THE NAVIGATION MAP-BASED COGNITIVE ARCHITECTURE—A NEW CLASS OF ARTIFICIAL INTELLIGENCE

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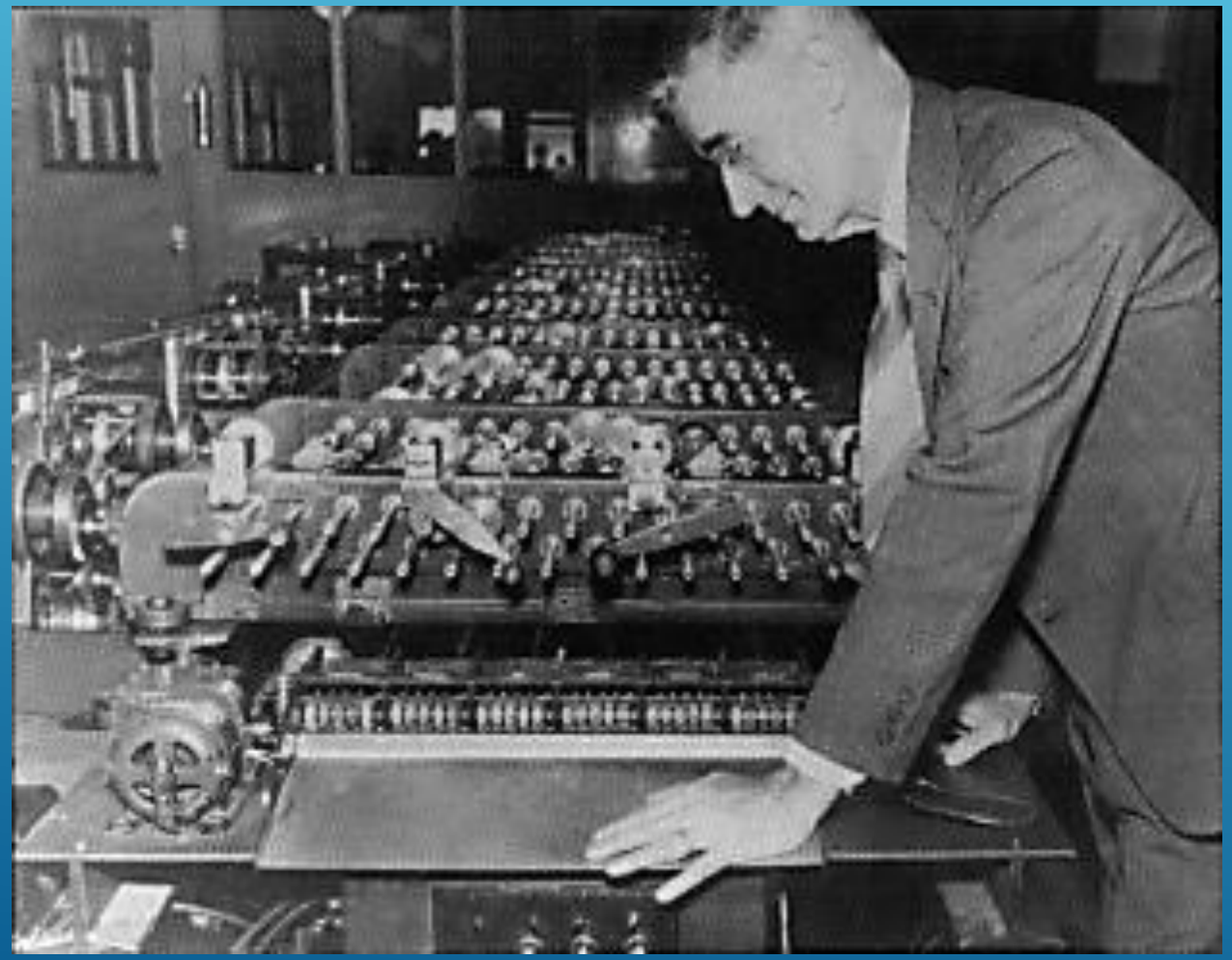
Paper 45

Navigation map-based cognitive architecture

-- A new class of artificial intelligence

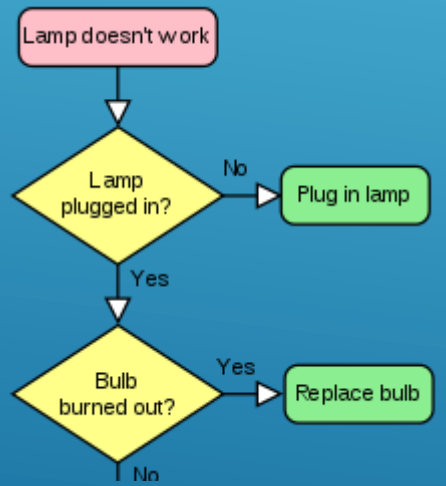
MANY WAYS TO ACHIEVING "INTELLIGENCE" OR "ARTIFICIAL INTELLIGENCE"

What are mechanisms machines can use to think…. to make decisions?

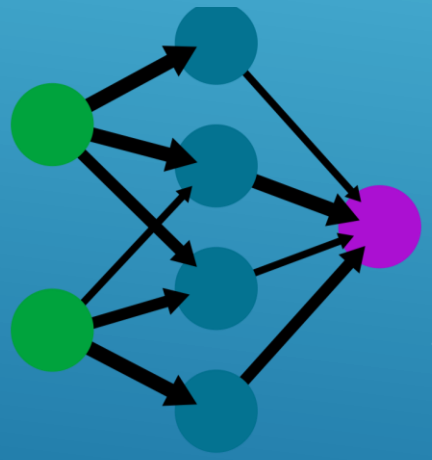


Differential analyzer, 1930's. 1940's solve differential equations, tricks for adding, multiplying

What are mechanisms we or machines can use to think…. to make decisions?



