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# **Science Should Expand Its Horizon: Suggestions to the US and Chinese Governments**

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# Abstract

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- **I have been involved with US-China collaboration:  
The Brain-Mind Problem**
- **A preliminary solution to the Brain-Mind Problem  
having a rigorous mathematical proof**
- **Implication: Science should expand its horizon**
  - **The mind is an “objective” subject**
  - **New opportunities for the Chinese government**
  - **New opportunities for the US government**
  - **New opportunities for US-China collaboration**

# Why Autonomous Mental Development?

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- Papers in 1st ICCV through 5th ICCV
- As soon as we do development:
  - sensor and motor must work togetherICCV and CVPR reviewers stated:  
This is not computer vision!
- Repeated rejections followed
- Then NSF IIS division director suggested:  
Develop a new research community

# Our Efforts toward Developmental Networks

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- Cresceptron (1990 - 1992)
- SHOSLIF (1992 - 1997)
- SAIL (1994 - 2000)
- Dav (1998 - present)
- MILN at MSU and Fudan U. (2005-2009)
- Where-What Networks (2007 - present):  
WWN-1, WWN-2, WWN-3, WWN-4, WWN-5 (Fudan U. and MSU)
- Developmental Network (2007 - present)
- From the hind side, I am extremely lucky to reach this point

# A Research Community on AMD

- **2000: ICDL series:** <http://cogsci.ucsd.edu/~triesch/icdl/>
  - Workshop on Development and Learning (WDL) 2000, MSU, MI USA
  - 2<sup>nd</sup> International Conf. on Development and Learning (ICDL'02): MIT, MA USA
  - 3<sup>rd</sup> ICDL (2004): San Diego, CA USA
  - 4<sup>th</sup> ICDL (2005): Osaka, Japan
  - 5<sup>th</sup> ICDL (2006): Bloomington IN, USA
  - 6<sup>th</sup> ICDL (2007): London, UK
  - 7<sup>th</sup> ICDL (2008): Monterey, CA, USA
  - 8<sup>th</sup> ICDL (2009): Shanghai, China
  - 9<sup>th</sup> ICDL (2010): An Arbor, Michigan USA
  - 10<sup>th</sup> ICDL (2011), Frankfurt, Germany
- **2001: EpiRob workshop series (01, 02, 03, 04, 05, 06, 07, 08, 09, 10)**
- **2004: AMD Technical Committee of IEEE Computational Intelligence Society**  
<http://www.ieee-cis.org/AMD/>
- **2004: AMD Newsletters**  
<http://www.cse.msu.edu/amdtc/amdnl/>
- **2009: IEEE Transactions on Autonomous Mental Development from 2009**  
<http://www.ieee-cis.org/pubs/tamd/>
- **No new federal funding to me since 2000**

# Theme: Developmental Science

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- **Brain-Mind: Arguably the most complex objects in nature**
- ***Developmental science:***  
**The science that studies mechanisms of development**

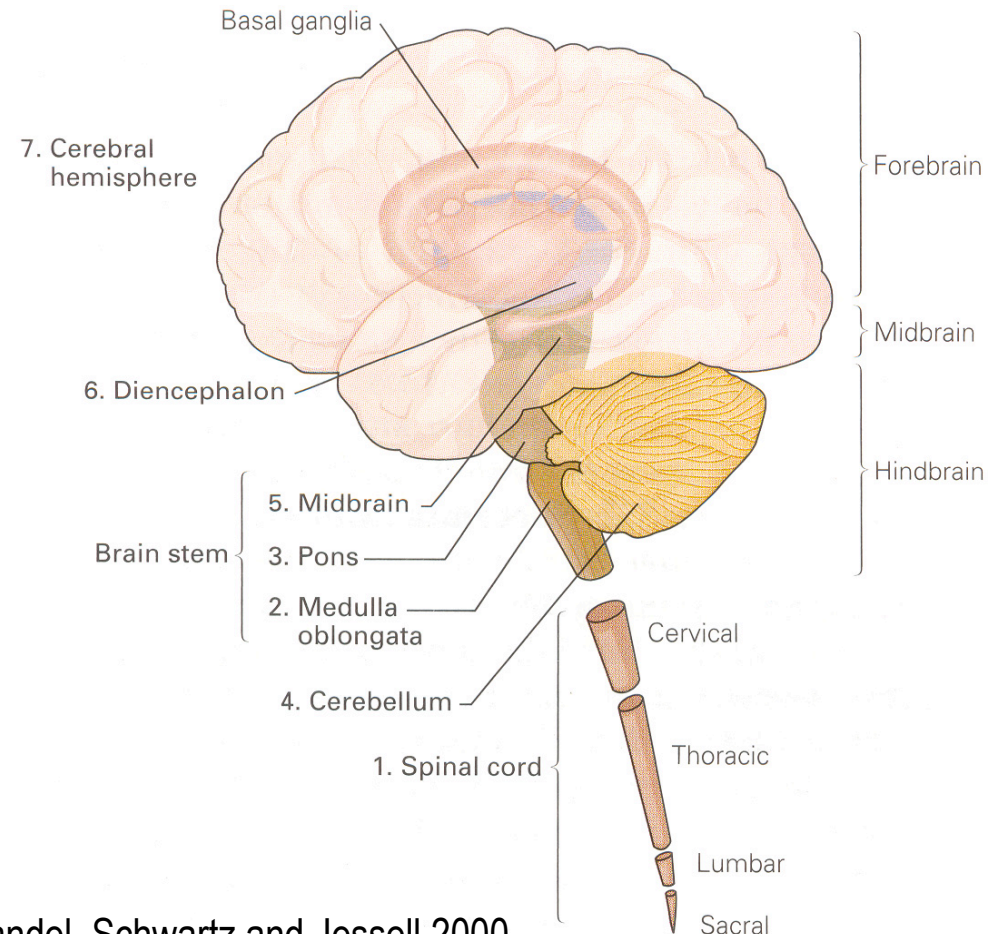
# Developmental Science: Two Scopes

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- **A single brain:**
  - Brain's developmental program --- human genome  
Fully autonomous inside the skull
  - The brain does not have a government (central controller)
- **Multiple brains:**
  - **Social developmental programs**
    - How can a society of intelligent beings develops more successfully?
  - **Basic principle: Checks-and-balances of power**
    - US as an example: US laws and research
    - China as an example: setbacks after 1949 and reform since 1977

