

Brain, Mind & Consciousness

CIFAR

June 1-2, 2021

Evidence for the dual role of feelings and attitudes in metacognitive awareness: educational implications

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L'ÉDUCATION NATIONALE**



Outline

1. Metacognition & metacognitive awareness: an introduction
2. Evidence for dual processing in metacognition
3. Representational feelings versus propositional beliefs :
Two formats of conscious thought ?

Conclusion : Educational implications

1. Metacognition & metacognitive awareness

Defining metacognition

• CONTROL

Consists in

- selecting a cognitive action,
- adjusting effort to expected rewards,
- modifying commands as a function of obstacles encountered on the way to the goal
- quitting a task,
- channelling outcomes to other mental areas.

• MONITORING

Consists in using feedback from control and from performance to predict discrepancies between expected and observed cognitive outcomes at several crucial junctures of the task.

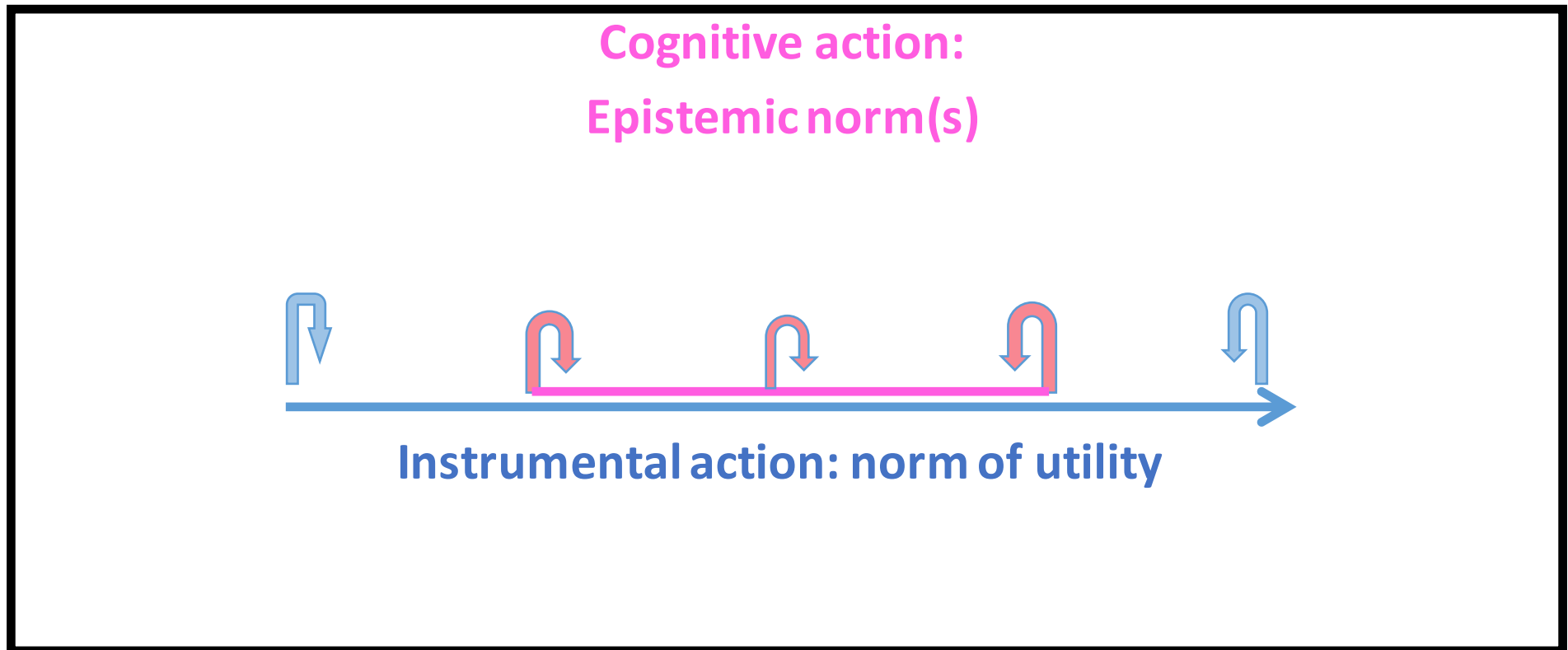
Defining cognitive action

A cognitive action consists in **using compensatory mechanisms** to maintain a trajectory toward a **cognitive (informational) goal**

Harry Frankfurt "The problem of action"



The embedded structure of cognitive action



The 3 targets of metacognitive monitoring

1. Goals :

1. **Feasibility:** is this goal achievable at all at present ?
2. **Chances of successful completion**

2. **Progress toward the goal:** does the action move in the anticipated direction?

