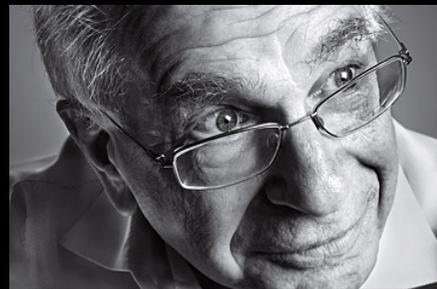


On-line seminar on Metacognition

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# Procedural or conceptual ? How metacognition guides cognitive decision-making



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# Outline

1. Introducing the contrast between two forms of metacognition
2. Evidence for dissociation between "procedural" and "conceptual"
3. Characterizing two types of metacognitive representations:
  1. Semantics and specific metacognitive functions of affordance sensings
  2. Semantics and specific metacognitive functions of attributive metarepresentations
4. Conclusion: about *aboutness*

Consensus: Metacognition regulates cognitive activity

dissensus : either through feelings or through beliefs

- To predict feasibility
- Select goal
- monitor progress to goal
- Accept or reject outcome

# Defining metacognition from its verbal "meta" prefix

. A number of researchers define "metacognition" as knowing what one knows". On their view, this involves

**Representing that one believes [remembers/perceives etc.] something (P) as true/false/clear/blurred etc.).**

ie. Metarepresenting one's own first-order thought content P along with one's corresponding attitude (belief/supposition/perception etc.) and its actual or likely truth value.

# Terminology hampers science

**The term "metacognition" was first used in the last century in an entirely different scientific context.**

- the first significant findings were those of Joseph Hart (1965) about what *he* called "memory monitoring".
- John Flavell coined the term of *metamemory* to refer to Hart's findings, on the model of the term "metalanguage" as used in philosophical logic by Tarski.
- It seemed obvious to Flavell that a feeling of knowing is a judgment about what one knows, hence a second-order representation about a first-order knowledge state.
- Research on metamemory went on taking metacognition states to consist in mechanisms whose function is to control and monitor one's own cognitive activity (Nelson & Narens, 1990).

# Currently there is still dissensus on how to define metacognition

- Under John Flavell's influence, metacognitive abilities were seen to emerge only in late preschool years (Flavell, Green & Flavell, 1995; Lockl & Schneider, 2002).
- A consensual justification of this finding **at the time** was that mental states cannot be accessed without being explicitly represented as mental states, that is: **without a capacity to read one's own mind** – a capacity that emerges at around 5 years of age.
- Evidence was found that *in verbal tests*, 3 year-old children are **unable to reliably report what they know or do not know, or assess their uncertainty** (Lockl & Schneider, 2002).

- Claiming in our present scientific context that metacognition is *by definition* a second-order state, however, has the unfortunate consequence of **making theory a matter of definition.**

# Methodological point

- We will use the term "procedural metacognition" in the sense of a non-metarepresentational kind of epistemic/informational self-evaluation, whose function is to control and monitor first-order cognition.
- This use will either be confirmed by evidence that there are indeed forms of nonjudgmental forms of epistemic self-evaluation, or disconfirmed by the absence of such evidence.

# Non-human procedural metacognition



# How to collect evidence on MC in comparative psychology ?

- Specific conditions for evidence on animal metacognition. Robert Hampton (2009)

## 1. Task structure

- There must be a primary behavior that can be scored for its *accuracy*.
- *Variation* in performance (i.e., uncertainty about outcome) must be present.
- A secondary behavior, whose goal is to *regulate* the primary behavior, must be elicited in the animal.
- This secondary behavior must be shown to benefit performance in the primary task (for example, animals must decline tests that they would otherwise have failed).

