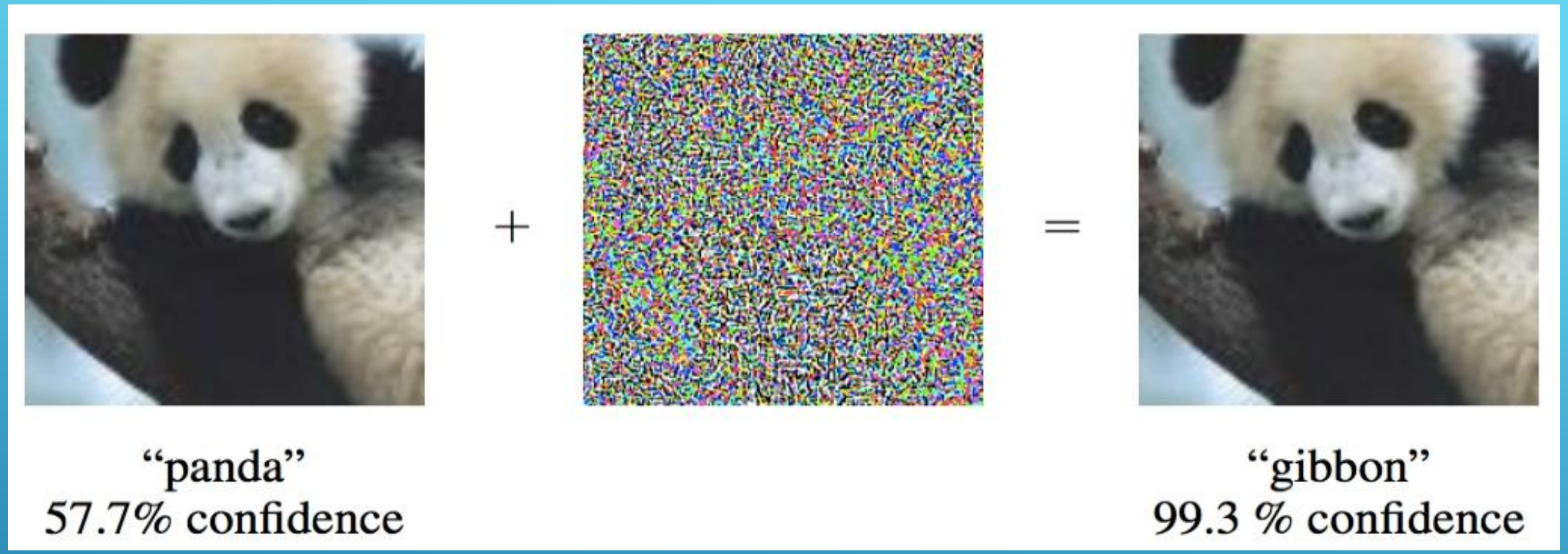
Meaningful-Based Cognitive Architecture **("MBLS")**

Howard Schneider
Sheppard Clinic North, Toronto, Canada

BICA 2018/HLAI-18 – August 2018
2018 Annual International Conference on Biologically Inspired Cognitive Architectures
2018 Joint Multi-Conference on Human-Level Intelligence
Prague, Czech Republic

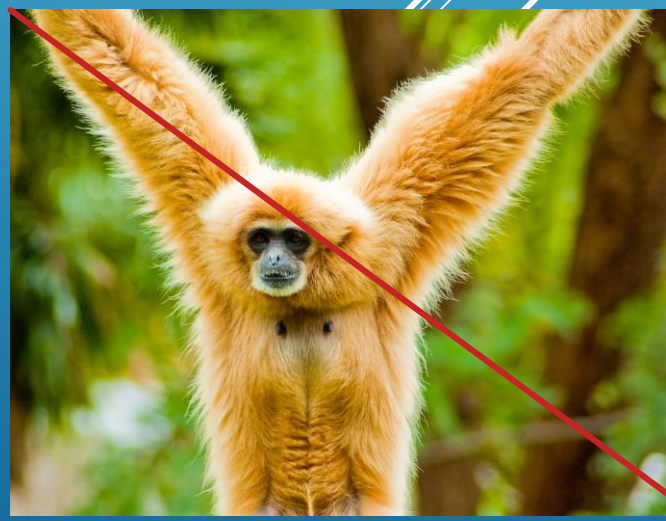
Neural Symbolic Gap

- **Neural Network** – phenomenal image processing and reinforcement learning
- **Child** – phenomenal causal learning with few examples (eg, Gopnik)



Goodfellow,I.J., Shlens,J. and Szegedy,C. (Google Mountainview), Explaining and Harnessing Adversial Examples, ICLR 2015.

It’s still a Panda – and the 3 year old boy would know this!!
(and….. 3 year old only needs 1 or 2 photos for training, not 1000s)



Deep Learning Neural Network	3 Year Old Human Child
Pattern Recognition →Recognize the World	Model Building +also Pattern Recognition →Explain the World
Need 1000's examples for learning	A few examples enough

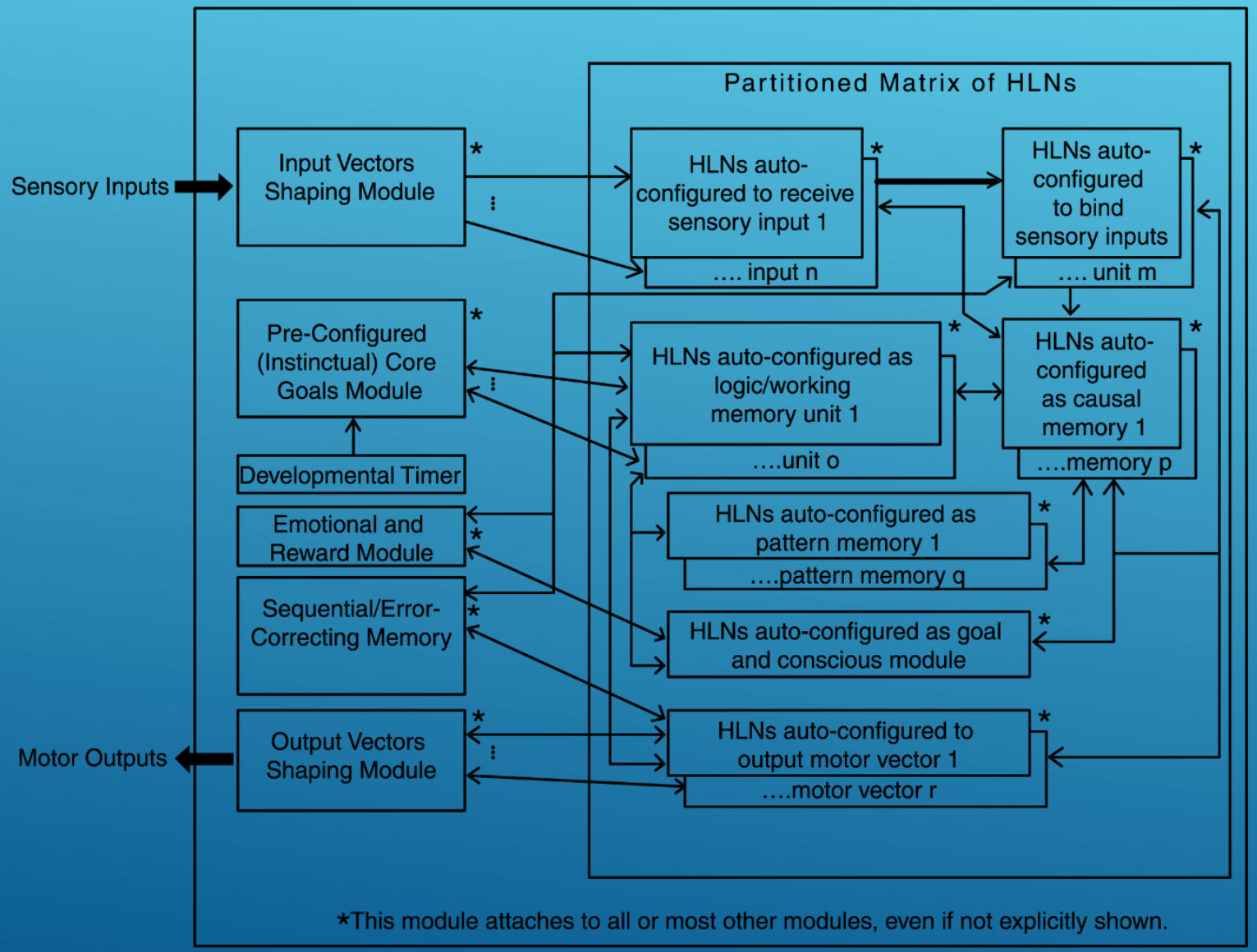
MBLS – Meaningful-Based Cognitive Architecture

