International workshop "Around Viability Boundaries"

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Epistemic viability

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Outline

Introduction: Epistemic viability: how is it possible, for a learner, to know whether she learns, understands, knows an item?

1. Regulation laws and Feedback laws as modelled by VT
2. Noetic feelings have as their function to carry an information about the viability core of a task.
3. Relevance of viability theory to education

Conclusion: epistemic and social viability in conflict

Introduction

- How is it possible, for a learner, to know whether he/she
  - can learn,
  - understands,
  - knows an item
  - discriminates two shapes?
- These predictions are necessary for controlling one's cognitive activity (controlled memory retrieval and learning, perception, reasoning).

Introduction

This set of functional predictions constitutes the domain of epistemic viability, i.e.

- the regulation of one's knowledge acquisition and use
- under uncertainty: in a changing internal and external environment

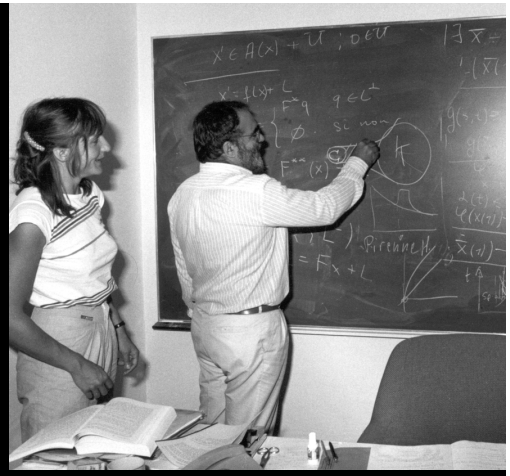
Introduction

My goal will be to show how viability theory could/should be used to model epistemic viability in order to clarify various dynamic dimensions of the processes involved.

At present, however, only intuitive overlaps will be presented.

1 - Regulation laws and Feedback laws as modelled by VT

Viability theory
(Frankowska et al. 1990,
Aubin, 2001, 2003)

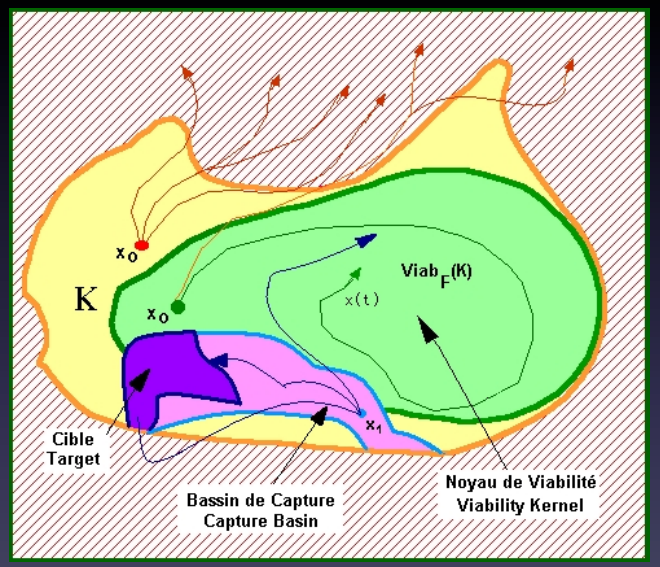


- describes the mathematical structure of the dynamic couplings of two evolving systems (for example: an agent and his/her environment).
- uses an inverse approach: what is the regulation mapping that contains all the evolutions that lead to a desired goal ?

Viability theory (Frankowska et al. 1990, Aubin, 2001, 2003)

- studies the regulation of complex evolutionary systems under uncertainty

- Among the simpler evolutionary systems are those that are described as differential inclusions (differential equations with set-valued right-hand sides).



Viability theory: Basics

- A system is evolving as a consequence of a non-deterministic engine + commands (regulons) that are in its repertory.
- VT aims at predicting whether, given a non deterministic engine and specific constraints, there exists one or several viable evolutions for that system:
- "the aim is to discover the feedbacks that associate a viable control to any state".
- When some of the evolutions are not viable (ie some fail to satisfy the constraints in a finite time), VT aims at determining the viability core.

