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Modeling executive functions in the prefrontal cortex

Frédéric Alexandre

► **To cite this version:**

Frédéric Alexandre. Modeling executive functions in the prefrontal cortex. XI Dubrovnik Conference on Cognitive Science, May 2019, Dubrovnik, Croatia. hal-02388018

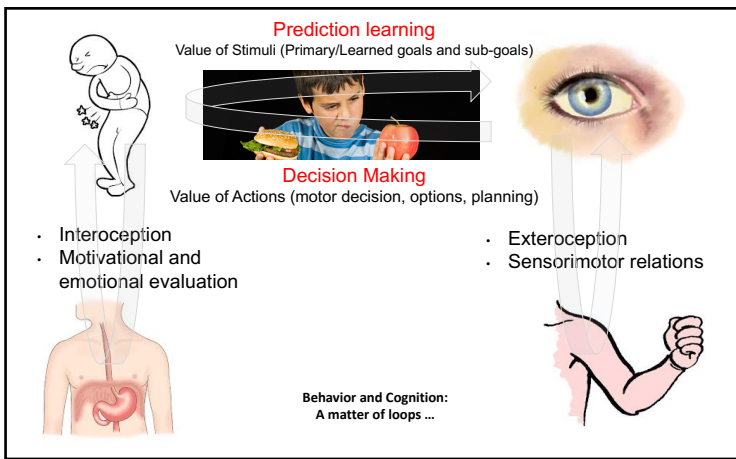
HAL Id: hal-02388018

<https://inria.hal.science/hal-02388018>

Submitted on 2 Dec 2019

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AUTONOMOUS LEARNING

WE DEFINE OUR GOALS BY OURSELVES :

- DETECTION OF PRIMARY REINFORCERS
- LEARNING OF SECONDARY REINFORCERS
- ATTENTIONAL PROCESSES

WE HAVE A MOTIVATION TO ACT :

- FUNDAMENTAL NEEDS
- INTRINSIC MOTIVATION
- GOAL-DRIVEN BEHAVIOR

WE SELF-EVALUATE OUR PERFORMANCES :

- META-CONTROL

WE ASSOCIATE DIFFERENT KINDS OF LEARNING AND INFORMATION REPRESENTATION :

- CUES
- ABSTRACTIONS
- EPISODES
- WORKING MEMORY

WE CUMULATE AND RE-EXPLOIT PREVIOUSLY LEARNT KNOWLEDGE AND STRATEGIES IN DIFFERENT CONTEXT :

- LIFE-LONG LEARNING AND TRANSFER LEARNING

WE ADAPT EVEN IF THE WORLD IS CHANGING AND UNCERTAIN :

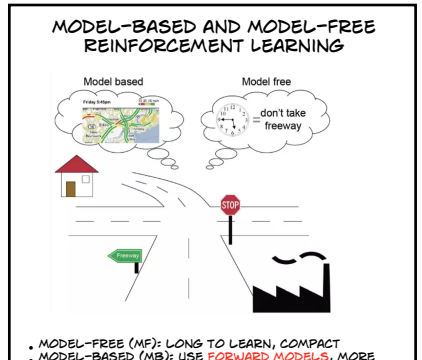
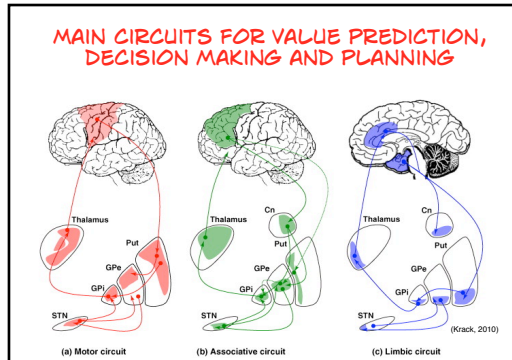
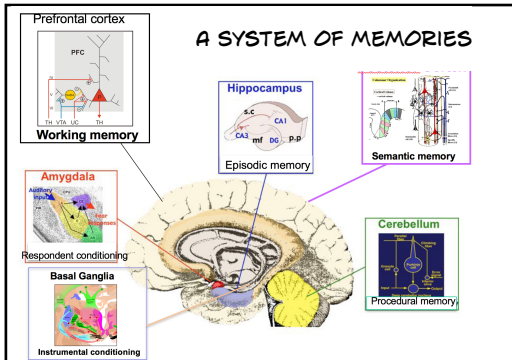
- STOCHASTICITY AND VOLATILITY

DEFINING EXECUTIVE CONTROL FOR A COGNITIVE AGENT IN ECOLOGICAL CONDITIONS, BY **AUTONOMOUS LEARNING**

- ROLE OF THE LOOPS BETWEEN THE **FRONTAL CORTEX** AND THE **BASAL GANGLIA** FOR **PREDICTING VALUES, DECISION MAKING AND PLANNING**
- THE **LIMBIC LOOPS** DECIDE FOR THE GOAL AND THE ACTION
- THE **ASSOCIATIVE LOOPS** BIAS THE DEFAULT BEHAVIOR
- THE **MOTOR LOOPS** EXECUTE THE BEHAVIOR
- **FORWARD MODELS** ASSOCIATED WITH LIMBIC AND ASSOCIATIVE LOOPS
- **THE TASK SET**, POWERFUL CONCEPT TO DESCRIBE THIS PROCESS

Modeling executive functions in the prefrontal cortex

Frederic.Alexandre@inria.fr Inria, Institute of Neurodegenerative Diseases, LaBRI



ROLE OF THE LIMBIC LOOPS : FORAGING OR DECISION BETWEEN SEVERAL TARGETS ?