# The Central Nervous System

- The forebrain
- The midbrain and hindbrain
- The spinal cord



Kandel, Schwartz and Jessell 2000

# A Brain Network, not Just Nearby Connections

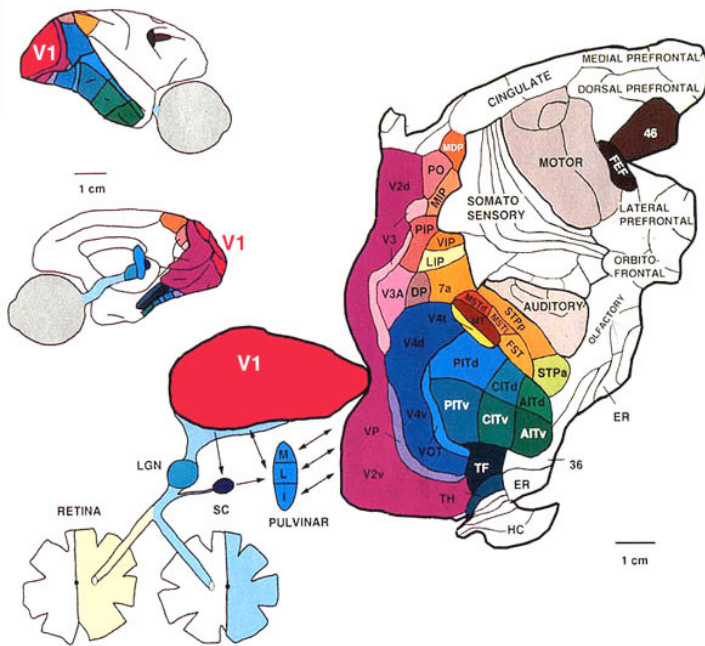
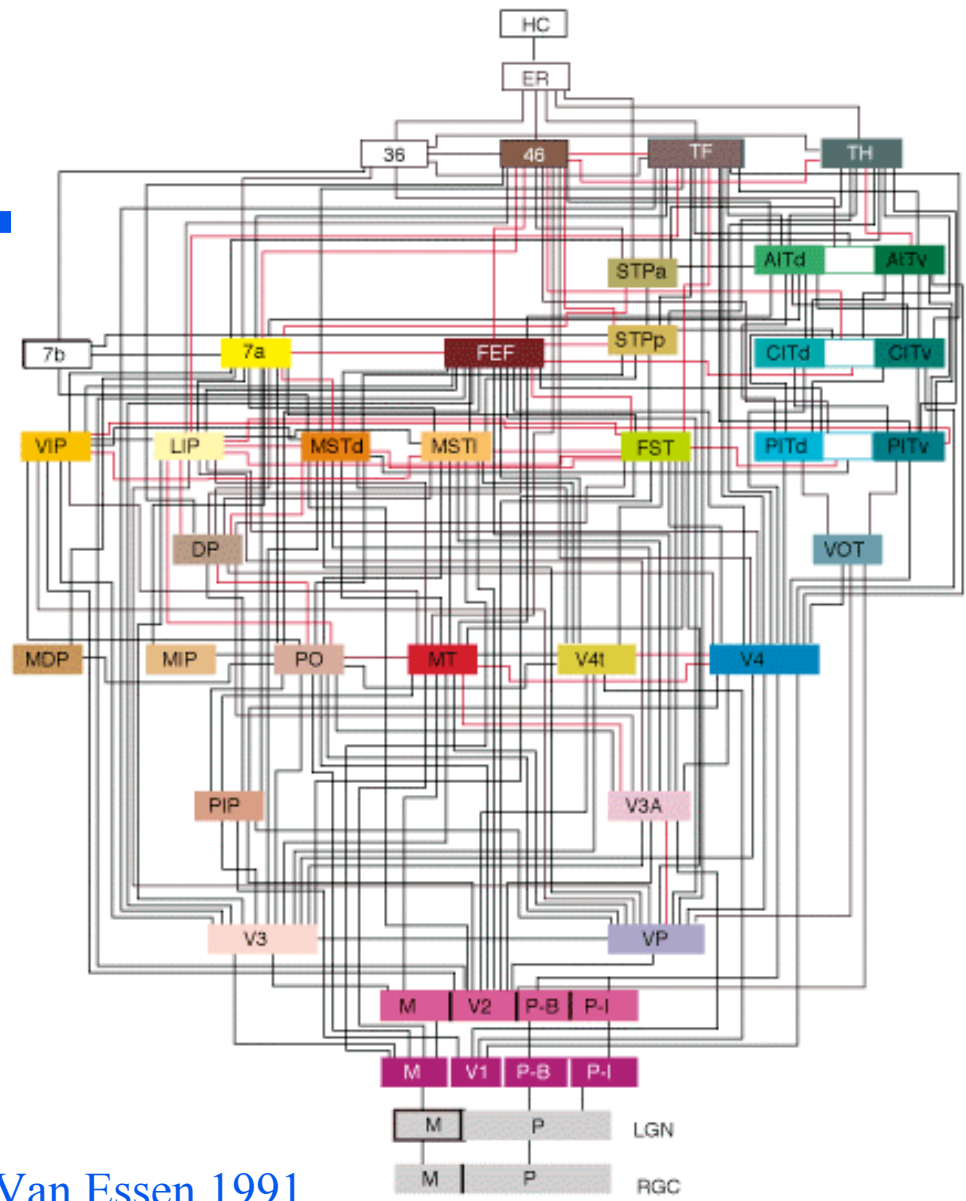


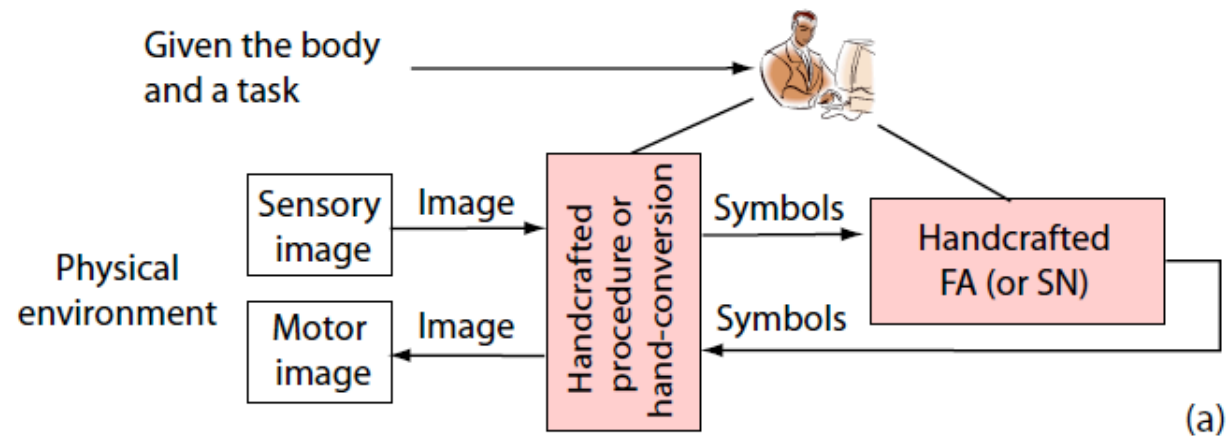
Figure 19. Much of V1 is located in the calcarine sulci and its relationship to other brain areas is best shown by unfolding the brain and showing it flattened open. The visually responsive areas of the macaque monkey are shown in color. From Van Essen et al. (1992).