1. Pragmatic solution to the neural-symbolic problem

2. Pragmatic technology -- not just pattern recognition but comprehension + learning from a few examples

3. MBLS as model re strategy towards brain disorders (eg, schizophrenia)

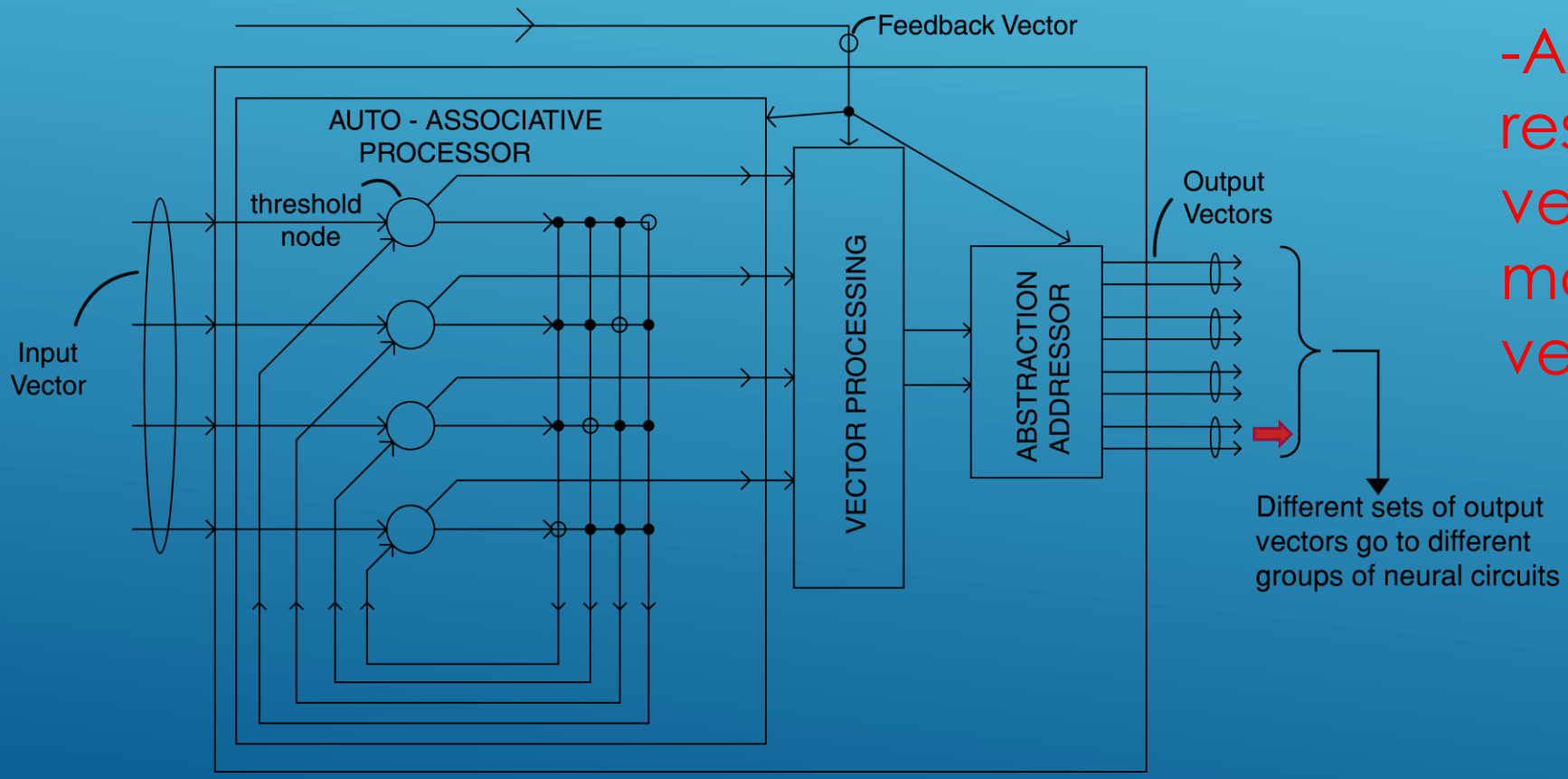
Meaningful-Based Cognitive Architecture



15 Minute Introduction to MBLS

1. HLN (Hopfield-like Network) is basic unit of MBLS
2. Causal Memory
3. HLNs forming Logic/Working Memory groups
4. Practical example to put it all together
5. Model of brain (devp't psychotic disorders in *H. sapiens*)

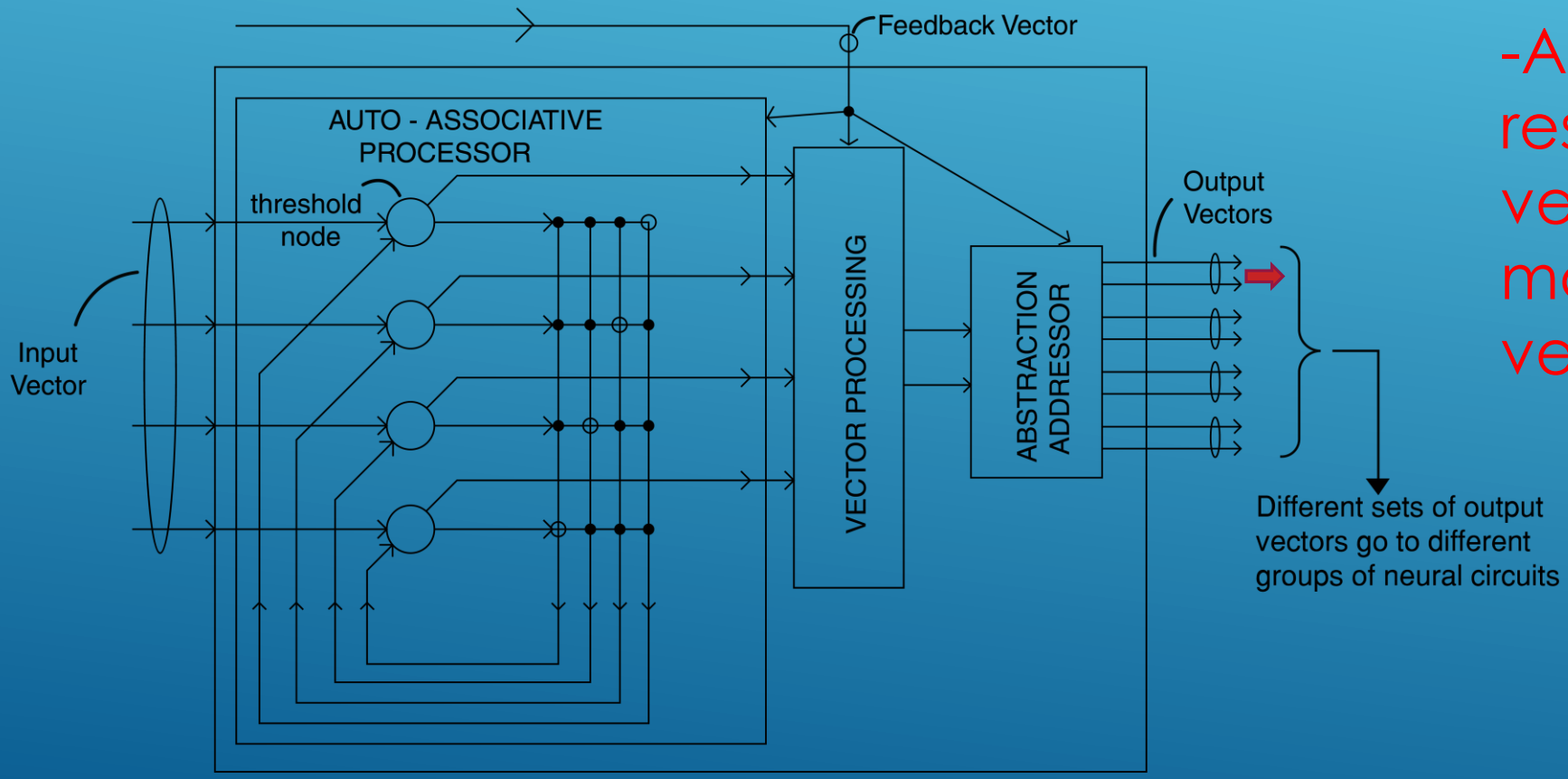
Hopfield-*like* Network == HLN



-Auto-Associative Processor is a pattern recognizer

-Abstraction addressor in response to the feedback vector, decides which of many possible output vectors to use

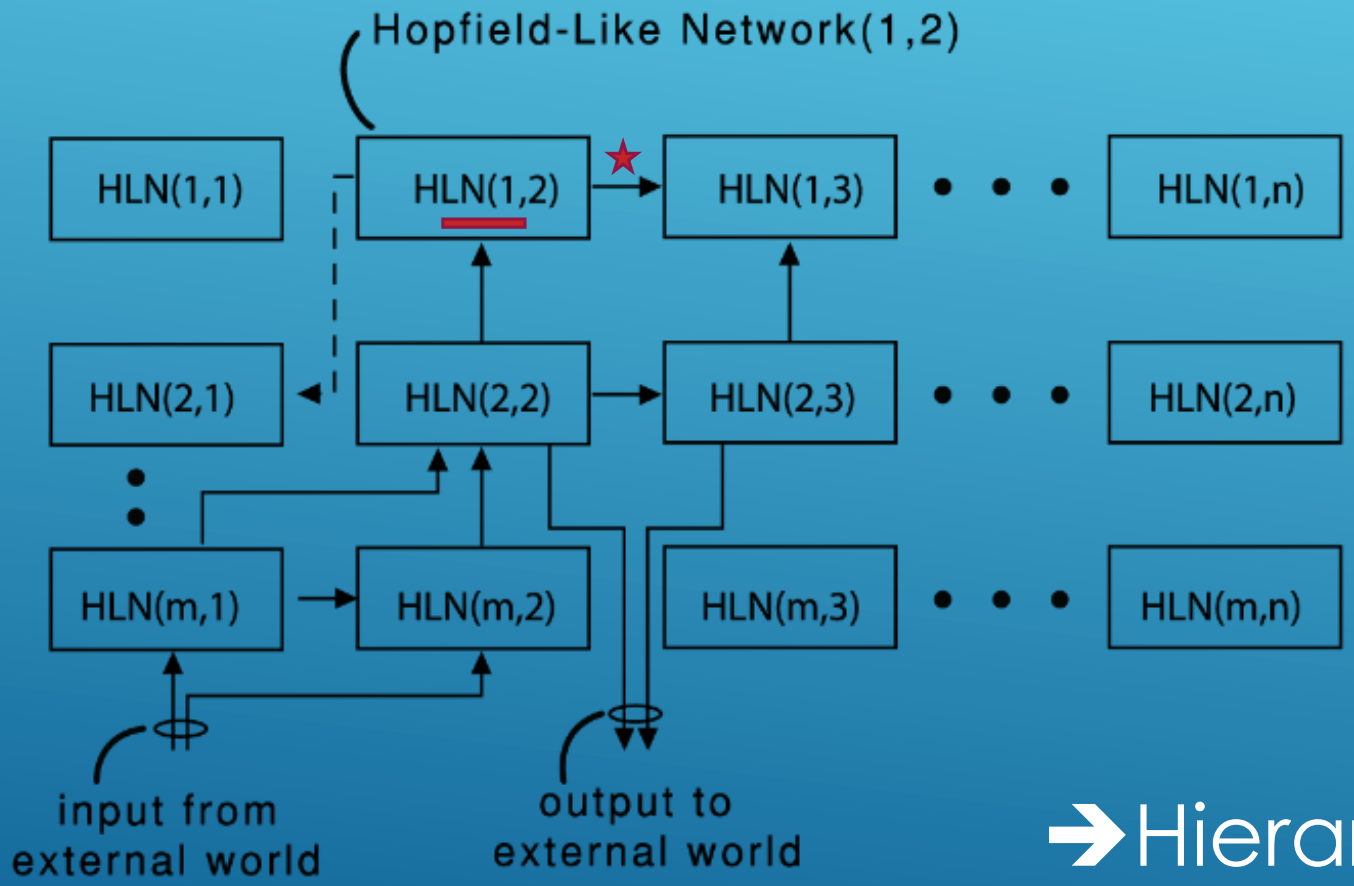
Hopfield-*like* Network == HLN



-Auto-Associative Processor is a pattern recognizer

-Abstraction addressor in response to the feedback vector, decides which of many possible output vectors to use

Matrix of HLNs



-Core structure of MBLS is a matrix of HLNs

-**HLN(1,2)** attaches to both **HLN(1,3)** and…..