Symbolic Logic GOFAI

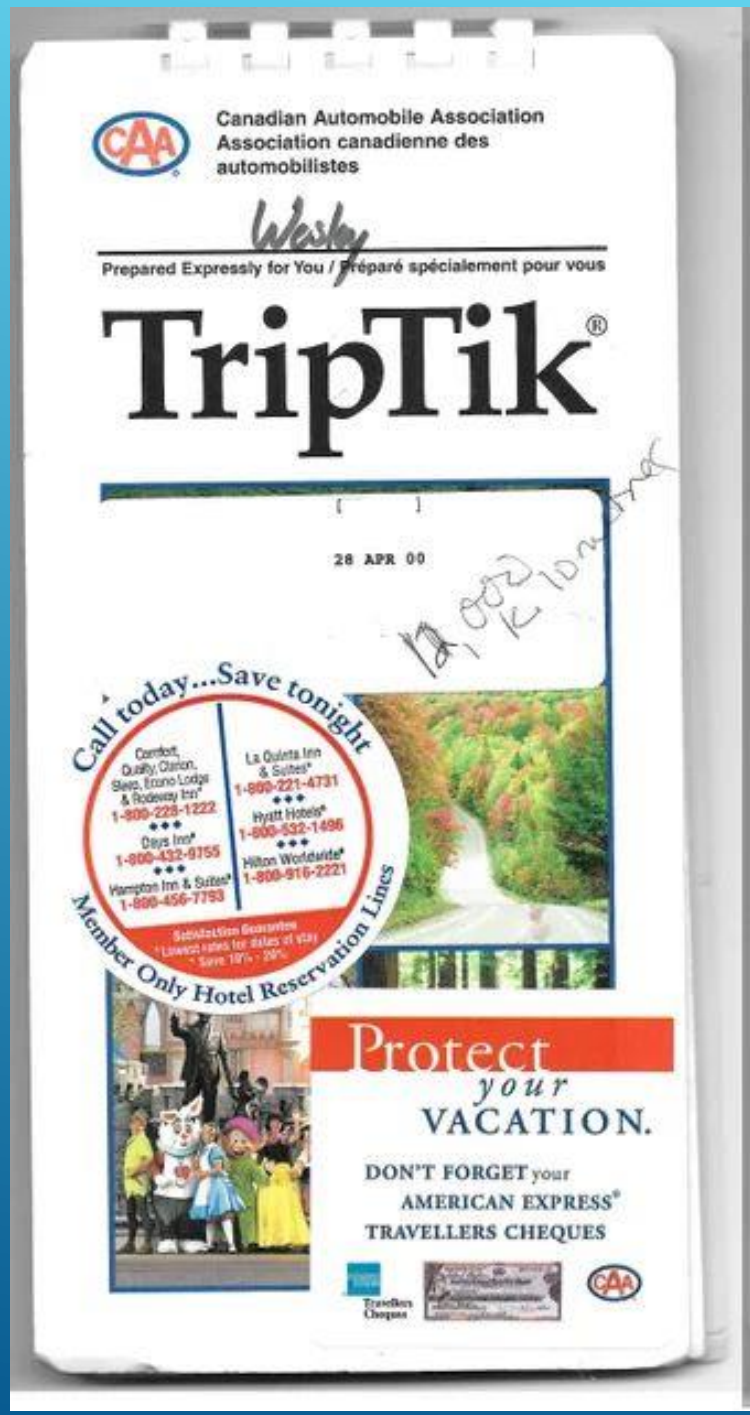


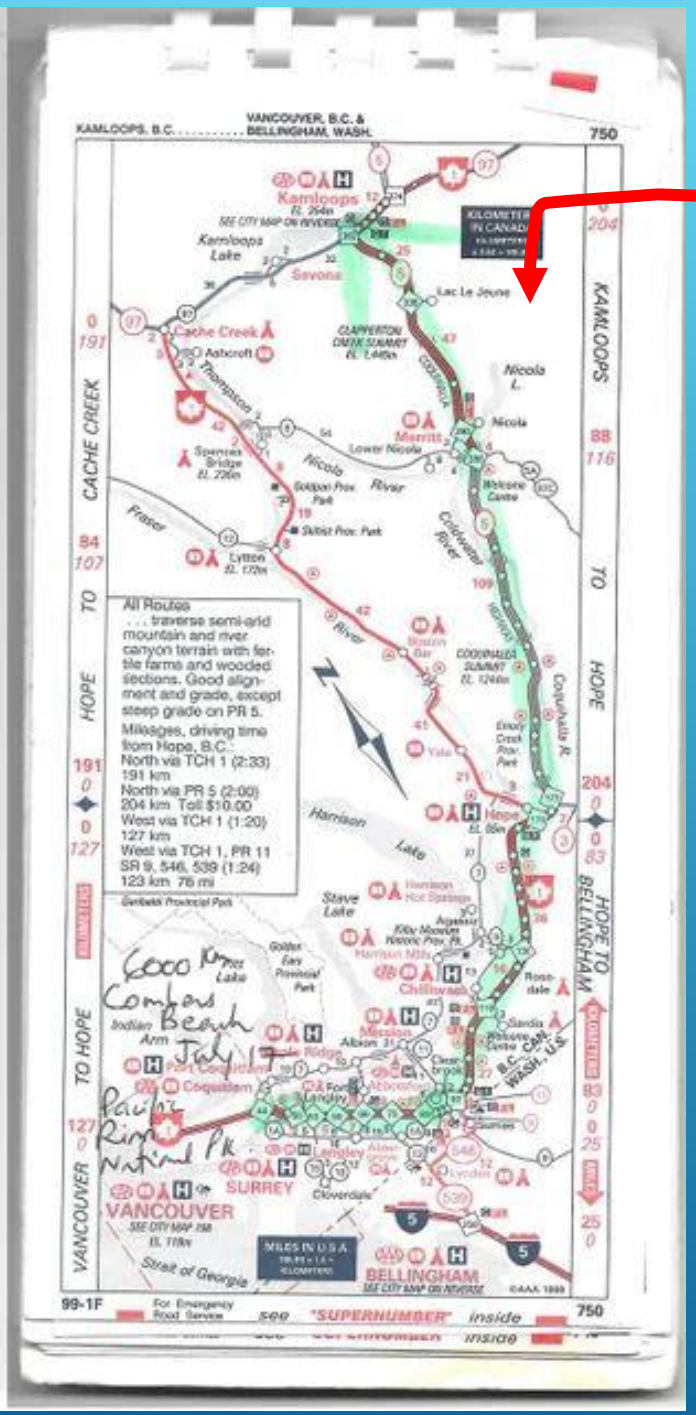
Neural Networks ANN, SNN

…

Navigation Maps with Pre-Causal and Full Causal Properties

symbolic logic, ANN -- wikipedia public domain, mouse, child – unsplash license





Navigation Map

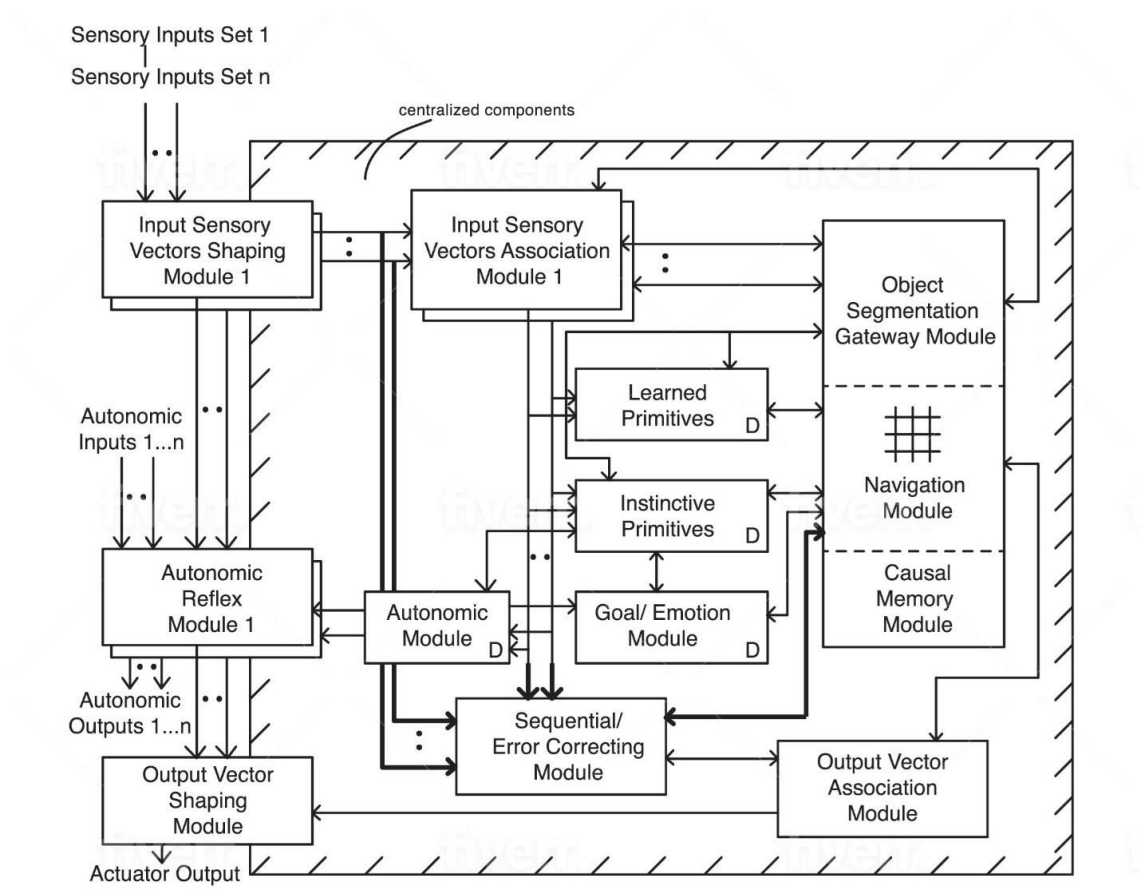
paper version,
2 spatial dimensions

```
self.total_labels = TOTAL_ASSOCIATION_LABELS #default 4
self.gb = np.empty((self.total_maps, 6, 6, 6, self.total_seg
# self.gb = np.empty((1000,6,6,6,16,4), dtype=object) (at ti
# gb[n,x,y,z,s,a]
# 1000 maps each 6×6×6 cube with up to 9 mapped objects -- a
```

Navigation Map

Python version,
3 spatial dimensions +
3 non-spatial dimensions

EVERY MODULE IN THE ARCHITECTURE USES NAVIGATION MAPS



Causal Cognitive Architecture 3

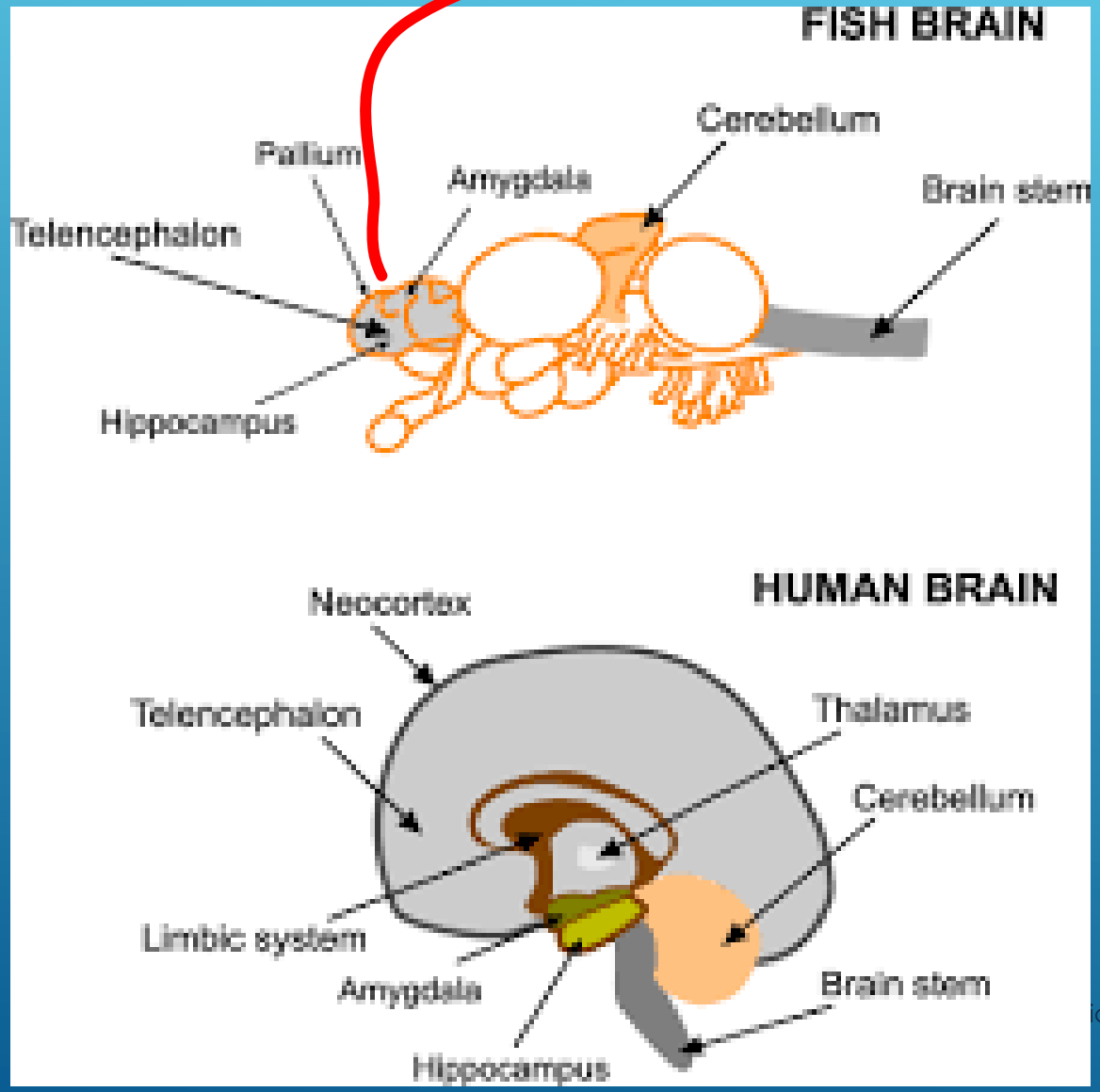
Navigation Maps:

Different way of making decisions

Most animals – invertebrates and vertebrates use some sort of navigation system

Navigation Maps:

Vertebrates – all have formal navigation systems similar to mammalian hippocampus (place and grid cells)



-possible homologue of hippocampus
-conserved gene markers of mammalian hippocampus in fish and birds

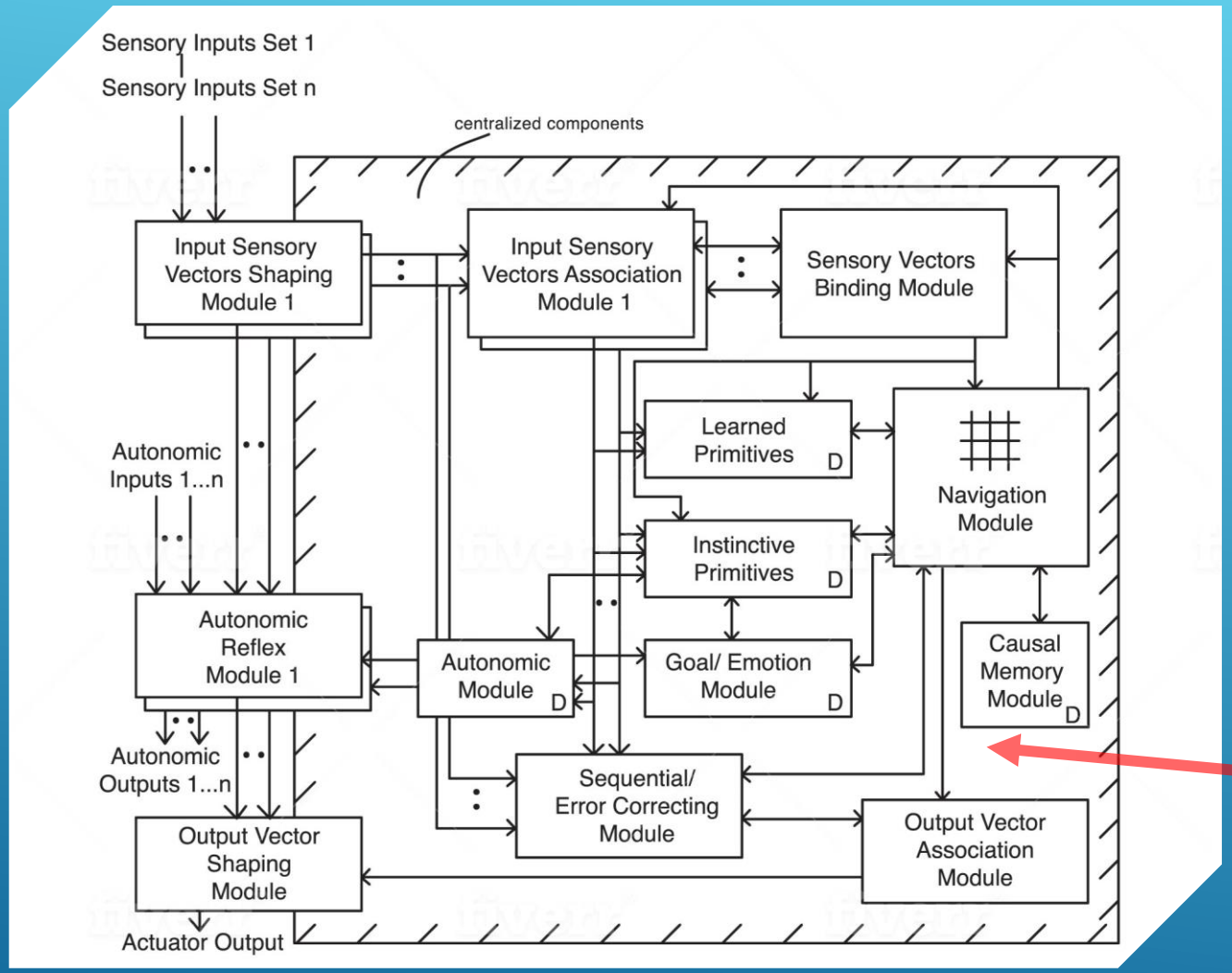
Spatial cognition exists in fish

Assumptions of the Causal Cognitive Architecture:

→Navigation map-like structures behind mammalian cognition

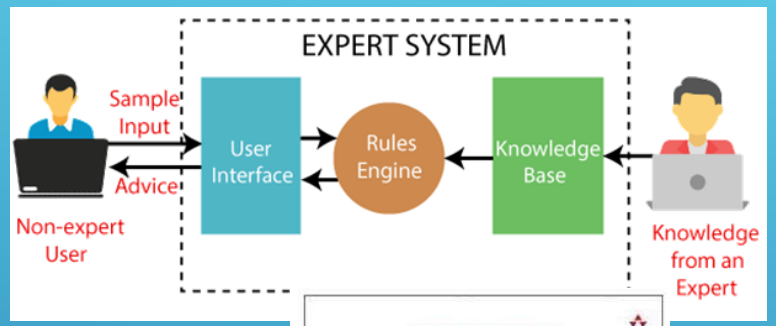
→Not just navigation, but most higher-level cognitive functions in the brain

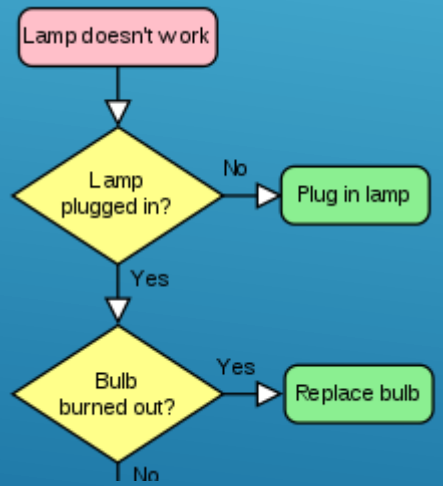
CAUSAL COGNITIVE ARCHITECTURE 1 (CCA1)
BICA 2018, 2019, 2020

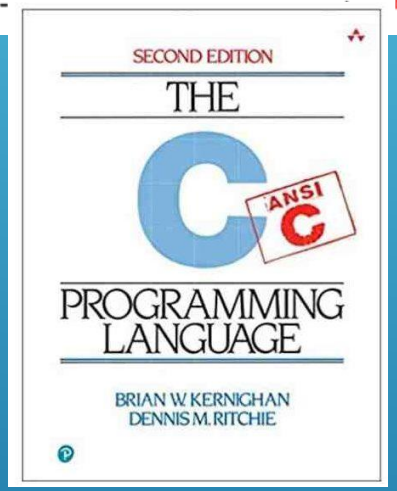


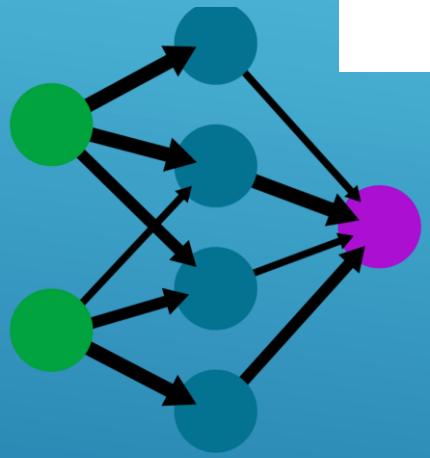
How do we engineer this type of architecture?

Tools to create systems with Symbolic Logic ….with Neural Networks

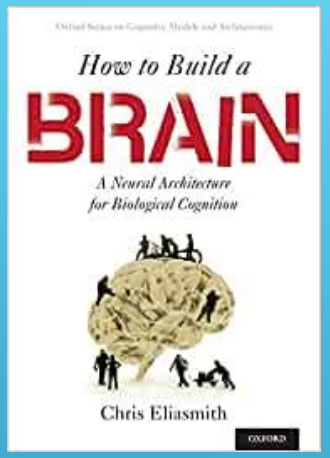








PyTorch



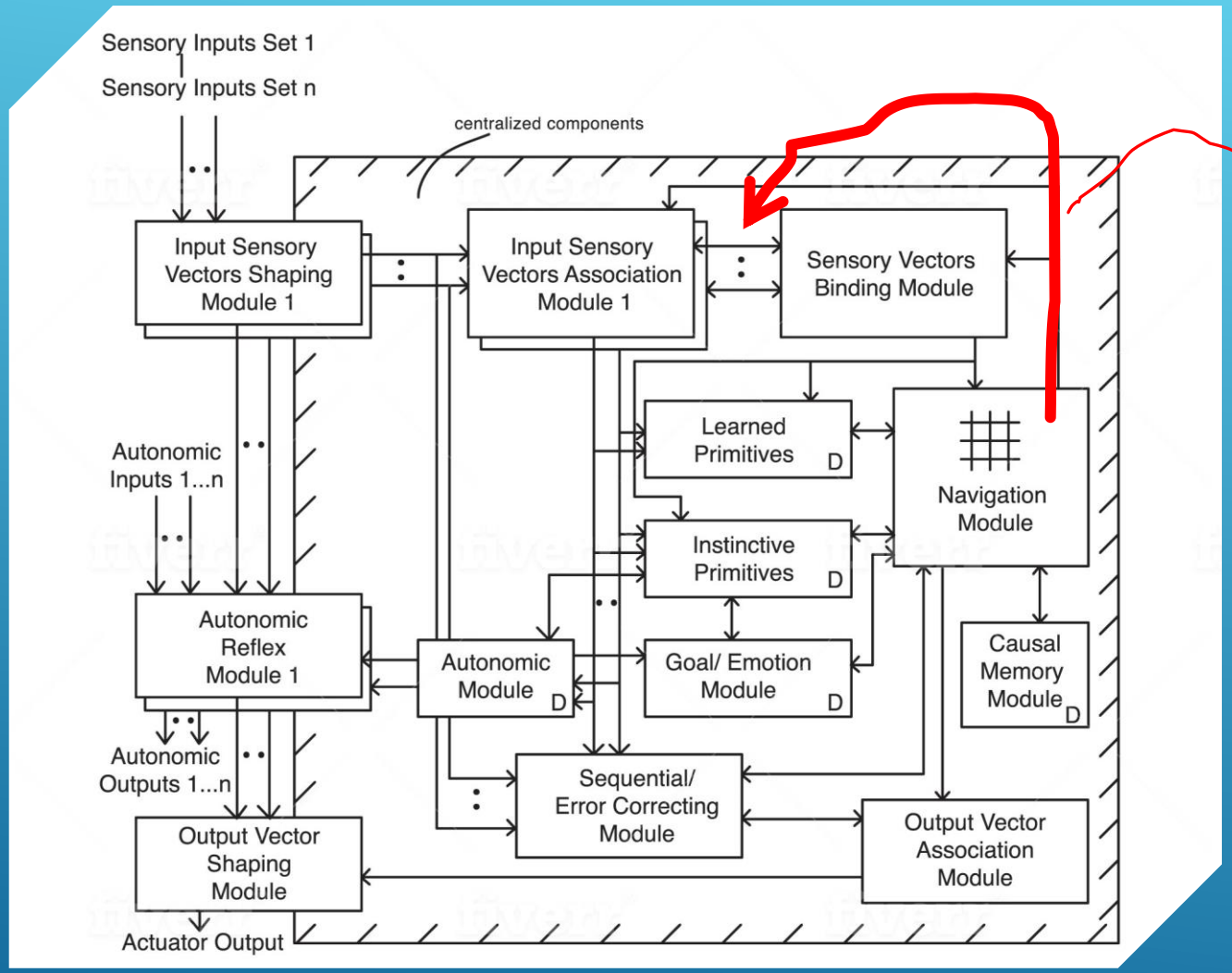
TensorFlow

Symbolic
Logic
GOFAI

Neural
Networks
ANN, SNN

symbolic logic, ANN -- wikipedia public domain, mouse, child – unsplash license

Tools to create systems with Nav Maps



Feedback of partial results, and re-operate on them
→causal behavior
→increase risk psychosis

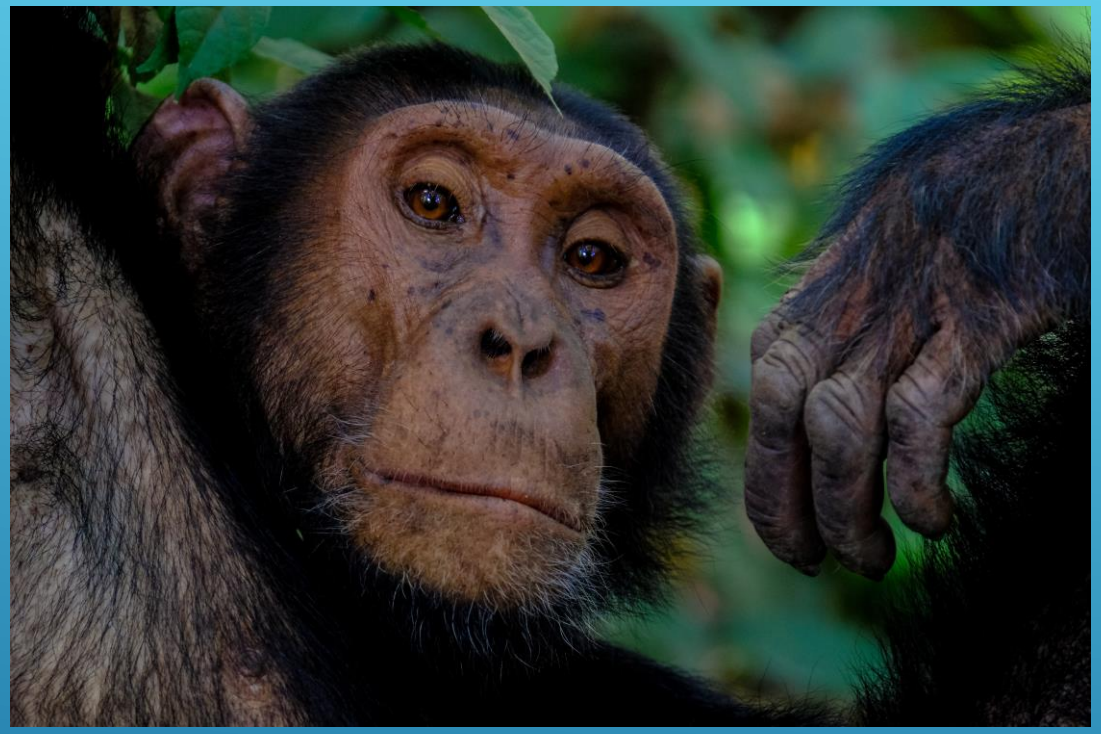
WHY PREVALENCE OF PSYCHOSIS IN HUMANS?