Viability theory: Basics

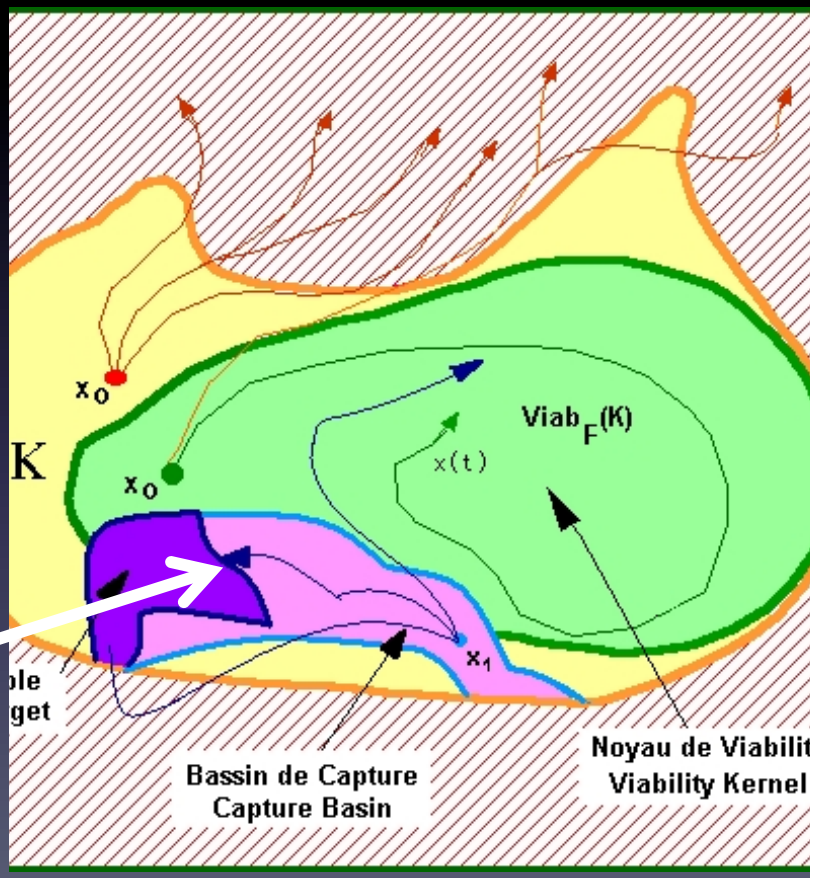
- The viability core is the set of initial conditions from which starts at least one evolution such that either:

  A) It remains in the constrained set for ever;

  or

  B) It reaches the target in finite time before possibly violating the constraints.

- The set of initial states that satisfies only condition B is the viable-capture basin of the target.



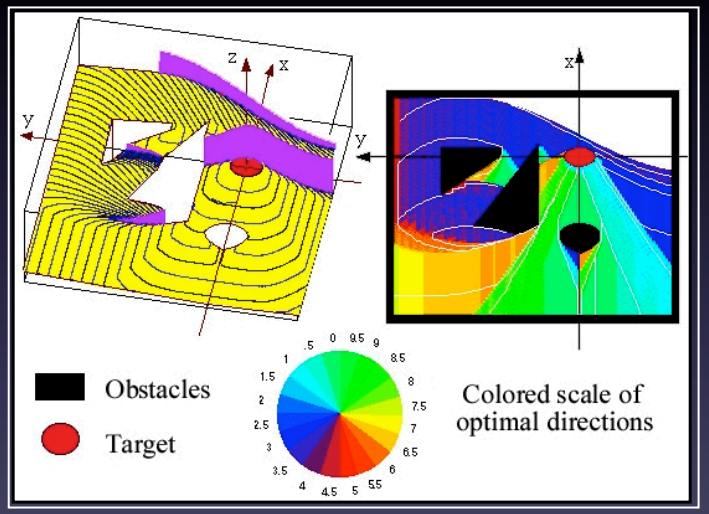
Viability theory

There are two forms of regularities that determine the way in which a given organism can interact with the environment in an adaptive and controlled way.

- **regulation laws** determine which affordances/ viability/capturability correlate with specific commands in specific environments.
- **feedback laws** determine what portion of the regulation space is accessible to an organism with a given history.