## 2. Negative constraints

### **The metacognitive responses must not be based on**

- response competition (stimuli are merely selected on the basis of their comparative attraction).
- environmental cue association.
- behavioral cue associations, i.e., “ancillary responses” (hesitation, or response latency)

## Main types of tasks eliciting Judgments of uncertainty

- Seeking for information (SI) tasks:  
Will an animal ask for information only when needed ? (Call & Carpenter, 2001)
- Buying hints when learning (Kornell, Son, & Terrace, 2007) .
- Choose-or-decline-to-respond (« opt out ») paradigm (Smith et al., 2006, Beran et al. 2010)
- Wagering tasks (risk icons for betting on a given response).
- Action control based on internal vs external confidence feedback (Beran et al. 2015)

# Evidence for metacognition in monkeys

- Rhesus monkeys decline most the most difficult trials in visual discrimination tasks (Shield, Smith & Washburn, 1997) and in memory tasks (Hampton, 2001).
- They generalize their U- responses to new tasks. (Washburn, Smith & Shields, 2006)
- Macaques also use U-responses with blocked feedback (Beran, Smith, Redford & Washburn, 2006)



Dense



Sparse



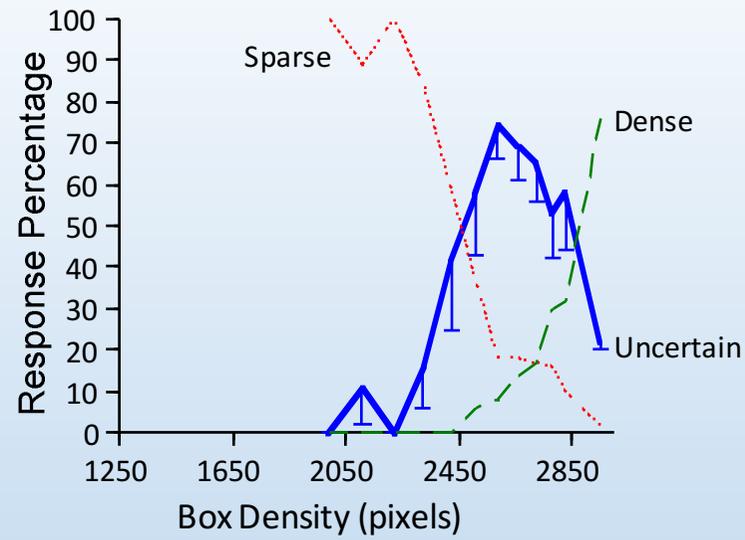
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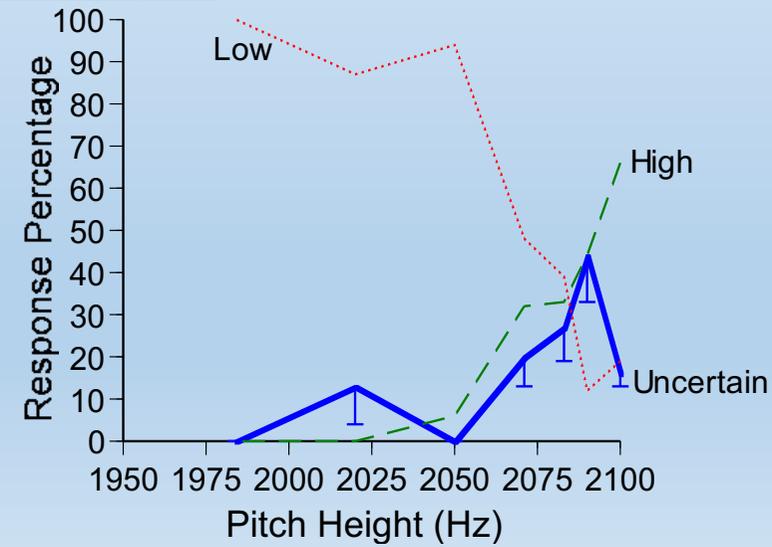
Uncertain



