Decision Making under Uncertainty – Its all in the functions of the Mind

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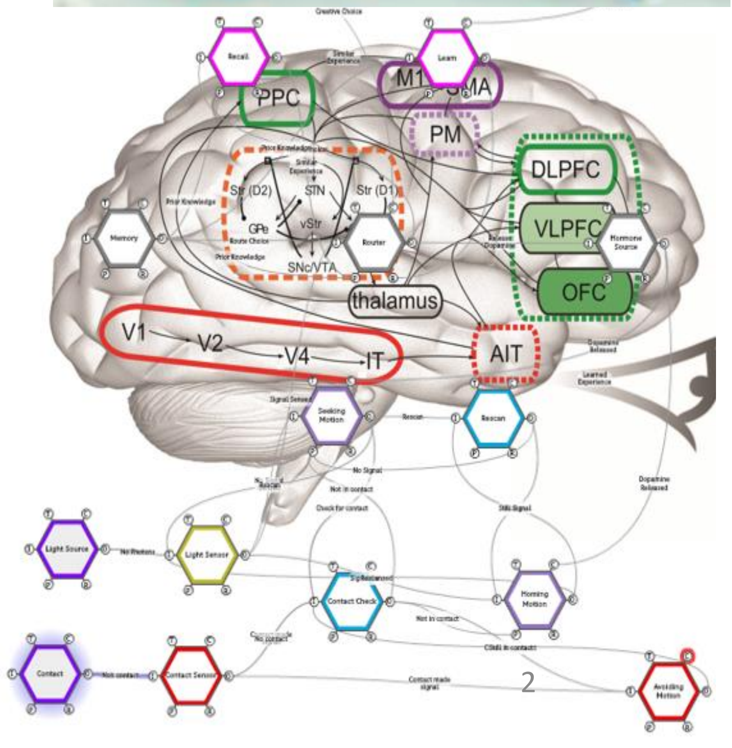
Presentation to FRAMily 2018

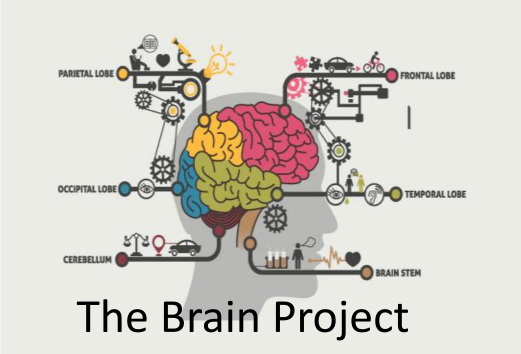
Cardiff University, June 11th – 14th.

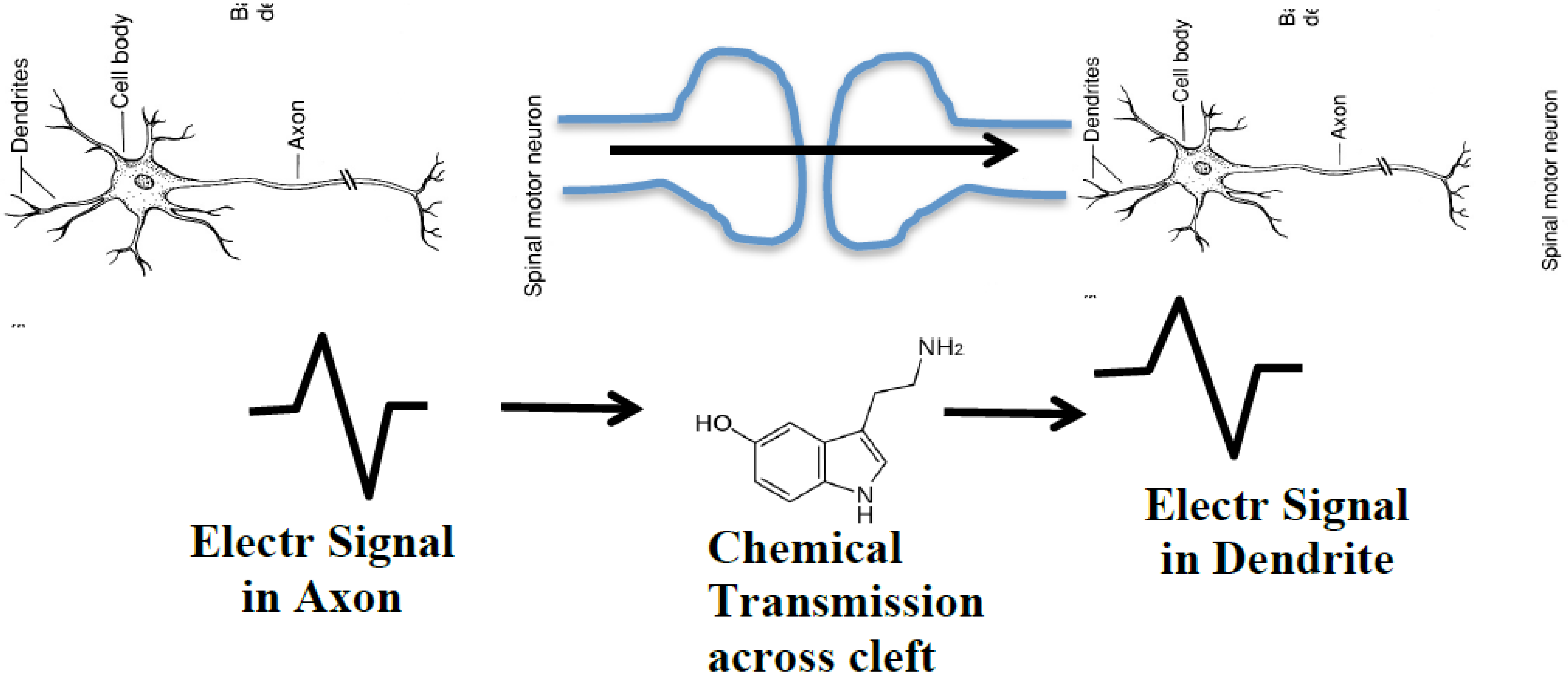
Our Objective

- Interested in understanding how we make decisions especially in stressful, uncertain situations
- Building on the “Walking in Tokyo Station Concourse” insights
- It is a Test to see how much a simple FRAM approach helps.
- See if it can help to cut through the confusing and conflicting Biology, Psychology, Philosophy, Digital and Pseudoscience literature and gain real insights.
- We assume that it is the Brain that does the thinking and makes decisions, but
- Our brain is a (wonderfully) complex adaptation; it allows us to handle billions of bits of information through electrical signals in some 86 billion interconnected neurons.
- Much effort has been devoted to try and explain its underlying architecture using simplified models and approaches; MRI and digital analogues are just the latest attempts at unravelling its inherent complexity.

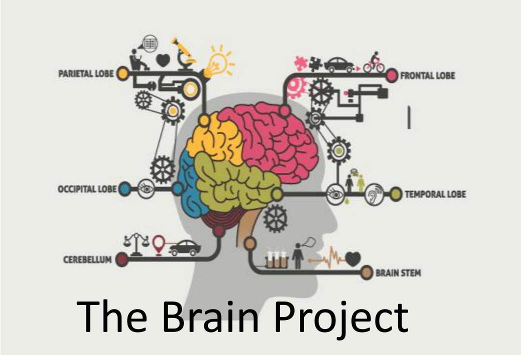


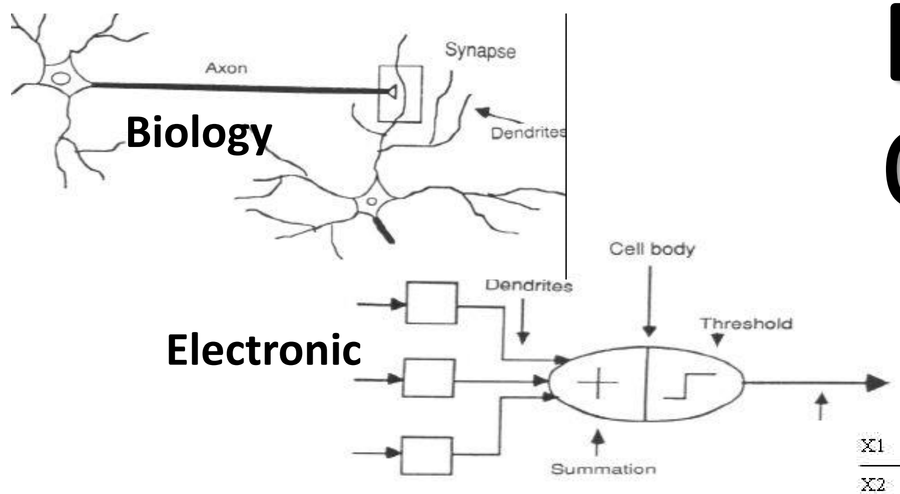
Digital Analogues are attractive “Models” as nerve impulses are electrical signals, chemically transmitted



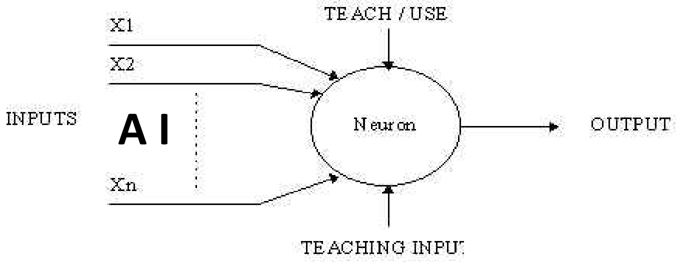


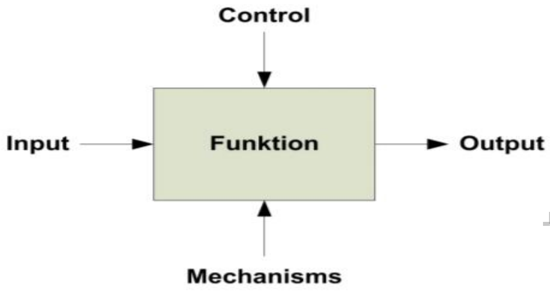
But FRAM is a more Obvious Choice?