Regulation laws

- Apply to the evolution of dynamic systems
- Determine regulation mappings between commands and relevant properties (viability and capturability)
- The respective sizes of the mappings measure robustness or resilience of viability for a system in an environment



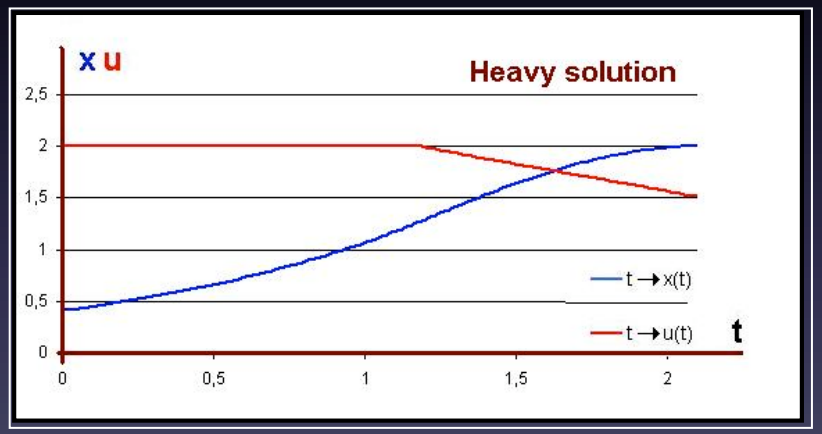
Regulation laws

- Can predict/describe viability crises and the kinds of transitions that can restore viability (impulsions applied to the state variables, changing velocities etc.)

Regulation laws: principles

- **Principle of inertia**
  Controls evolve only when viability is at stake.

  Most evolutions are governed by this principle: for example those that select the controls with the **smallest velocity** ("heavy solutions").



The principle of inertia

- Explains punctuated equilibrium: only when viability is at stake does selection affect speciation.

- Also describes resistance to change, habit formation and social conformism.

Feedback laws

- Inter alia, these laws describe **the objective hierarchy that is self-organizingly generated through mind-world coupling.**
- There are quite interesting observations on how developmental sequence is constrained, and how higher-order competences require feedback from lower-order ones.