➔Hierarchies and other topologies easy to organize

Hierarchies of Pattern Recognizers (== HLNs) can do Pattern Recognition

- Work by others – Hawkins, Kurzweil, George and others on "pattern recognizer" hierarchies (the pattern recognizer in the MBLS is effectively the HLN unit)
- Various hierarchies of pattern recognizers can recognize, for example, from lines to letters to words to ideas associated with those words

Weights of Connections change….

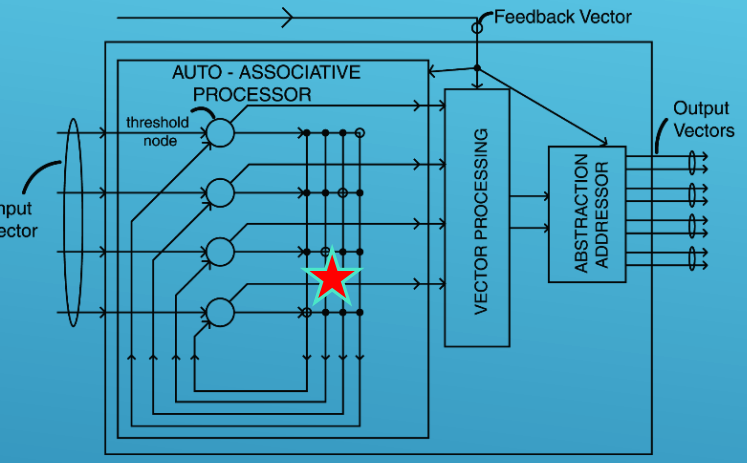


Figure 2 Hopfield-Like Network (HLN)

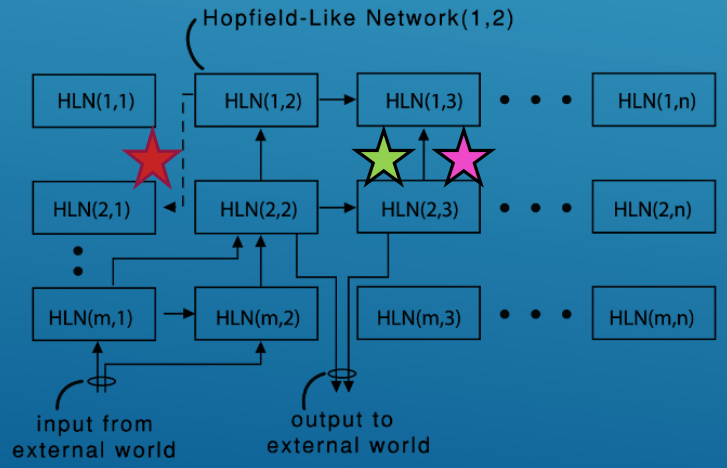
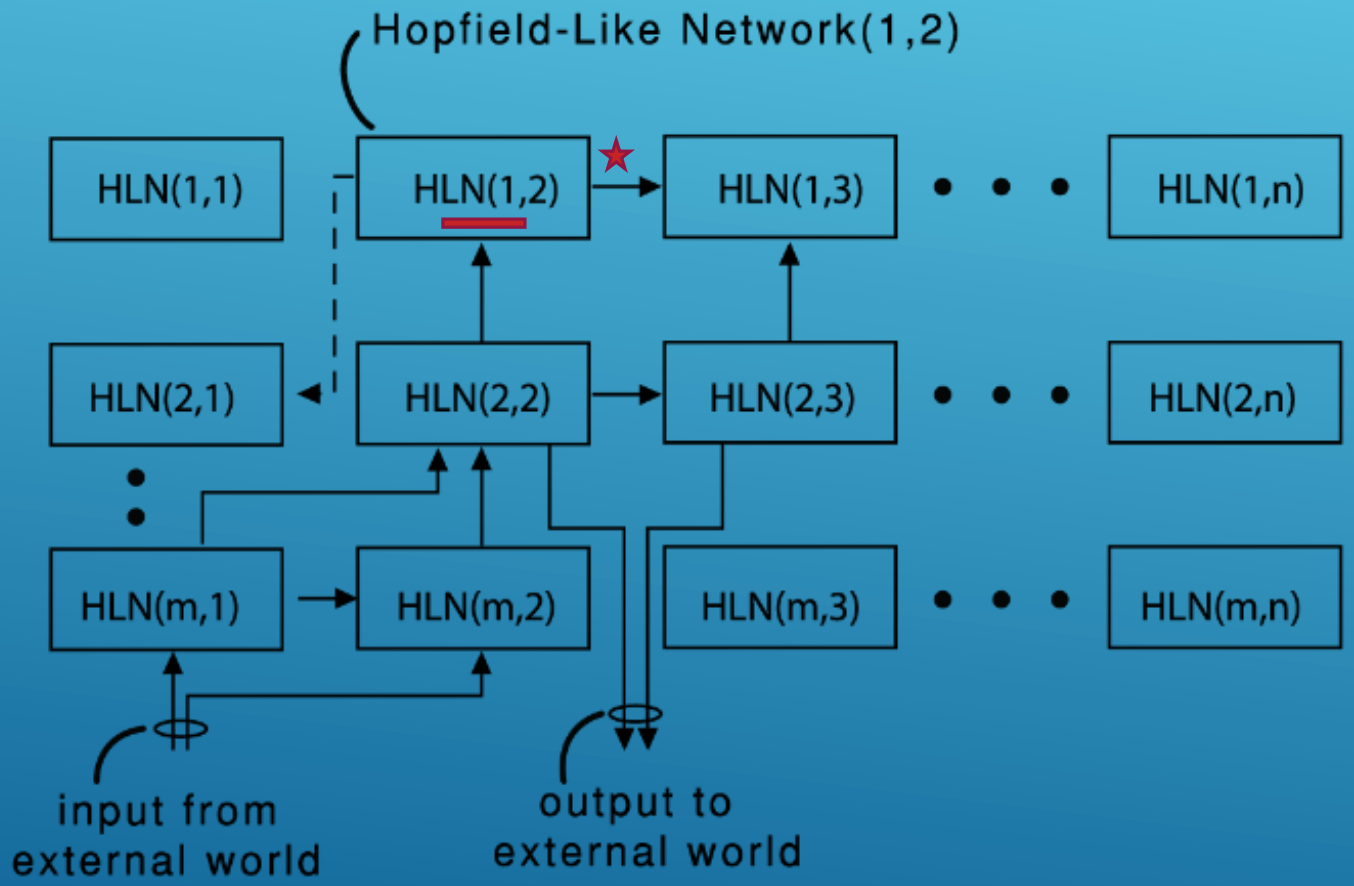


Figure 1 MBLS Core Structure

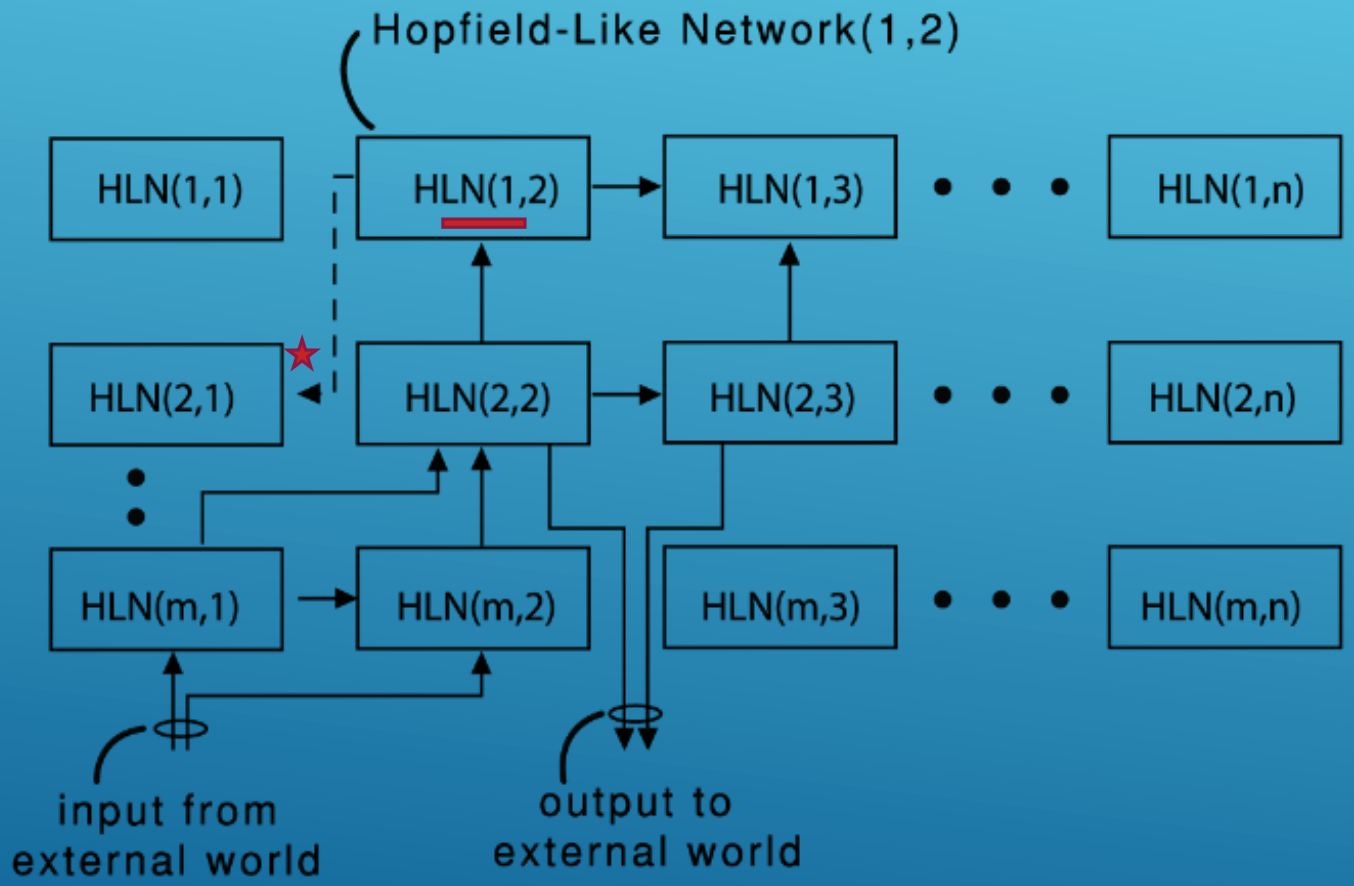
- Weights within individual HLN auto-assoc processor ← *gradually*
- Weights between HLNs ← *gradually as in conventional ANN*
- Weights between HLNs ← *large, long-term changes to form more discrete logical relations*
- Weights between HLNs ← *extreme rapid reconfigurations*

