



# **FROM ATTENTION TO DECISION-MAKING**

## ***A Neuropsychological study***

***First International Conference on Driver Distraction  
and Inattention***

***Armelle Jacquet-Andrieu***

***Université Paris Est – UMR CNRS 8049***

***Robert Martin (Leader of AR5 Program)***

***Institut des Sciences de l'Homme***

# Research Teams & Technical Research Teams



## **LEACM/CRIS – Université Lyon 1**

Robert Martin (Leader of the AR5)

Armelle Jacquet-Andrieu

Annick Maincent

Chantal Combe-Pangaud

## **INRETS/LESCOT**

Alexandra Fort



## **MMB – Institut des Nanotechnologies de Laboratoire de Physique de la Matière – INSA, Lyon**

Christian Collet

André Dittmar

Claudine Gehin



## **Pôle de Ressources Informatiques (PRI) Institut des Sciences de l'Homme – Lyon**

Gérald Foliot

Didier Leblanc

Nicolas El-Sayegh

## **CERMEP/MEG – Lyon**

Claude Delpuech

Sébastien Daligault

Françoise Lecaiguard

Alexandra Fort



## 2. Attention (1/2)

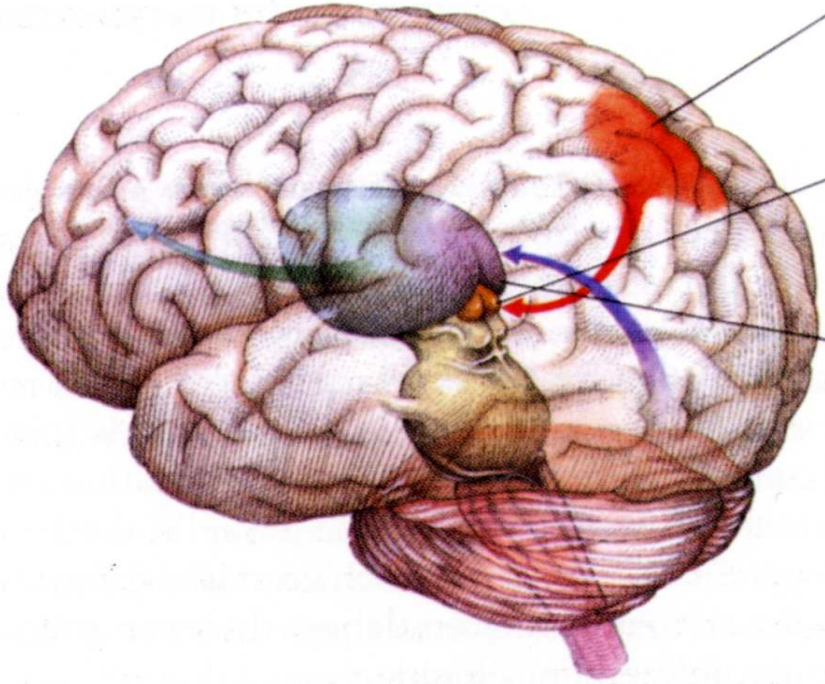
- **Attention function**  $\Rightarrow$  *specific vigilance*<sup>[1]</sup> *level* (alert)
- **Attention rests on** a gradient of **consciousness states** which runs from the **alert** to the **reflex action** – in the less elaborate states of the function – to the **conscious decision-making**, explicitly.
- **Attention** = interaction between a *vigilance* state and an *activation* process, determinant factors: Notion of intent (intentionality).
- **Concept of Activation** (excitation/inhibition): linked with the **variations of the physiological alert**, as **effect of external solicitation**, stimulation or an auto-solicitation.
- <sup>[1]</sup> **Vigilance**: “The ability to be in alert and, for the Nervous System, the adaptation capacity to a new situation” (translation). *DMF*, p. 888.