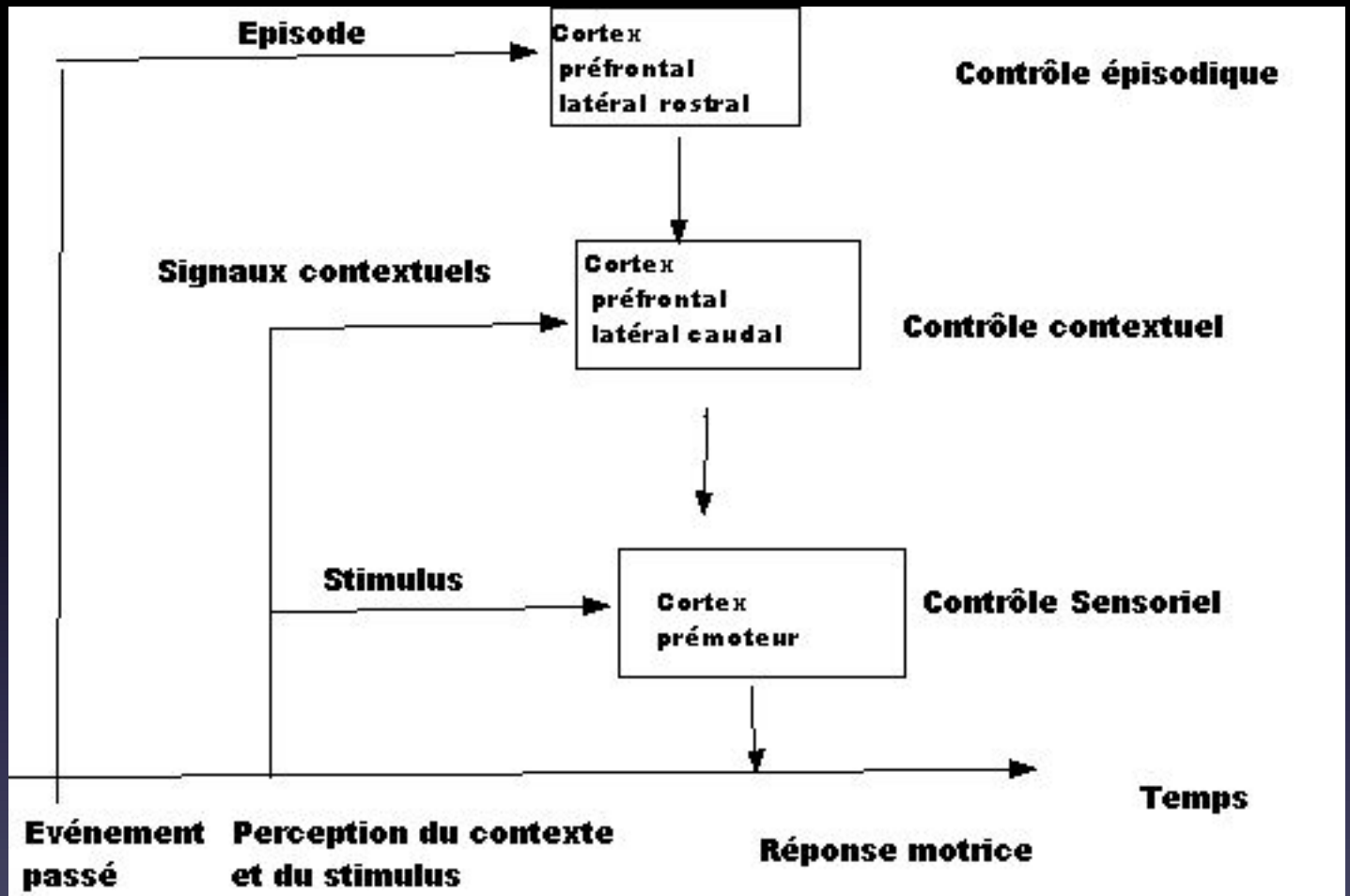


Fig. 6.1 - Le modèle fonctionnel de l'architecture cognitive frontale selon E. Koechlin (d'après Koechlin et al., 2003).

Feedback regularities

- Are exploited by the brain to predict its own abilities.
- By sampling network propagation velocity, in associative networks, **it can predict its own achievement curve in given cognitive tasks.**
  - These predictions trigger emotional feedback signals ("noetic feelings")
  - These signals in turn influence decision making (also in some non-humans)

Why is viability theory important?

- Because it allows the dynamical-teleological constraints on cognitive control to be systematically and globally characterized.
- In particular, it entails that:
  - not every command is available to a system at any given point in time and in control space
  - Not every retro-action is a source of a potentially viable command