Weights between HLNs ← *extreme rapid reconfigurations*



← **HLN(1,2)** attaches to both **HLN(1,3)** and **HLN(2,1)**

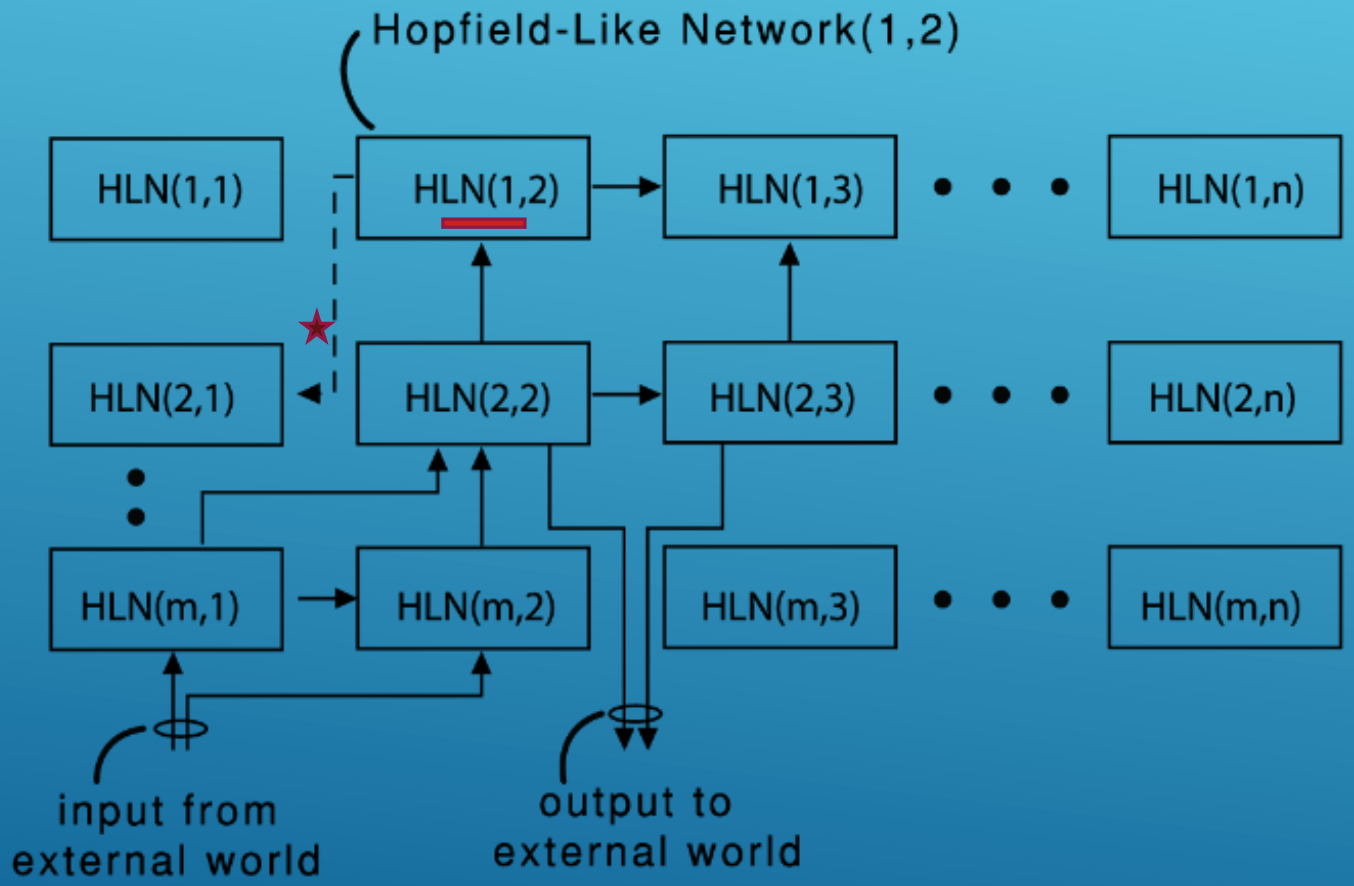
Weights between HLNs ← *extreme rapid reconfigurations*



Rapid Reconfiguration of HLNs possible – we can try a number of reconfigurations

Which HLNs do we connect to other HLNs?

Try to Maximize Meaningfulness



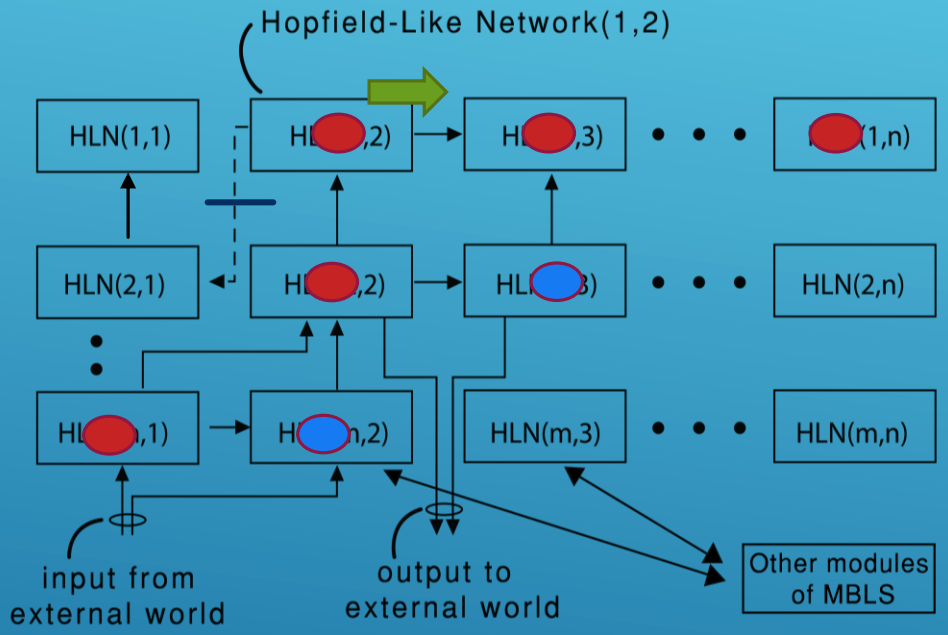
What is *Meaningfulness* ?

$H = -\sum_i P(x_i) \log_2 P(x_i)$ ←*Shannon entropy*

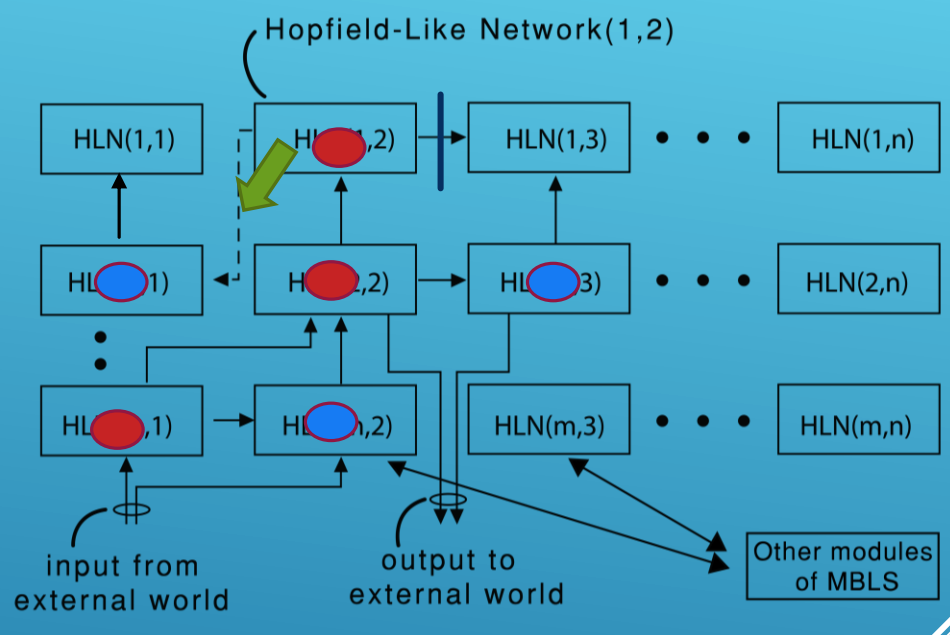
$M = 1/H$ ←*Meaningfulness*

Unfair coin: Tails, Tails, Heads, Tails, Tails, Tails
Therefore, low entropy, high meaningfulness