## 2. Attention (2/2)

### ■ Locations

- **Attention:** concerns extraction of pertinent signs for decision-making & comportment.
- **Functional anatomy of attention** (Picture 1):
  - 1) ***Posterior parietal cortex*** (***warning*** & **disengagement** from the previous situation),
  - 2) ***Superior colliculus*** (displacement & reorientation)
  - 3) ***Pulvinar (posterior nucleus of the thalamus)***: **Information relay** towards associative areas of parietal cortex, focus, preparatory and **behaviour processing are successive and overlap.**



1 **Posterior Parietal Lobe:**  
**warning & disengagement**

2 **Superior Colliculus:**  
**Displacement**

3 **Pulvinar: Ampliation**

**Picture 1:** The brain circuitry of Attention  
M.I. Posner & M.E. Raichle. *Images of Mind* (p. 168)

- **Control: various levels of consciousness**
- **Sub-cortical structures of attention (Sch. 1).**





### 3. Memory (1/3)

- Supported by attention
- Necessary for all **acquiring/behaviour** and for the **availability of knowledge**.
- In direct drive with the emotional system (*cf. infra*).
- **Memory** takes charge of “**writing**” memories with their affective, social... **connotations**
- **Memory** has to be accessible = **AVAILABILITY**
- **Consciousness**: Various **levels**.
- The Schema 2: **Memory and his fixing points in the cognition** (B. Laurent, A. Jacquet).

### 3. Memory (2/3)

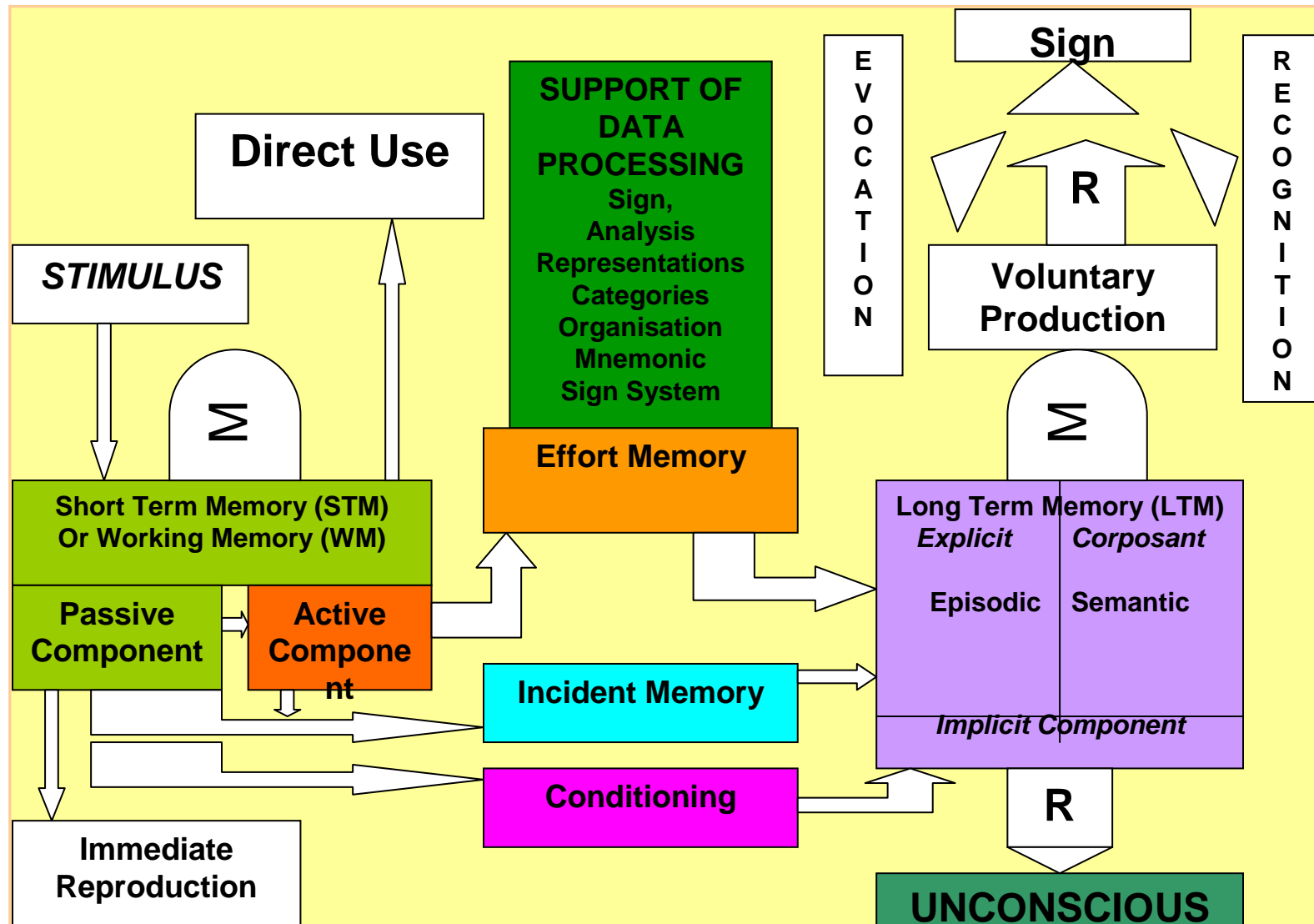


Schéma 2:

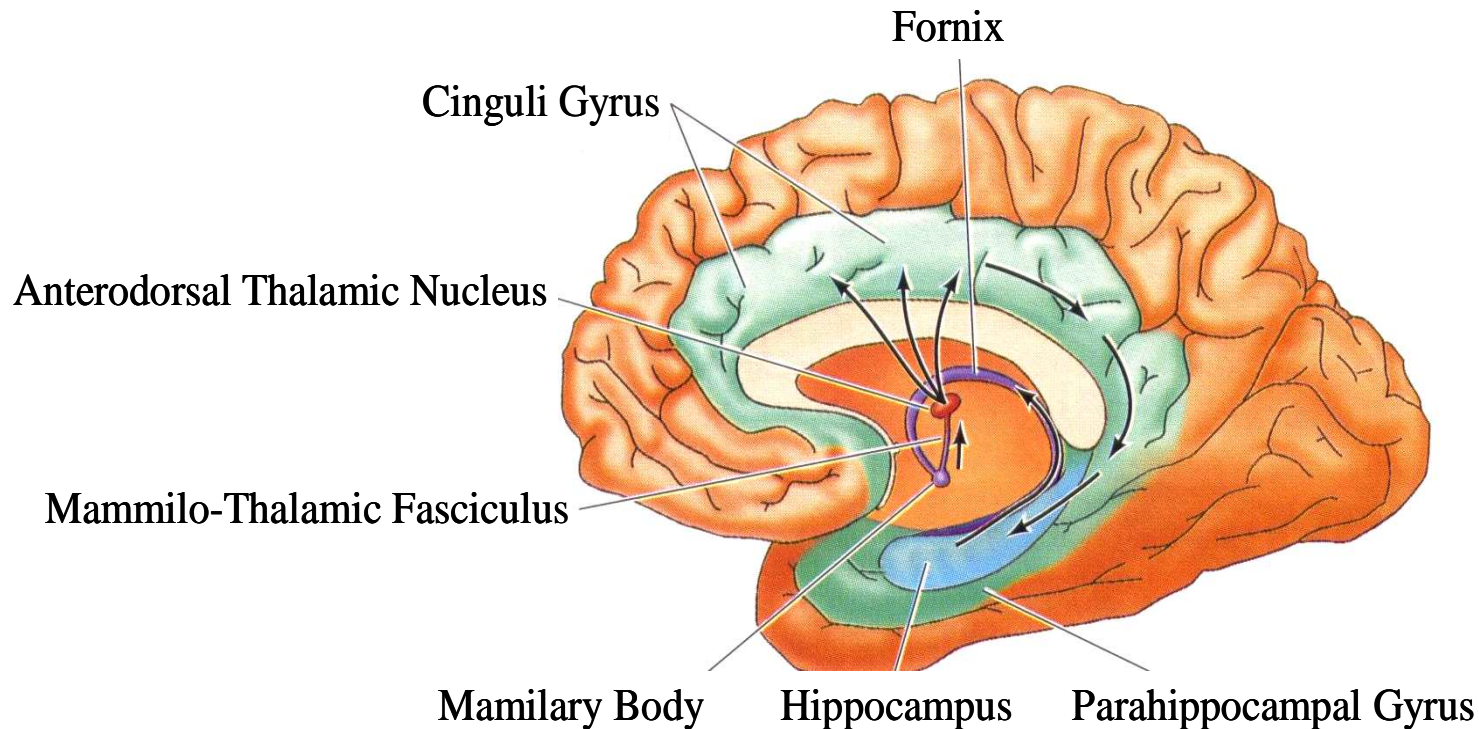




## 3. Memory (3/3)

- Two components:
- *Short Term Memory (STM)* or *Working Memory (WM)*
- Long Term Memory (LTM).
- Passive & Active component (PSTM & PSTM).
- LTM: 2 components = Two kinds of knowledge
  - a) *Encyclopaedic knowledge*, in *semantic memory (SM)* controlled by the subject to be evoked.
  - b) *Events of live*, stocked, organised in the *episodic memory (EM)*, less controlled than *SM*: impact of the emotions of the subject.
- **Dissociation** observed in the memories disturbs.
- **Normal conditions**: **synchronous working** of these two components with a specific and control and **various degrees of consciousness** and contextualisation.