### Macaque

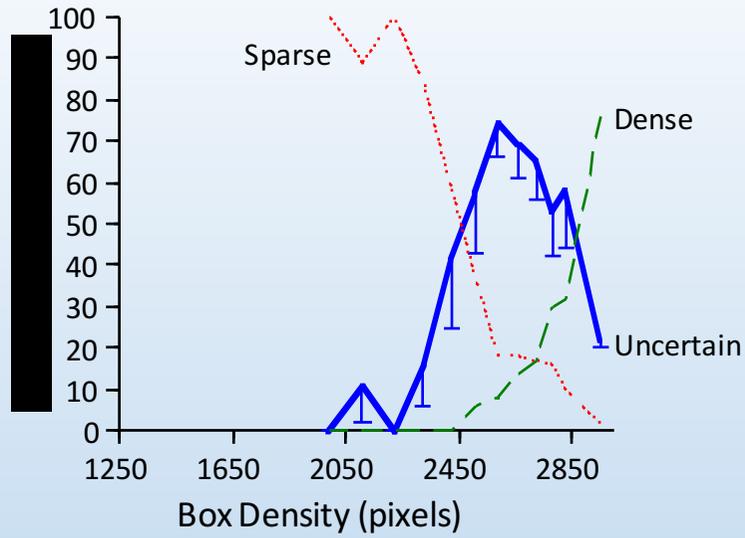


### Dolphin

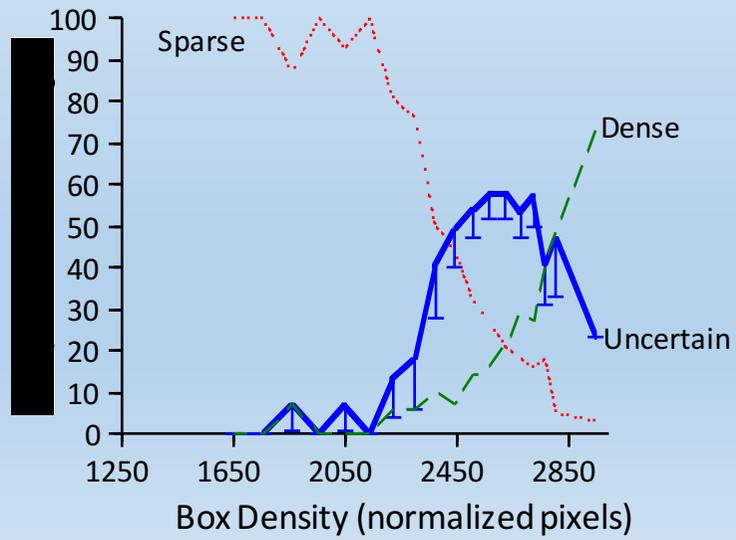




### Monkey



### Humans



# Metacognition in Phylogeny:

## Yes

- Primates:
  - chimps and orangutans search for info (SI)
  - Chimps have MC control
  - Rhesus macaques (SI & U-R)
- Marine mammals:
  - Bottle-nosed dolphins U-R
- Pigeons, bantams (Fujita & al, 2011): retrospective U-R
- Rats: Kepecs et al. 2008

## No

- Pigeons: no prospective U-R (Sutton & Shettleworth, 2008)
- Capuchin monkeys: no SI, no U-R (Beran et al. 2006)

Evidence for procedural  
metacognition from  
developmental psychology

# Balcomb & Gerken, 2008

## Evidence for procedural metacognition in 3 yr olds

- Based on a non-verbal opting-out task replicating the memory-monitoring paradigm first used by Shields (1999) and Smith et al. (2003).
- Children learned a set of paired associates, and were given a recognition memory test, with an option to skip uncertain trials.
  - accuracy for accepted items was higher than for skipped items (as shown by a subsequent forced-choice recognition test).
  - This finding indicates that the children used metacognitive information to flexibly adjust their decision to item difficulty.