Meaningfulness – via Shannon Entropy



Reconfiguration A



Reconfiguration B

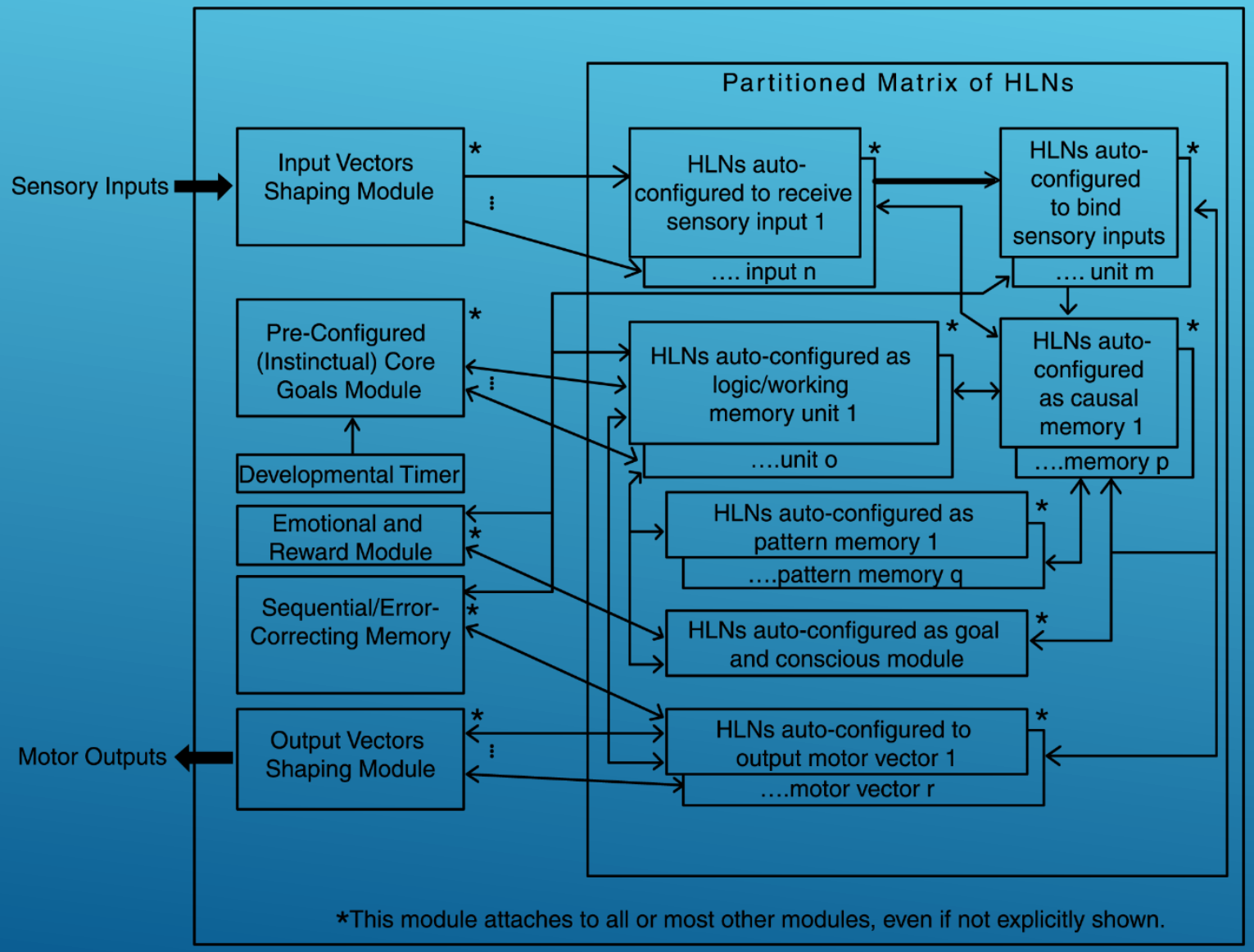
5 HLNs 'On', 2 HLNs 'Off' vs. 3 HLNs 'On', 3 HLNs 'Off'

p(ON)=5/7, p(OFF)=2/7 vs. p(ON)=3/6, p(OFF)=3/6

H= 0.86 → **M=1.2** vs. H=1.0 → **M=1.0**

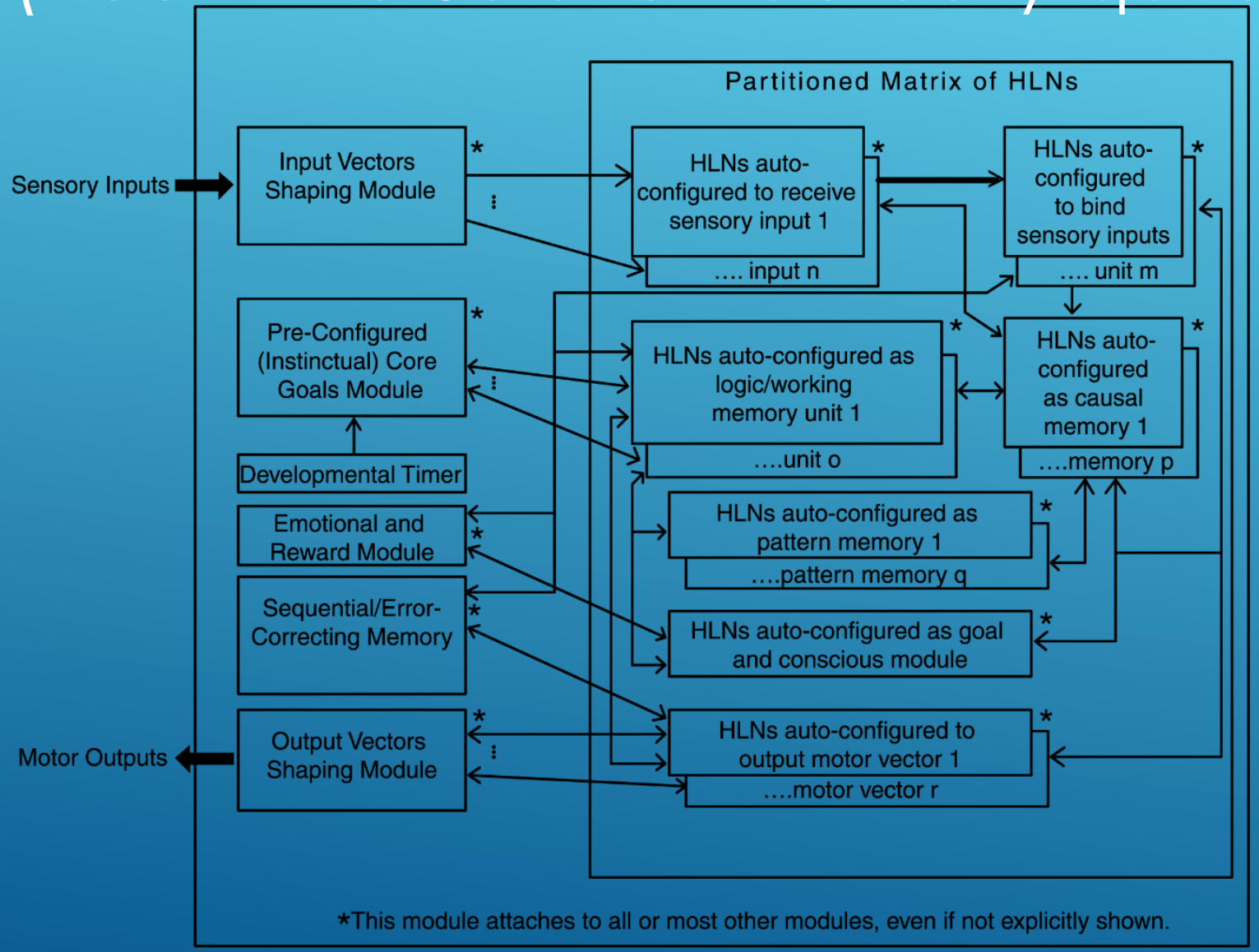
(via Counting: 5 on vs. **via Counting: 3 on)**

Meaningfulness – good idea but intractable ?



←Infinite time for millions of HLNs to auto-configure to this very useful configuration

Meaningfulness – Polynomial-Time Solution
(Real Time Solution actually quite feasible)



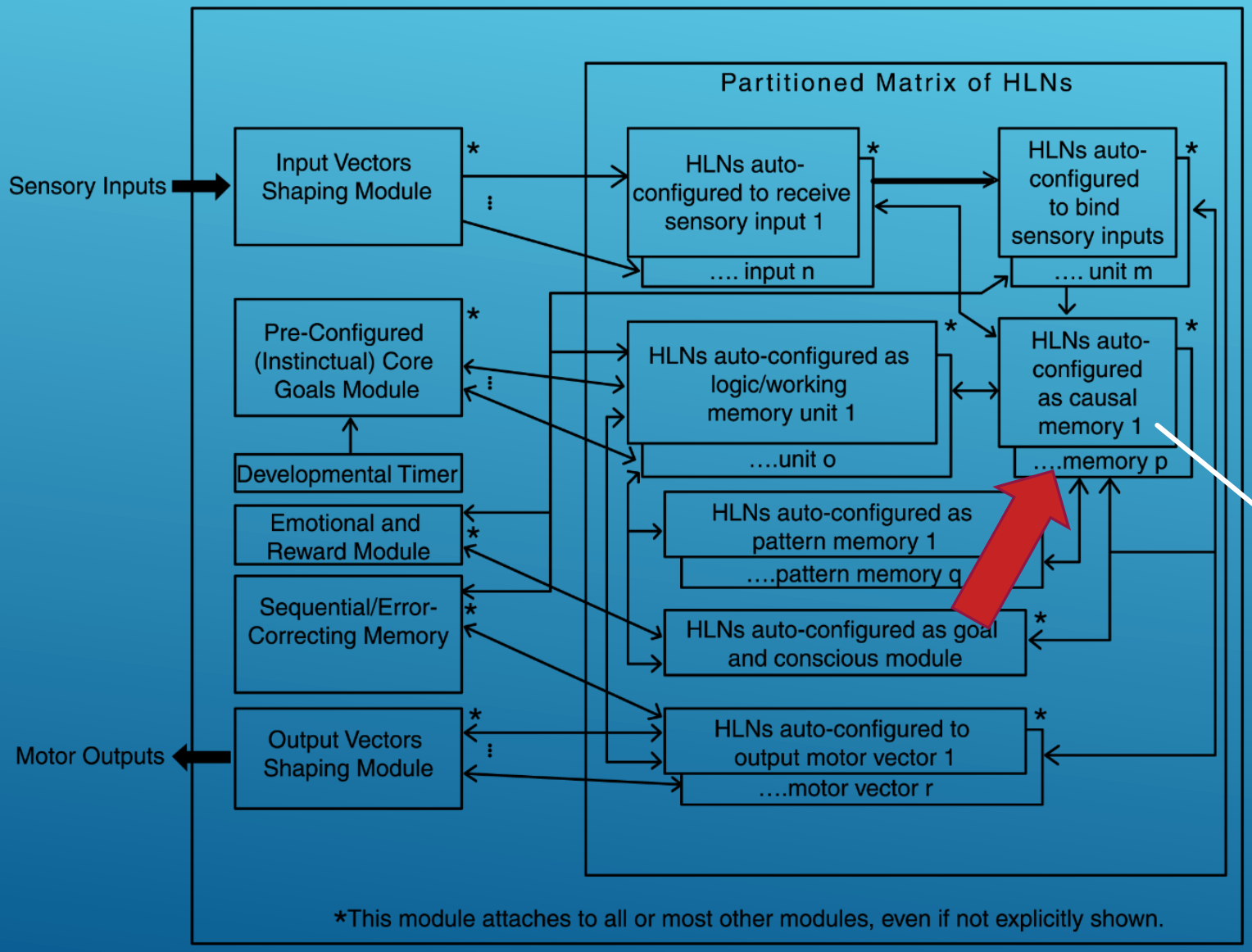
←Basic architecture of system, ie, relations between HLNs auto-configured via design via default weights and default pathways/topology

