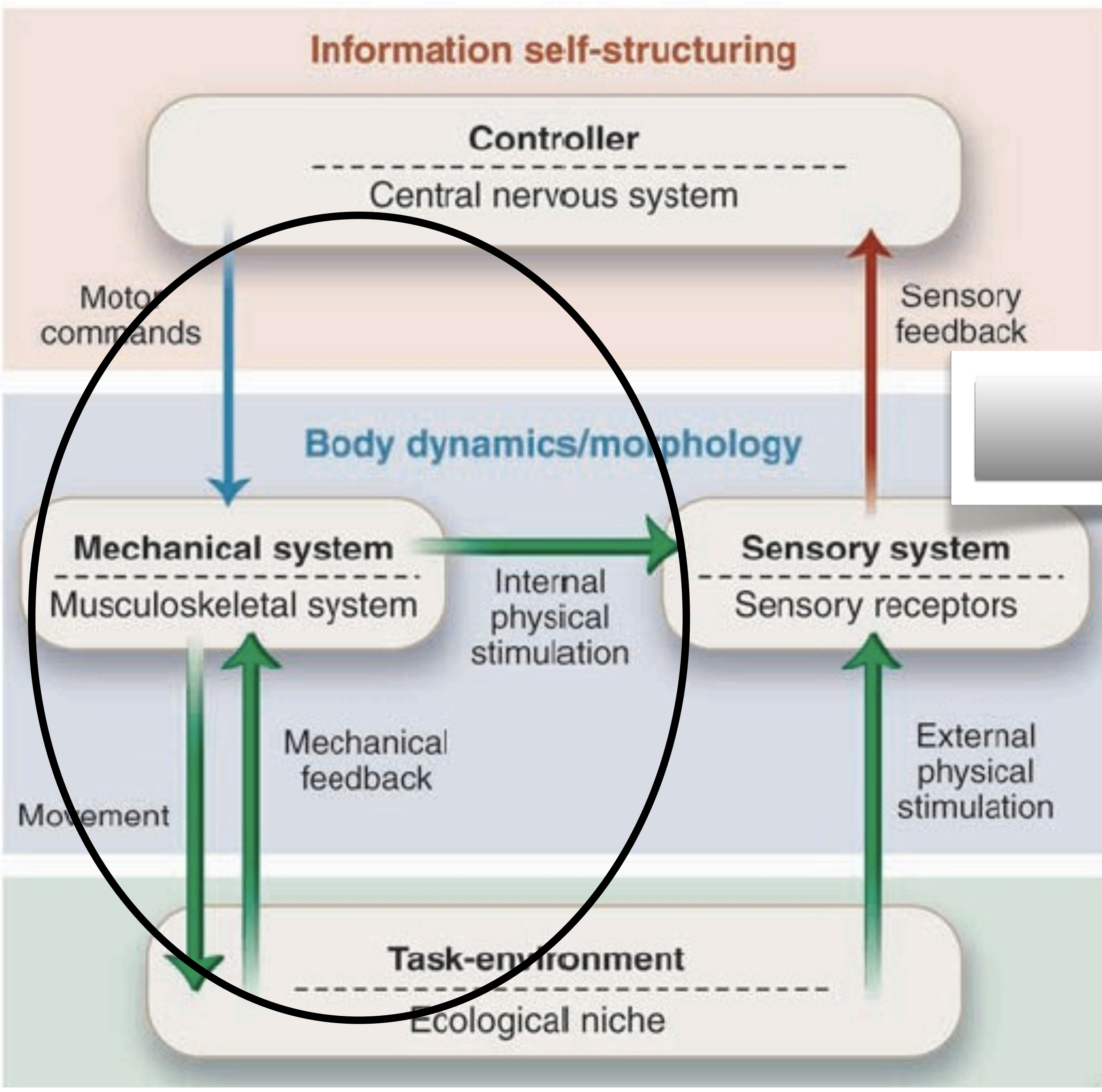
includes reflex: contact sensor on foot - if activated: move other leg forward. Because "Denise" builds on a passive dynamic walker, very little control is required to get stable walking behavior. Again, we can ask the question of where the memory for walking is located: it's distributed throughout the robot and the reflex.

Overall scheme: Self-stabilization in the Passive Dynamic Walker



self-stabilization

Pfeifer et al.,Science, 16 Nov. 2007

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Circle on left: responsible for self-stabilization.
There is very little sensing, only a contact sensor on the feet which triggers the – very simple – actuation.

Constructive memory, dynamical systems, attractors

Walter Freeman's experimen
(1991)