# Developmental dissociations between attribution and self-evaluation

- Young children are **unreliable in reporting their underlying knowledge states** (Smarties task, Gopnik & Astington 1988, partial knowledge, Rohwer et al. 2012, lexical knowledge: Marazita & Merriman, 2004)
- However, they **can reliably monitor their perception & memory in implicit decisions, e.g.**
  - opting out from a task. (Balcomb & Gerken, 2008) Bernard; Trupist; Clément.(2014)
  - Fixation patterns on a confidence scale (Paulus, Proust & Sodian, 2013).

## Goupil, Romand-Monnier & Kouider (2016)

- 20-month old preverbal children **can non-verbally ask adults for help in a strategic way**, in order to decline the choices which they assess as too difficult. (also: Goupil & Kouider 2019)
  - **Error-related negativity** signals are elicited when (preverbal) infants make an incorrect choice (Goupil & Kouider 2016).
- Infants can estimate decision confidence, monitor their errors, and use these metacognitive evaluations to regulate their behavior.

## Kim, Paulus, Sodian, Proust (2016): dissociation reporting/informing

This study examines 3 and 4 year-old performances

- - in an explicit mc task (do you know or not where the object is located?) replicating Rohwer et al. 2012
- In an implicit mc task (do you want to inform an adult with no visual access to object's aspect and location?)

→ 3 and 4 yr-olds are able to provide information in a strategic way as a function of what they know, but are unable to accurately report when they know.

DISSOCIATIONS PROCEDURAL-  
CONCEPT-BASE METACOGNITION  
IN ADULT HUMANS

# DISSOCIATIONS IN ADULT METACOGNITION

- Subjects can change their decision when they learn that a given feeling of fluency is predictively misleading
- **but under time pressure they will act again on it:**
- Nussinson & Koriat's (2008) anagram experiment.

# KORIAT AND ACKERMAN (2010)

## dissociation self/other JOL

- Subjects are invited to form judgments of learning (words pairs) in a self-pacing learning task :
  - About their own performance
  - About other's performance (no access given to specific stimuli)
- Their judgment of others' learning was asked
  - Either before they themselves performed the task
  - Or after they completed it.

# Dissociation

## Observing others first

Participants rely on the **incorrect naive theory** that the longer you study a pair of words, the better you can remember them.

## Performing first

Participants **correctly judge** that the longer a pair of words is studied, the less well it will be remembered.

An implicit memorization effort heuristic guides the decision.

(Koriat & Ackermann, 2010)

## Two types of explanation for dissociations

1. Additional executive demands in verbal tasks? But, given the animal evidence, this explanation fails to be parsimonious.
2. Comparative and prelinguistic infants' results suggest rather: Different types of representation involved.

Two representational structures?

# Semantics and function : proposal

- Procedural metacognition is based on an associative mode of fluency-sensitive evaluation, resulting in metacognitive feelings.
  - FUNCTION: guide engagement/avoidance in cognitive tasks
- Concept-based metacognition is based on
  - propositional reasoning about competences and self-identity (a truth-sensitive evaluative structure) **along with:**
    - Contextual self-identity preferences
    - fluency-based evaluations
  - FUNCTION: report/justify/revise engagement and avoidance in cognitive tasks

# Guiding ideas : Gawronski & Bodenhausen, 2006

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## Associative and Propositional Processes in Evaluation: An Integrative Review of Implicit and Explicit Attitude Change

Bertram Gawronski  
University of Western Ontario

Galen V. Bodenhausen  
Northwestern University

Other "dual-processing" theories:

Bazerman et al., 1998; Kahneman, 2003; Nussinson & Koriat 1999,  
Lieberman et al., 2002; Sloman, 1996; Smith & DeCoster, 2000; Strack &  
Deutsch, 2004

# Two types of evaluative tendencies

1. **Associative processes** give rise to **implicit attitudes**, ie automatic affective reactions automatically activated by a stimulus.

Example: racial prejudice demonstrated by Greenwald Implicit association test (IAT)

- no assignment of truth values;
- No endorsement involved
- Pattern activation : relative fit between stored information and present cues.
- Primary influence of context on type of affective reaction.
- "not truly unconscious" (attending feelings makes them conscious) but often not reportable.