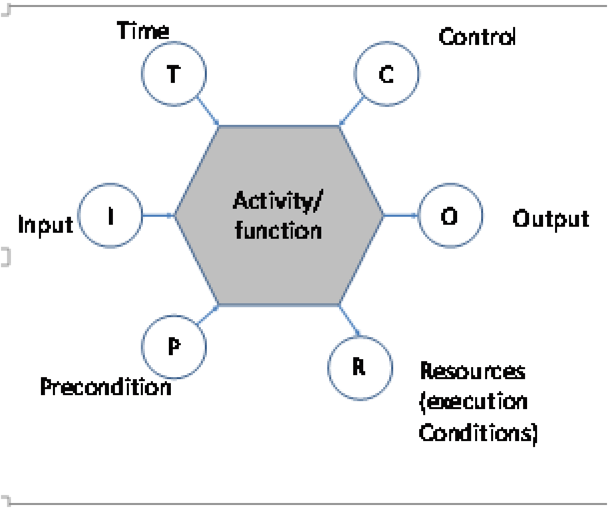
- How to model this complex system of systems?

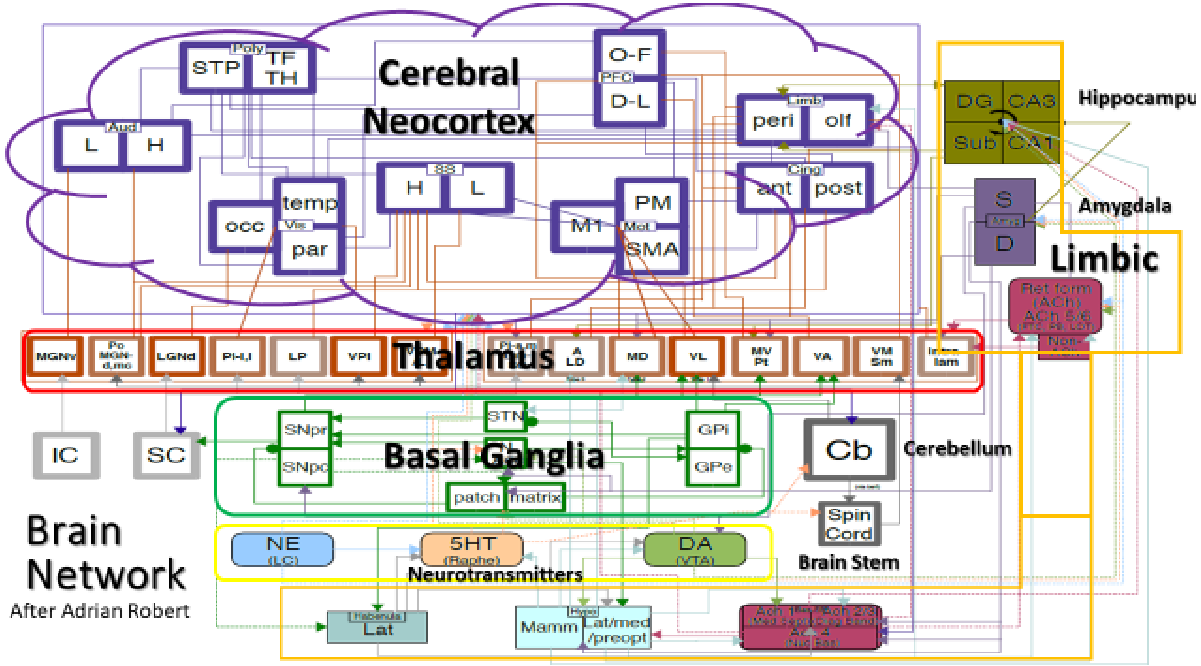




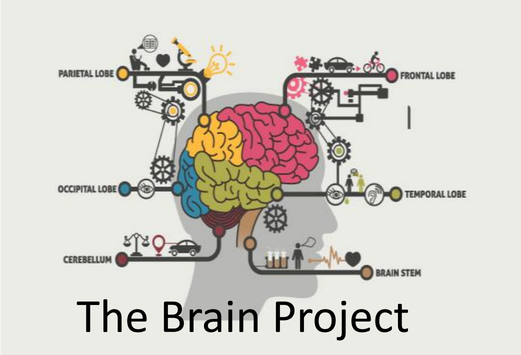
Software Programming

Functional Analysis

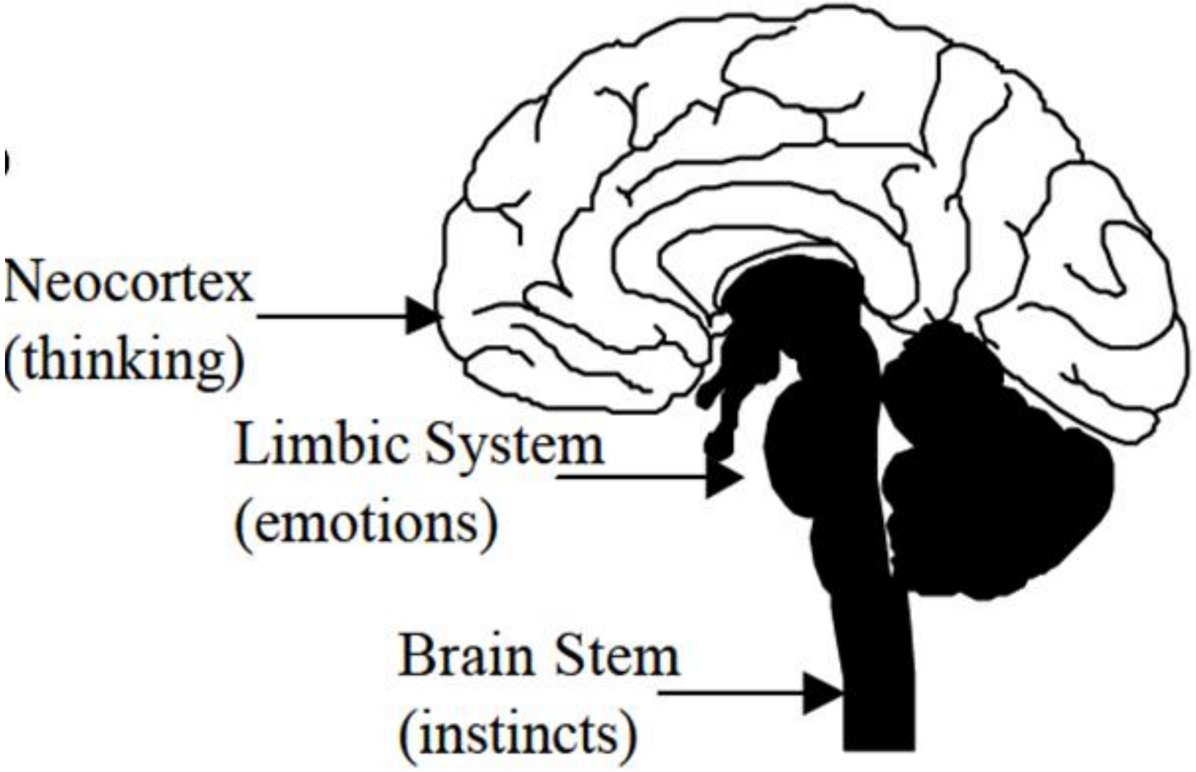




So what Functions do we need to model?

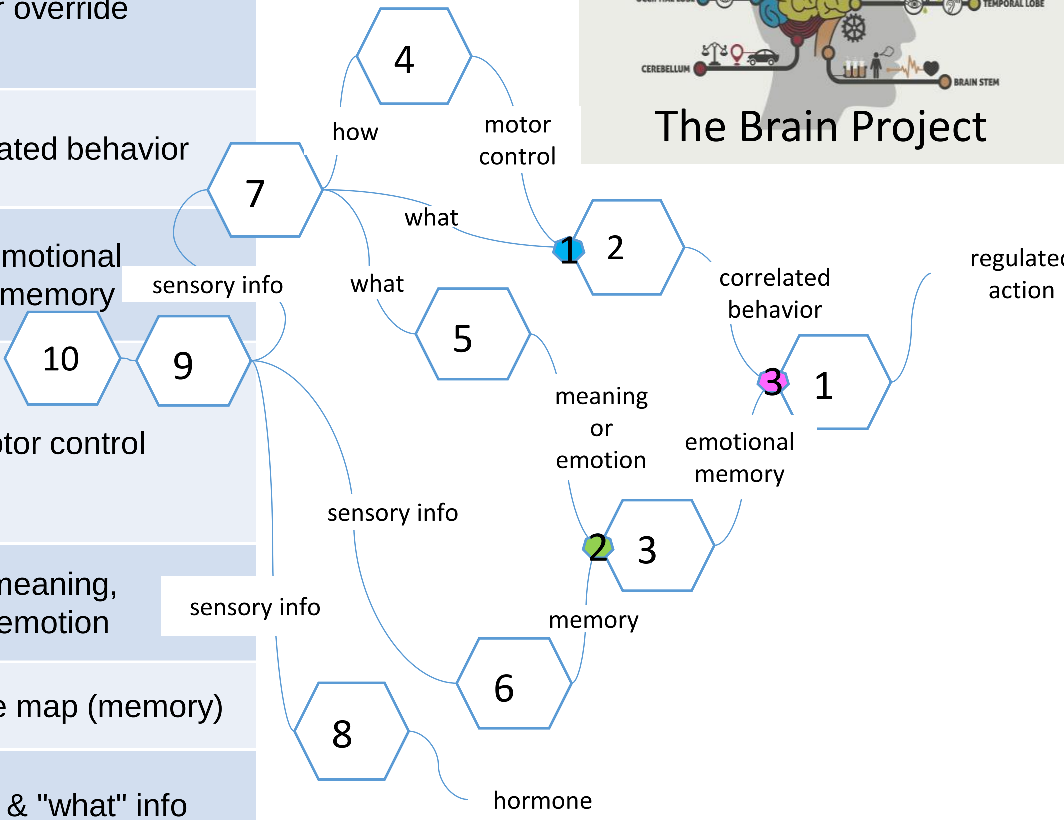


- Start simple? - An early model by Maclean proposes three areas of the brain which evolved sequentially to progressively add functionality to the Central Nervous Systems of early organisms,
- A **“Primitive”** set of functions to take care of “automatic” activities, metabolism, breathing, digesting, etc.(**Hindbrain**)
- A **“Reptilian”** set which added emotions and memory (**Midbrain**) and finally
- A **“Mammalian”** set (**Forebrain**), which allows us to think etc.
- We started to test our FRAM approach on a simplified set of Functions.