## 4. Memory & emotions: functional anatomy of *limbic system* (Pict. 2)



**Picture 2: Limbic system (internal and medial faces of the *encephala*, Cortical & sub-cortical structures).**

**D. Purves & al. *Neuroscience* (p. 519)**



## 5. Attention and memory: specifications

- Two correlated dimensions
- Passive component,
- Active component,
- Series of filtering.
- Passive attention (*reflexive attention* of James, 1890), corresponds to **hearing or visual alert states**, for example,
- In a *t* time state, PA on a sign modifies it.



## 5.1. *Passive attention & memory*

- **Changing of orientation** :for motor response (driving, for example).
- ***Unconscious data processing:*** **recognition** only).
- Concerns the **senses** (auditory, visual and/or proprioceptive percepts, *etc.*):
- ***Alert of attention*** is **correlated to sensations, memory and automatic response.**



## 5.2. *Active attention & memory* (1/2)

- **Active attention**: linked to **mnemonic activity**
- **Various classifications** but **three properties**:

### 1) *FOCALISED ATTENTION & FILTERING*

**Perception** of an object inducts **conscious or unconscious acknowledgment** of *signs* and *signals* and/or the **discovery** of information.

The **attentive subject** **selects** **signs** (moves away from others, consciously or unconsciously) and/or **recognises** it as a **signal**.

It needs to have a **true meaning** (basic definition of the data processing)



## 5.2. Active attention & memory (2/2)

### 2) FLEXIBILITY

- Adaptation to current environment.
- State of automatic or conscious attention: a surprising sign may “*distract*” the subject (driver here) ⇒ **REORIENTATION** = modification of programmed sequence of responses (or under way) FOR new adapted responses.

The *flexibility* is linked to the *control of attention*

### 3) CONTROL

- Unity of signs and kinds of signals: nature and processing.
- Plurimodal sensory percept can ⇒ Perceptual conflicts & errors ⇒ Accident.



## ***5.3. Automatically, sustained attention and prolonged attention: memorizing (1/2)***

**PARALLEL** to the concept of **PASSIVE & ACTIVE ATTENTION**, another three concepts:

- 1) *Automatic attention*** (unconscious),
- 2) *Sustained prolonged attention*** (conscious).
- 3) *Filtering system***

- **Selection of a sign** suppose a kind of ***filtering system*** for **comprehension of signals** (spatial and temporal organisation).



### ***5.3. Automatically, sustained attention and prolonged attention: memorizing (2/2)***

- **Frequent percept:** Recognised without necessity of processing: *training effect*.
- ***Training effect* ⇒ SWITCHING FROM Sustained prolonged attention TO Automatic attention (AT) and TO Mnemonic immediate Availability (MIA).**
- **Good Attention funct. ⇒ Correct memorizing**
- **High controlled processing system ⇒ Adapted responses (Table1)**
- **Incident & controlled aspects of MEMORY and ATTENTION in GENERAL COGNITION.**



INT-Table. 1. Memory and control, relation with attention (A. Jacquet-Andrieu, *Bulag* 32, p.217.

Biological control in all level				
MNEMONIC COMPOSANT		EVOCATION STATE		EVOCATION
1/ STM	→ NO DATA PROCESSING, Unconscious run (-) control	IMMEDIAT REPRODUCTIO N	→	Inconscient/ Motor <u>Control</u> (+)
2/ PSTM <u>PASSIVE ATTENTION</u>	→ CONDITIONING Voluntary control (-)	CROSSING TO ILTM → <u>Control</u> (-)	→	Inconscient/ Control (-) Motor → <u>Control</u> (+)
3/ PSTM <u>PASSIVE ATTENTION</u>	→ CROSSING TO IM <u>Voluntary control</u> (-)	CROSSING TO ELTM → <u>Control</u> (+)	→	If it is EVOCATED Motor <u>Control</u> (+)
4/ PSTM <u>ACTIVE ATTENTION</u>	→ CROSSING TO ASTM → <u>ACTIVE ATTENTION</u>	→ Support of Processing ASTM = WT Phases 5, 6 7 8		

■ Concordant data with Picture 2 (cf. Slide 10): interpretation of B. Laurent. 17

INT-Table. 1. Memory and control, relation with attention (A. Jacquet-Andrieu, *Bulag* 32, p.217[23d].