- **2. Propositional processes** give rise to **explicit attitudes**
- Example: "I believe in the equality of capacities among humans"
- Based on reasoning (i.e. with attention to epistemic constraints such as coherence and evidentiality):
  - ✓ Truth values are assigned
  - ✓ Endorsement present
  - ✓ Conscious and thus, reportable

# Dual processing in metacognition

- Implicit, procedural
- Affective
- no assignment of truth values;
- No endorsement involved
- assesses fluency
- Primary influence of context on type of affective reaction.
- Based on unconscious heuristics, "cross-over" to conscious feelings
- Explicit, concept-based
- Not centrally affective
- Truth evaluable
- Endorsable
- Assesses truth value and cognate norms
- Influence of context : on relevant beliefs and inferences
- reportable

Our ultimate research question: how to procedural and declarative mc differ functionally ?

- Function should be inferred from semantic structure.

→ **first research question: what is exactly their respective semantic structure?**

- Semantic structure can be derived

**1. For procedural metacognition:**

from behavioral, neural and computational evidence involved in epistemic decision-making

**2. For concept-based metacognition:**

From an analysis of the types of reasoning and behavioural guidance involved in the production of metacognitive metarepresentations.

# Methodological constraints

- The semantic analyses that are to be discussed need to extend beyond metacognition.

If metacognitive feelings have a representational content, then other feelings should also have it, with a similar structure and function.

If concept-based metacognition has the structure of metarepresentations, this structure must be present outside the realm of metacognition.

The semantic structure of  
procedural metacognition is that  
of feelings

# Semantics of procedural metacognition

**As all emotions**, noetic feelings have representational structure as soon as they track the likely correction of a recurrent cognitive activity.

Their semantic structure needs to include

- a combination of valence and intensity measuring subjective uncertainty
- Indexical markers of place and time
- Indexical marker to type of activity (this opportunity)
- A reactive program of engaging in/declining the current activity
- Hypothesis: **these elements** are part of an evaluative attitude, called an **affordance-sensing**.

As the word "affordance" suggests,

- Such an attitude has the double function of **detecting opportunities and acting on them.**
- An AS is a **conscious, non-propositional attitude whose function is to detect and evaluate** the opportunities and risks present in an agent's current environment.
- On these attitudes: see philosophers Cussins (1992), Dreyfus & Kelly (2007), Gendler (2008), Griffiths & Scarantino (2009), Proust (2015), Strawson (1959), and psychologists Gawronski & Bodenhausen (2006).