3. **Final outcome :** is the outcome likely to be correct ?

Conscious awareness seems to play a role at each juncture of a cognitive action

1. **Goals** (**conscious imagery** associated with WM), + predictive monitoring:
 1. Prediction of feasibility: is this goal achievable at all at present? (e.g. **feeling of knowing**)
 2. Prediction of success (**feeling of confidence**)
2. **Progress toward the goal**: does the action move in the anticipated direction? (e.g. **feelings of understanding/confusion, feelings of error**)
3. **Final outcome** : is it correct ? (**feeling of being right**)

Variety of cognitive actions generate very different types of metacognitive awareness

- Metaperception
- Metamemory
- Metareasoning,
- Metacomprehension (e.g., in reading)
- Consciousness **may or may not depend on** metacognition (Seth, Edelman, & Baars, 2005).
- We will explore its role **within** metacognition

Two inter-related research questions

1. What is the representational basis of metacognitive **phenomenal awareness** ?
2. How does documented **duality** in metacognitive processing fare with **unicity** in phenomenal awareness ?

2. Evidence for dual processing in metacognition

Dual-process theory (applied to human metacognition)

(Koriat & Levy Sadot (1999))

- There are two informational sources used by agents to regulate their own cognitive activities:
- activity-dependent indicators are "experienced based": "noetic" feelings
- inferences from naive theories about : one's mind, the task, etc. are "concept based".

The **weight** given to the different predictive cues varies with conditions and with practice. [Koriat \(1997, Koriat & Levy-Sadot 1999\)](#)

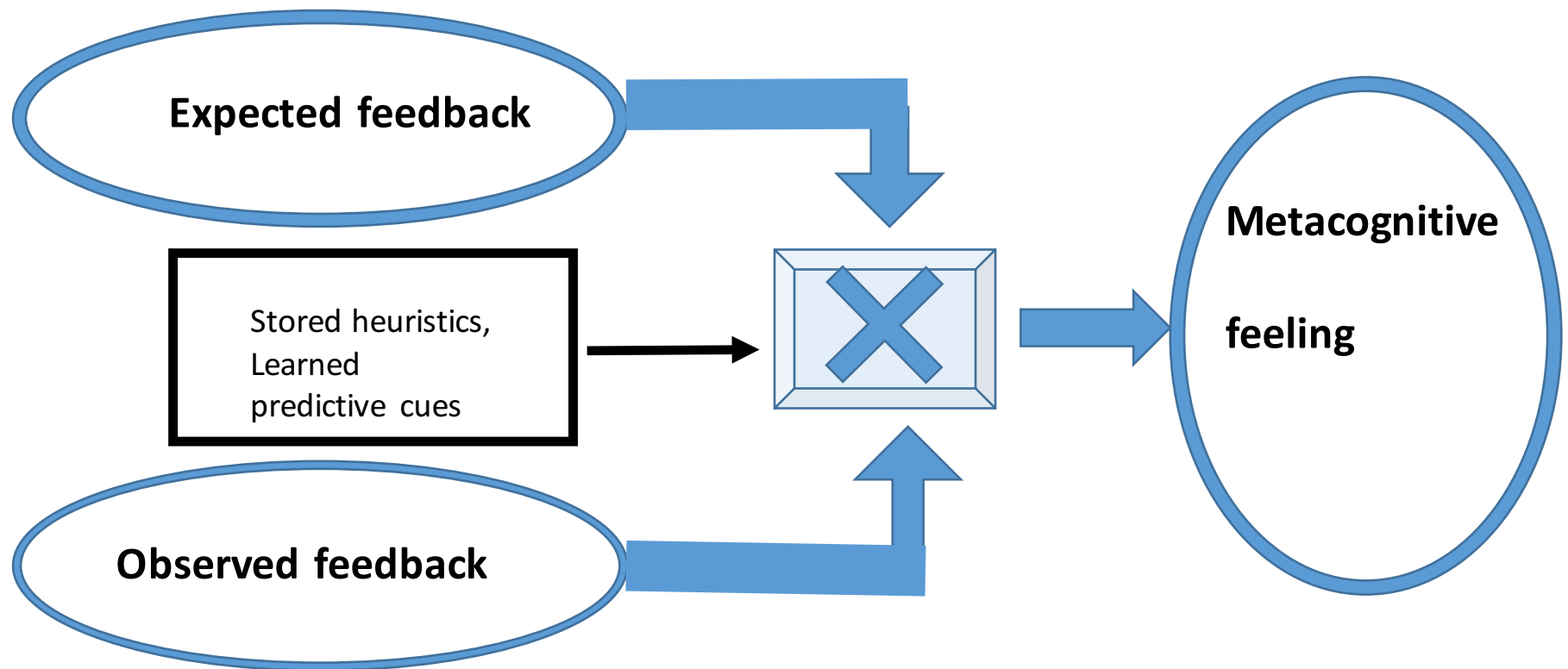
At first (in a metamemory task):