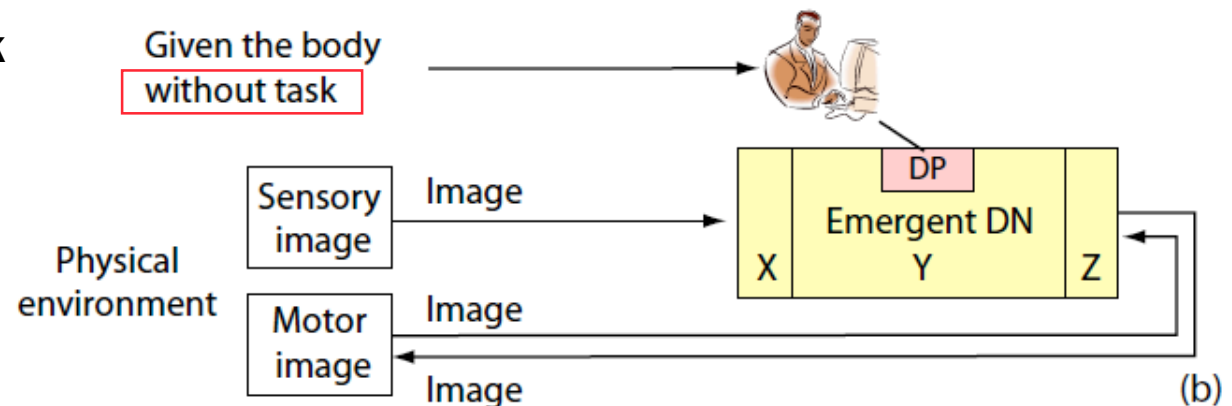
Felleman & Van Essen 1991

# The Brain Problem

**Symbolic network (SN)  
not a brain problem:**



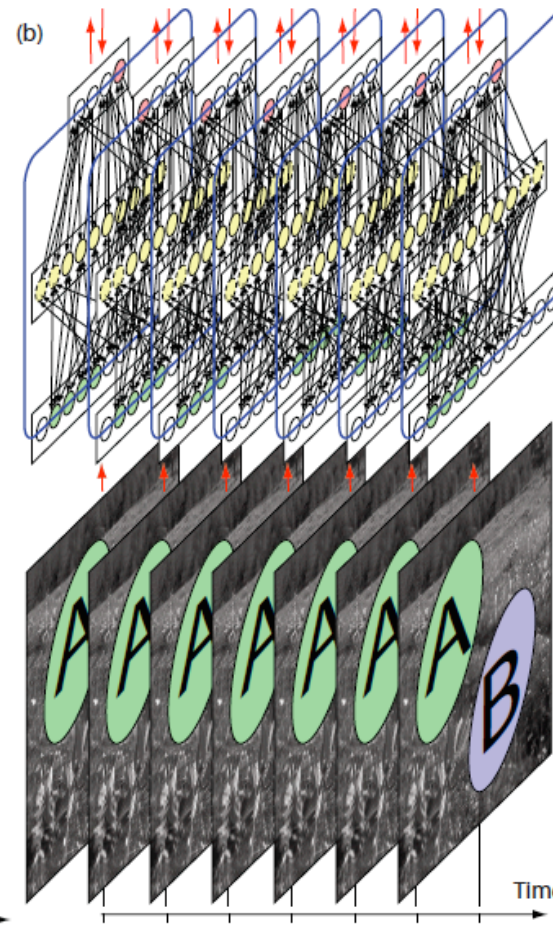
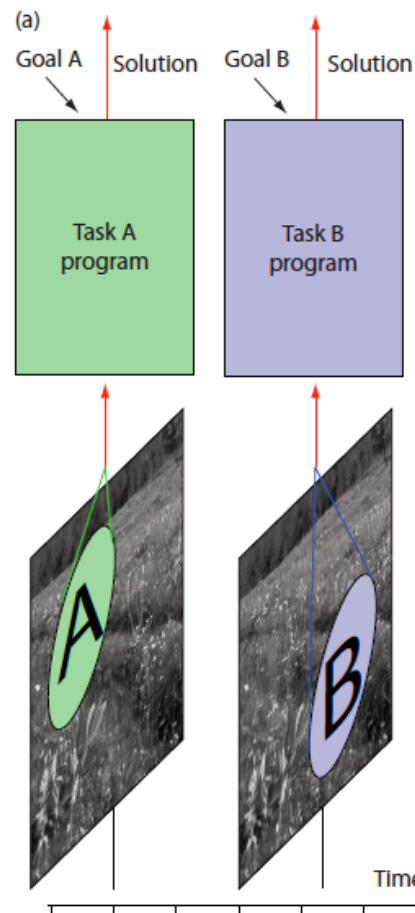
**Developmental network (DN)  
the brain problem:**



Weng IJCNN 2011

# The Brain Problem: Real Time

Not a brain problem



Brain problem

# Brain Has Internal Symbols?

AMD Newsletter

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## Dialog Initiation

**Are Natural Languages Symbolic in the Brain?**



*Juyang Weng*

*Department of Computer Science and Engineering, Cognitive Science  
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Many of the readers may think that I am asking a stupid question: "Can the symbol grounding problem lead to meaningful further dialogs and hopefully some clarification of the symbol grounding problem? Or maybe not?" initiate a dialog with me. See "The Symbol Grounding Problem Has Been Solved: Or Maybe Not?" initiate a dialog with me. AMD Newsletter vol. 7, no. 1, April 2010.

Stevan Harnad wrote: "The symbol grounding problem is the problem of causally connecting a symbol system to their referents in the external world without the mediation of an external blown natural language (not all of them, but the ones that cannot be grounded by

# Brain-Mind: Need 6 disciplines

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- **Biology**
- **Neuroscience**
- **Psychology**
- **Computer science**
- **Electrical engineering**
- **Mathematics**

# Clarification 1 for the Two Schools

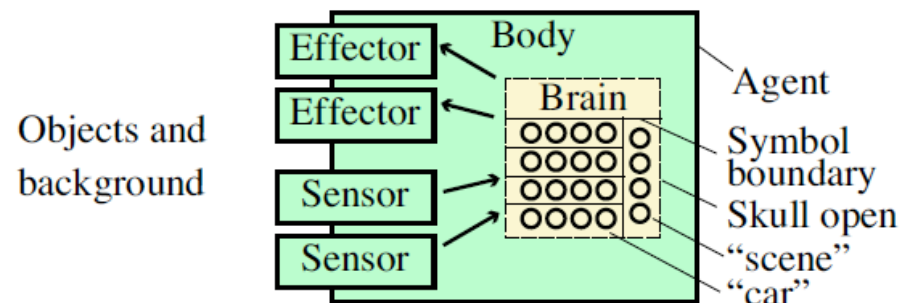
- **Symbolic:**

- Symbols are for human consensual communications
- Handcrafted concepts
- Rigid concept boundaries
- Task-specific goals

- **Emergent:**

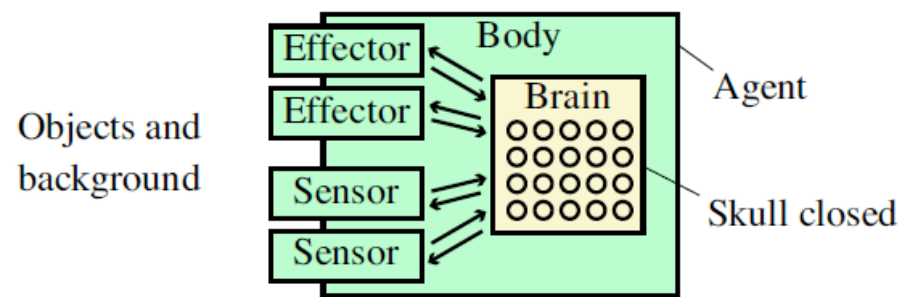
- Fully autonomous inside
- No handcrafted concepts
- No concept boundaries
- Without given a task let alone a task goal