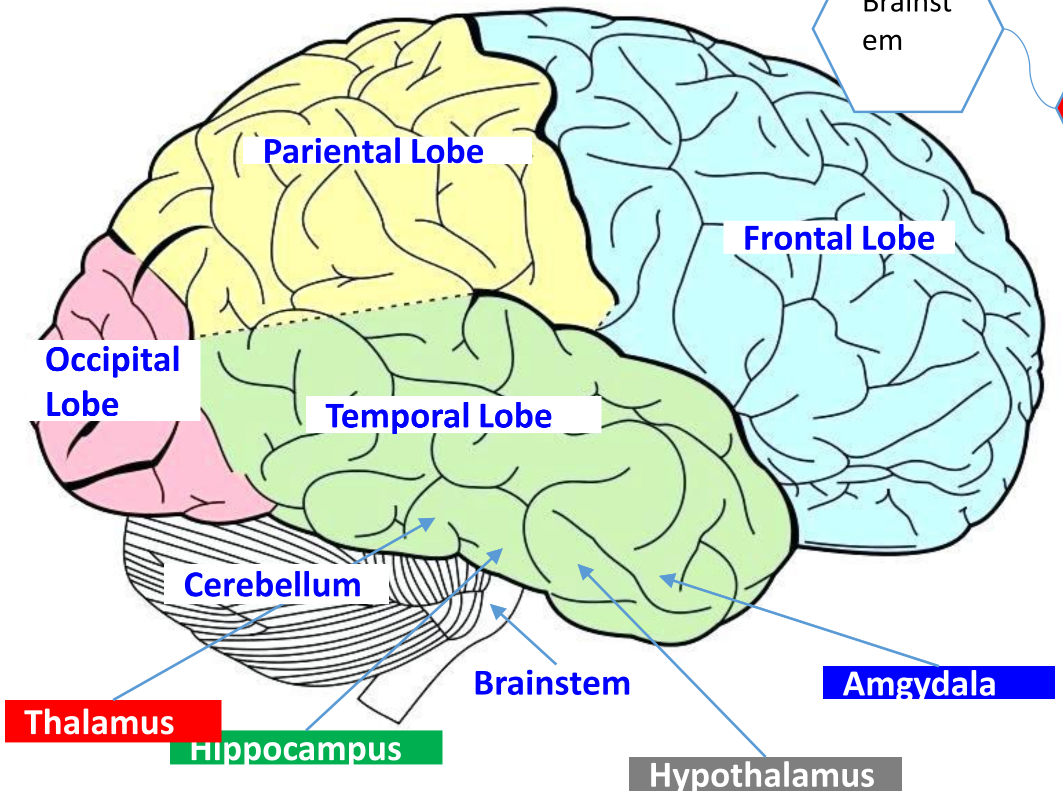
	Name	Function	Input	Output
1	Frontal Lobe	Regulate voluntary activities Project future consequences resulting from current actions (override/suppression)	correlated behaviour & emotional memory	regulated action command or override
2	Cerebellum	Integrate cognitive data & motor control	cognitive info ("what") & motor control ("how")	correlated behavior
3	Amygdala	Emotional learning Modulate long term memory	memory & emotion	emotional memory
4	Pariental Lobe	Integrate sensory information for manipulation	"how" info	motor control
5	Temporal Lobe	Processing sensory input into derived meanings for the appropriate retention of visual memory, language comprehension, and emotion association	"what" info	meaning, emotion
6	Hippocampus	Episode memory, Spatial cognition	visual sensory info	cognitive map (memory)
7	Occipital Lobe	Project visual sensor data into ventral stream ("what"), and dorsal stream ("how")	sensory info	"how" & "what" info
8	Hypothalamus	Hormone release	external signals	hormone
9	Thalamus	Routing the sensory signals to cerebral cortex	sensory signals	sensory info
10	Brainstem	cardiovascular system control, respiratory control, pain sensitivity control, alertness, awareness, and consciousness	sensory signals regulated action command	sensory signals regulated action command