- Subjects use a **theory-based** type of evaluation (theory of the task, or theory of their competence in the task)

With repeated practice:

Processing changes from a theory-based to a **heuristic-driven subjective experience**

Heuristics are used by comparators, whose output are metacognitive feelings



Predictions based on different informational sources

(Koriat & Levy Sadot (1999))

- **Phenomenal immediacy of metacognitive feelings** tends to create an impression of transparent or accessible content
- **HOWEVER**, these feelings are not based on the *content* of the associated cognitive activity, but **on its vehicle** (eg, activity onset, accumulation profile, etc.)
- **Predictive inferences drawing on theories and beliefs in contrast**, are content-specific: they are a basis for explicit self-justification. (Frith, 2012)
- They are often taken to be a form of self-directed mindreading.

Predictions based on different informational sources

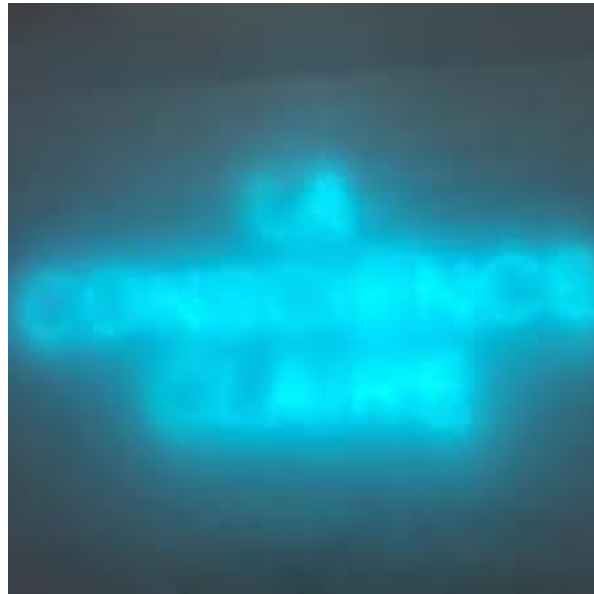
(Koriat & Levy Sadot (1999))

A primary kind of evidence for a dual-process view of metacognition consists in dissociations in cognitive decision-making

- in adults
- in infants and young children
- In nonhumans

Evidence for dissociation in human adults

Jean-Michel Alberola, La
conscience claire, 2014



Evaluating activity in action versus reporting/attributing knowledge

Procedural evaluation

- Nussinson & Koriat (2008): Anagram **difficulty rating (for others)** based on subjective fluency
- Koriat & Ackerman (2010): JOL **inversely** correlated with study time
- Thomson & al (2013): bat and ball problem **failed**

Concept-based evaluation

Strategic revision after debunking **becomes inoperant under cognitive load.**

JOL **directly** correlated with study time

Bat and ball problem **solved**

Evidence for dissociation in human children



Evaluating activity in action versus reporting/attributing knowledge

Procedural evaluation

Verbal report of knowledge

False belief tests

- **20 mth olds infants ask for help when they know they don't know**
(Goupil, Romand-Monnier & Kouider, 2016)
- **12-month old and 18-month-old infants persist in their choices** only when they are likely to have been correct and change their mind when they are likely to have been wrong
(Goupil, & Kouider, 2016)

No verbal report available

No verbal report available

Evaluating activity in action versus reporting/attributing knowledge

Procedural evaluation

- **opting out from a memory task.** in 3 year-olds (Balcomb & Gerken, 2008)
- **opting out from a perceptual discrimination task.** in 3 year-olds (Bernard, Clément & Proust, 2015)
- **Correct fixation patterns on a confidence scale for memory** in 3 and a half year-olds (Paulus, Proust & Sodian, 2013).