- (Biological analogy – genetic pre-configuration of central nervous system – cortical columns all look similar but specializations and groupings)

15 Minute Introduction to MBLS

1. HLN basic Unit of MBLS
2. Causal Memory
3. HLNs forming Logic/Working Memory groups
4. Practical example to put it all together
5. Model of brain (devp't psychotic disorders in *H.* sapiens)

Causal Memory



Many of the HLNs configured as causal memory (world models, procedural info, declarative info, episodic info)

What event follows another event, what spatial feature leads to next spatial feature, etc

15 Minute Introduction to MBLS

1. HLN basic Unit of MBLS

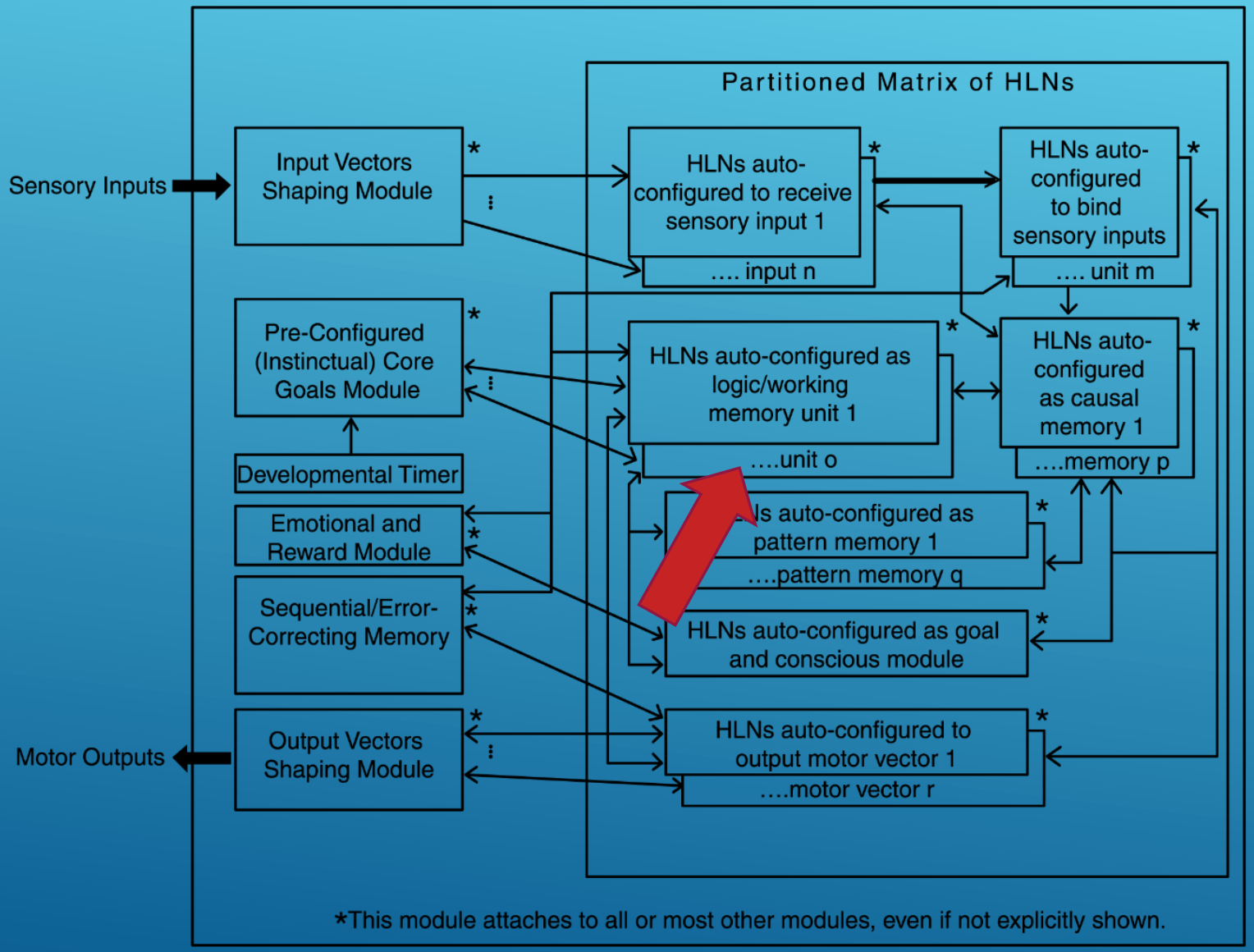
2. Causal Memory

3. HLNs forming Logic/Working Memory groups

4. Practical example to put it all together

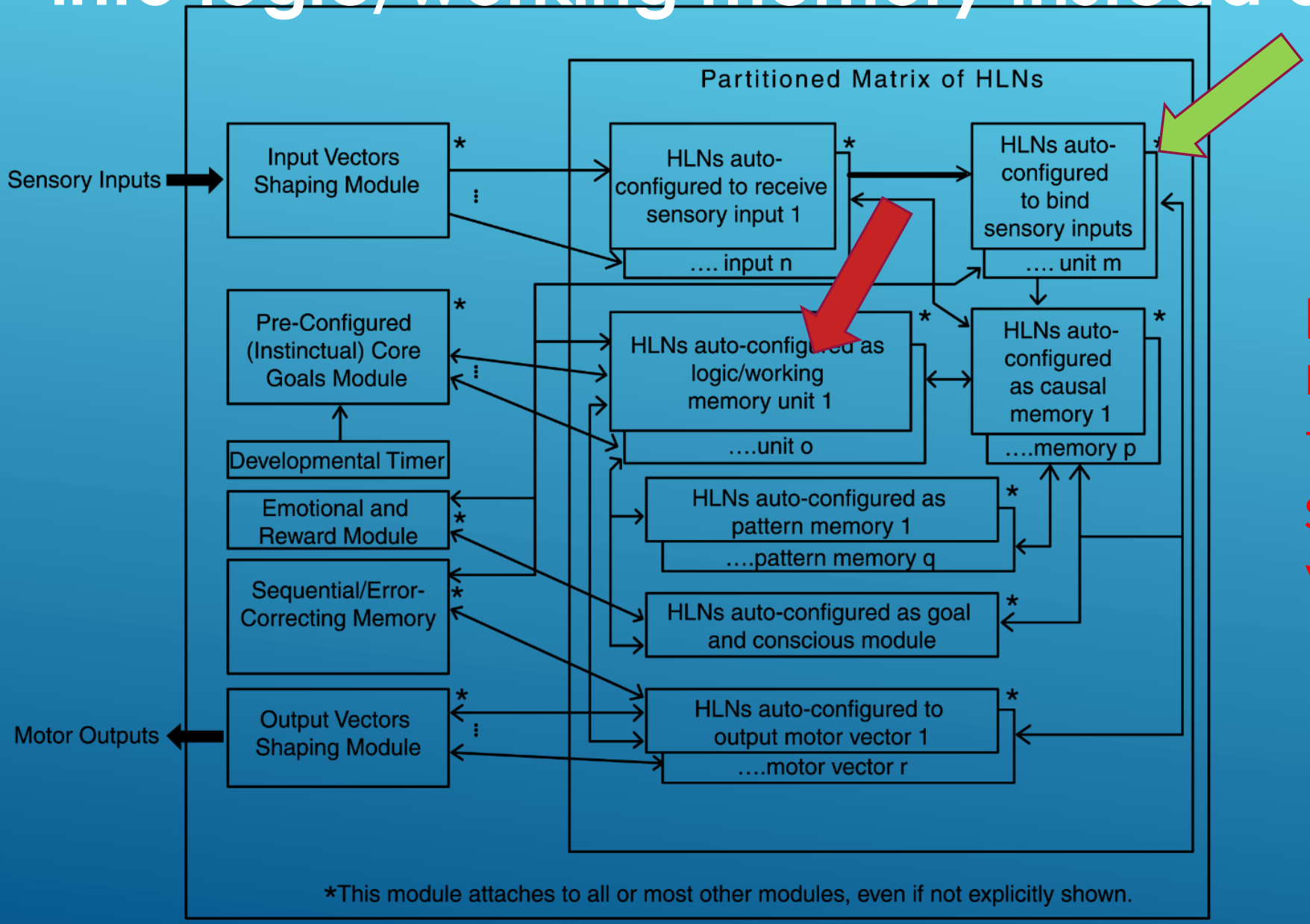
5. Model of brain (devp't psychotic disorders in *H. sapiens*)