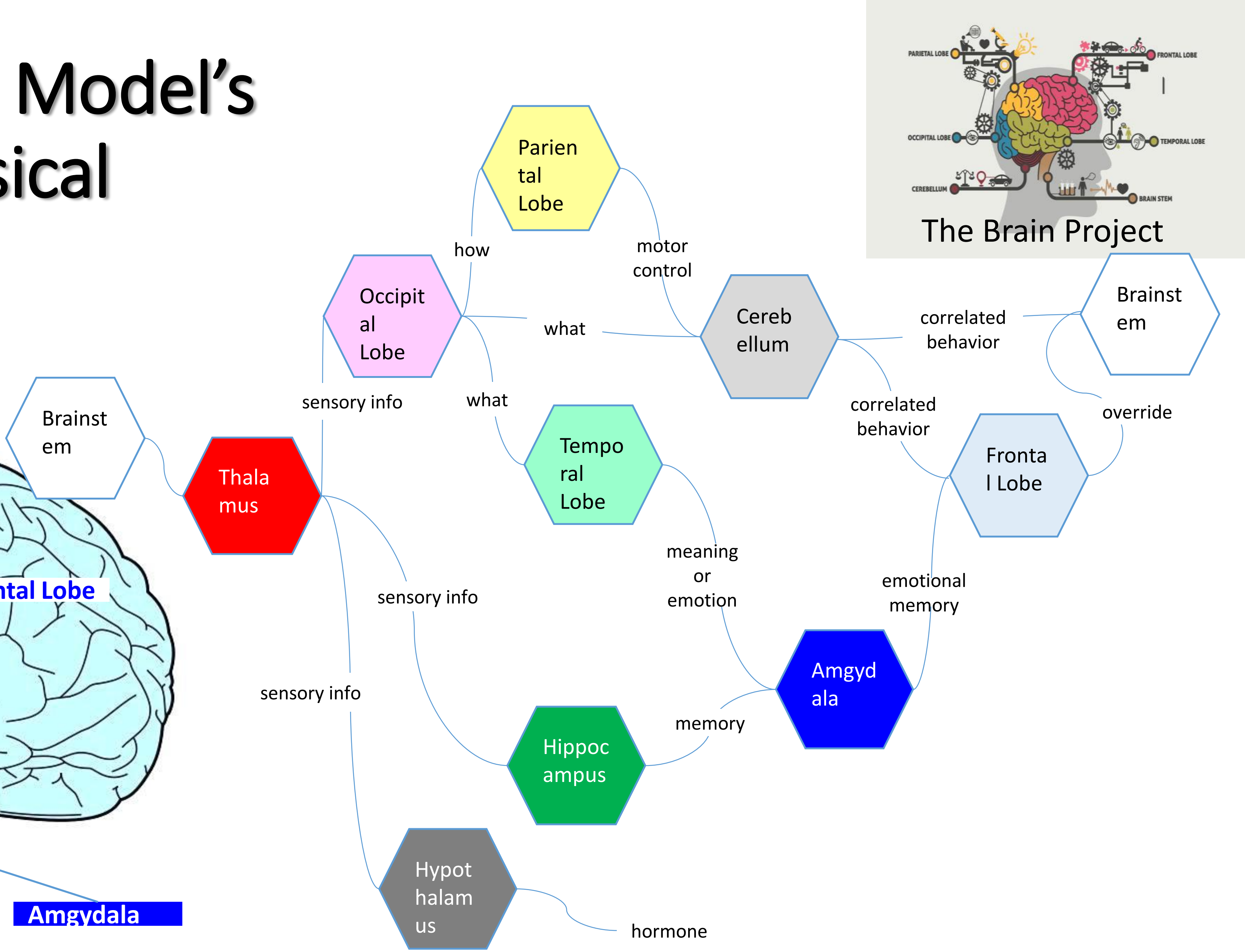
The Brain Project



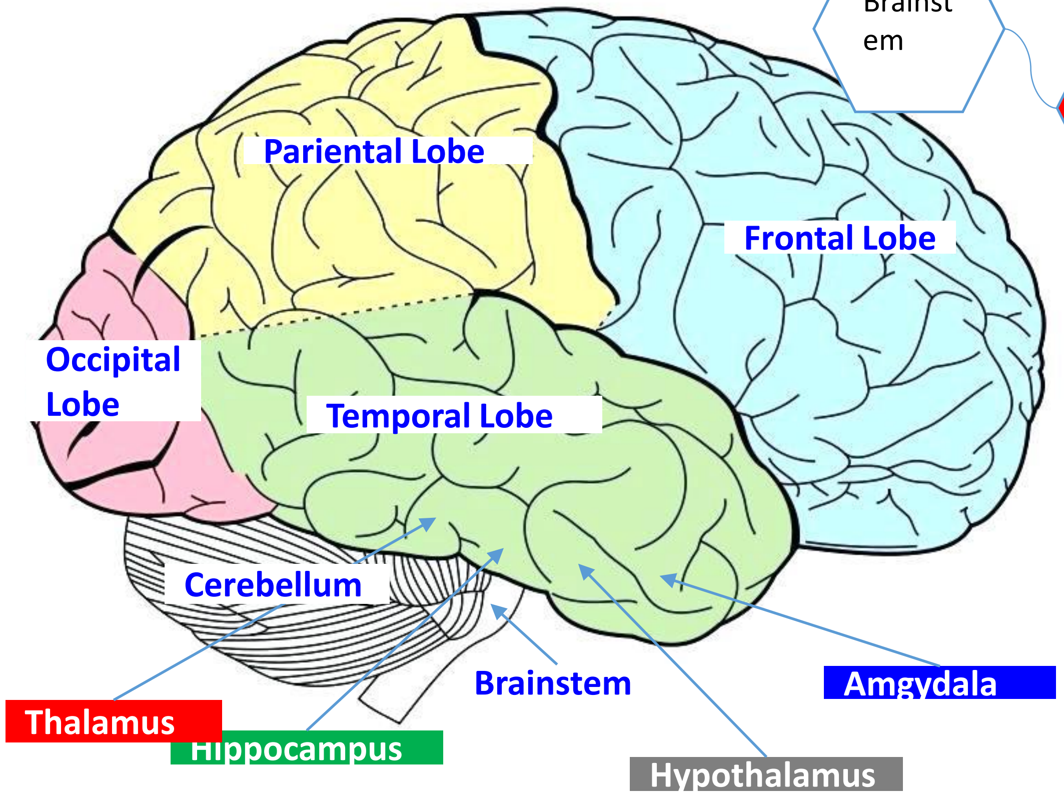
Simple Brain Model from brain components' functional descriptions

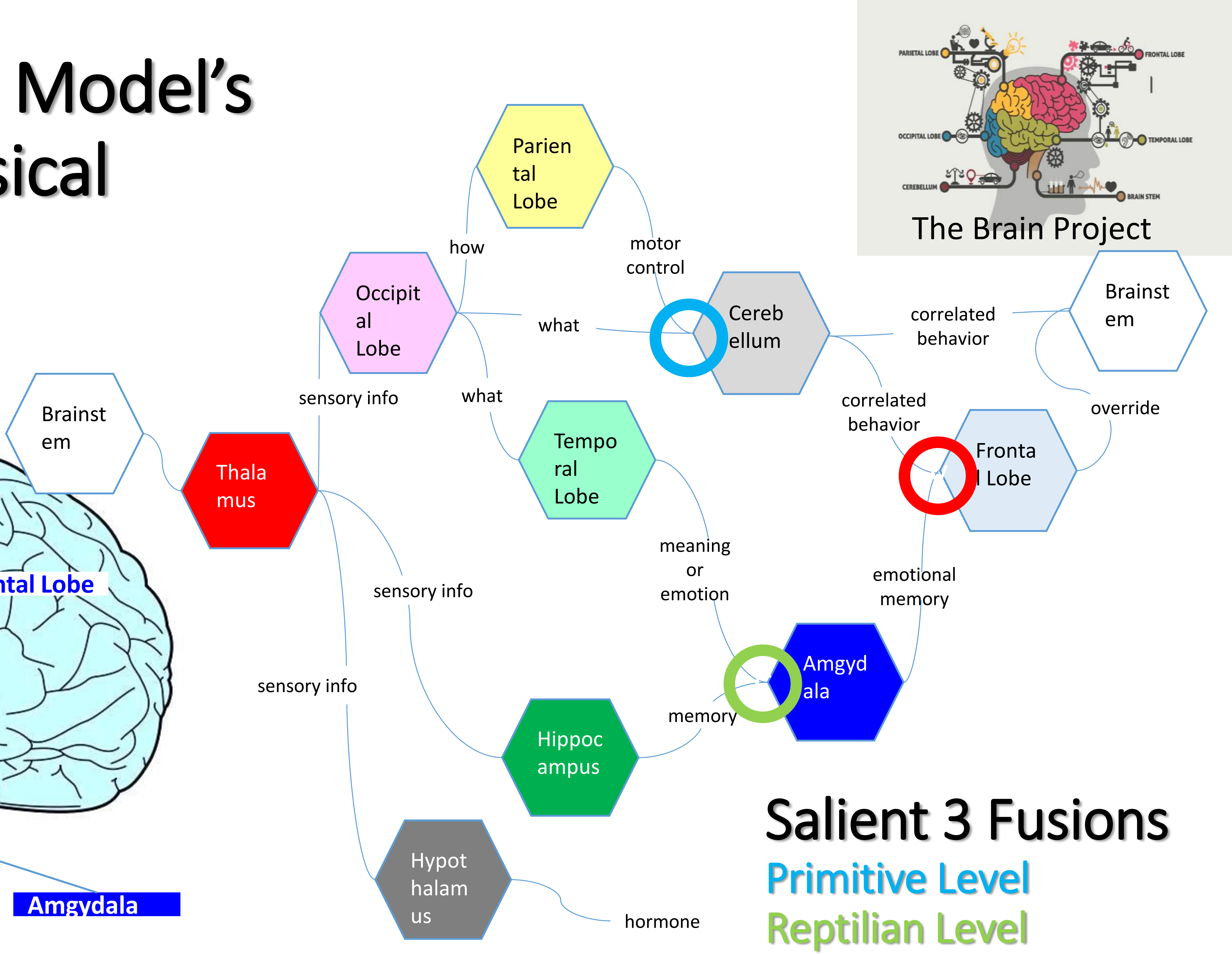
Very Simple FRAM Model's formation fits physical brain map





Very Simple FRAM Model's formation fits physical brain map





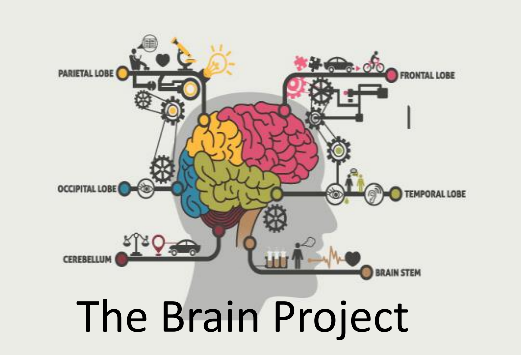
Salient 3 Fusions

Primitive Level

Reptilian Level

Human Level

Initial Ideas from Insights obtained

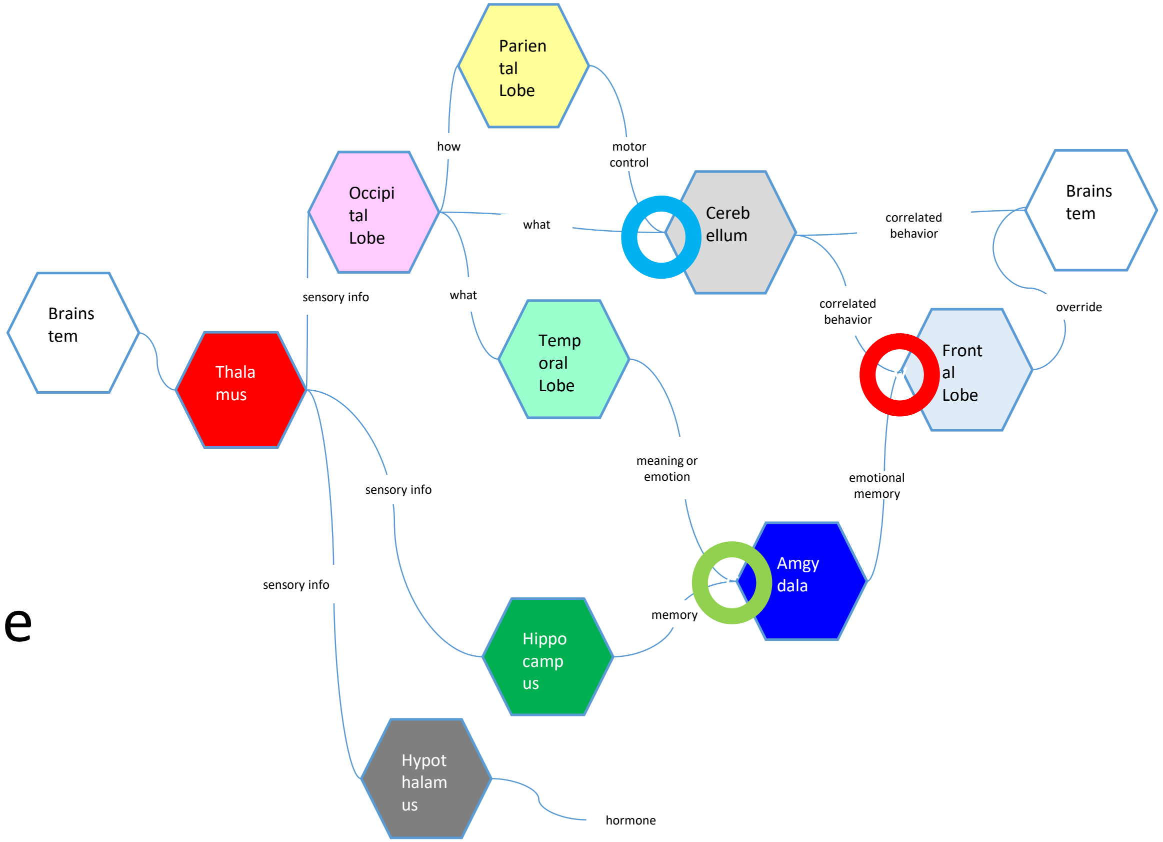


- **Primitive fusion**
  - FAST: "how"
  - SLOW: "what"

  ➡ Correlated Behaviour
- **Reptilian fusion**
  - FAST: “emotion"
  - SLOW: “memory"