# The representational structure of affordance sensings (Proust, in prep .)

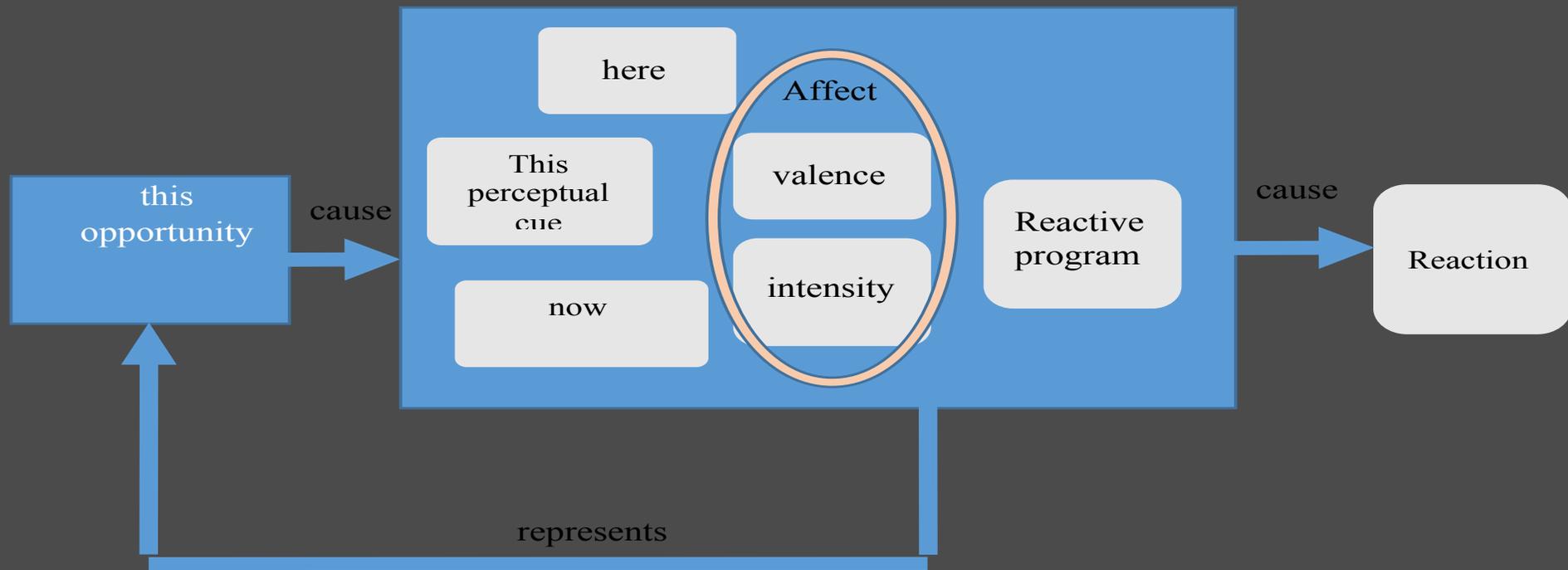


Figure 5

Ce schéma présente les éléments d'un ressenti d'affordance donné en tant qu'il représente subjectivement une opportunité. Il est constitué par des relations associatives entre un indice perceptif d'opportunité, l'affect

# Acting requires **minimally** a sensitivity to one of two types of "affordances":

- Opportunities & risks in the environment: **world affordances**
- Opportunities & risks in information acquisition/retrieval: **cognitive affordances** (Proust, 2013, 2015, 2016)



# Differentiating two kinds of affordances

- Evaluating likely reward in acting on a given external opportunity (sensing a **world affordance – physical or social**)
- Evaluating likely cognitive success in cognitively acting on a given opportunity (sensing a **cognitive affordance**)

Depend on different sources of information and are processed by distinct brain structures. (Kepecs & Mainen, 2012).

Most decisions to act, however, integrate cognitive uncertainty and world affordances, including social affordances (being liked, recognized, approved, etc.)

# Cognitive "affordance" sensing

- Does not require concepts such as uncertainty, memory, perception, reliability.
- It requires
  - Pursuing a **cognitive goal** ( < sensitivity to a given informational need)
  - **detecting the present availability of information** or lack thereof while performing a task (cognitive monitoring)
  - **Adjusting commands to task progress ("control sensitivity")**

# Noetic feelings represent ("sense") cognitive affordances

## Examples:

- Affordance  $f_{\text{familiar/rememberable, clear}}$ , [Time= present task],
- [Valence<sub>a</sub>],  $f_{\text{positive}}$
- [Intensity<sub>a</sub> (on a scale 0 to 1)],
- [motivation to act of degree<sub>d</sub> according to action program<sub>a</sub>].  $f_{\text{Identify! Remember! Accept!}}$
- New cues can be added over time

# Functions

1. Regulate cognition (control and monitor it) (Nelson, & Narens, 1990)
2. in a **swift, non-costly way (Proust, 2015)**
3. **"Common currency" for decision-making (conscious awareness)** (Sugrue et al. 2005) enables
  - ✓ **Fusion** of feelings from different affordance-sensings
  - ✓ **Decision flexibility based on most powerful opportunity in a context.**
  - ✓ **Availability to episodic memory** (and verbal report in humans)
4. **Ability to remember prior encounters**

# The semantic structure of metarepresentations

Definition : A **metarepresentation** is a representation that refers to – is about -- the **content** of a first-order representation.