17% some other psychosis or psychosis-like (van Os et al 2001)

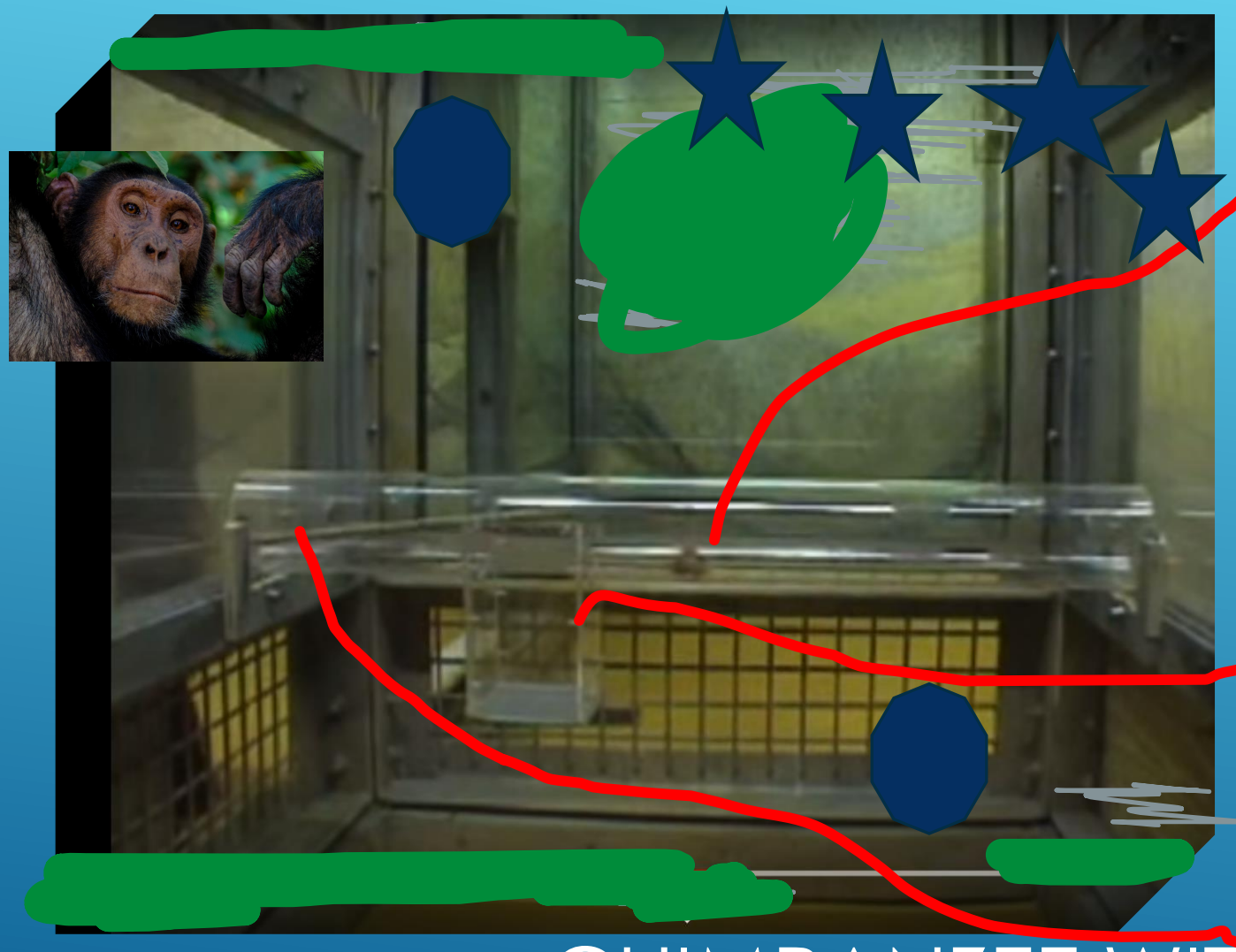
(albeit, 1% schizophrenia)

image woman – unsplash license

WHY NO FULL CAUSAL BEHAVIOR IN ANIMALS?