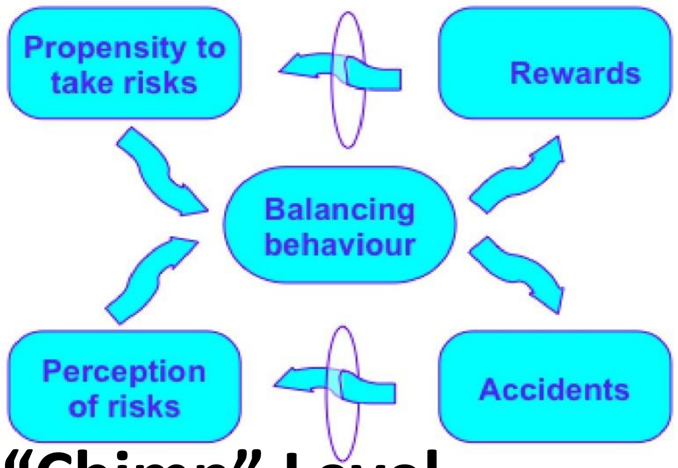
  ➡ Emotional Memory
- **Human fusion**
  - FAST: "correlated behaviour“
  - SLOW: “Emotional Memory"

  ➡ Intelligence



Insights 1 *Fits with the Triune Brain Theory

- **Reptilian Level** - Pavlovian** / Adams Risk Thermostat



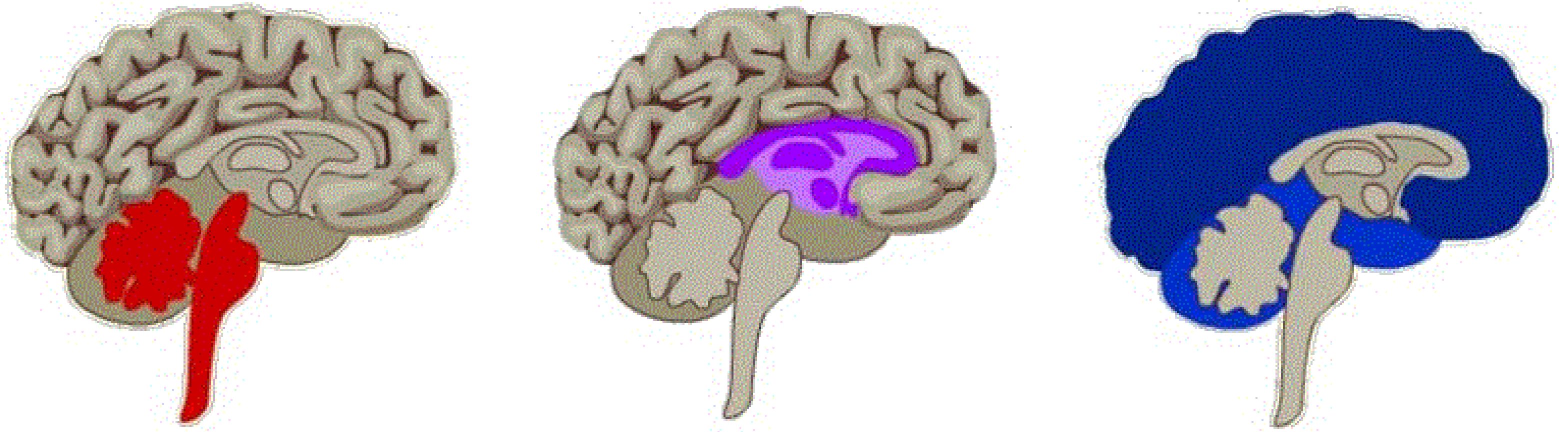
- **"Chimp" Level**

- Perception

- **Human Level**

- Persona

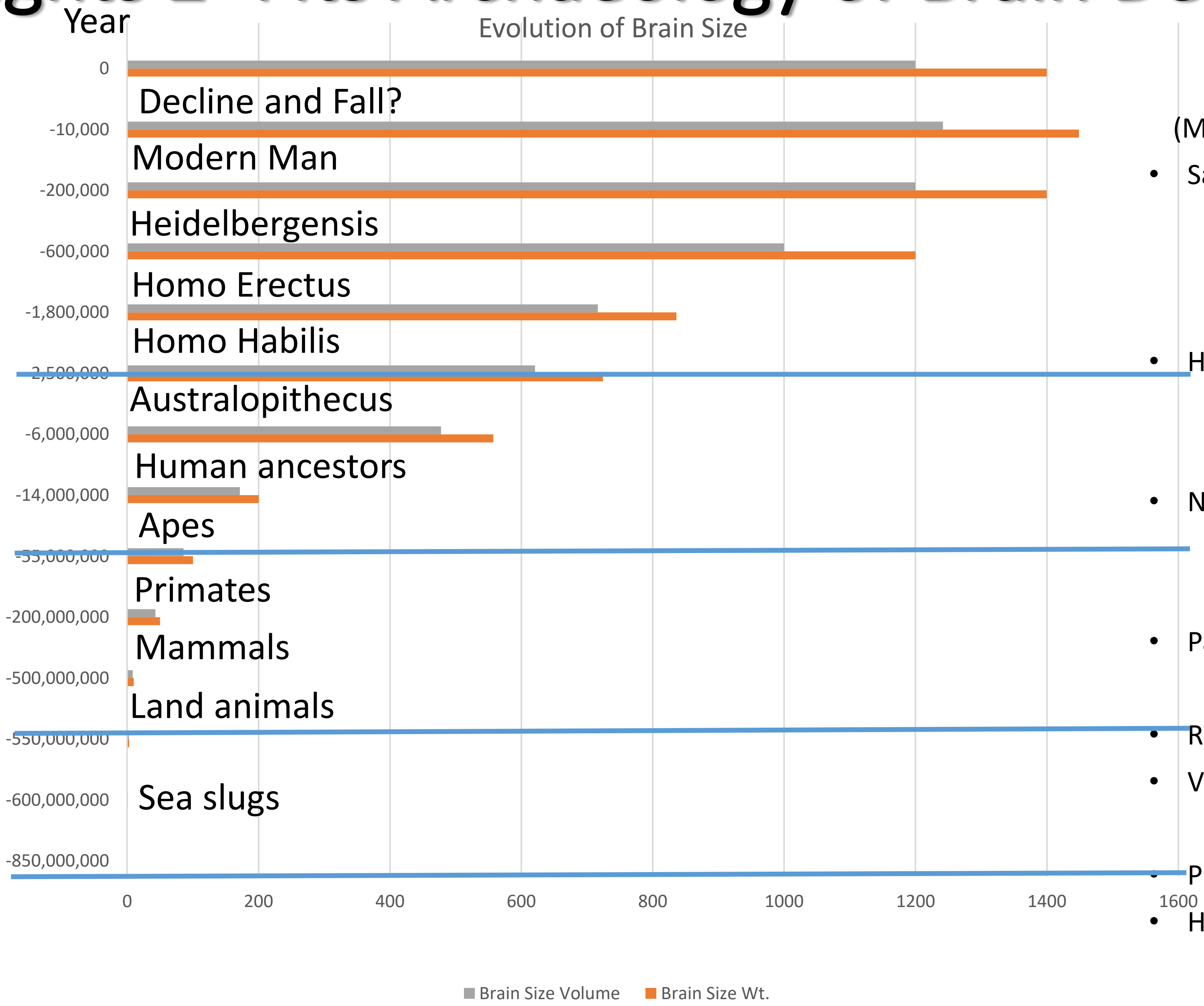
Lizard Brain	Mammal Brain (CHIMP)	Human Brain
Brain stem & cerebelum	Limbic System	Neocortex
Fight or flight	Emotions, memories, habits	Language, abstract thought, imagination, consciousness
Autopilot	Decisions "Gut Feel"	Reasons, rationalizes



**Coding of reward probability and risk by single neurons in animals, Christopher J. Burke* and Philippe N. Tobler (2011)

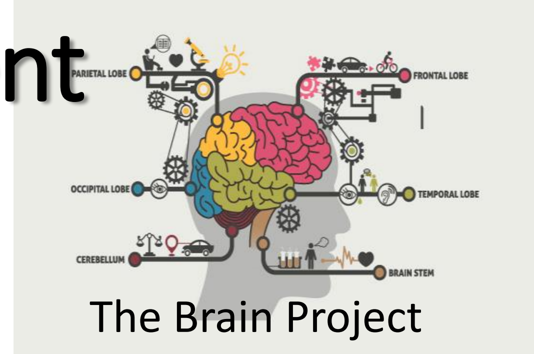
*The Triune Brain in Evolution, Paul MacLean, 1960