Extra-body environment



(a)

Extra-body environment



(b)

# Clarification 2 for the Two Schools

- **Symbolic:**

- A model *outside* the brain via *X* and *Z*

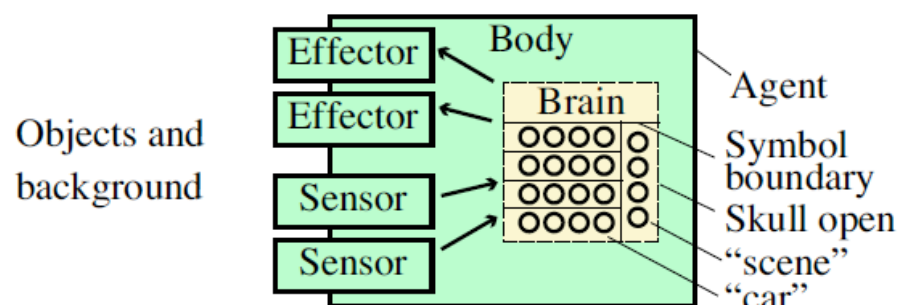
*X*: **Sensors**

*Z*: **Motors**

- **Emergent:**

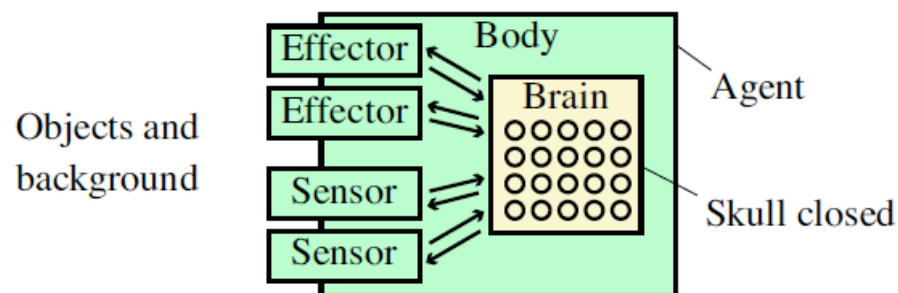
- A model *inside* the brain:  
**Internal representations as *Y***

Extra-body environment



(a)

Extra-body environment



(b)

# 5+1 Chunks of a Brain-Mind Model

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1. **Development:**  
task nonspecific “genome” program for muddy tasks
2. **Architecture:**  
“bridge” helps two “banks”; how areas connect two-way
3. **Area:**  
building block: optimal performance from limited resources
4. **Space:**  
concept-based top-down attention
5. **Time:**  
detecting spatiotemporal events from complex backgrounds
6. **Plus: Neuromodulation**  
likes, dislikes, novelty, confidence, etc.

Weng IJCNN 2010, IJCNN 2011

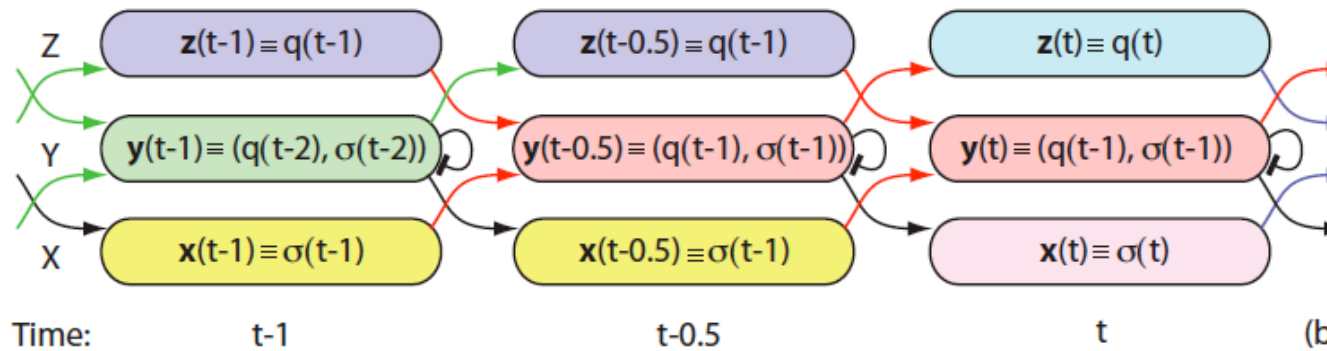
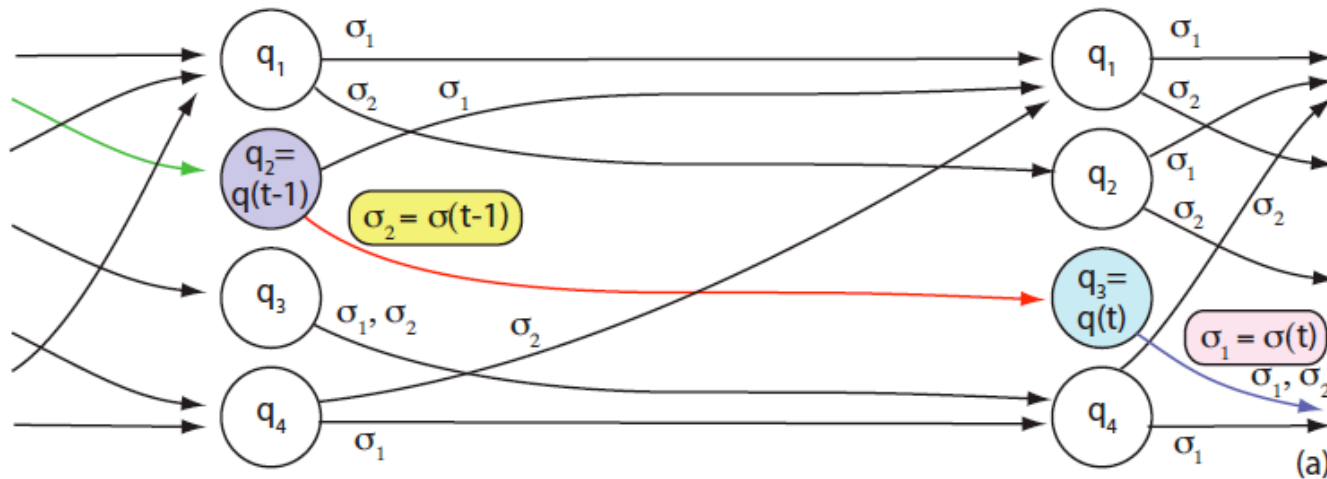
# Three Theorems for Brain-Mind

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- **Theorem 1: DN learns any FA, incrementally, immediately and error-free, using a finite memory.**
- **Theorem 2: If the above DN is frozen, but runs for infinitely many vectors for the real world, it is optimal (Maximum Likelihood, ML).**
- **Theorem 3: If the above DN is allowed to learn, it “thinks” optimally (ML) based on its limited resource and learning experience.**