animal – unsplash license

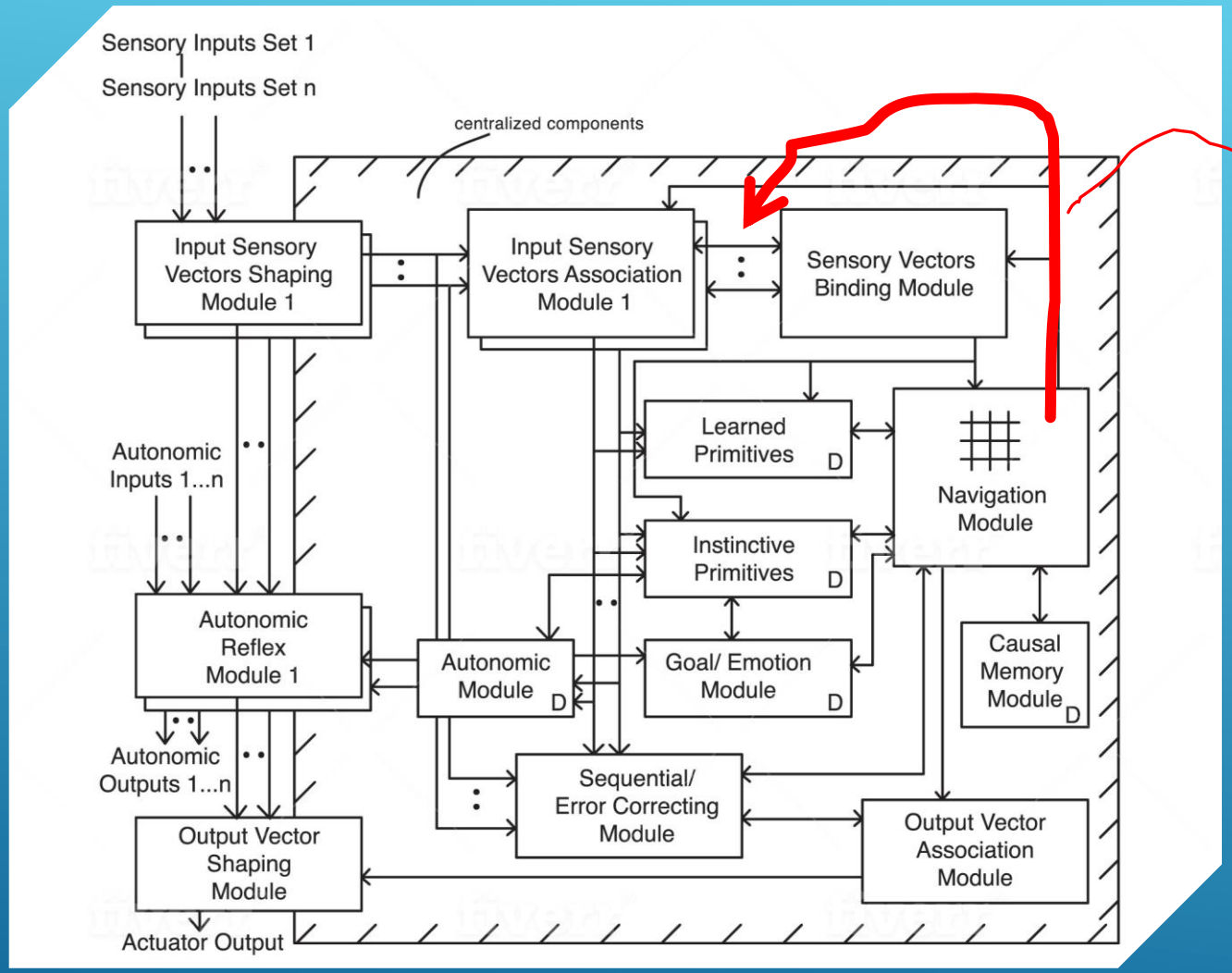


FOOD IN PLEXIGLASS TUBE

GRAVITY TRAP

CHIMPANZEE WITH STICK

youtube image modified by author plus unsplash license chimpanzee face



Feedback of partial results, and re-operate on them
→causal behavior
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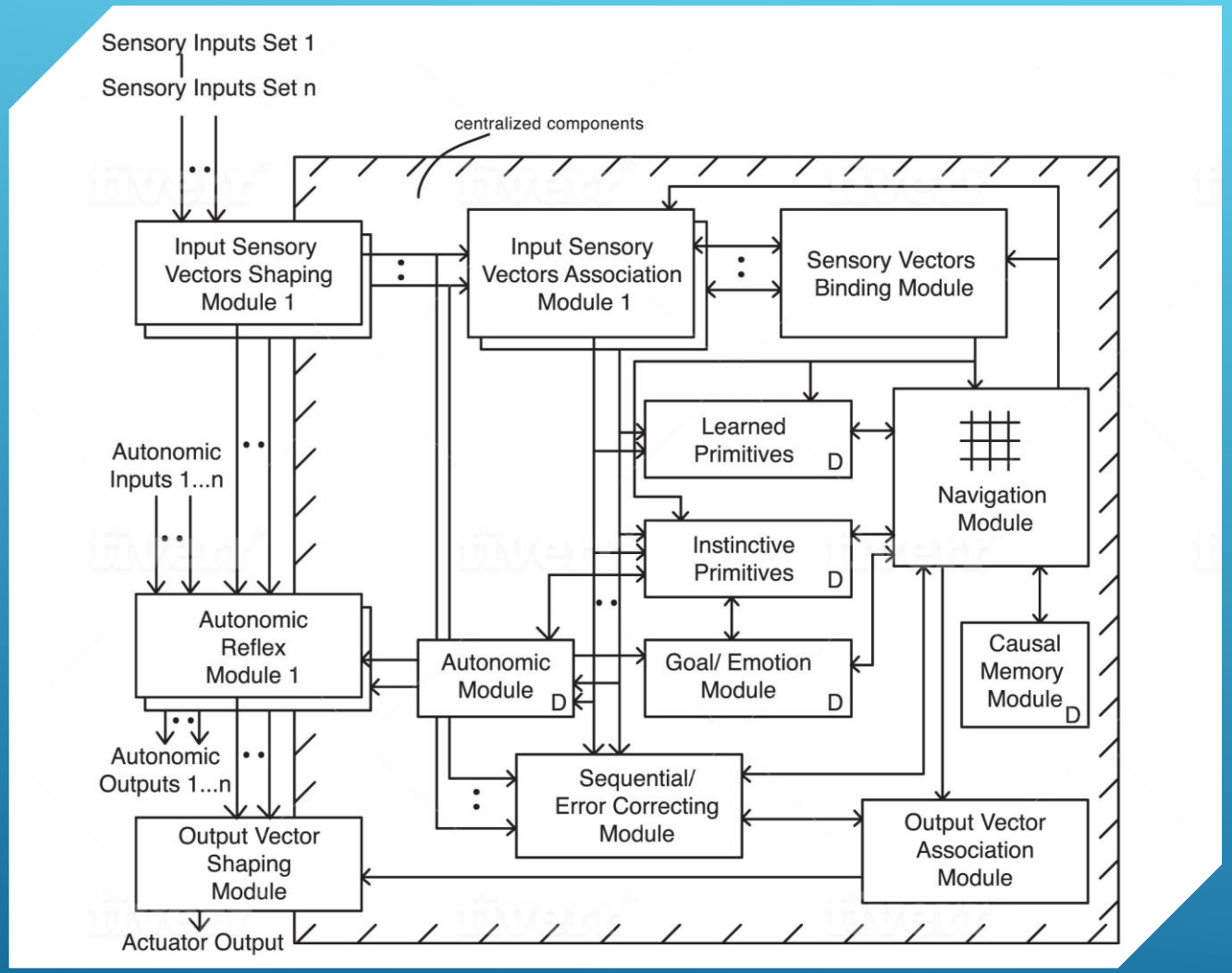
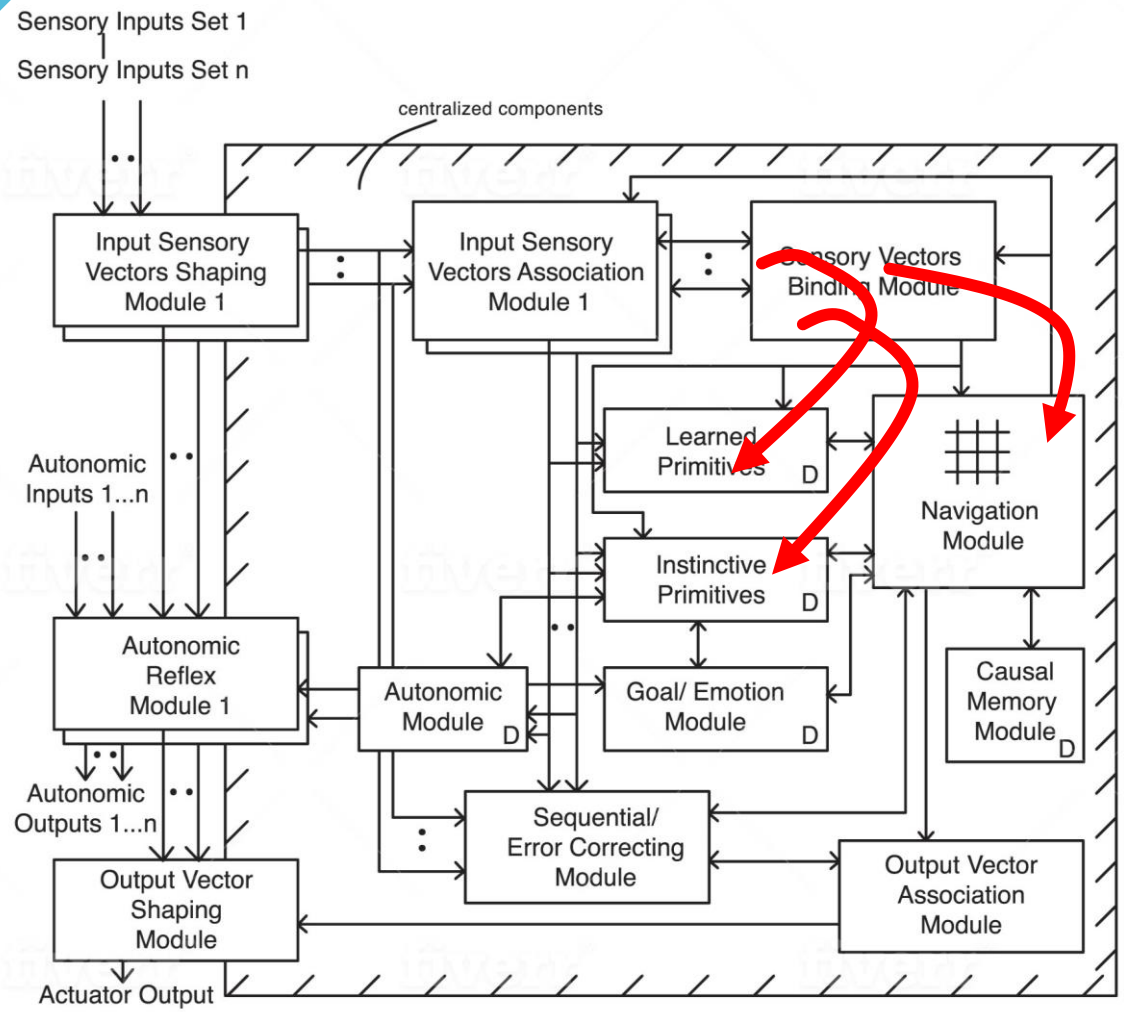
CAUSAL COGNITIVE ARCHITECTURE 1 (CCA1)
BICA 2018, 2019, 2020



Works for toy problems

Do we need a “binding language” ?



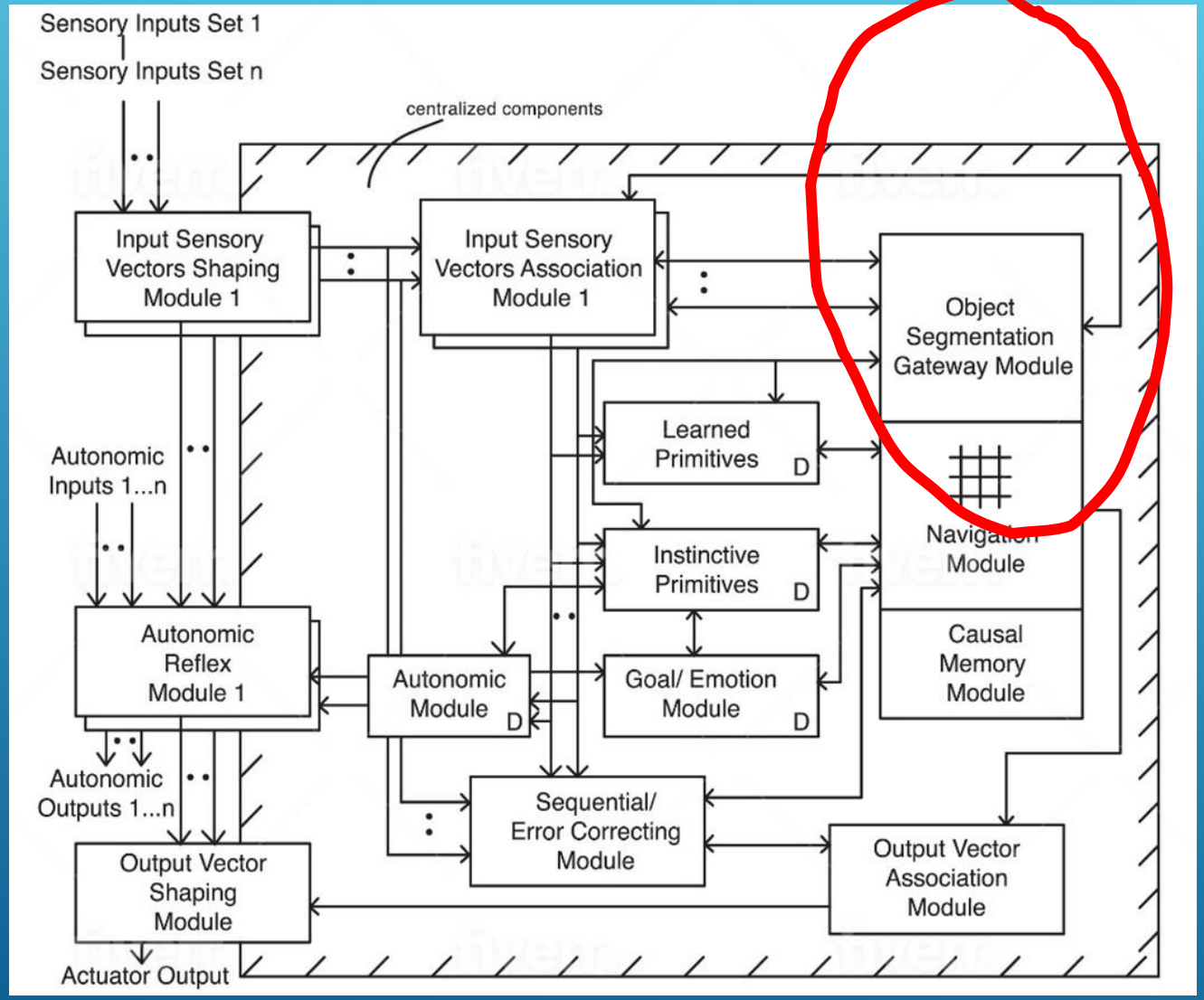
[“river”, “water”] → river, water

Or maybe: water, river

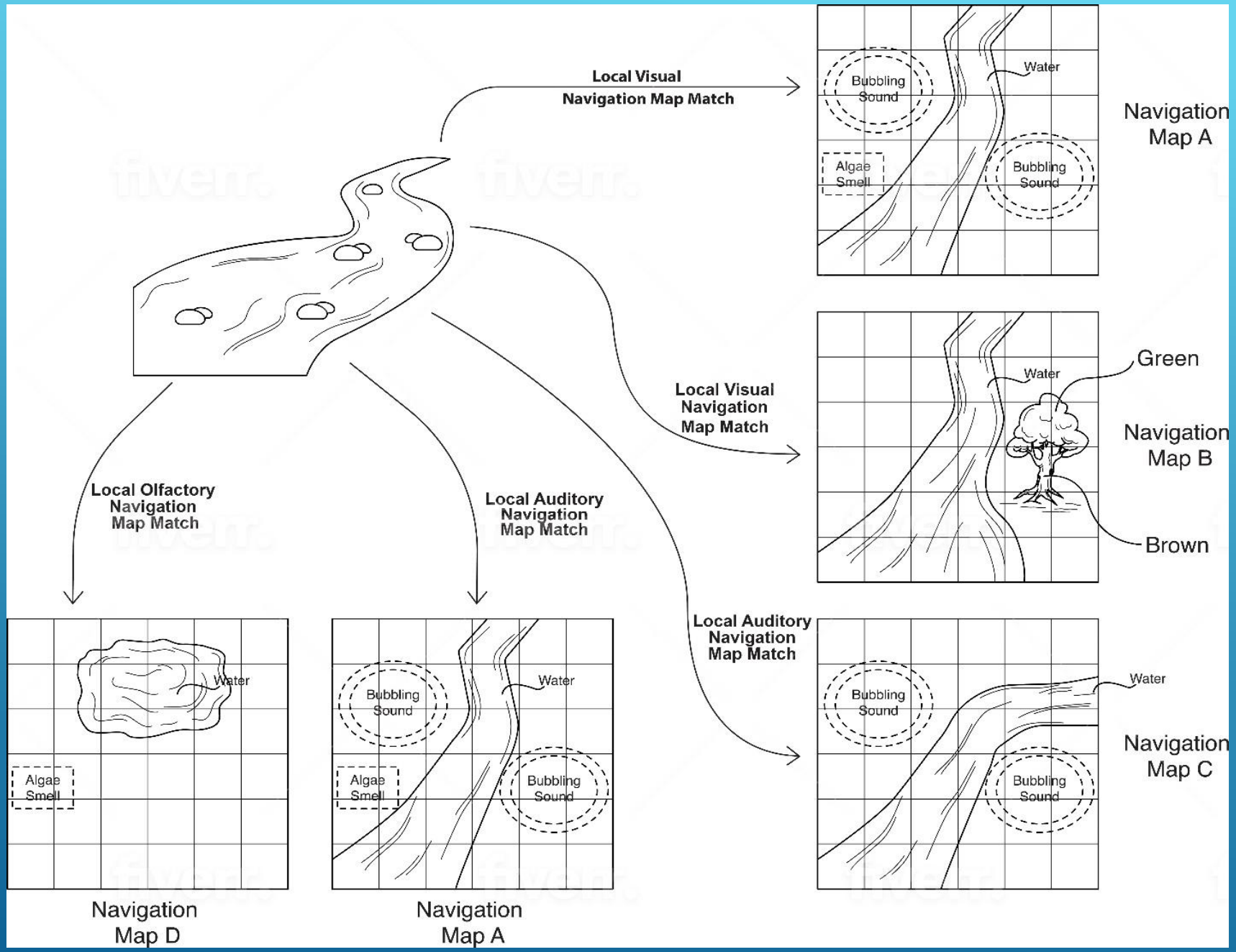
[“river”, “water”, “object”, “bubbling”, “algae”, “floating”, “lines”, “turn right”, “turn left”, “straight”]

→ ?? 10! = 3 million possible steps ??