Biological control in all level				
MNEMONIC COMPOSANT			EVOCATION STATE	EVOCATION
4/ PSTM <u>ACTIVE ATTENTION</u>	→ CROSSING TO ASTM <u>ACTIVE ATTENTION</u>	→ Support of Processing ASTM = WT Phases 5, 6 7 8		
5/ ASTM <u>ACTIVE ATTENTION</u>	→ <b>5 / EVOCATION AVAILABILITY</b> →			→ CONTROL (+)
6/ WM = ASTM <u>ACTIVE ATTENTION</u>	→ CROSSING TO IM <u>Voluntary control</u> (-)	→ CROSSING TO ELTM <u>Voluntary control</u> (+)	→ 6 / AVAILABILITY Possible Evocation	→ CONTROL (+)
7/ WM <u>ACTIVE ATTENTION</u>	→ CROSSING TO EM <u>Voluntary control</u> (+) <u>ACTIVE ATTENTION</u>	→ PASSING TO ELTM <u>Voluntary control</u> (+)	→ 7 / RECOGNISED Possible Evocation	→ CONTROL (+)
8/ WM <u>ACTIVE ATTENTION</u>	→		→ 8/ Effective Recognition & Evocation	→ CONTROL (+)

■ Concordant data with Picture 2 (cf. Slide 10): interpretation of B. Laurent. 18



## 6. Executive functions (1/8)

### 6.1. *Psychology and Neuropsychology of attention and decision-making*

- **FRONTAL LOBES (FL)**

- a) **Control of behaviours**

- b) **Most developed cognitive processes:**  
**ABSTRACTION...** For K.F. Burdach (1919)

**FL = “*Special workshop of the processes of thought.*”**

### 6.2. *Martin’s model*

- **Psychological and Cognitive modelling & afferent process of behaviour : 3 LEVELS ORGANISATION.**

- 1) **Collection of signs & Recognition of signals;**

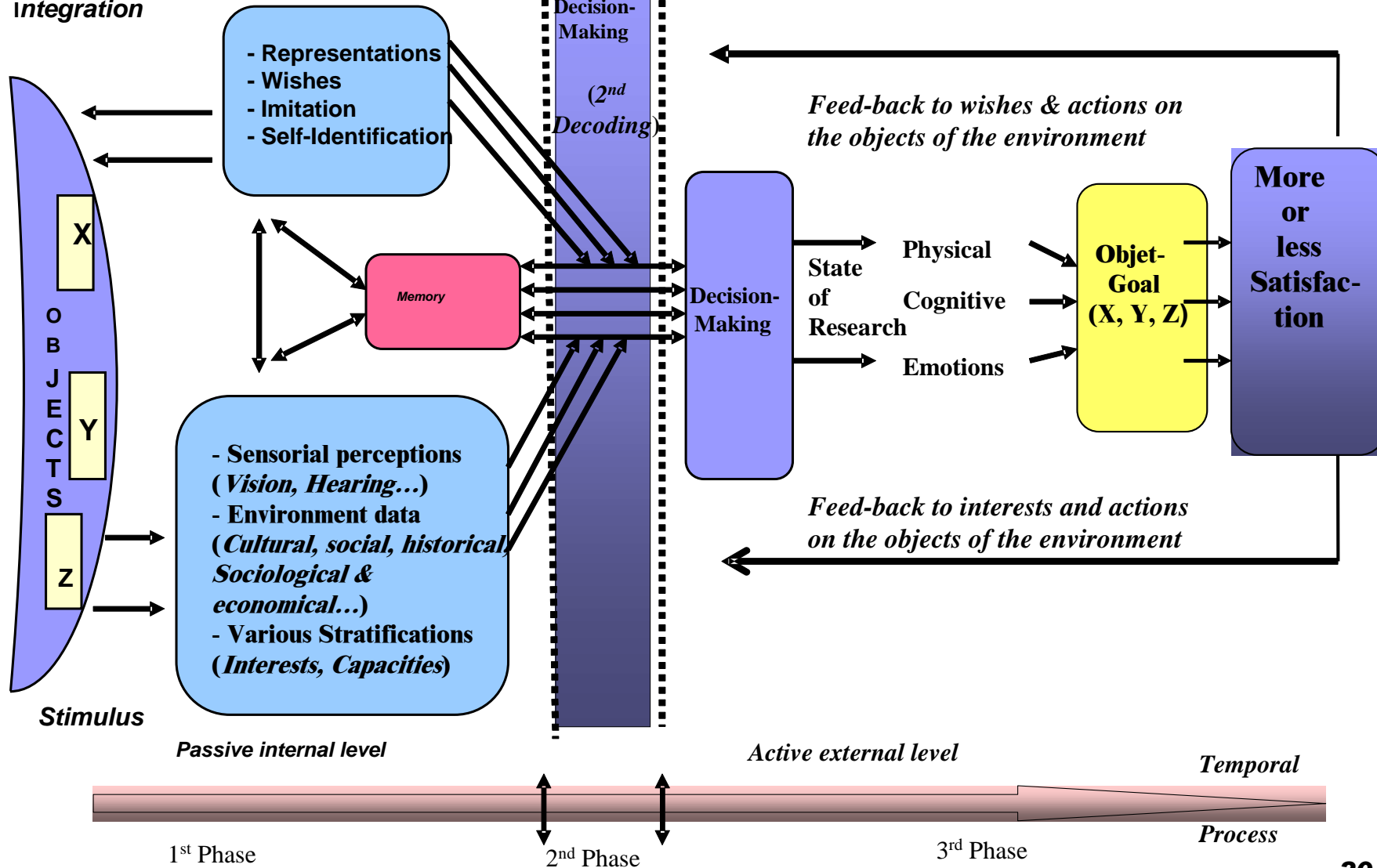
- 2) **Thought & Composition of the information (data process**