Logic/Working Memory Units



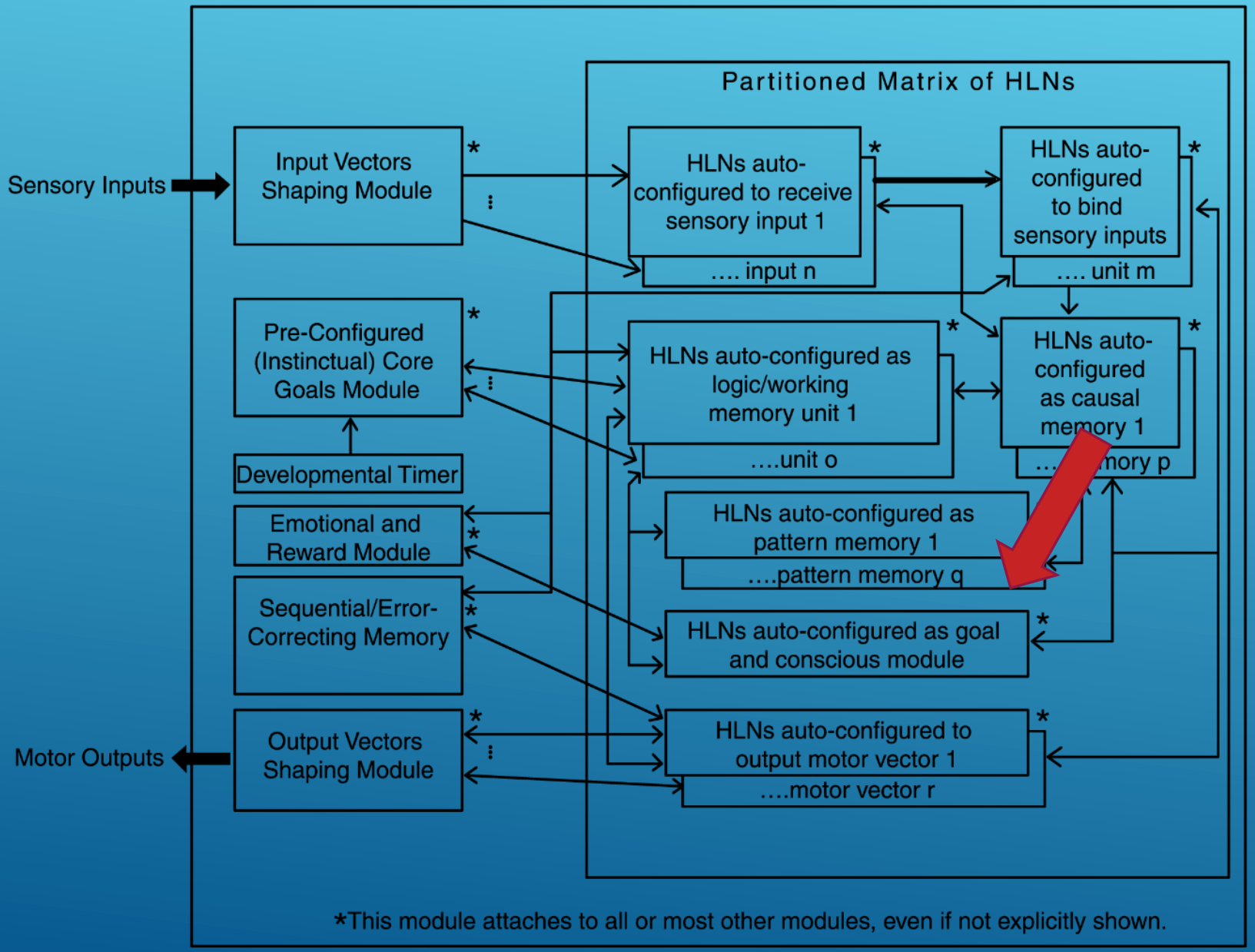
HLNs auto-configured via default weights as logic/working memory units

Feed vector from logic/working memory unit back into logic/working memory instead of sensory input



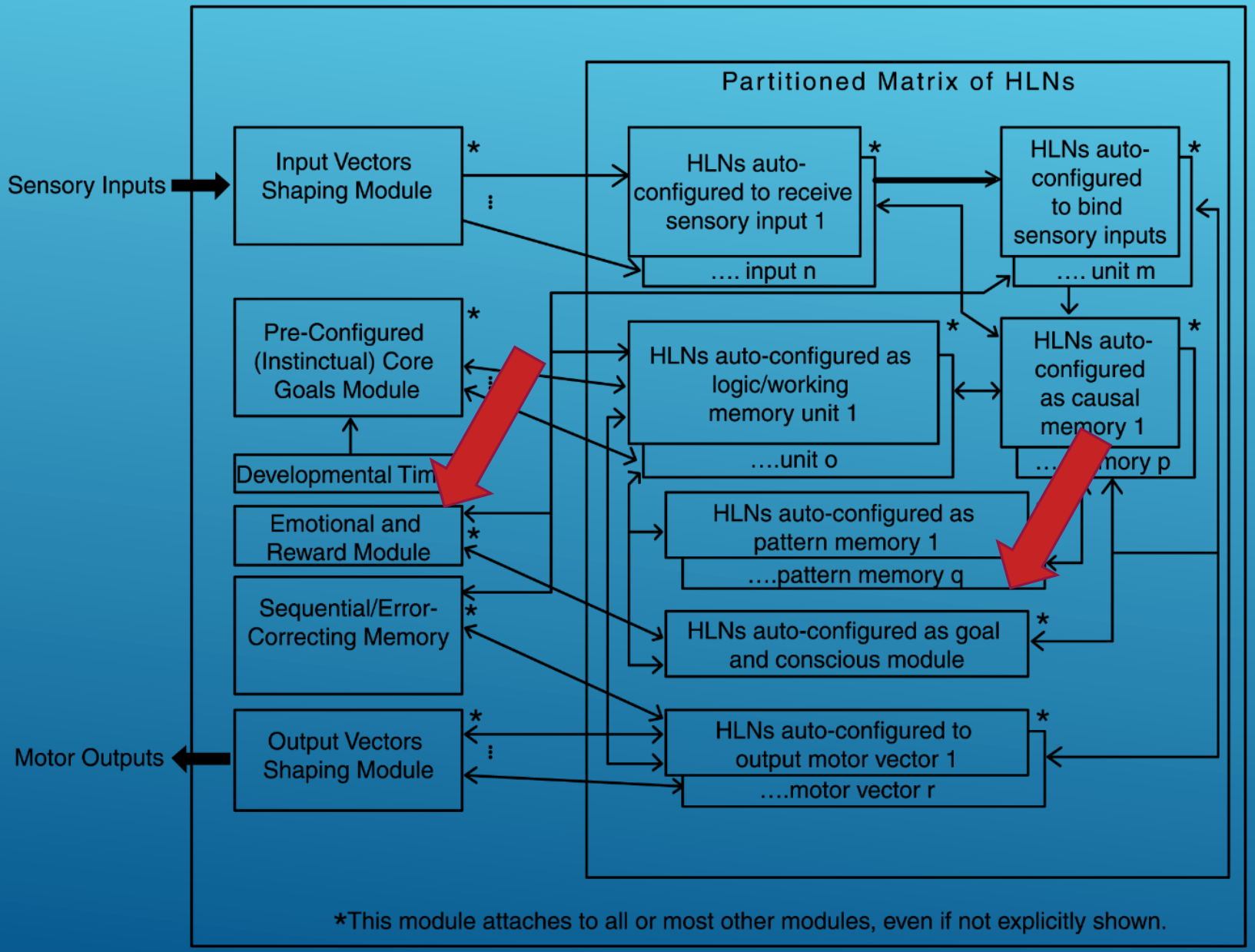
'Thought-like' – now processing internal memories rather than external sensory input vectors

Store actions of logic/working memory



Advantage – helps to guide future actions and logical operations. (Also solves part of the 'black box' problem.)

Rare Events *can* be Important Events to Learn



Solves much of the 'class imbalance' problem
(and overfitting in attempts to fix).

15 Minute Introduction to MBLS

1. HLN basic Unit of MBLS

2. Causal Memory

3. HLNs forming Logic/Working Memory groups

4. Practical example to put it all together

5. Model of brain (devp't psychotic disorders in *H. sapiens*)

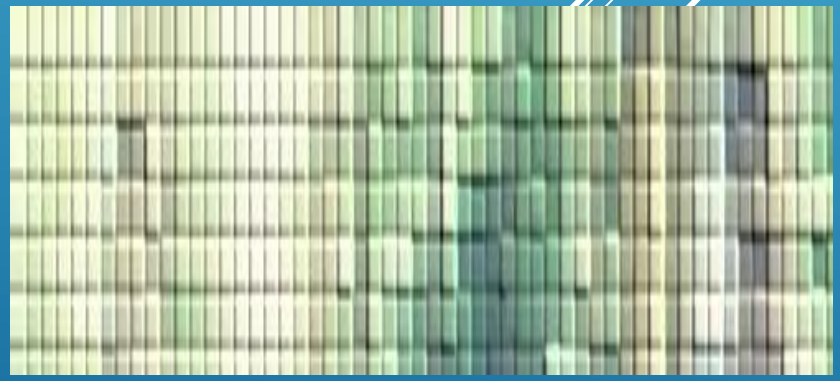
Example: Hiker lost in the woods…..

Search and rescue robot dispatched to the forest

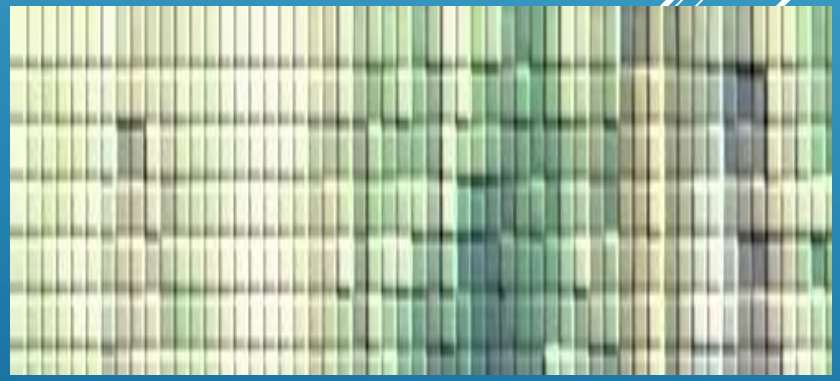
← *Controlled by an MBLS*

Note: This is hypothetical. It would take a simulation of 100 million HLNs and a large effort developing the basic algorithms to create such an MBLS.