Insights 2 -Fits Archaeology of Brain Development

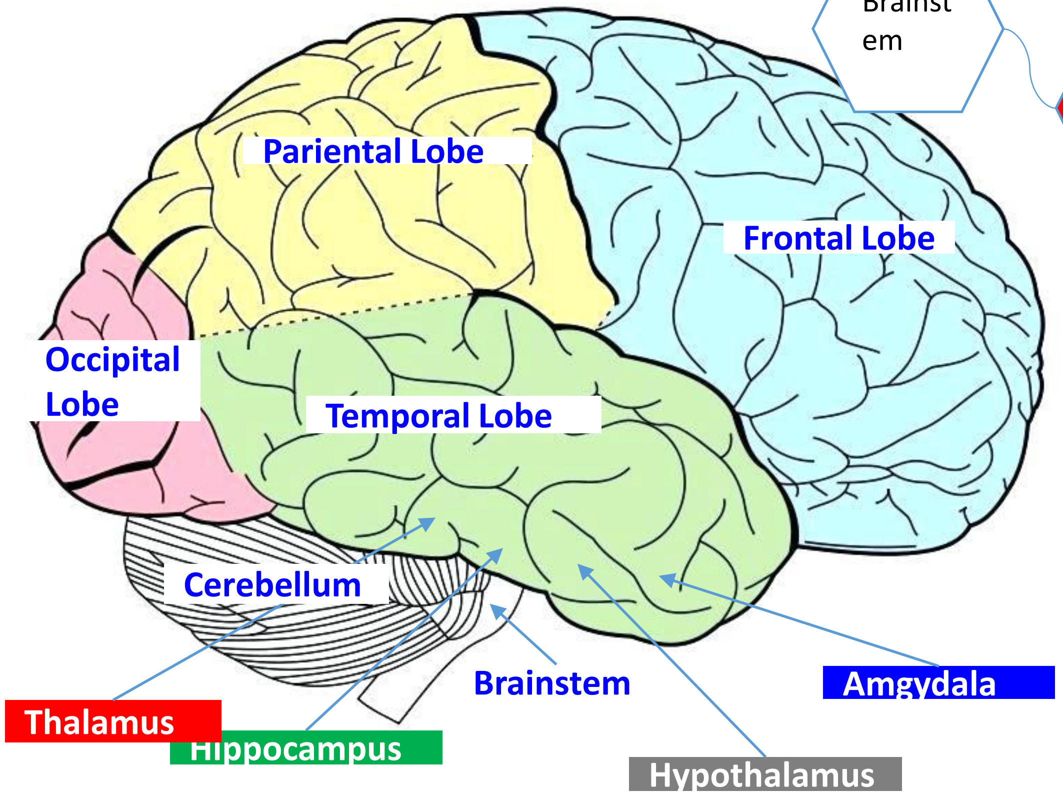


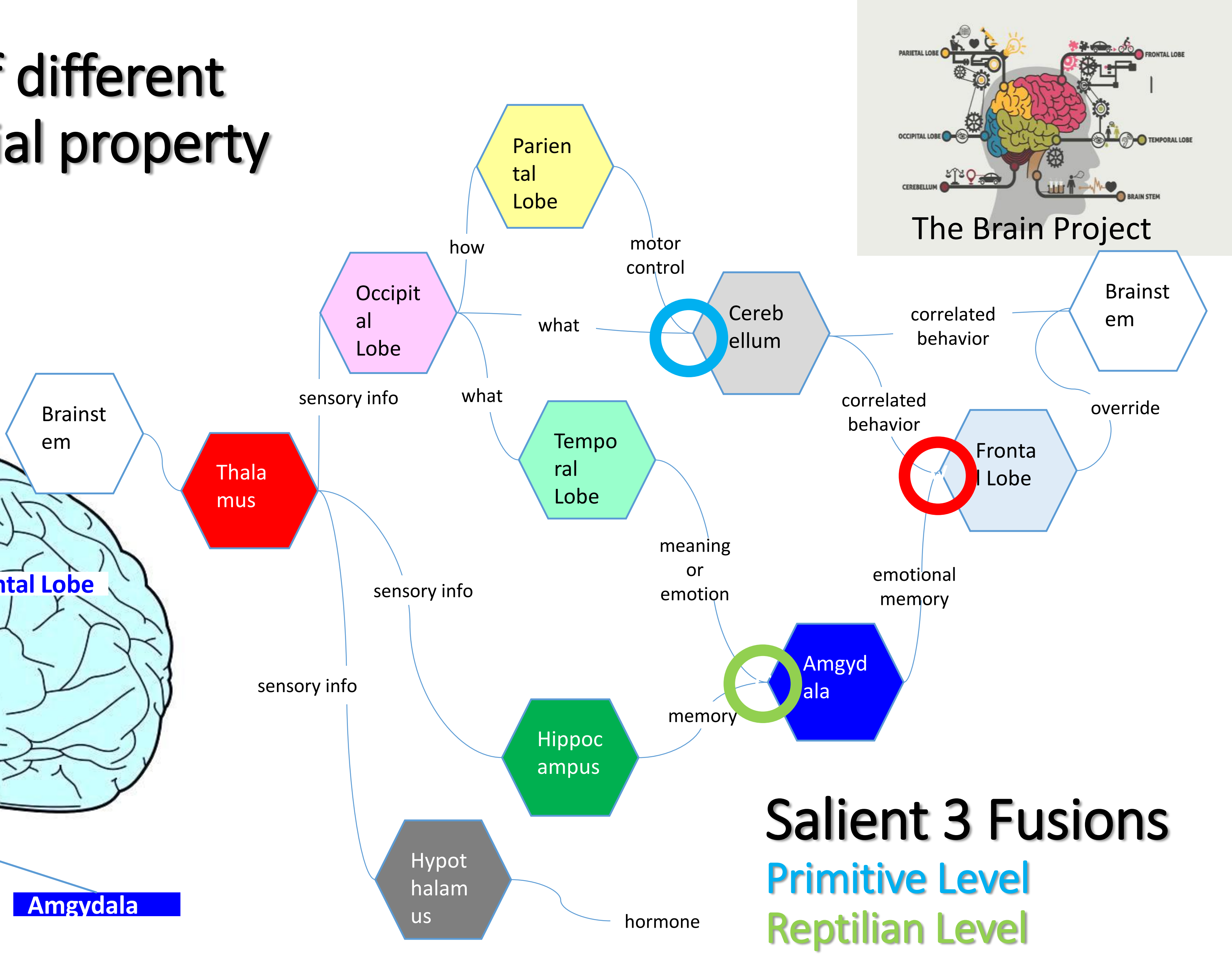
(Maclean Model)

- Sapiens Brain
- Human Brain
- Neomammalian Brain
- Paleomammalian Brain
- Reptilian Brain
- Vertebrates
- Primitive CNS
- Hard wired organisms



Insights 3 – “Fusion” of different sensor signals is a crucial property of the Level System





Salient 3 Fusions

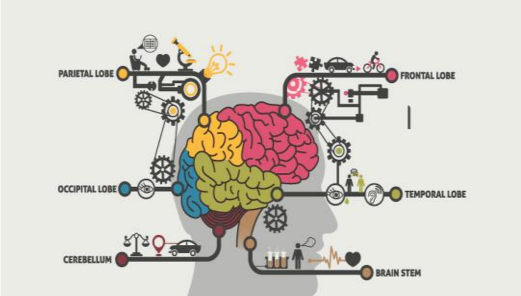
Primitive Level

Reptilian Level

Human Level

Insights 4 – this fusion centre model explains separate “How and What” processing streams

– as in Millner’s* 2 Path Model of the Eye / Brain System



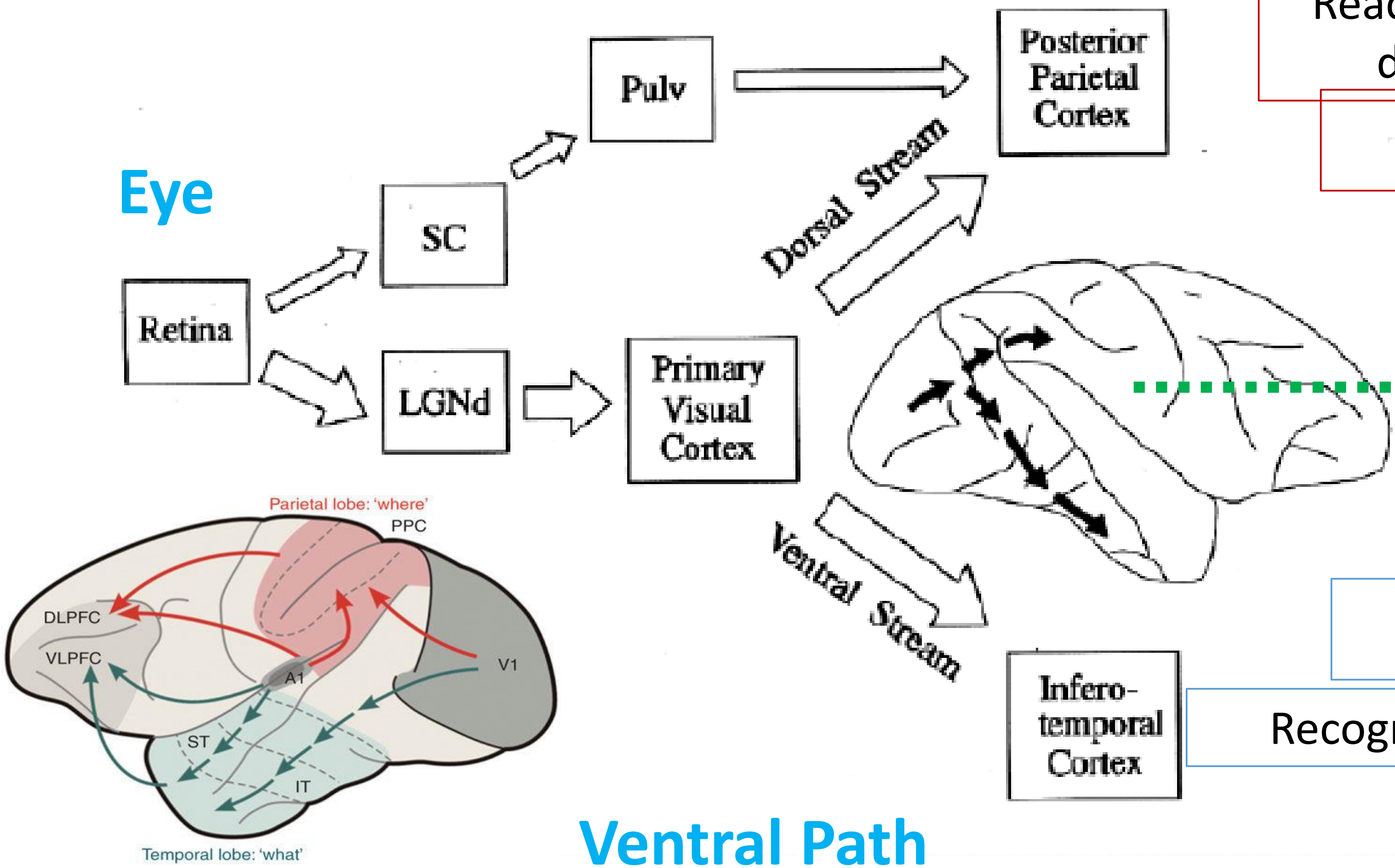
The Brain Project

Dorsal Path

React with the tactics “**How** to deal with the situation”.