CCA2

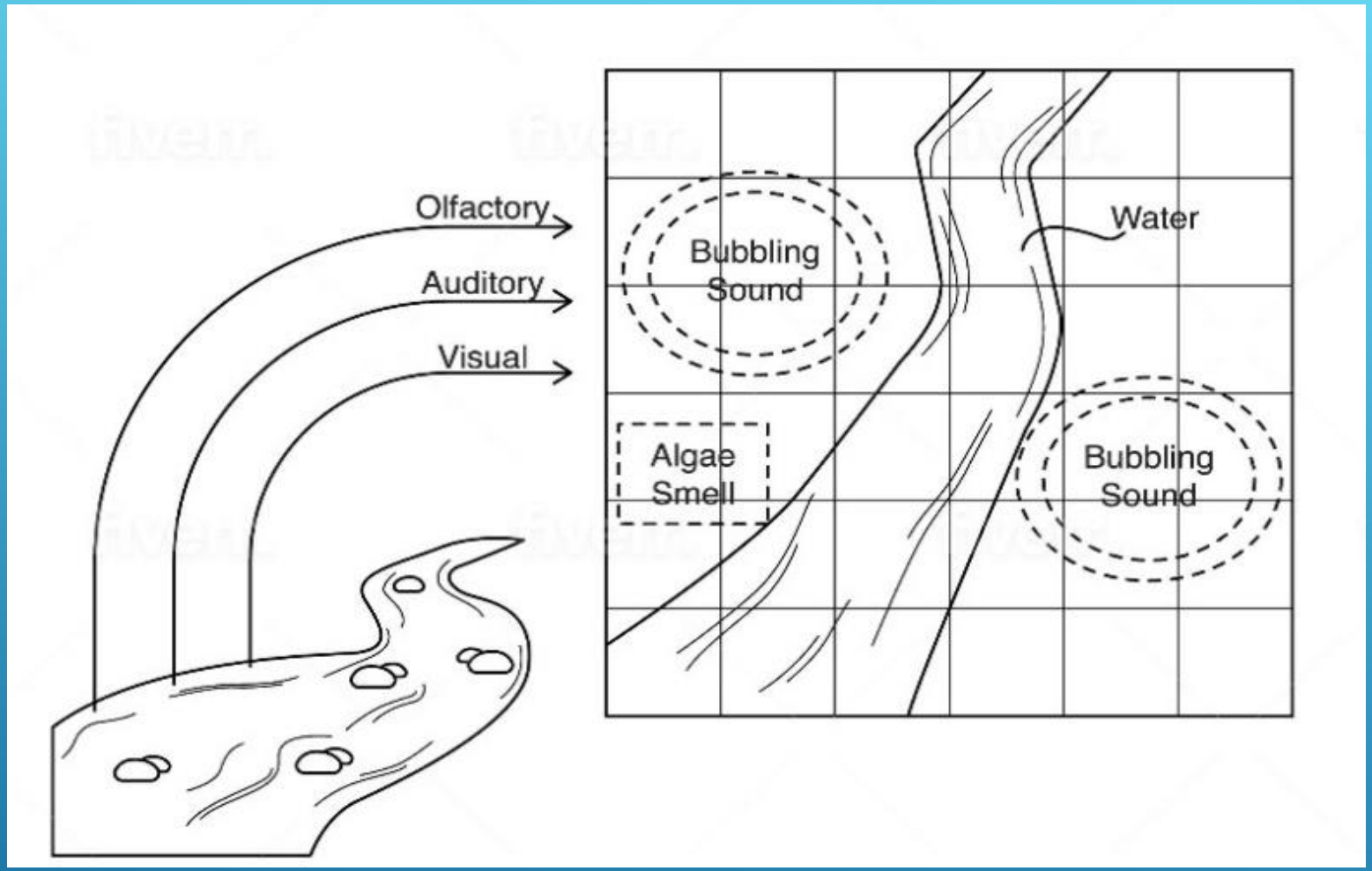


To handle real world problems, the binding issue needs to be addressed



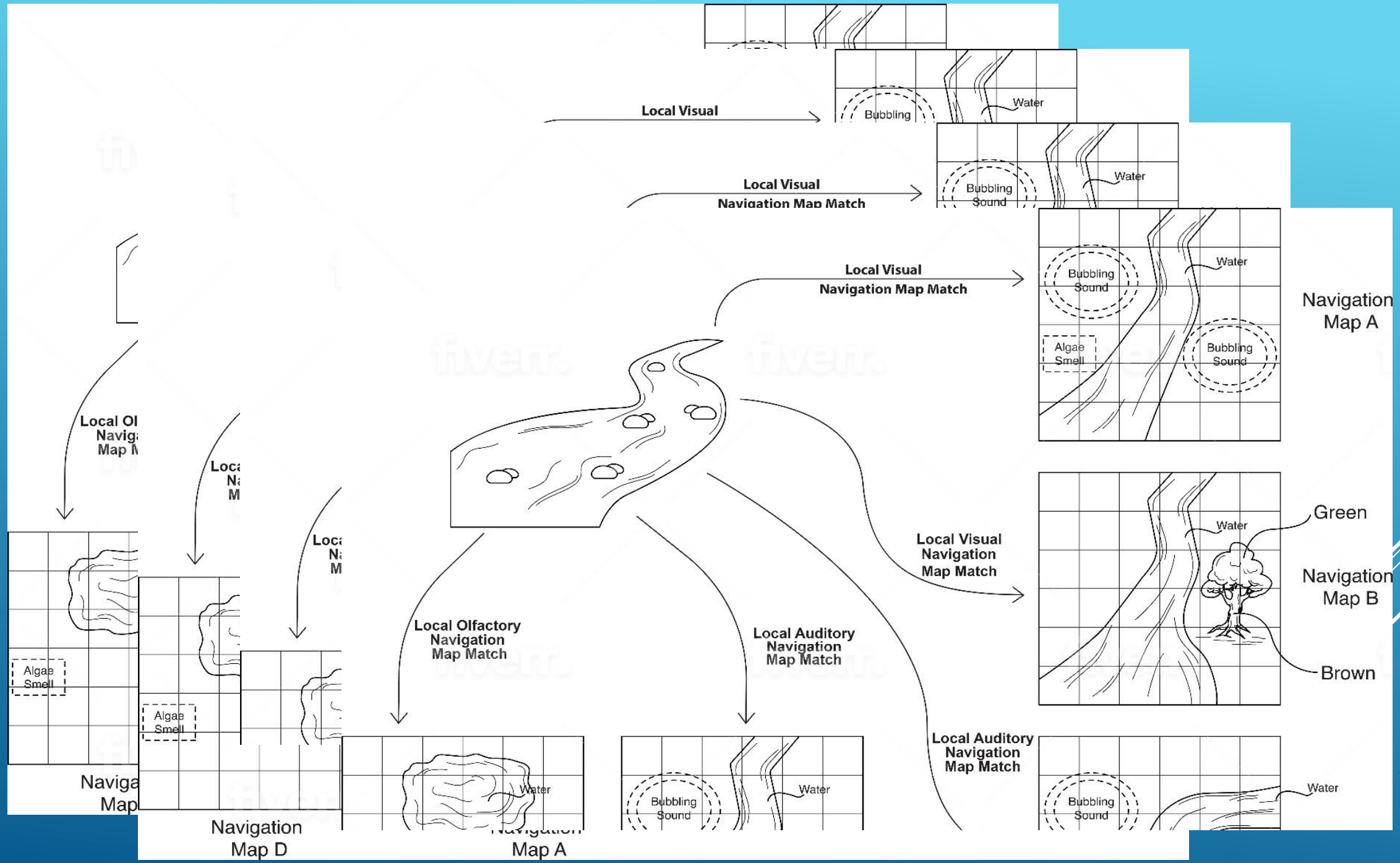
Use Navigation Maps for everything…..

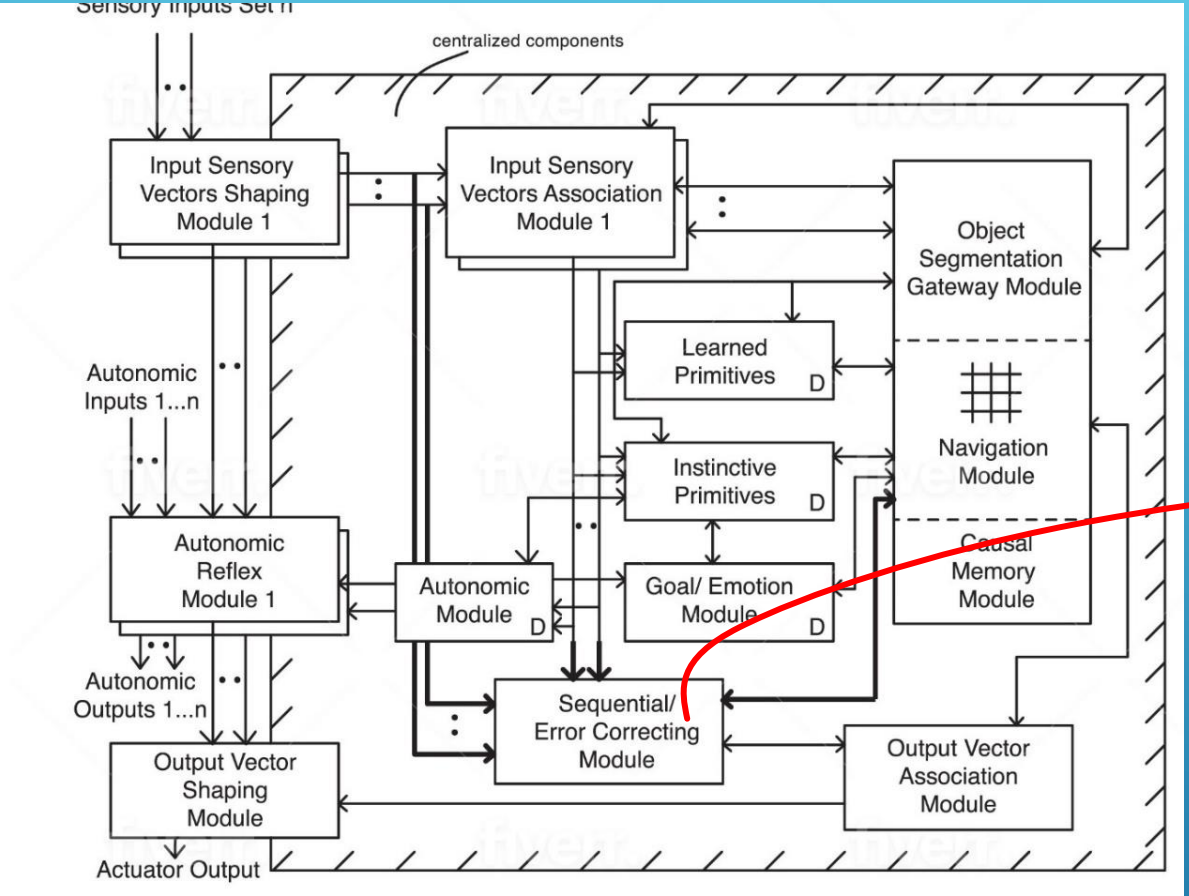
Copy NavMaps…..
Compare NavMaps….
Add NavMaps….
Subtract NavMaps….