Weng IJCNN 2011

# Sketch of Proof



# Importance of Theorem 1

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- **Symbolic Network (SN):  
Human Society's Knowledge**
  - Each career corresponds to an FA, partial from the human society's FA
- **Developmental Network (DN):**
  - Zero error for all re-substitution tests, regardless tasks
  - Generalization for unobserved but state-equivalent sequences
  - Build probabilities inside the network

# Importance of Theorem 2

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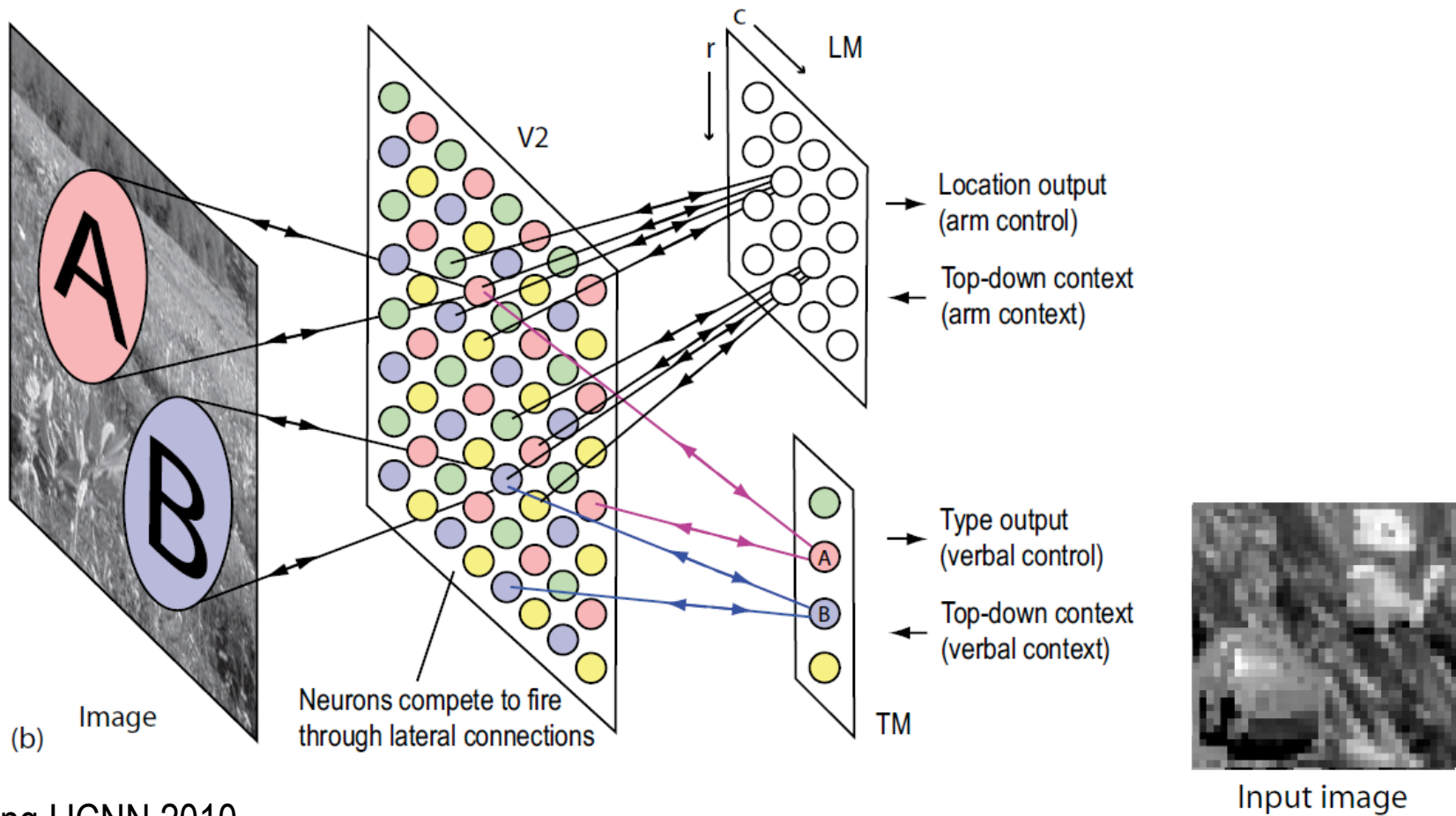
- **Better than SNs in terms of optimality:**  
An SN does not consider the distance between different nodes, but a DN does
- **DN deals with an exponential number of nodes in SN through:**
  - Interpolation among exponential number of nodes
  - Distance in the inner product space
  - Optimal in terms of:  
memory and  
learning experience

# Importance of Theorem 3

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- **A model about how the brain thinks**
- **A model about brain's creativity**
  - The programmer does not know the tasks
  - No re-programming for each new task
- **No need for modeling knowledge hierarchy**
- **No need for modeling brain modules about extra-body concepts**
- **Internal brain structures autonomously emerge from experience**

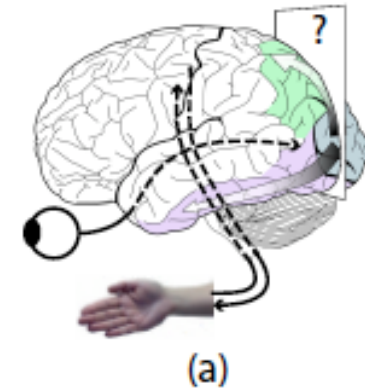
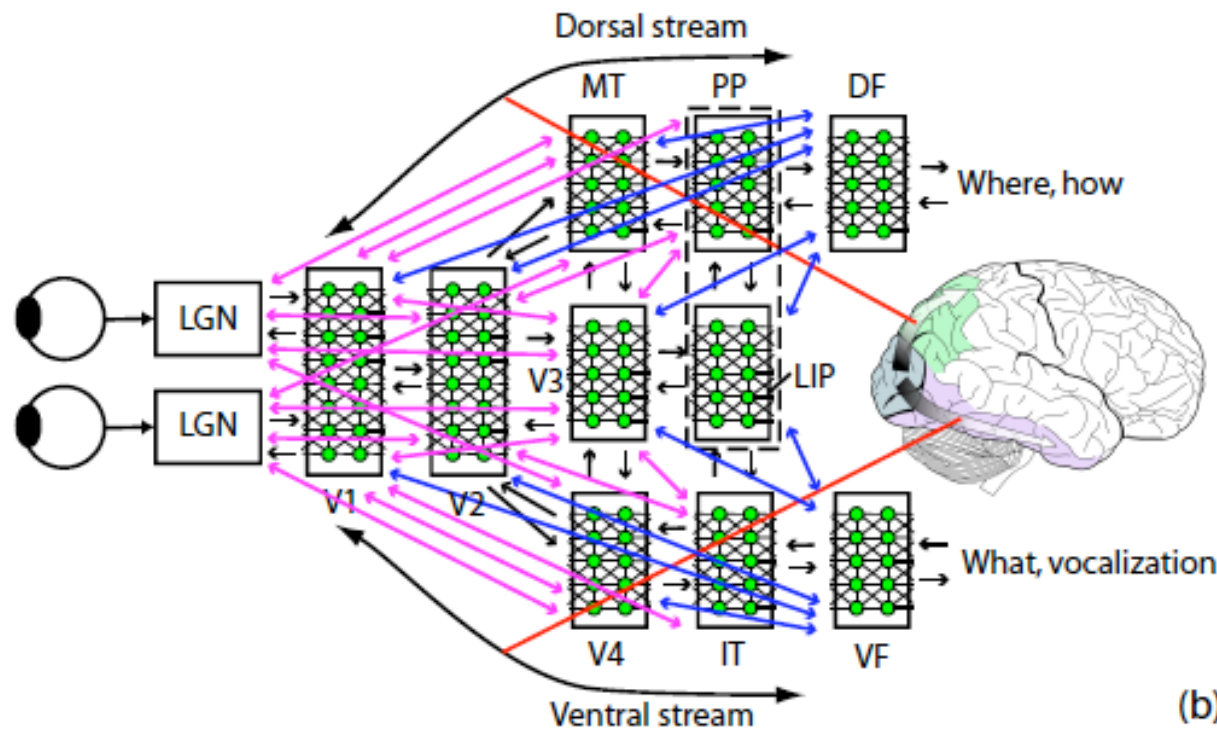
# Concept Learning from Physics