How

Eye



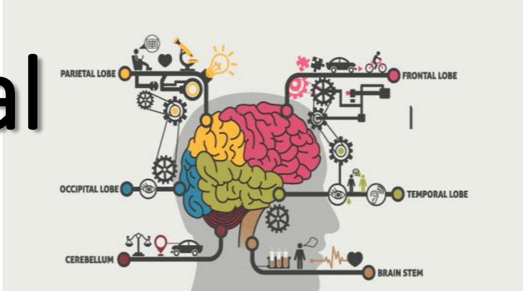
What

Recognize **what** is the object.

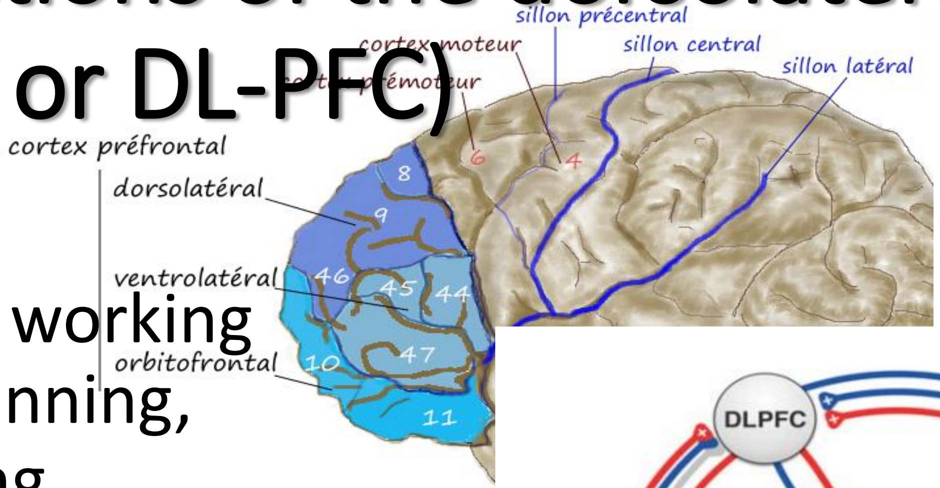
Ventral Path

*Milner, A.D. & Goodale, (1995) “Visual brain in action” Oxford University Press

Insights 5 - The Key Functions of the dorsolateral prefrontal cortex (DLPFC or DL-PFC)



The Brain Project



- The DLPFC is responsible for the executive functions, such as working memory, cognitive flexibility, planning, inhibition, and abstract reasoning
- Complex mental activity requires the additional cortical and subcortical circuits,
- The DLPFC is also the highest cortical area that is involved in motor planning, organization and regulation.
- It undergoes a prolonged period of maturation which lasts until adulthood

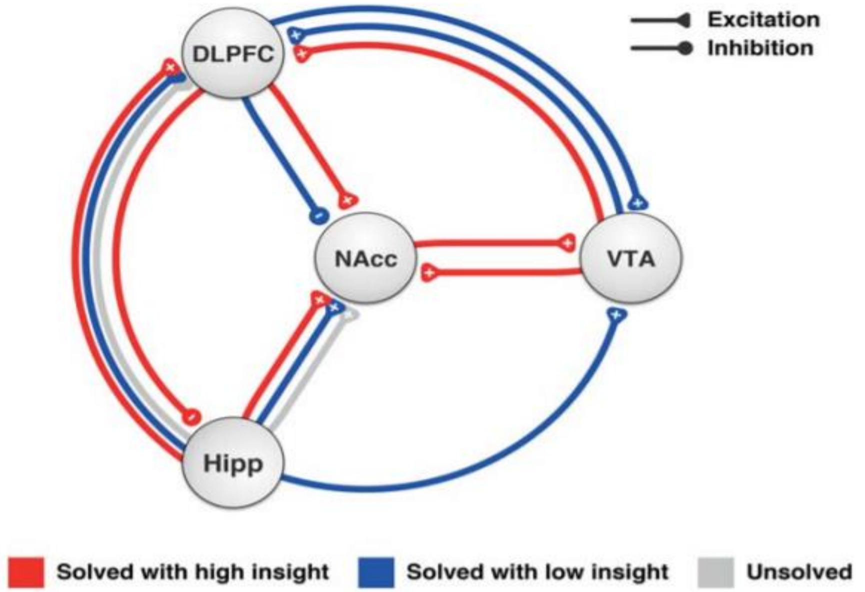
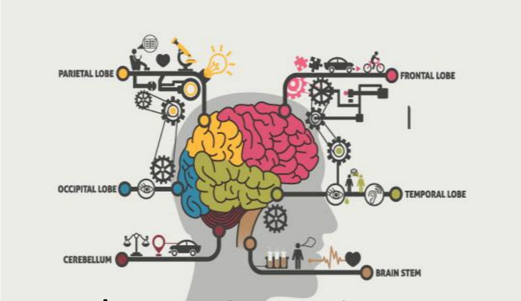
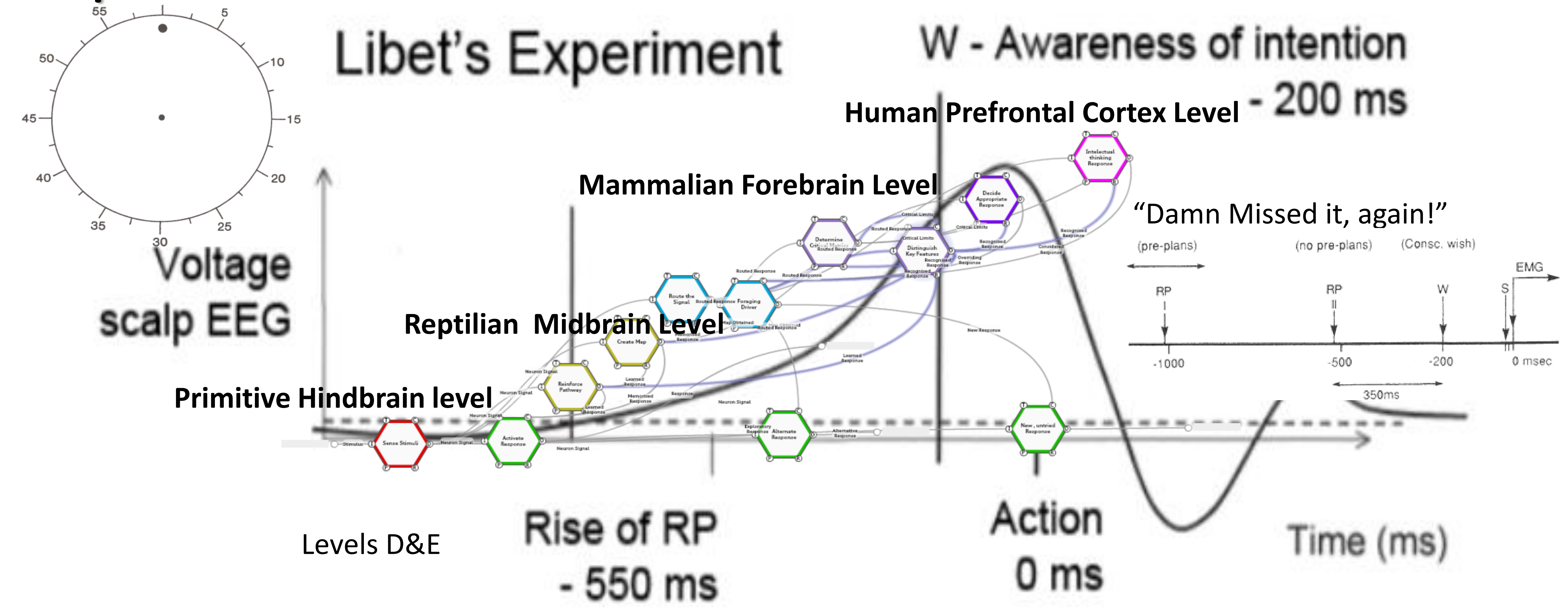


FIGURE 5 Condition-dependent effective connectivity of subcortical structures. Most importantly, DLPFC connectivity was only positive during high insight and negative for low insight moments. Additionally, high insight was associated with significantly positive VTA to NAcc forward (+0.072 ± 0.136) and backward connectivity (+0.072 ± 0.134). Bayesian model averaging group results of intrinsic connectivity plus modulation, $p < .05$ [Color figure can be viewed at wileyonlinelibrary.com]

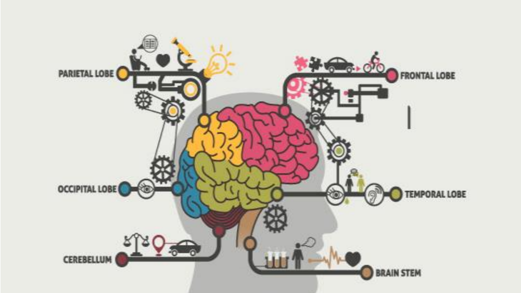
Insights 6 - "Speed" of thought - involvement of different FRAM Levels as a definite time sequence as can be seen in