Olfactory
Auditory
Visual
Bubbling Sound
Water
Algae Smell
Bubbling Sound

Most definitions of the 'Binding Problem' do not take time into account, ie, binding changes

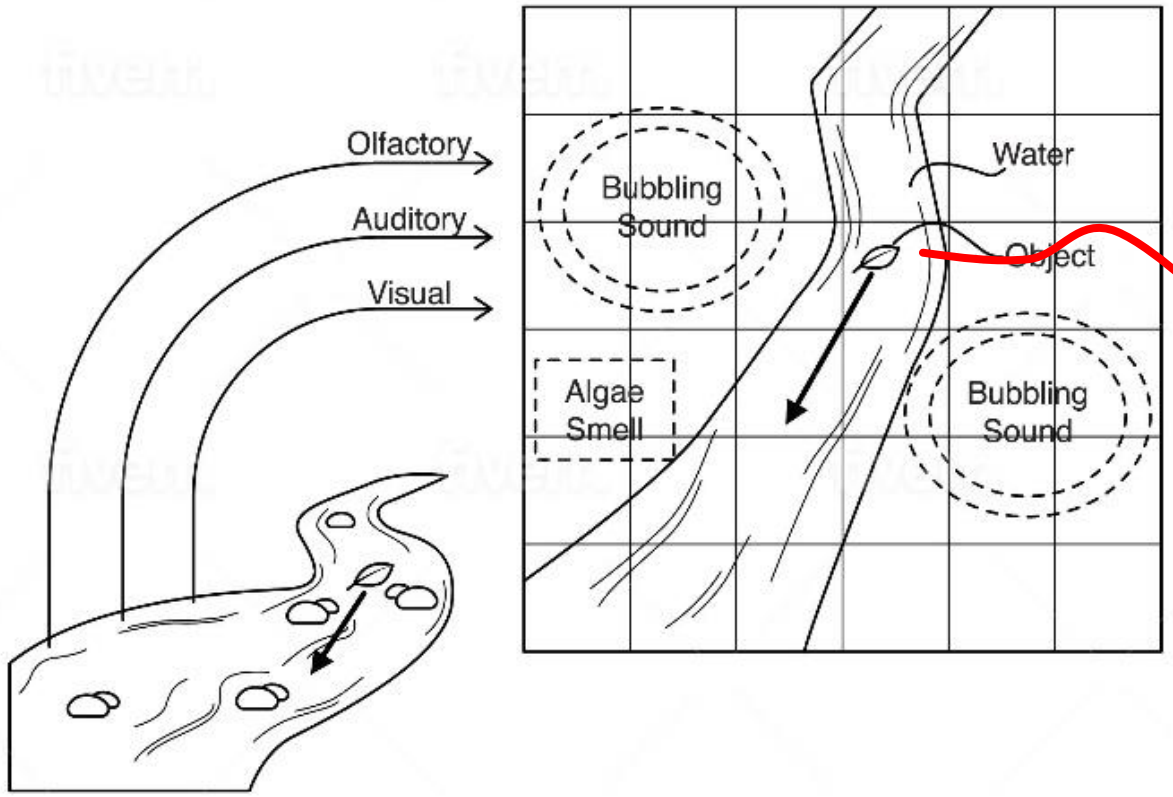
- However, CCA2 shows changes in sensory inputs with time, that *must* bind time also
- **CCA3** – bind space *and* time


Local Visual
Bubbling
Water
Local Visual
Navigation Map Match
Bubbling Sound
Water
Local Visual
Navigation Map Match
Bubbling Sound
Water
Algae Smell
Bubbling Sound
Navigation Map A
Local Visual
Navigation Map Match
Water
Green
Navigation Map B
Brown
Local Olfactory Navigation Map Match
Local Auditory Navigation Map Match
Local Auditory Navigation Map Match
Bubbling Sound
Water
Water
Algae Smell
Algae Smell
Navigation Map D
Map A



- CCA2 – binding of space
- CCA3 – need to bind changes with time also

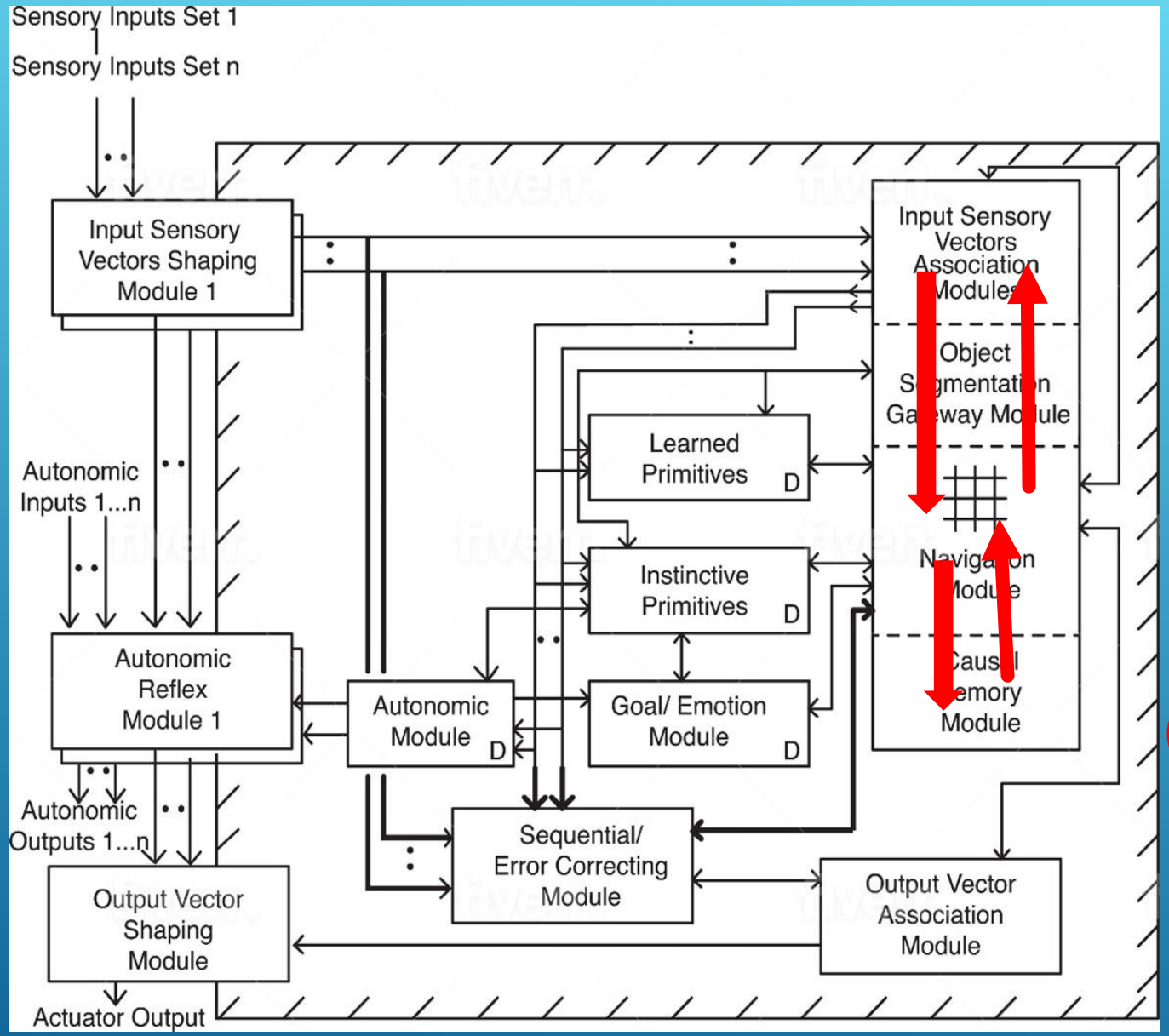
GENERATE **MOTION PREDICTION VECTORS**



Use Navigation Maps for everything…..

Copy NavMaps…..
Compare NavMaps….
Add NavMaps….
Subtract NavMaps….

Add Vectors to NavMaps…..



Use Navigation Maps for everything…..

Copy NavMaps…..
Compare NavMaps….
Add NavMaps….
Subtract NavMaps….
Add Vectors….
Feed back NavMaps +
Copy NavMaps +
Subtract NavMaps….

Schneider Paper 45 Navigation Map-Based Cognitive Arch--A New Class of Artificial Intelligence

$(\mathbf{action_t} \neq$ "move*" and $\mathbf{WPR_t} \neq$ ["discard*"] and $\mathbf{WPR_t} \neq$ ["feedback*"])
or $\mathbf{WPR_t} =$ ["analogical*"],

$\Rightarrow$ `Navigation_Module.feedback_intermediate`$(\mathbf{WNM'_t})$ (86)

$\Rightarrow \mathbf{WNM'_t} =$ `Causal_Memory_Module.match_best_multisensory_navmap`$(\mathbf{WNM'_t})$(87)

$\Rightarrow$ **short_term_memory** $\in R^{mxnxo}$ (88)

$\Rightarrow$ **short_term_memory** $= \mathbf{WNM'_t}$ (89)

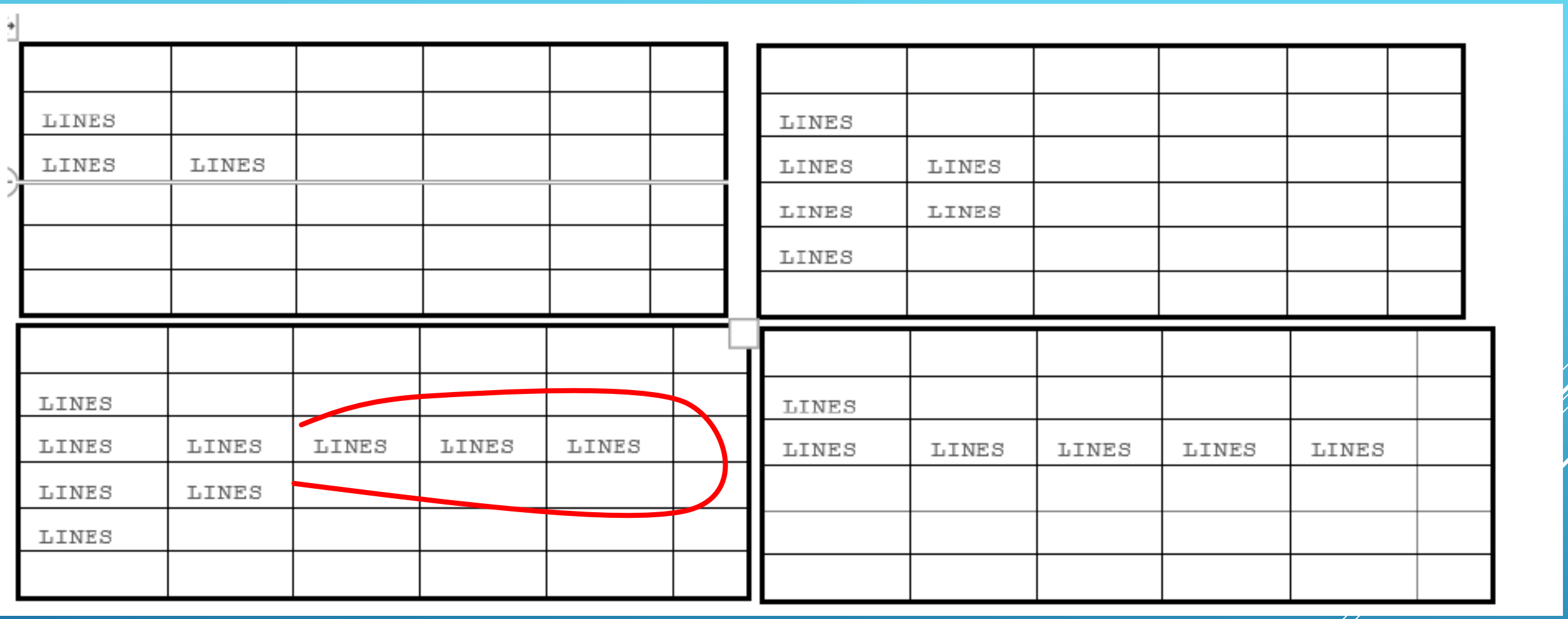
$\Rightarrow \mathbf{WNM'_t} =$ `Navigation_Module.next_map1` $(\mathbf{WNM'_t})$ (90)