- 3) **Decision-making & Action.**

## Sub-System of Information

(1<sup>st</sup> Decoding of environment)

Integration



## Sub-System of actions on the objects of the environment: "Acting"



## 6.2. *Martin's model*

(3/8)

### 6.2.1. *Information sub-system (IUS)*

Continuous process of interaction between 3 components : **Perceptions & Environment states:**

- 1) **STIMULATIONS,**
- 2) **INTEGRATION**
- 3) **MEMORIZATION**

### 6.2.2. *Thought sub-system (TUS)* (Driving context)

- 1) the driver **DEFINES** the **GOAL**
- 2) He may have to **MANAGE** some **contrary interactions** and **lacks of information**.
- 3) He **ORGANISES** his choices into a **HIERARCHY: DECISION-MAKING** with many **AUTOMATISMS**.



## 6.2. *Martin's model*

(4/8)

### 6.2.3. *Action sub-system (AUS)*

- **Decision-making** and **Action** results of collecting and using **all kind of needed means** and **automatisms process**.
- **SATISFACTION** (Driving context): driver is more or less **satisfied** of his behaviour  $\Rightarrow$  **good or bad feed-back** for another similar choice.
- **Degree of satisfaction: impact** on the possible **replication** of a specific behaviour.

## 6.2. Martin's model

(5/8)

- **IMPORTANT:** Three stages in a short space of time  $t$  are overlapping indeed.
- Each driver has his own behaviour.
- For Robert **MARTIN**:
  - “Attention is a virtual entity and a label who act on a lot of data (stimulation, integration, and memorization) and a label of decision-making; also, the study of attention requires the field of neuropsychological and psychological analysis.*
- **Martin's model:**
  - a) No specific correlations with the anatomical **cortico-sub-cortical organisation**.
  - b) **Schematic & Synthetic** representation
  - c) **Coherent visualisation** of the human **decision-making and acting cognition**.



## 6. Executive functions

(6/8)

### 6.3. *EF: Functional locations*

a) **Posterior frontal cortex (LFP): Motor function & Control.**

b) **Anterior prefrontal cortex (LFA): planning behaviours** (pragmatic).