The Brain Project



Insights 7 – Level and Speed - Kahneman's "Thinking Fast and Slow" findings



The Brain Project

"Thinking" or Human Brain - Kahneman System 2

- Reasoning, Insights
- Rationalisation, Creativity

"Autopilot" or Higher animal Brain – Kahneman System 1

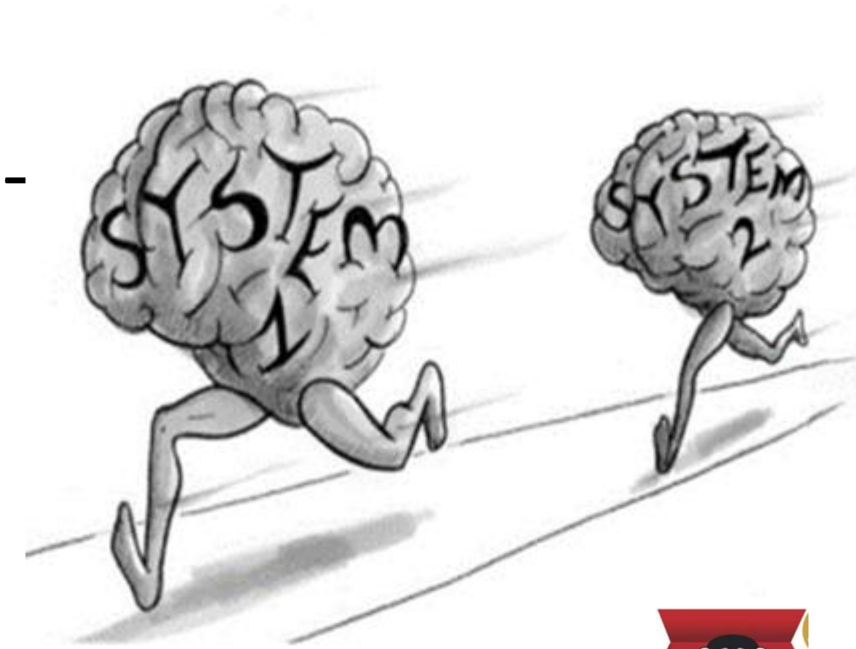
- Perception
- Learning & Memorizing
- Motivation, Heuristics and Biases

"Awareness" or Animal Brain

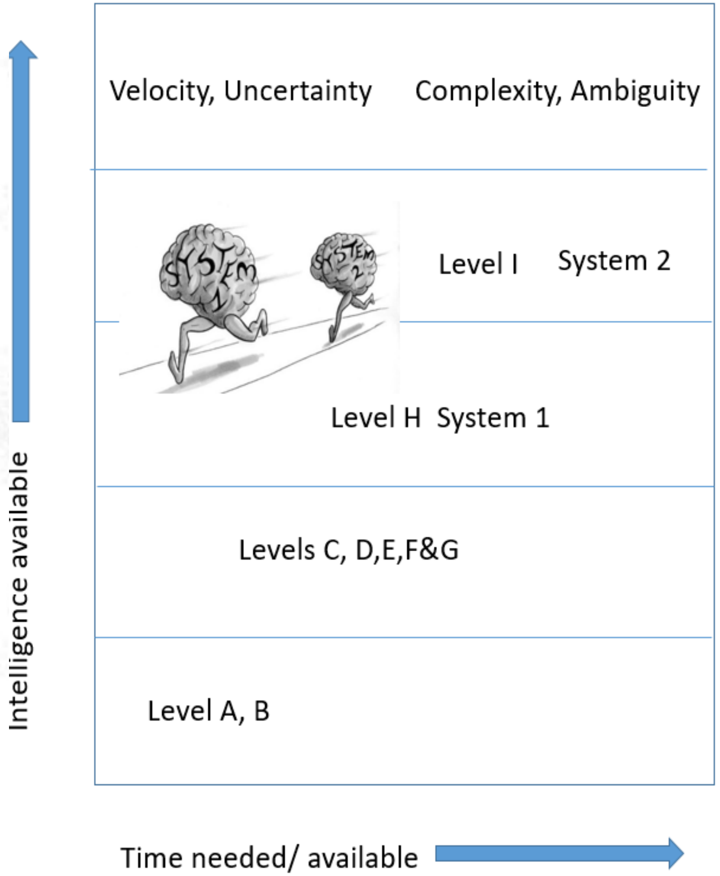
- Arouse & Alert, Instincts
- Reflex Motor Control

"Basic" or Primitive Brain

- Autonomic, Control Homeostasis

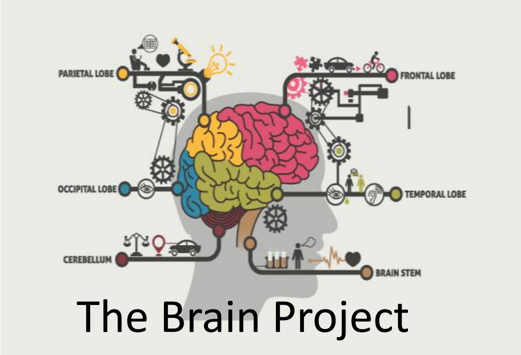


See also Peters "The Chimp Paradox"!



Explains VUCA classification of risky decision environments!

Insights 8 – Thinking can get you killed!



- In the process of making decisions, the thinking opportunities are often too little, or too late.
- There is a clear need to pre-program the mid brain “memory” functions’ with relevant experiences such that the deep emotional “animal” instincts are all pulling the right way.
- But this education of our subliminal survival instincts is normally only gained from painful experience.
- It follows then, that this can’t be done in a classroom by rote and thankfully real situations are relatively rare and cannot be scheduled.
- Field exercises are the next best thing are valuable in that you learn how much time you have to act.
- But full immersion simulation can reach parts -----!

Insights 9 – Medical and Psychological

The Brain Project

- Having established a model which seems to predict effects seen in real life applications, we can now do a normal FRAM variability exercise / analysis in specific instances
- Variability in function performance and interactions result in symptoms which can be observed as outputs from the system
- **Dementia** – short term memory impaired
- **Autism** – DLPFC (intelligence?) boosted, but Parietal inputs (emotion and Sensitivity) degraded
- **Strokes and Injuries** – effects diagnosed from function impairment, etc.

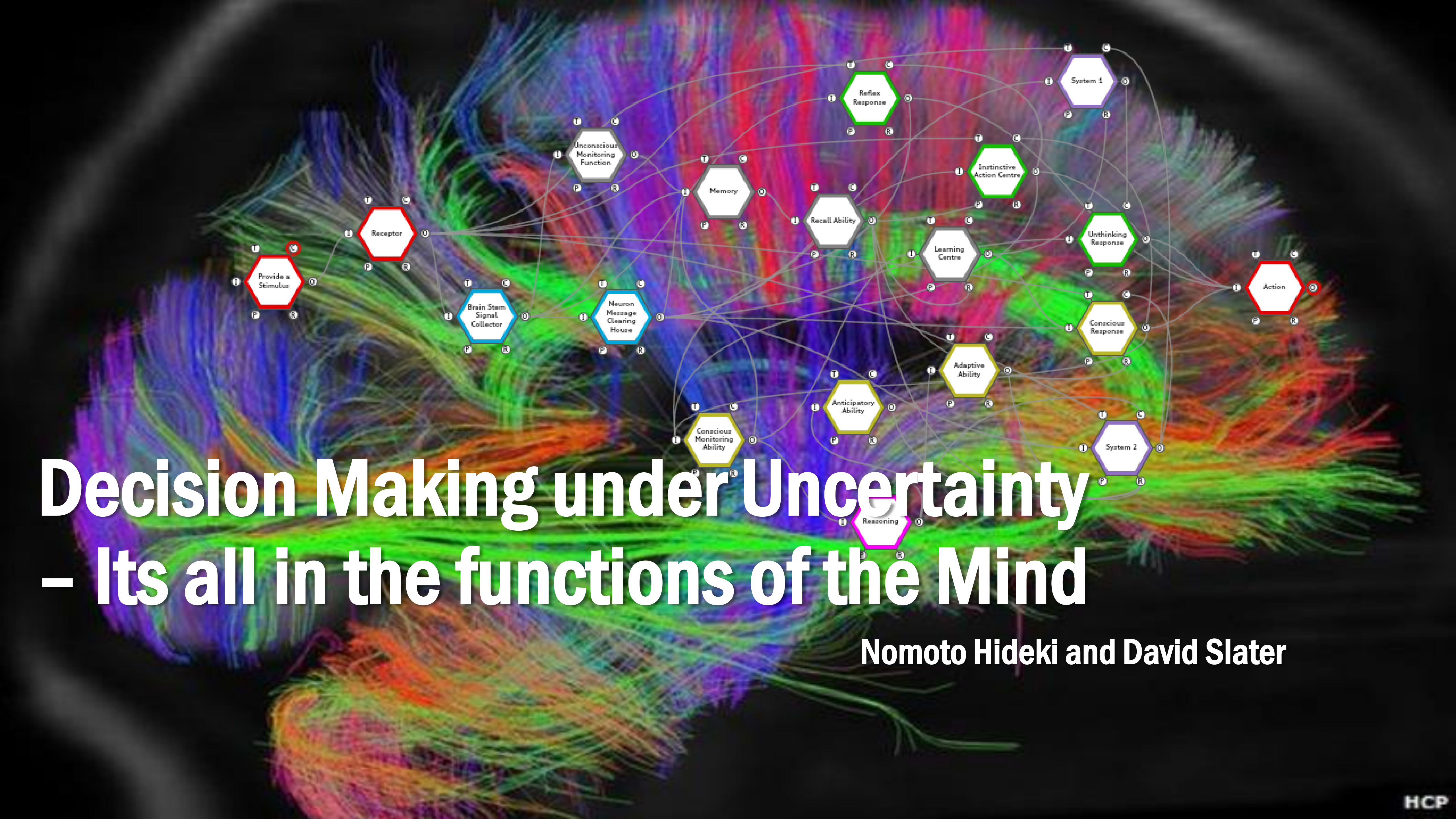
Conclusions

The Brain Project

- Modelling such a challenging, highly complex system as the Brain is a huge task.
- This work was undertaken as a first step aimed at seeing if we could usefully employ the FRAM approach to do two things:-

1. To see if a simple functional model was sensible and appropriate?
2. Given that we could define and link these functions in a meaningful way, can we probe for significance, the effects of variabilities in interactions and interdependencies; and see if resonances could be picked up and if these are meaningful?

- Although initial correlations with observations and previous work are encouraging and have provided some interesting insights and explanations, we have a long way to go and are still considering the implications of results so far and the sensible next steps!
- We think the modelling of multi level, multifunctional systems will be required and will be a non trivial extension of the current FRAM approach.



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