EEG recordings from
rabbit's olfactory bulb

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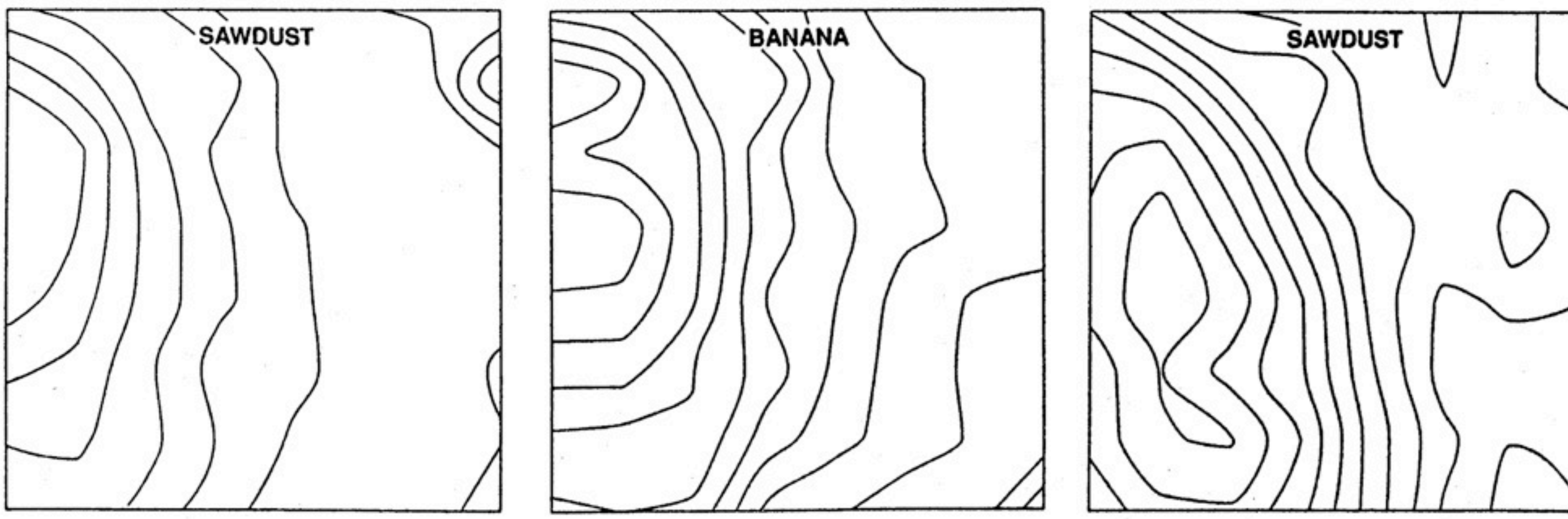
Brain dynamics in olfactory bulb of rabbits



EEG patterns recorded from rabbit olfactory bulb

Walter Freeman's experiment (Freeman, 1991): EEG patterns recorded from a rabbit's olfactory bulb during a classification task. Left: Pattern for sawdust at initial presentation. Center: Pattern for bana, presented between the two presentations of sawdust. Right: Patter for sawdust at second presentation. The striking result is that the patterns for sawdust on the left and the right are completely different. Because the animal showed the same response in the cases on the right and the left, we can conclude that the animal had remembered the scent of sawdust but the category was represented by a different pattern of activation of the respective neurons (from Skarda and Freeman, 1990).

Embodied memory

- storehouse vs. embodied
- memory as theoretical construct (Ashby)
- strong dependence on interaction with real world: "situatedness"; continuously changing (Rosch; Loftus; Neisser)
- memory as aspect of complete agent acting in real world (Glenberg; Koriat & Goldsmith)
- memory as dynamical system (aspect of complete agent); not passively stored structures (Freeman)

Embodied memory (2)

- coordination of brain processes in olfactory bulb through interaction with environment ("cooperation" to recognize smells; principle of parallel, loosely coupled processes)
- behavior not stored as structure, but emerges as agent interacts with real world
- "Where?" maybe wrong question —> complete agent
- experimental methodology: cognitive vs. sensory-motor tasks

Assignments for next week

- Read chapter 10 of “How the body …”
- Try to figure out Simon Bovet’s experiment (at the beginning of chapter 10) on “Delayed reward learning without memory”.

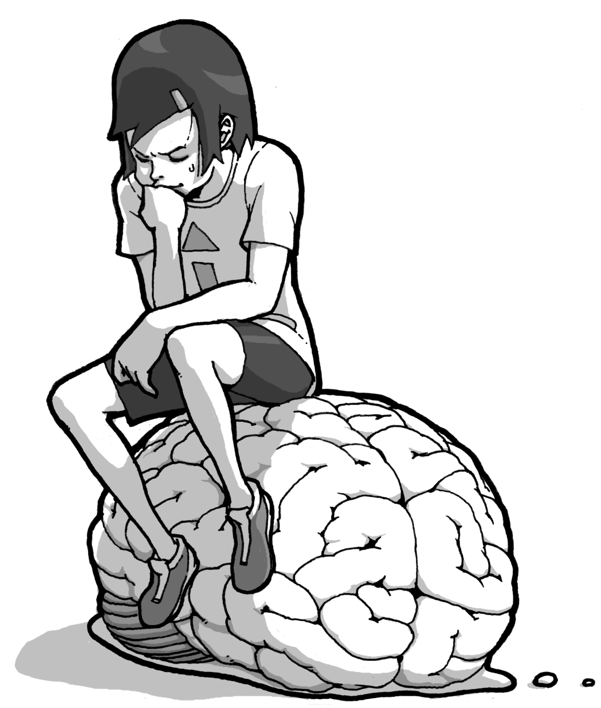
End of lecture 8

Thank you for your attention!

stay tuned for guest lectures

Prof. Vera Zabotkina

Prof. José del Millán



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Lecture 8: Guest speaker

from RSUH, Russian State University for the Humanities

Prof. Dr. Vera Zabotkina,
"Cognitive modeling in linguistics: conceptual metaphors"

10.00h Zurich time (13.00 Moscow time)

I am Vice-Rector for International innovative projects at RGGU(Russian State University for the Humanities) in Moscow,Director of the Center for Cognitive programmes,professor of the Department for Translation and Interpreting at RGGU (from Prof. Zabotkina's Facebook page). Very accomplished linguist.

Lecture 8: Guest speaker

from EPFL, Switzerland

robotics Swiss National Centre of Competence in Research

Prof. Dr. José del Millán
"Brain-machine interfacing"

10.30h Zurich time

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World champion in brain-machine interfacing. Defitech Foundation Chair in Non-invasive Brain-machine Interface CNBI, EPFL, Lausanne, Switzerland. Group leader, NCCR Robotics.

End of lecture 8

Thank you for your attention!

stay tuned for lecture 9

“Development: From locomotion/movement to cognition”