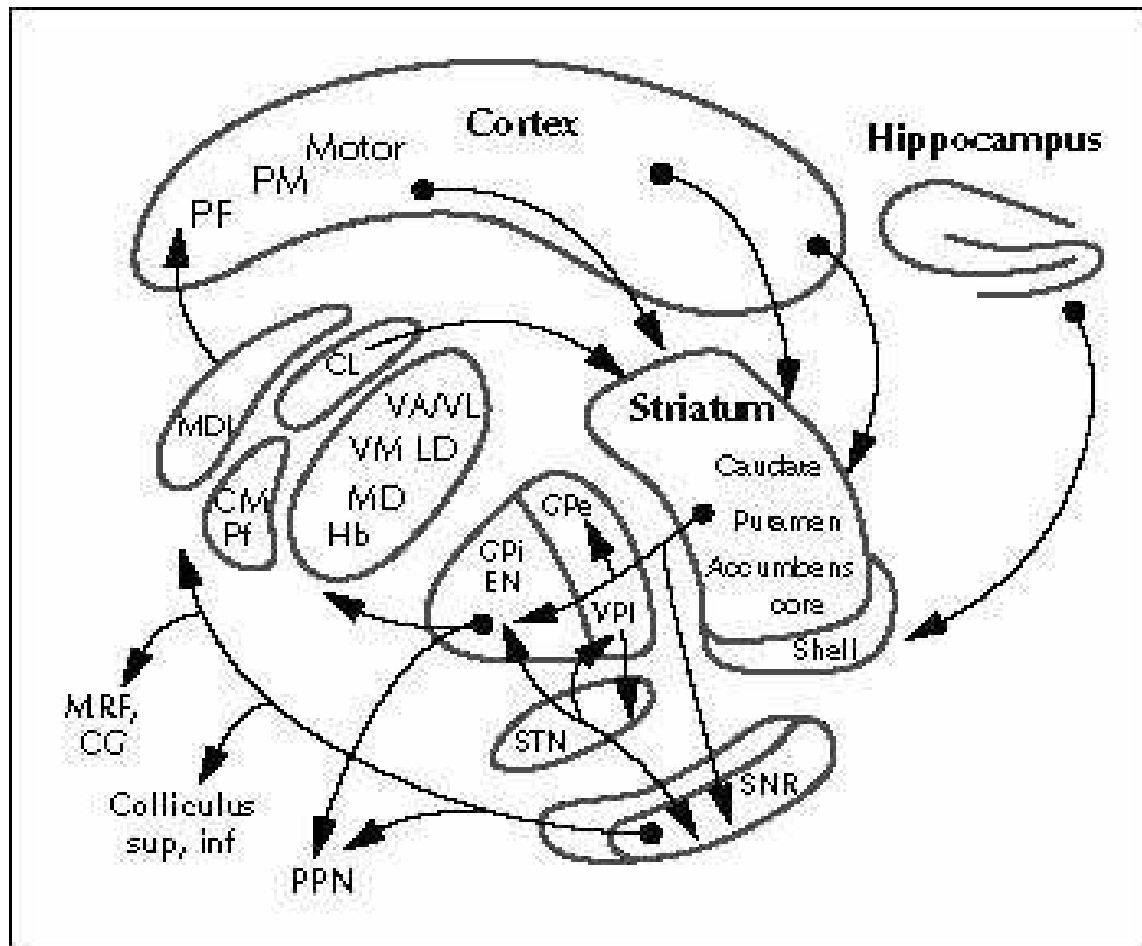
Adjustments: visual, auditory, space and time information... from all major regions of the cortex.

c) ***Planning areas and visual information:*** (Occipital lobe, **OL, BA 17, 18, 19**), language (part of temporal lobe, **BA 22**), space and temporal information process, in the right temporal lobe (RTL) and the two parietal lobes: **BA7: Somato-sensorial system**). **20** (memory), **39, 40** (reading) & **6** (AMS).

d) **Indirect projections, cortico-subcortical correlations.**



## 6.3. Neuropsychology of Attention and (7/8) executive functions



As we said (Slides 5 & 6):  
All these connexions are a schematic representation of the complex system of relations between cortex, thalamus, hypothalamus, hippocampus, sensorial & motor areas...


Schema 1: Cortical and thalamic connexions of cognition  
(Cortical and thalamic connections to STN omitted)



## 6.4. *Neuropsychology of attention and (8/8) decision-making*


- **Cinguli gyrus** concerned in: **Consciousness**, emotions (internal origin), **motivation** (volition)
- Interface between **frontal cortex** (decision-making) and **Amygdala (emotions)**
- Connections on the **frontal lobes**
- **Inter connexions LH and RH** (*Callosus corps*)
- **Sub-cortical structures (thalamus)** relieve the transmission, for the conjunct information subjected to attention: visual, auditory, proprioceptive... and its inscription in the memory.