Verbal report of knowledge

False belief tests

- Untested, but FBT typically failed
- At chance in FBT
- At chance in reporting confidence

Evaluating activity in action versus reporting/attributing knowledge

Procedural evaluation

- In a partial knowledge condition, 3- and 4-year-old children **perform correctly** when asked to **accept or decline informing** another person about hidden content of a box.

(Kim, Paulus, Sodian & Proust, 2016)

Verbal report of knowledge

False belief tests

- Same children **overestimate their own knowledge** when asked to **verbally report whether they know** the hidden content of a box

Evidence for dissociation in non-humans

Main types of tasks eliciting decisions under uncertainty

- **Seeking for information**

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 ») (Smith et al., 2006, Beran et al. 2010)

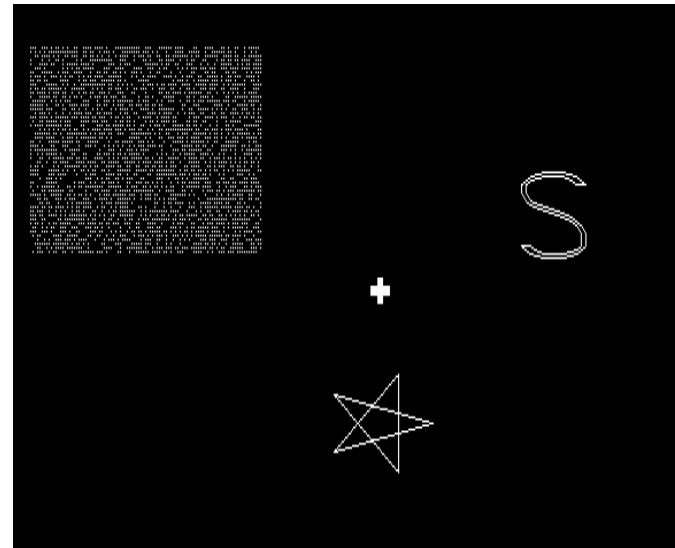
- **Wagering** (betting on a given response).(Kepecs & Mainen, 2012, Miyamoto et al. 2017))

- **Action control** based on **internal confidence feedback** (Beran et al. 2015)