Weng IJCNN 2010

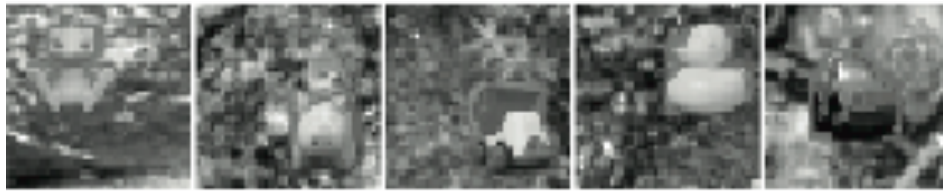
# Brain's Vision System

The brain has only two exposed ends to interact with the environment:



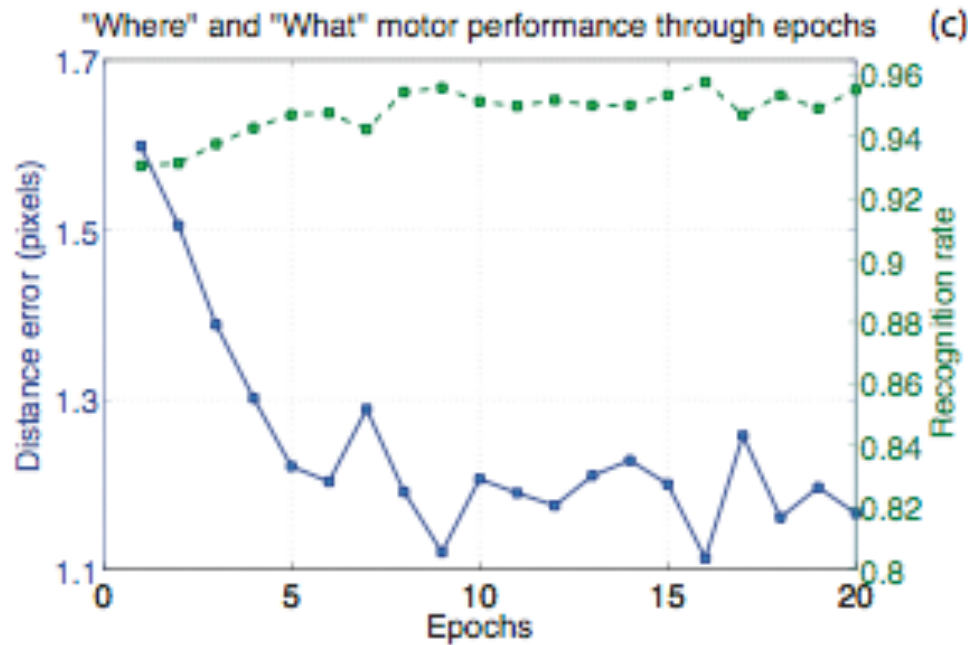
Weng IJCNN 2010

# Training and Tests



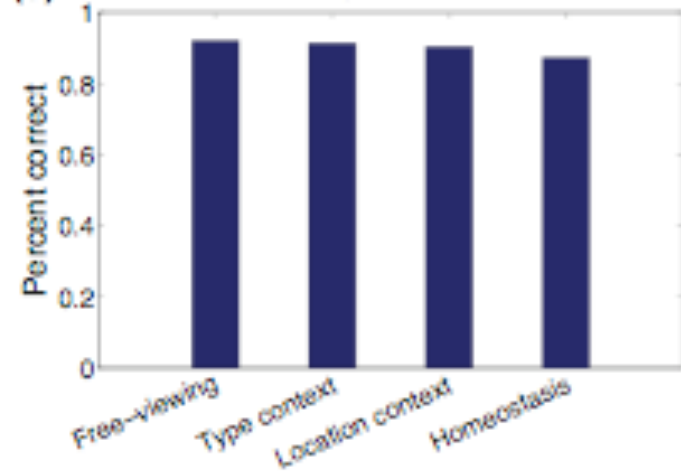
(a)

(b)



(d)

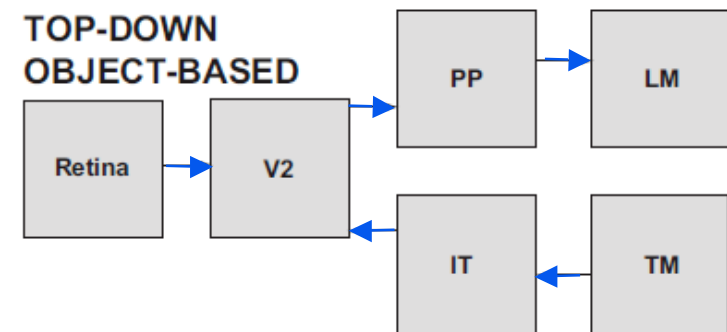
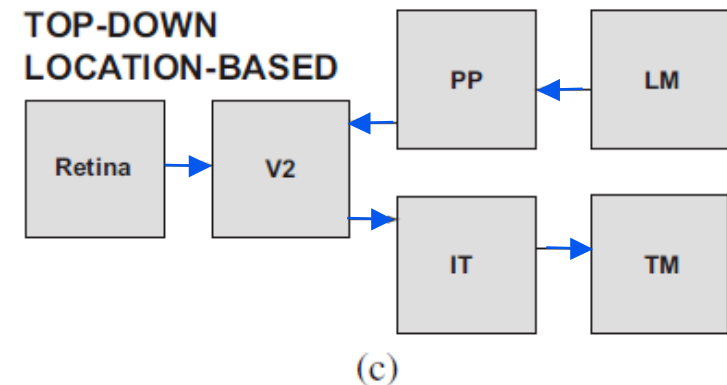
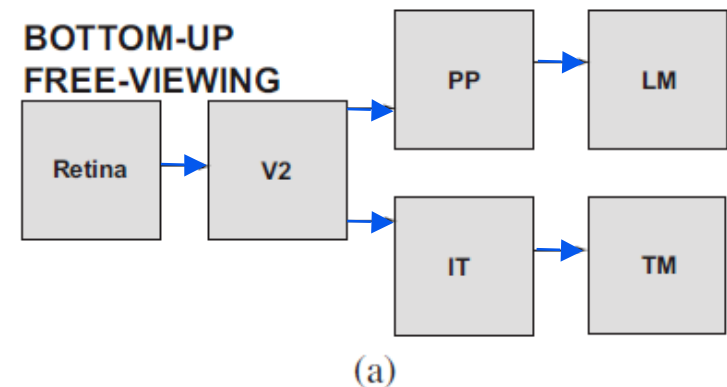
Two competing objects in the scene