- **Metarepresenting one's own or another's belief [it is raining outside consists in forming a metabelief such as:**

(1) I believe that it's raining outside

(2) Anna believes that it's raining outside.

- Crucially, (1) and (2) have the same structure
- This holds as well for other attitudes such as: desiring, perceiving, reasoning, intending, hoping

## Implications of the definition of MR

- Let us suppose that a thinker does not understand the content of a representation, but can still recognize when this representation is produced (e.g. through its sound pattern)
  - Example : an animal learns that a certain verbal pattern predicts trouble. It has no idea, however, of what this pattern exactly means.
- There is, in this case, **no metarepresentational use of P**. It is just a case of predicting a world property on the basis of a perceptual cue.
- This applies to the human brain when it predicts correction in a cognitive task: it has no access to mental contents, only to its predictive dynamic features.

# Two semantic accounts for metarepresentations

## View 1: opacity Quine (1953)

- *Referential opacity is a defining feature of MR: a name may occur referentially in the embedded statement and yet not occur referentially in the embedding one.*
- **opacity suspends the constraint that the semantic properties of referentiality and truth in the embedded representations should determine the semantic properties of the whole proposition.**
- Opacity results from the fact that, in the context of attitude reports, the object-representation is not *used* to make an assertion, i.e., to describe the world; it is, rather, *mentioned* as being the content of a propositional attitude.

## Implications of the opacity view: Leslie (1994)

- **About reference** : truth of a metarepresentation compatible with **reference** failure of the embedded proposition:
  - "Peter believes that Santa Claus will visit his home" can be true.
- **About truth value**: truth of a metarepresentation compatible with **falsehood** of the embedded proposition:
  - "John believes that SARS-CoV-2 leaked from the Wuhan Institute of Virology"
- **Decoupling** embedded content from embedding content
  - explains how a child makes sense of her own pretending.
  - allows mindreading inferences to be truth evaluable.

## Objections to the opacity view: Recanati 2000

- It fails to account for the fact that metarepresentations offer a characterization of the world **as seen from the ascriber's viewpoint**.
- Second order reference (being *about a representation*), then, should **not** sever the link between the first-order representation and what it is about.
- Why should, for example,
  - **[SARS-CoV-2 leaked from the Wuhan Institute of Virology]** change its meaning when embedded in the metarepresentation:  
**"John believes that SARS-CoV-2 leaked from the Wuhan Institute of Virology"**.

## View 2: transparency

The fact that a metarepresentation is about a specific first-order representation does not suspend the capacity of the embedded representation to represent the state of affairs it expresses when unembedded.

Slogan : metarepresentation is **“pretence cum betrayal”**:

The ascriber first **simulates** the embedded representation;  
Then she **evaluates it from outside** the ascriber's world.

# Implications

- **Some belief reports fail to be metarepresentational because they lack iconicity** (they cannot be simulated).
- For example : (1) [**Peter has the same beliefs as John**] is not metarepresentational.
- An attitude verb **indicates how to simulate and shift circumstances** (for example: John believes, imagines, finds plausible, that P etc.)
- **BUT an attitude verb is not mandatory for MR:** [for John, the earth is flat]

## Shifting context requires :

- **Inhibiting one's own context of evaluation (own background knowledge)**
- **Selecting and applying the concepts and norms that determine the kind of shift to be made (attitude, place, time, truth, plausibility, coherence, informativeness)**
- **Selecting one's epistemic decision in the shifted content**

How does this apply to concept-based  
metacognition ?