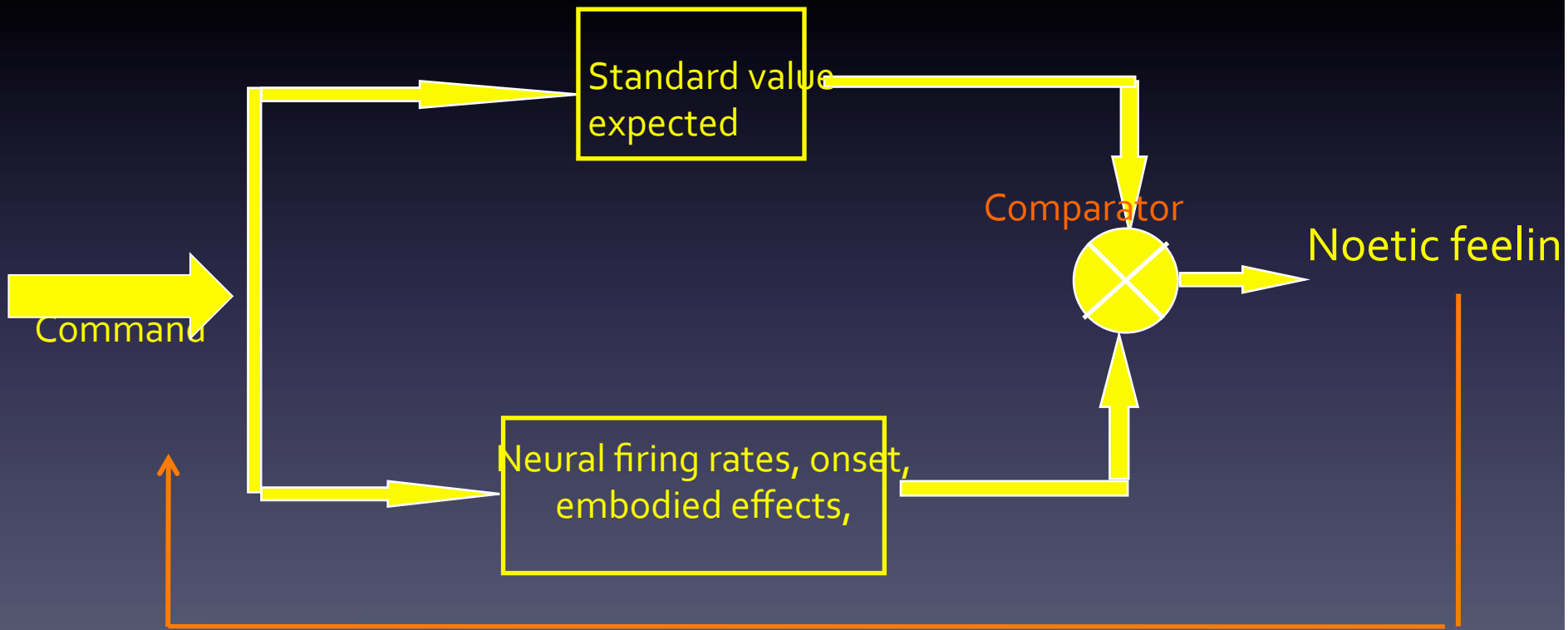
1 - The case of noetic feelings

What is the function of NFs?

Noetic feelings have 3 functions

- Evaluate correctness in past or future cognitive performance : monitoring aspect (→ next slide)
- Motivate epistemic decision accordingly: control aspect.
- Be a source of entitlement for taking one's decision to be the correct one.

Metacognitive monitoring through noetic feelings



Noetic Feelings

Predictive

- cognitive effortfulness
- Familiarity
- knowing
- Tip of the tongue
- Coherence, incoherence

Retrodictive

- Uncertainty about correct performance
- Uncertainty about existing competence
- Feeling of being right

What is the function of NFs?

- They constitute a feedback from a current cognitive task
- They express and implicit comparison between an expected and an observed value, and help select on this basis one in a limited set of viable commands
- The NFs represent « epistemic affordances », ie. the set of commands that are epistemically viable given a task, at a given time.

Example 1: TOT feelings (Schwartz et al., 2000)

Appraisal processes

Peripheral expression

Action tendencies (« affect programs »)

Subjective feelings

- Word within reach or not
- Muscular activation in tongue
- Motivates longer search in memory
- Variable in
  - Intensity,
  - Emotional content,
  - Sense of imminence

TOT : Schwartz et al., 2000

More intense

→higher resolution rate
→Higher recognition rate
→FOK

More emotional

→better recognition,
→not better resolution (retrieval blocking)

With feeling of Imminence → better resolution
→ better recognition.

Example 2: feelings of perceptual uncertainty

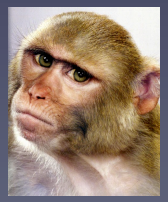
- These feelings tell us whether, e.g.,
- we are able to discriminate two shapes, two colors,
- we correctly heard a name, recognized an odor,
- Etc.

The neural correlates of procedural metacognition in rhesus monkeys

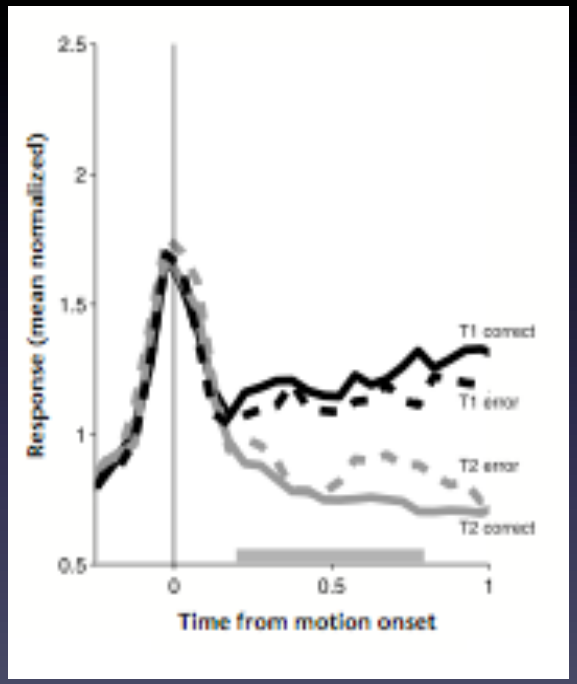
were studied in an opt-out task, where monkeys must

- discriminate whether a shortly presented stimulus is moving left or right.
- respond, after a delay, with an eye movement.
- "Sure bet" option available in some trials

(Kiani & Shadlen, *Science,* 2009)



How to implicitly access one's own uncertainty?