- MBLS search & rescue robot **goes into the forest**
- Environment **full of noise** with a variety **faint signals**



- MBLS starts looking for recognition of some inputs with patterns it has seen before (or been transferred)
- Any matches?
- Reconfigure some HLNs
- Ahhh…2 input sensory vectors cause higher Meaningfulness



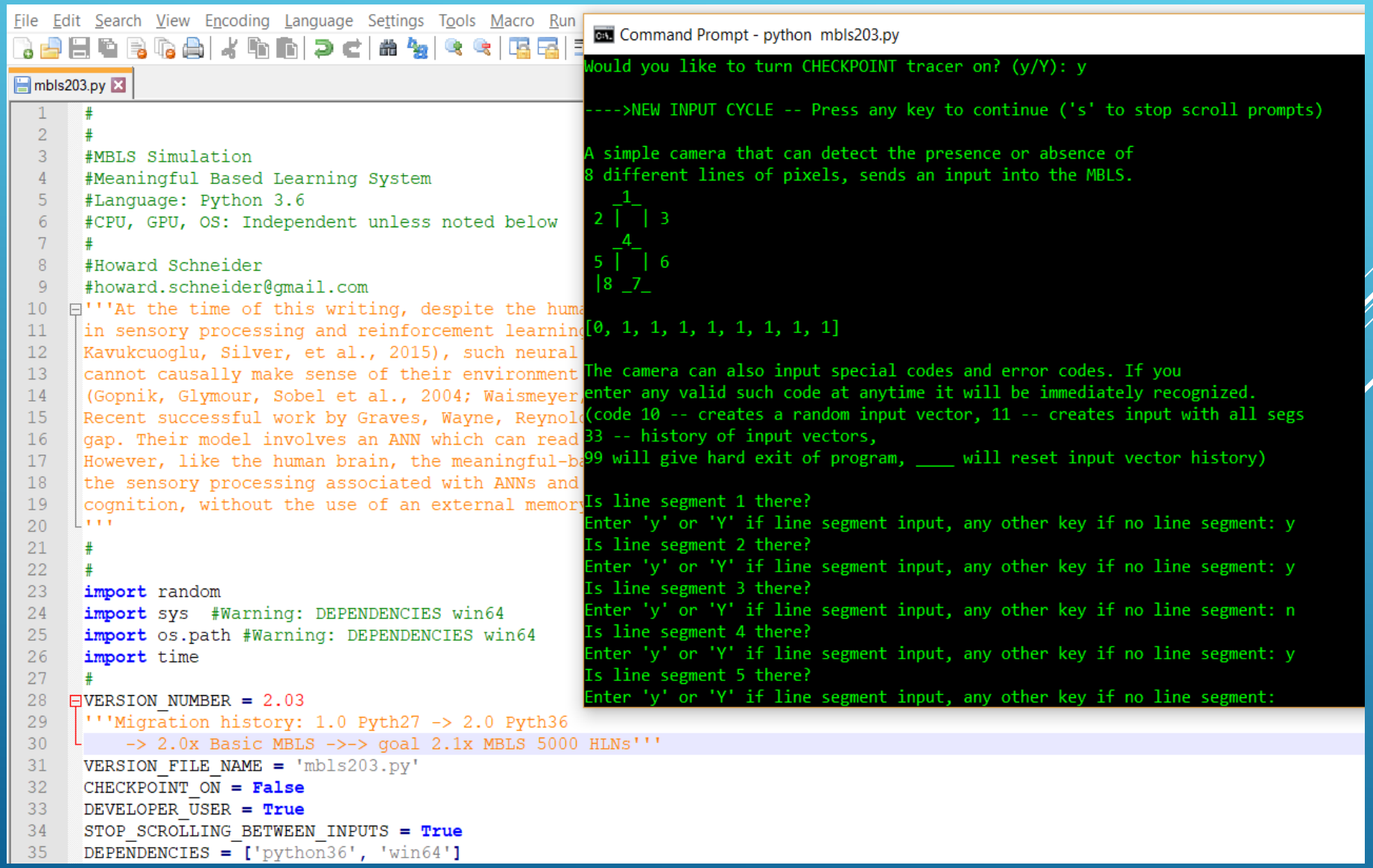
- High M sensory input vectors:
- #1 -Sound from southwest that matches with human cry for help and with bird mating call
- #2 -Odor from north that matches with commercial perfume/cologne

- Processed sensory input vectors sent to Logic/Working Memory unit (can compare vectors and create vectors, output action,….)

- Better match of odor sensory input with goal vector → robot directed to north

- After a few more minutes to the north – success – the lost hiker is found

Simulation of the MBLS Transition to 5000 Simulated HLNs --

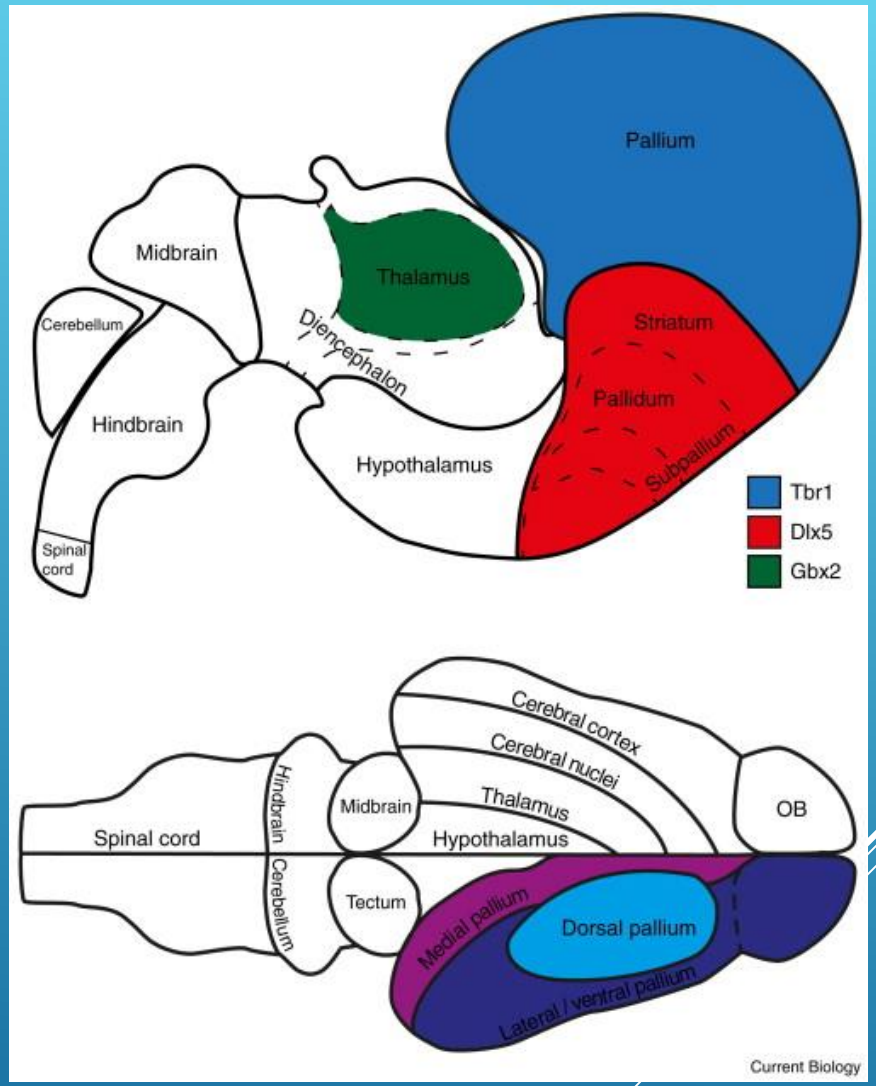


15 Minute Introduction to MBLS

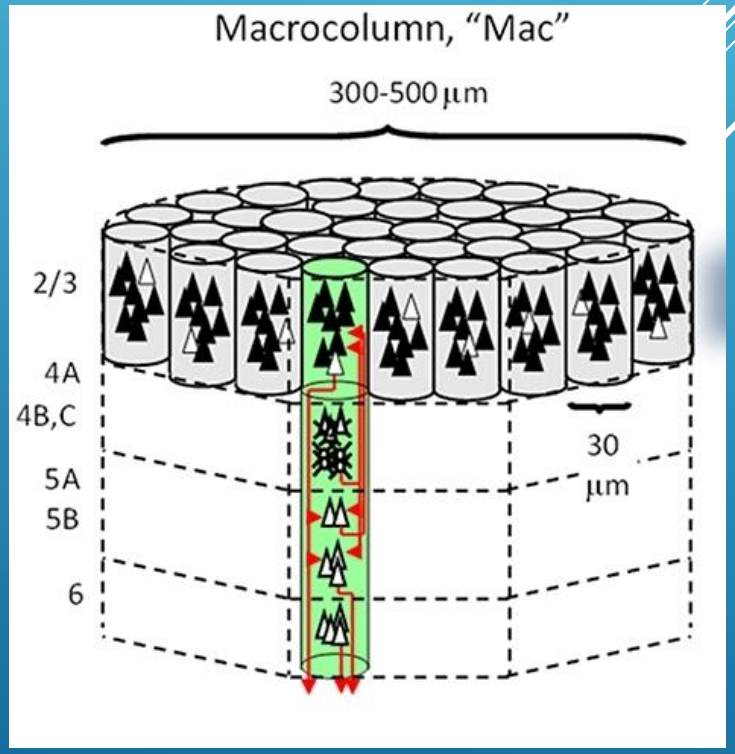
1. HLN basic Unit of MBLS
2. Causal Memory
3. HLNs forming Logic/Working Memory groups
4. Practical example to put it all together
5. Model of brain (devp't psychotic disorders in *H. sapiens*)

Reptilian Brain

No cerebral neocortex, but sensory information does reach circuits in the pallium



Mammalian cerebral cortex



Model re Psychotic Disorders in *H sapiens*

- If…. HLNs form Logic/Working Memory units (human Working Memory)
- Then…. Much more complex configuration than rest of MBLS (rest of brain less likely for fatigue or failure)
- Then…. Increased risk of failure to impede cognition and retrieve inappropriate memory vectors for any small issue (in humans this is 'psychosis')
- Then… As MBLS matures, Logic/Working Memory units stressed by more complex and powerful algorithms -- this is when risk of failure the greatest (psychosis in teenage years)
- Solution: More redundant methods/self-protection to Logic/Working Memory units (in humans protect Working Memory in teen years to prevent schizophrenia)
- Caveat: Speculative….but some evidence supports above clinically

MBLS – Meaningful-Based Cognitive Architecture

1. Pragmatic solution to the neural-symbolic problem

2. Pragmatic technology -- not just pattern recognition but comprehension + learning from a few examples

3. MBLS as model re strategy towards brain disorders (eg, schizophrenia)

Future Work

- Larger, more comprehensive simulation
- More formal proofs of the features of the MBLS

howard.schneider@gmail.com