***Attention* is highly linked to it.**  
**The subject gives an adjusted and appropriate response, in correct time and place.**



## 7. Synthesis of neuropsychological Attention function (1/2)

- **Three aspects of modelling interpretation:** *direct access model*, the *corpus callosum relay model* and the “*attention expedient*” model (Springer & al., 2000).
- **Firstly:** Cerebral hemisphere that *firstly receives the percept* that is specified by an inter-hemispheric collaboration (*corpus callosum*). It explains the activation of the LH & RH.
- **Secondly:** the data processing is realised in the more adapted H & *corpus callosum* relay, if it's necessary. There is also a data specification of the percept.
- “**Attention expedient**”: a fully duplicated process ⇒ The subject introduces cognitive strategies in the LH, generally: frequent recognition of Highway Code information, in the right visual field.
  - **AR 5 experiment can concord with that.**



## 7. Synthesis of neuropsychological Attention function (2/2)

- **Magnetoencephalographical study (MEG); first results**

**A non-invasive and high performance system:**

**275 Channels / Spatial resolution = mm / Time resolution = ms.**

**CERMEP, INSERM** (Bron: France), by **Alexandra Fort & Claude Delpuech**.

- **Study of human Electrodermal activity: INSA, Lyon (France); MMB** (Micro Capteurs biomédicaux), **Nanotechnology**, UMR CNRS 551, by **C. Collet**.
- **Self-assessment ; Questionnaires & Memory tests; LEACM/CRIS – EA 647**, by Chantal Combe-Pangaud & Armelle Jacquet-Andrieu.



## 8. Conclusion

- All **sensorial *stimuli***, **motor response**, adapted or not, call a **large network of neuronal structures**.
- Considering the **decision-making**, **executive functions** are directly concerned, with an important relation with **volition** (intent), **attention**, **memory**, **planning**,...
- **Decision-making & actions**, in the most elaborated forms, take in account the **adjustment** and **changes** (reorientation of the attention and situated cognition) indeed the **auto-correction**, if there is a perceptible and corrigible error, for example, with an important effect in the driving context.



## References

- Burdach, K.F. (1819/1826). *Vom Baue und Leben des gehirns*. Leipzig: Dik (3 vol).
- Caird J.K., Edwards C.J., Creaser J.I., Horrey W.J. (2005). "Older driver failures of attention at intersections: using change blindness methods to assess turn decision accuracy". *Human factors*, 47(2): 235-49.
- Damasio, A. R. (1999). *The feeling of what happens: body, emotion and the making of consciousness*. London: Vintage, 1999. XII-385 p.
- Duus, P. (1998). *Diagnostic neurologique : les bases anatomiques*/Trad. de la 6e éd. Paris: De Boeck Université, 486 p.
- Jacquet-Andrieu (2007). « Langage : fonction neuropsychologique et biologique hautement contrôlée ». *Bulag* 32 : 211-220.
- James, W. (1890). *The Principles of Psychology*. London, Macmillan, XII-689 p.
- Laberge, D., Auclair, L. & Sieroff, E. (2000). "Preparatory attention: Experiment and theory". *Consciousness & cognition*, 9: 396-434.
- Martin, R. "La pensée humaine et sa modélisation : un modèle structuro-fonctionnel ou une entreprise complexe". In B Cadet (ed). *La complexité. Cahiers de la MRSH*, n° Spécial 4-2005 : 19-28.
- Posner, M.I. & Raichle, M.E. (1994). *Images of Mind*. New York: Scientific American Library, IX-257 p.
- Tulving, E. ed. (1999). *Memory, consciousness and the brain: The Tallinn Conference*. Philadelphia (PA): Psychology Press, XVIII-397 p.
- Wright, R.D.& Ward, L. (2008). *Orienting of attention*. Pref. by M.I. Posner. Oxford/New York: CUP, XIV-289 p.

# Thank you for your attention



## **LEACM/CRIS – Université Lyon 1**

Robert Martin (Leader of the AR5)

Armelle Jacquet-Andrieu

Annick Maincent

Chantal Combe-Pangaud



## **INRETS/LESCOT**

Alexandra Fort



## **Pôle de Ressources Informatiques (PRI) Institut des Sciences de l'Homme – Lyon**

Gérald Foliot

Didier Leblanc

Nicolas El-Sayegh



## **MMB – Institut des Nanotechnologies, Laboratoire de Physique de la Matière – INSA, Lyon**

Christian Collet

André Dittmar

Claudine Gehin



## **CERMEP/MEG – Lyon**

Claude Delpuech

Sébastien Daligault

Françoise Lecaiguard