- Neurons predicting a saccade in a given direction respond less strongly in the erroneous decisions (dashed lines).
- This difference is the basis for judments of confidence about decision.

Kim & Shadlen, 2009

Kiani & Shadlen, 2009

- They found that the firing rate of neurons in the lateral intraparietal cortex (LIP) correlates with the accumulation of evidence, and the degree of certainty underlying the decision to opt out.
- This result fits nicely with an accumulator model of judgments of self-confidence.

The accumulator model

. Evidence for the two alternatives is accumulated in parallel, until one of the evidence totals reaches a criterion value, and the associated response is emitted.

Vickers & Lee, 1998

The accumulator model

An adaptive accumulator is a dynamic comparator, where the values compared are rates of accumulation of evidence relative to a pre-established threshold for each possible answer.

How is calibration performed?

- A secondary type of accumulator, called "control accumulator", accumulates positive and negative discrepancies between the expected and the observed levels of confidence in two independent stores.
- If, for example, a critical amount of overconfidence has been reached, then the threshold of response in the primary accumulator is proportionally reduced

Vickers & Lee, 1998).

What is epistemic viability?

To be reliable,however, noetic feelings must be:

- Well-calibrated: the standard (expected value) for a cognitive task must be based on previous sufficient, unbiased recurring feedback.
- Relevant to a given epistemic decision

Why should VT be useful to model Noetic Feelings?

- One might hypothesize, on the basis of animal evidence, that noetic feelings are an ancestral evolutionary way of being sensitive to the viability core in cognitive actions such as trying to perceive or trying to remember

Why should VT be useful to model Noetic Feelings?

- VT uses dynamic parameters to characterize control-related evaluations.
- NFs are an original sort of regulons, which, surprisingly, correlate with the dynamic properties of neural activity in first-order task, rather than with contents.

→ dynamic coupling across temporal scales?

3 – Viability theory and education

How (not) to predict one's epistemic viability core ?

If one's goal is

- to master an intended competence
  - → **Feedback: progress in the competence (effort-outcome, persistence, choice of strategies)**
- To prove one's existing competence
  - → **Feedback: performance level (grade), not relevant ../**

How (not) to predict one's epistemic viability core ?

Feedback on intended competence

- Focusses on epistemic agency,
- emphasizes the role of viable strategies (epistemic "robustness") and of sufficient motivation

Feedback on observed performance encourages competition:

→ Good grade: satisfaction, motivation to be the next winner is encouraged

→ Bad grade: failed attempt, demotivation

→ In both cases: **the justification of having a good or a bad grade is overlooked.**

How to (mis)calibrate one's confidence?

- Predictive confidence in a perceptual or memorial response often depends on having a noetic feeling.
- This feeling itself is generated by the dynamic properties of the neural activity engaged in the task (its "fluency")
- This feelings must be calibrated to be reliable.

The dynamics of the calibration

- Overconfidence in future performance in the beginner
- Experience of error leads to underconfidence
- Finally calibrated confidence occurs .. in favorable feedback conditions.

Calibration can be compromised (feedback laws from VT)

- When feedback is inappropriate (e.g. targetting performance rather than competence)
- When beliefs about tasks and competences are false (e.g. "female students are bad at doing math")
- When the concept of a viable self **interferes** with that of epistemic feedback (don't be a "nerd")
- When social attitudes lead to deny error in one's performances

Conclusion

When epistemic and social viability are conflicting

A Copernican revolution

- Teachers do not convey contents merely as a function of their own pedagogical goals and authority
- Students' cognitive goals alone can determine which contents deserve the effort of being mastered.
- Once in place, these goals allow students
  - to evaluate prospectively the differential viability of learning strategies.
  - To check retrospectively how far they are from the boundaries of the viability core for a task.

Conclusion

- Social "hyper-regulons" encouraged by a fixist view about educational contents, are interfering with the processes of epistemic evaluation and regulation.
- These hyper-regulons prevent school children from
  - Understanding that learning is a form of agency
  - Experiencing pleasure in self-monitoring epistemic activity

Research needs to be conducted on

- how to encourage children to build up their own cognitive regulons,
- how to restore epistemic regulation in children who never had a chance to develop it.

Merci de votre attention !

Ce powerpoint est mis en ligne sur:

http://joelleproust.org