$\Rightarrow \mathbf{WNM'_t} = \mathbf{WNM'_t} - \mathbf{short\_term\_memory}$ (91)

$(\mathbf{action_{t-1}} \neq$ "move*" and $\mathbf{WPR_{t-1}} \neq$ ["discard*"]) or $\mathbf{WPR_{t-1}} =$ ["analogical*"],

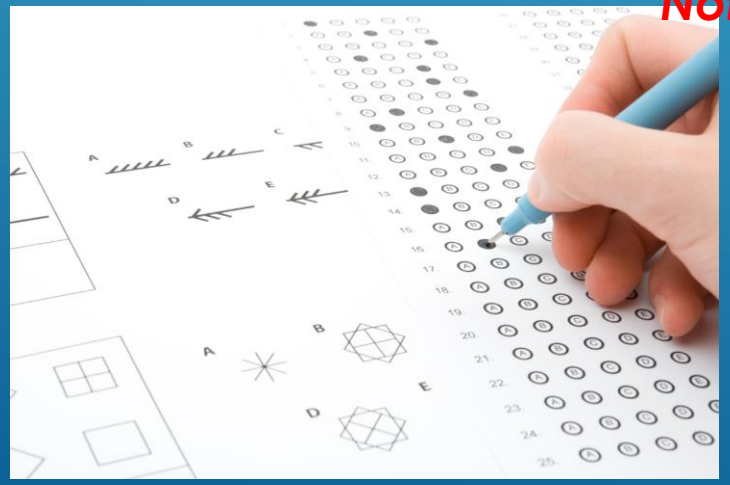
$\Rightarrow \mathbf{WNM'_t} =$ `Navigation_Module.retrieve_and_add_intermediates` (92)

CCA4 – Inductive Analogic Reasoning



Simplified from Chollet's Abstraction and Reasoning Corpus

- Analogical inductive abilities are a core mechanism now of the architecture.



Not a module for IQ tests

CCA5

Inductive Analogical Feedback Mechanism allows a full solution to the Symbol Grounding Problem

Paper #14 -- to present on September 24, 2022 at 10AM (BICA*AI 2022)

Inductive Analogical Properties → Stronger Symbol Grounding

Copy NavMaps…..
Compare NavMaps….
Add NavMaps….
Subtract NavMaps….
Add Vectors….
Match NavMaps…
Feedback NavMaps + Copy NavMaps + Subtract NavMaps….
Feedback NavMaps a slightly different way….

Causal Cognitive Architecture one of many possible implementations of a

"Navigation Map-Based Cognitive Architecture"

Basic Operations and Properties of a Navigation Map-Based Cognitive Architecture

-The existence of navigation map-like structures with the representation of the physical dimensions as well as the utilization of non-spatial dimensions, and their use as the core data and processing elements of the system

-The ability to match navigation map-like structures and determine closest matches, and compare same and different navigation map-like structures

-The ability of navigation map-like structures and their cells to have links to other navigation map-like structures and their cells

-Mapping of input sensory data onto closest matching navigation map-like structures or create a new navigation map-like structure if needed

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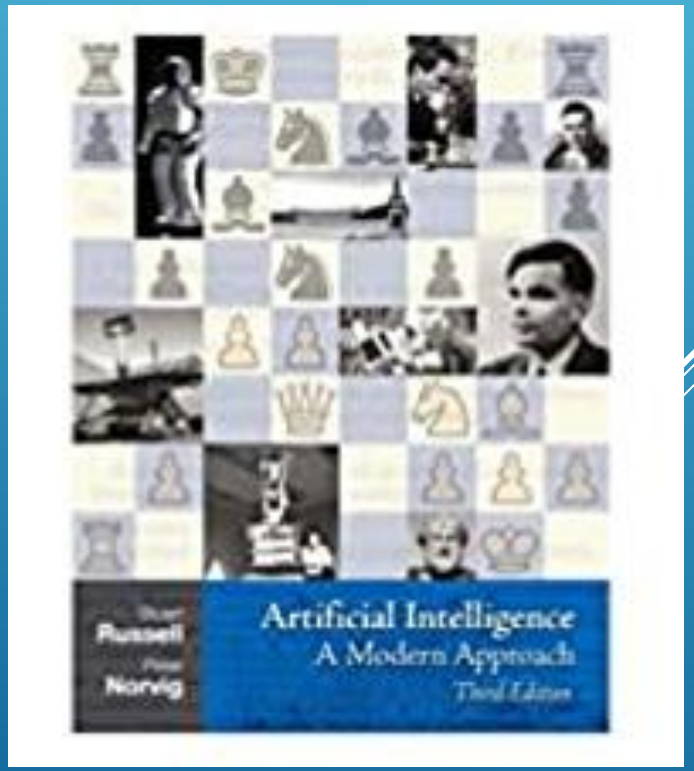
....

....

-The ability to feed back the results of simple operations so as to be able to reprocess by analogic induction the intermediate results in the next cognitive cycle

Differences between Navigation Map-Based Cognitive Architecture and other Approaches to AI
-compare to Russell and Norvig, "Artificial Intelligence: A Modern Approach" – 4th Edition"



-compare to Russell and Norvig, "Artificial Intelligence: A Modern Approach" – 4th Edition"

e.g., Russell and Norvig logic-based agent vs Navigation Map-Based Cog Architecture

- CCA3 uses a very minor subset of first-order logic in its core operations,
- embedded as a very specific part of an overall architecture
- to exhibit the more complete first-order logic, or even propositional logic, a combination of additional instinctive primitives and learned primitives are required

e.g., Russell and Norvig deep learning vs Navigation Map-Based Cog Architecture

-completely different architecture
-however, elements of deep learning can be used within a given navigation map

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....

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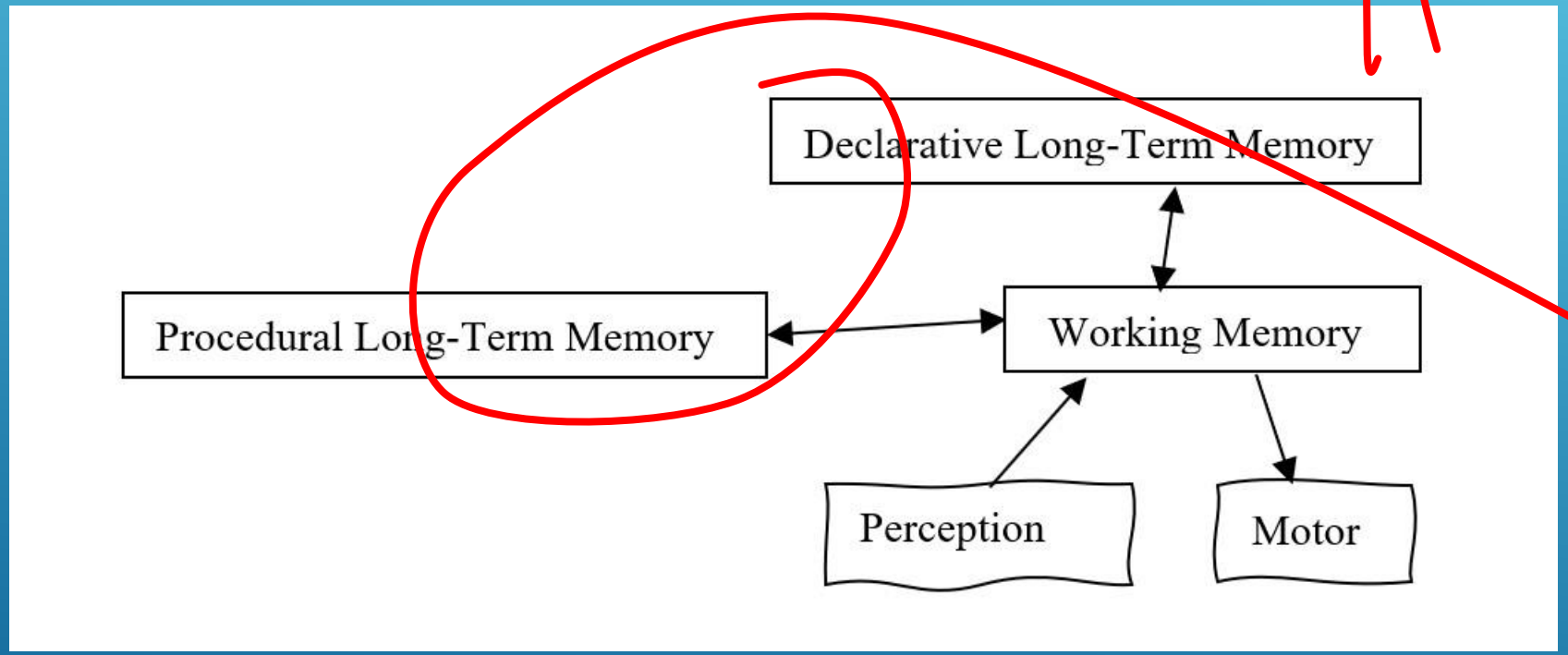
Navigation Map-Based Cognitive Architecture

→ A new and different class of artificial intelligence

Navigation Map-Based Cognitive Architecture

→ What type of Cognitive Architecture is it?

Laird, Lebiere and Rosenbloom -- **standard model of the mind**



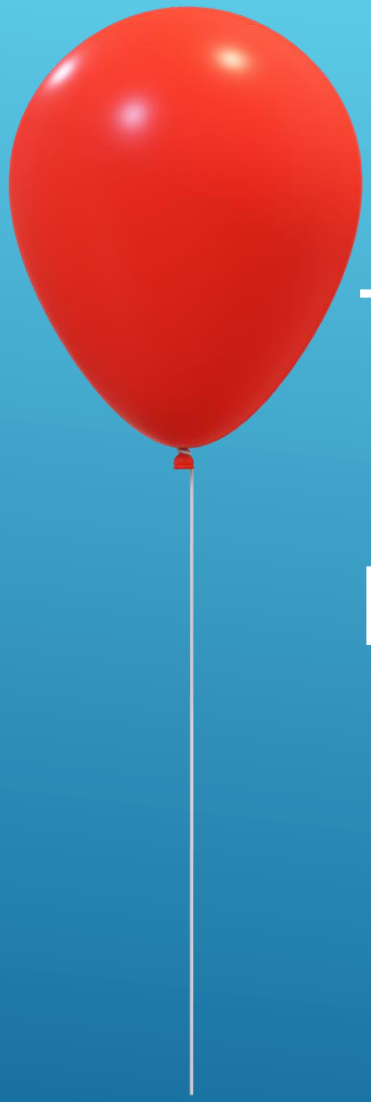
CCA3 binding ??

CCA5 grounding ??

CCA3 link together and can be stored together in the same nav maps cells

Navigation Map-Based Cognitive Architecture

→ A new and different class of artificial intelligence (and cognitive architecture)



Thank you

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