Luciw & Weng IJCNN 2010

## Three Types of Flow in Thinking

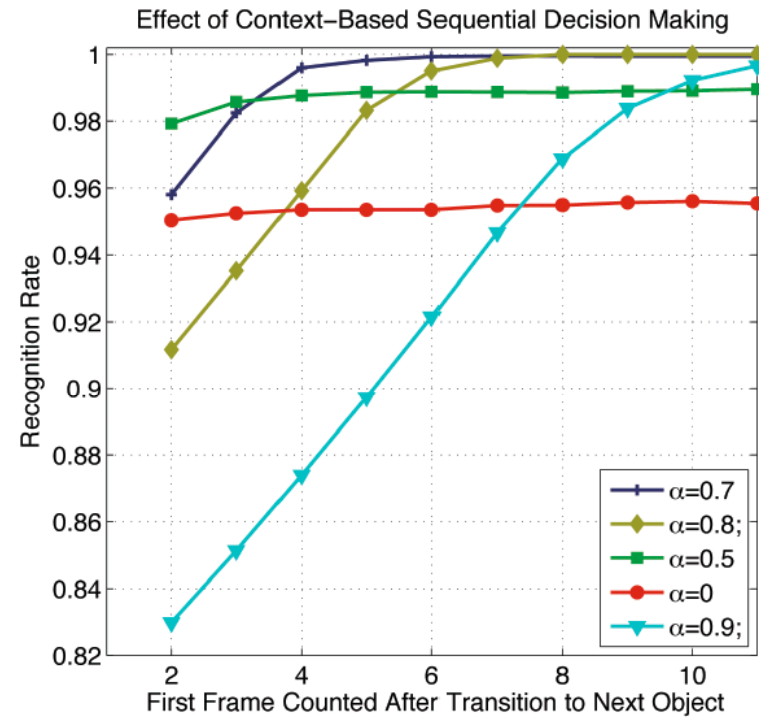
- Different directions for different intents/goals
- Mixed modes are possible
- There is no “if-then-else” type of logic switches



# Almost Perfect Disjoint Test Using Temporal Context



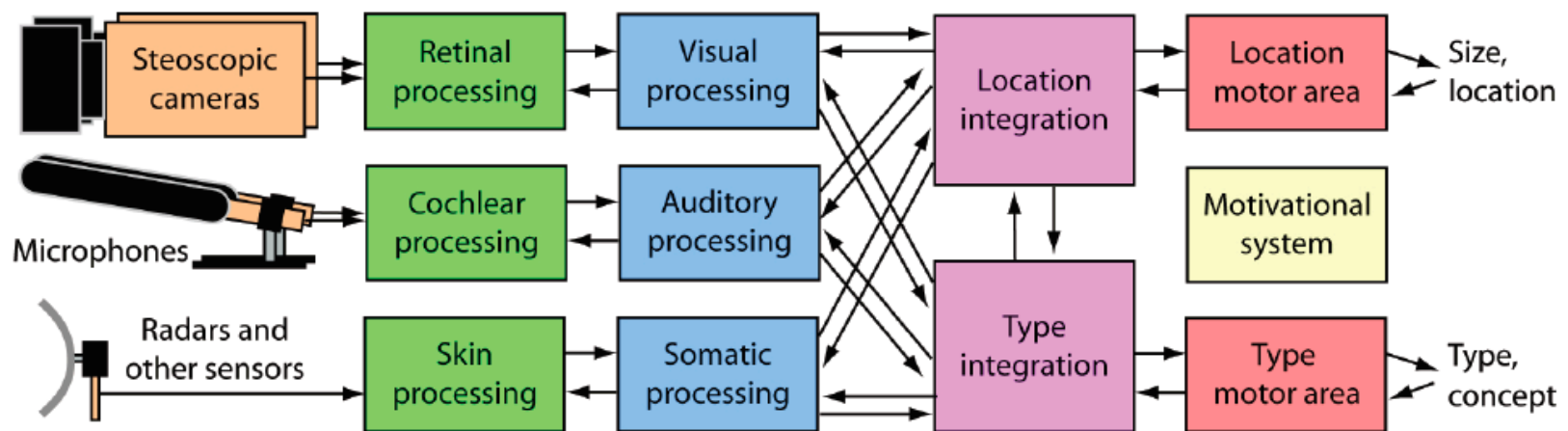
(a)



(b)

Luciw, Weng & Zeng ICDL 2008

# All Integrated While Developing



# Language Understanding and Thinking

- **Natural Language Processing**
  - **New sentence problem**
    - Recognize new sentences not observed from synonyms
  - **Word sense disambiguation problem**
    - Temporal context, semantics
  - **Part of speech tagging problem**
    - Label words according to part of speech
  - **Chunking problem**
    - Grouping sequences of words and classify them by syntactic labels
- **Thinking: fully autonomous inside**
  - Member to super-class (e.g., from Sally to US, to Human)
  - Super-class to member (e.g., from Human, to countries, to persons)
  - Member to member (from Sally to Amy, from Amy to Sally)

Weng, Zhang, Chi & Xue ICDL 2009; Miyan & Weng ICDL 2010

# Two Largest Hindrances of Science

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AMD Newsletter

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## Dialog Column

Reply and Summary:

**Through the Symbol-Grounding Problem See the Two Largest Hindrances of Science**



*Juyang Weng*

*Department of Computer Science and Engineering, Cognitive Science Program, Neuroscience  
Michigan State University, East Lansing, Michigan, USA.*

While approaching a scientific subject, it seems ineffective to adopt an approach that take — restrict the subject to a narrowly defined domain. For example, the symbol-grounding dialog addresses seems to be related to a super science, called developmental science, the development of multi-agent systems, natural and artificial. Why? Just through this short reply I hope the reader to convincingly understand a brain-mind solution to this problem. But I hope that the reader can suggest here to reach a conclusion for himself. Furthermore, I wish that we humans collectively can solve fundamental problems in our existing infrastructures. I call them two largest hindrances of science.