- **LOFC**: LEARNS VALUES OF STIMULI (PAVLOV); MENU DEPENDENT; SENSORY REPRESENTATION OF REWARDS; CONSUMMATORY BEHAVIOR, MODEL BASED; SELECT THE BEST TWO OPTIONS
- **MOFC**: REWARD REPRESENTATION FOR PREPARATORY BEHAVIOR (OPERANT, MODEL FREE), INTEGRATE LEVELS OF NEED; VALUE DIFFERENCE SIGNAL; **DECIDE FOR THE GOAL**
- **ACC**: INTEGRATE COST OF EFFORT TO **DECIDE FOR THE ACTION**; INVERSE VALUE DIFFERENCE SIGNAL; IF STRONG SIGNAL OF CONFLICT, ASK FOR A SWITCH
- **FEF**: **ORIENTATION TOWARD THE GOAL**
- **MC**: **MOVE FORWARD FOR GOAL CONSUMPTION**

• **MODEL-FREE (MF)**: LONG TO LEARN, COMPACT

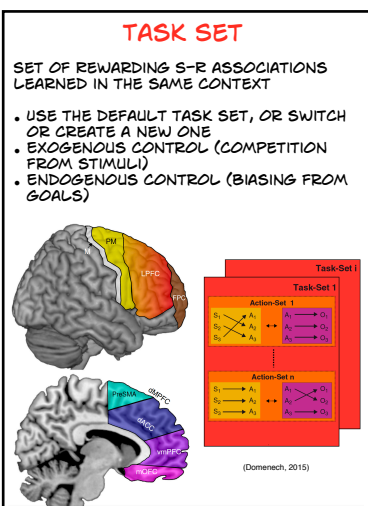
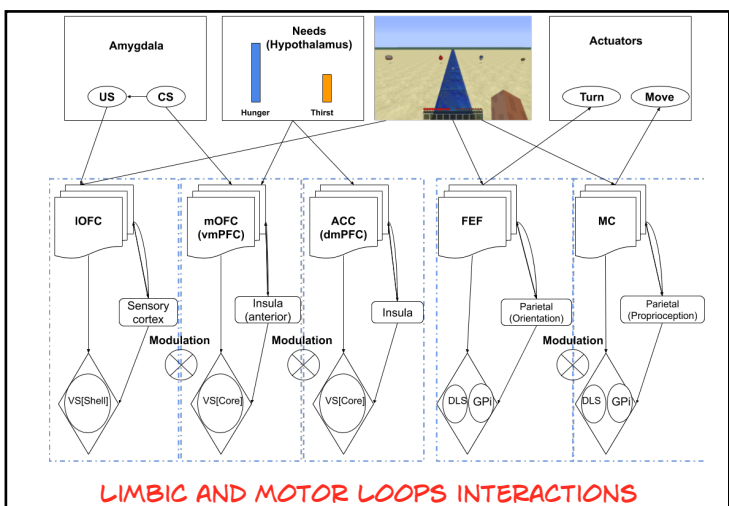
• **MODEL-BASED (MB)**: USE **FORWARD MODELS**, MORE FLEXIBLE BUT HEAVY TO COMPUTE

• WITH **FORWARD MODELS**, **GOAL-DRIVEN STRATEGIES** MORE TRACTABLE THAN **STIMULI-DRIVEN STRATEGIES**

(Sutton, 1990)

• MF CONTROLS THE BEHAVIOR

• MB TRAINS MF BY REPLAYS (RETROSPECTIVE MEMORY) AND SIMULATIONS (PROSPECTIVE MEMORY)



ASSOCIATIVE LOOPS : BIAS THE DEFAULT BEHAVIOR

TOP-DOWN CONTROL OF BEHAVIOR BY PFC AND HIPPOCAMPUS

- PFC CAN BIAS COMPETITION FOR NON-DOMINANT BEHAVIOR
- ROLE OF LPFC FOR WORKING MEMORY AND ATTENTIONAL PROCESSES
- THE HIPPOCAMPUS CAN RAPIDLY BIND ARBITRARY REPRESENTATIONS NOT YET FORMED IN THE CORTEX
- EXPLICIT REPRESENTATION OF EPISODES AND REPLAYS
- DEFINE SUBGOALS (INTENTIONS, MEANS) AND THOUGHTS (COVERT ACTIONS ENCODED BY THEIR PERCEPTUAL EFFECTS, FORWARD MODELS)