## A twin-planet case

**PLANET 1** Teacher reminds the students that today they have a control in maths

- Mary is asked to perform a mathematical exercise
- She reads the problem statement
- **She finds it difficult**
- **She infers that "it is not for her"**
- **Anticipating failure, she does not seriously attempt to solve the problem, AND FAILS**

**PLANET 2** Teacher introduces her course with the stunning contributions of f mathematician Sophie Germain in number theory. She then goes on to her routine

- Mary is asked to perform a mathematical exercise
- She reads the problem statement
- **She finds it difficult**
- **She infers that the challenge is worth it.**
- **She seriously attempts to solve the problem, AND SUCCEEDS**

# Context-shifting

Cognitive actions are performed in different contexts

Each context comes with a specific salient identity-concept (Yan & Oyserman, 2012).

For one and the same feeling in input, (effortfulness) context shifts (associated with identity, value, and social opportunities)

- Change salient beliefs

- Motivate different goals.

# Steps of metarepresentational metacognition based on the iconic view of MR

Case 1: if procedural assessment is available

- The thinker first **simulates activity and** own procedural assessment
- Then she **evaluates it from a perspective that depends on salience of theories and concepts applying to the current activity.**

# Steps of metarepresentational metacognition based on the iconic view of MR

Case 2: if procedural assessment is **unavailable or discredited**:

- The thinker first **simulates** herself and others engaging in the activity as in Koriat & Ackerman 2010 (from the outside, unengaged mode)
- Then she **evaluates her simulation from a theory-based viewpoint**: "me-like things to do" (Oyserman), theory of fixed vs. flexible intelligence (Dweck), theory of time efficiency (Koriat/Ackerman).

- **In both cases:**
- **Context shifting is heavily dependent on primed, activated representations associated with the present context:**
  - **School self representations**
  - **Gender self**
  - **Social group self**
  - **Religious self**
  - **Ethnic self etc.**

# Granting semantic differences, how does verbal report gain access to affordance sensings?

- Hypothesis (discussed in Proust 2013 p. 68 sq)
- Attitude words are first learned through the kind of shallow metarepresentational procedure identified by Gareth Evans under the term "ascent routine"

## Ascent routine

- In making a self-ascription of belief, one's eyes are, so to speak, or occasionally literally, directed outward – upon the world. (...) **I get myself in a position to answer the question whether I believe that  $p$  by putting into operation whatever procedure I have for answering the question whether  $p$ .** If a judging subject applies this procedure, then necessarily he will gain knowledge of one of his own mental states. (...) But it seems pretty clear that mastery of this procedure cannot constitute a full understanding of the content of the judgment “I believe that  $p$ ” (Evans, 1986, 225).

## 4 functions of concept-based metacognition

1. Describing sensed **fluency in proto-conceptual terms (shallow report)** (young children's "I know that P".)
2. Rationalizing cognitive guidance of affordance sensings through concepts and theories. (adults' "I know that P".)
3. Revising / discrediting cognitive guidance of affordance sensings through concepts and theories (twin Mary)
4. Elaborating : control the production of affordance sensings in the service of normative goals (for example Descartes' rules of method)

# René Descartes

## *Discours de la méthode, Rule 3*

- “To conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex; assigning in thought a certain order even to those objects which in their own nature do not stand in a relation of antecedence and sequence.”



# Conclusion

Why does (1) (Procedural metacognition) seem to many researchers to collapse with (2) (concept-based metacognition) ?

- i. Because humans are prompt in expressing their evaluations in conceptual terms. Hence it is difficult to pry apart (1) from (2) in ordinary life.
- ii. Because the definition of metarepresentation (as "representation about a representation") seems to be self-explanatory. However, a careful analysis of the cognitive mechanisms underlying "metarepresentational **aboutness**" make things much more complex than it seems

# Affordance sensings are not "about" affordances

1. They sense opportunities to act on them, they do not describe them

Affordance sensings are reactively generated by current cognitive activity and are merely associated with current goal representation.

2. **Metarepresentations, in contrast, offer a descriptive evaluation of a first-order content.**

Being descriptive, metacognitively relevant metarepresentations (for example: the cognitive competences of males versus females) can be transmitted in explicit theories, but also in specialized toys, career offers, division of domestic labour etc)

Thank you for your attention !

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<http://joelleproust.org>