# Two Hindrances

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- **Developing countries:**

- Lack of checks-and-balances of power**

- Government Central Control, e.g., China, North Africa
    - Scientific research is emphasized, but low quality

- **Developed countries:**

- Lack of checks-and-balances of power**

- Collectively, humans have sufficient knowledge to solve the brain-mind puzzle
    - Since 2000, our line for solving the brain-mind puzzle has been repeatedly rejected for funding and for publication
    - Now, a brain-mind solution is presented: still rejections

# Hindrances: Basic Reason

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- **US brains and Chinese brains are basically the same**
  - Ego centric first
  - Education causes different ways of thinking
- **Same reason: a lack of checks-and-balances of power (re: Kernell et al. *Logic in American Politics*)**
  - **China: Government emphasizes science; but the government:**
    - has too much power,
    - does not know research well,
    - are rigid
  - **US: Government emphasizes science, but has not done enough:**
    - Lack of 6-disciplinary curriculum
    - “Racial” profiling: University ranking system
    - Peer review system: corrupted?

# China: Lack Checks-and-Balances

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- **Government still largely plans everything:**
  - **Lands**
  - **Major industries: monopoly**
  - **Research: rigid metrics extracted from a Singapore list**  
**While metric number goes up, research goes down**
  - **Lead to:**
    - **Widespread inefficiency, inflated GDP figures**
    - **Widespread corruptions**
    - **After 30 years, average income raised very slowly, compared to Taiwan and Japan for the same length**
    - **Chinese people deserve better life**
    - **Unfair competition, hurting US jobs and economy**
    - **Centralized power led to instability, causing international concerns**

# Proposed Solutions in Terms of China

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- **US: change strategies**
  - “Human rights” is a less-effective message. “Food” is more basic?
  - Study regime’s psychology. They are humane, intelligent humans.
  - Promote educational programs for “developmental science”
  - Engage Chinese government officials in all sectors, not isolation
- **NSF and scientists: stop considering politics not a science**
  - Provide a platform for scientists to study *Developmental Science*
  - Establish NSF cross-disciplinary program: *Developmental Science*
  - US-China exchange on *Developmental Science*
    - checks-and-balances of power
    - dynamic stability, and people’s happiness on the basis of brain science
- **UN: change strategies**
  - Educate *Developmental Science*, not just handing out loans and food

# US: Lack Checks-and-Balances 1

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- **NRC and media rankings on research:**
  - Rigid metrics
  - Stereotypical “means” or “percentage means”
  - Each faculty member is “racial” profiled
    - Treated as a random number in a complex distribution
    - Complex research becomes a single number
    - Force faculty members to play games for ranking metrics
    - Force universities to play games for ranking metrics
    - The ranking metrics goes up, research goes down
- **Lack of laws to forbid ranking research: stereotypical worldwide**

# US: Lack Checks-and-Balances 2

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- **NSF Program Director's (PD's) role vs. reviewer power**
  - Distribution of funded major subjects in science and engineering
- **Absence of peer-review bylaws**
  - Existing conflict of interest rule is insufficient
  - Existing review criteria are insufficient
- **Funding agency's cross-disciplinary programs:**
  - Lack of qualified cross-disciplinary researchers as reviewers
  - Bias from stereotypical "rankings"
  - Although "revolutionary ideas" are required, lack effective means in place
  - The problems of peer-review documented by Thomas Kuhn have been largely ignored

# Proposed Solutions for US

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- **Break down disciplinary walls:**
  - Need unprecedented scope: 6 disciplines: biology, neuroscience, psychology, computer science, EE, and Math
  - Planned Brain-Mind Institute at MSU
    - Distinguished Speaker Series from Fall 2011
    - Summer institute from Summer 2012
- **Discourage university research rankings**
  - This discourages universities from seeking artificial numbers: e.g., the total number of research funds, the pure number of publications
  - This encourages universities to invest on unique areas
- **Peer review bylaws:**  
a proposed draft for us to consider

# 1. The Cross-discipline Rule

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- **We should not require that every reviewer could understand everything in a submission for him to recommend an acceptance. Each reviewer checks his home discipline only.**
  - **Monetary cost: Zero**
  - **Ways to execute: Declare areas of expertise and select level of confidence in each area. Total transparent review process, like a jury.**

## 2. The Literature Rule

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- **Every reviewer is fully responsible for keeping track of the relevant literature including those cited in the submission. A full self-containment of the submission is impossible with the 15-page limit and should not be required, but the references contain related major prior publications.**
  - **Monetary cost: Each reviewer is given some explicit number of literature search time. Current review fund is insufficient, encouraging irresponsible reviews**
  - **Ways to execute: Ask reviewers to follow the literature. Transparent reviewer ID. Add a round of rebuttal, which the PD should read before making funding decision.**

## 3. The Social Bias Rule

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- **For equal opportunity, every reviewer should divorce himself from his own social bias. This includes, but not limited to, his own approach, his own geographic locations, and his social acquaintance, and social groups.**
  - **Monetary cost: zero.**
  - **Ways to execute: He cannot use anything related to his social bias as an argument during panel discussion or for his written comments. (E.g., I knew her and she is a careful person)**

## 4. The Ranking Rule

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- **Each submission should be evaluated based on its own individually and it should not be treated as a random number in prior rankings of his institution, his country, or other scales.**
  - **Monetary cost: zero.**
  - **Ways to execute: He cannot use anything related to the past ranking of the institution as an argument during panel discussion or for his written comments. (E.g., Can this university do this?)**

# 5. The Open Ceiling Rule

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- **To advance the state-of-the-knowledge with an open ceiling, every reviewer should not expect that his background can fully understand, during the review, all detail of the submitted method. His individual capability of understanding should not become a ceiling for the submission.**
  - **Monetary cost: zero.**
  - **Ways to execute: Each reviewer is responsible for his own knowledge domain, not to check for other domains. Collective checking for a submission is sufficient. That is, a union of knowledge domains, not intersection of domains.**

## 6. The Paradigm Rule

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- **It is not always practical for a new paradigm to address all the known problems of existing paradigms during an early investigation stage of the new paradigm. Every reviewer should not reject a new paradigm on the ground of incompleteness judged from his wish list.**
  - **Monetary cost: zero.**
  - **Ways to execute: It does not do "X", compare it for an old problem, etc., cannot be a basis for rejection.**

# 7. The Burden of Proof Rule

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- It is the responsibility of the reviewer to substantiate his doubts (e.g., possible fabrication of data), flaws (e.g., mistakes or errors), and weakness (e.g., writing style or grammars) about the submission by providing instances of such doubts, flaws, and weakness, in his review comments.
  - Monetary cost: zero.
  - Ways to execute: A claim in review without sufficient instances to support of such a claim constitutes an invalid claim.

## 8. The Grievance Committee Rule

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- **The author may file a grievance by filling a grievance form available from the web.**
  - **Monetary cost: nearly zero.**
  - **Ways to execute: Upon receiving the grievance, the PD/EIC (editor in chief) sends the grievance form to a grievance committee. Each of the committee members arrives at his vote independently, without contacting other committee members or the PD/EIC. PD/EIC uses the simple majority to decide. All ID of the grievance committee and votes are open.**

# Conclusion: Politics Is a Brain Science

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- Traditionally, “objective” sciences such as mathematics and physics are considered science, simply because they mature earlier
- Politics is becoming an “objective” science, as the brain-mind puzzle is being solved
- Developmental science is a new science. It will enable more disciplines to become objective science, including political science, laws, government, management, humanity, and international relations