Dense

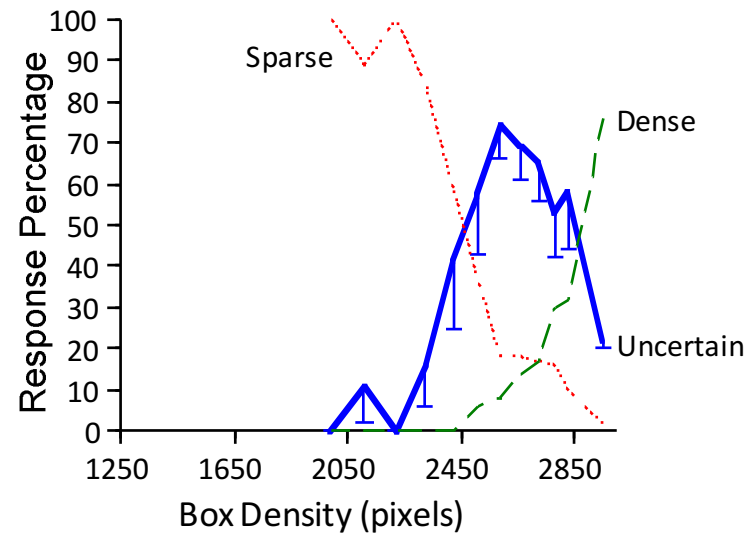
Sparse



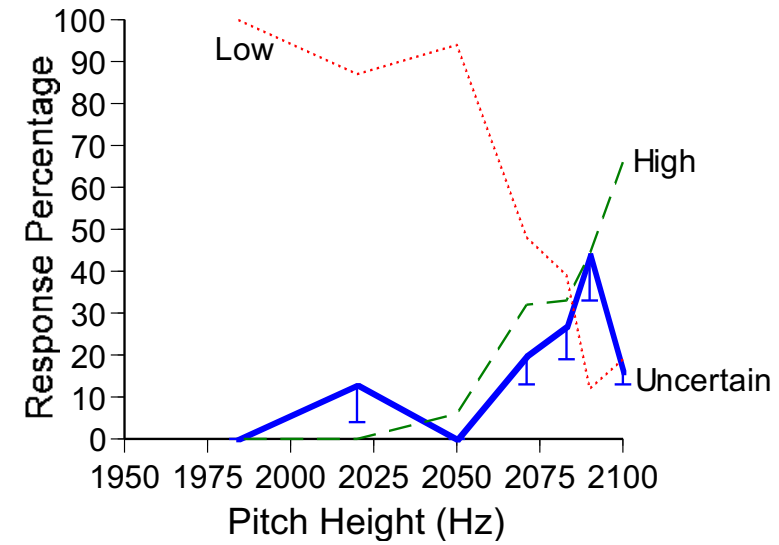
Uncertain



Macaque

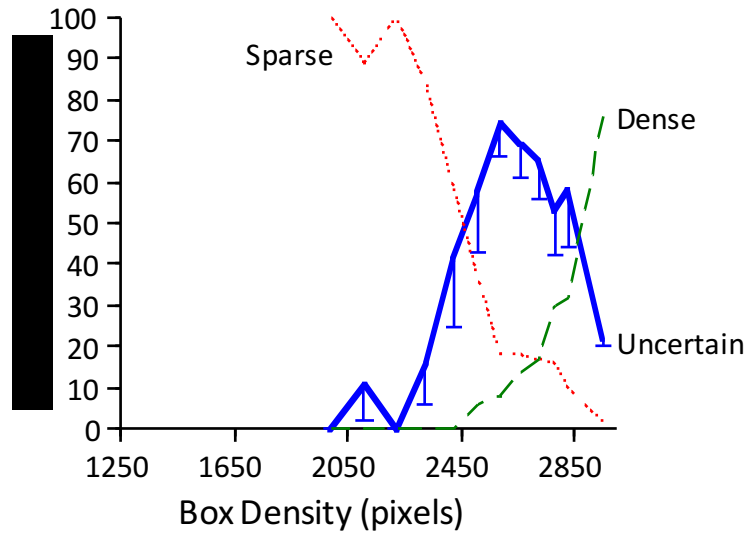


Dolphin

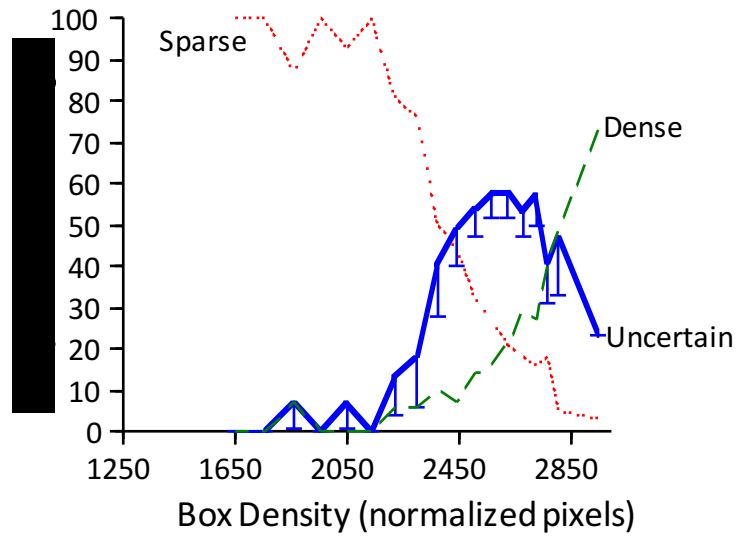




Monkey



Humans



What monkeys can do

- They can **solve the 5 types of tasks** in perceptual discrimination and memory paradigms
- They can **generalize their uncertainty responses** to new tasks.
- They can also use uncertainty responses **with blocked feedback** (which demonstrates that these are not conditioned responses)

3. Representational feelings versus
propositional beliefs :
Two formats of conscious thought ?

Hypothesis 1 : Difference in processing associated with differences in representational format

- **Metacognitive feelings**

- Express **GRADIENTS** of valence, intensity **associated to a detected subjective opportunity** (a relational property)
- In relation to a target (goal or step) for a **current or upcoming cognitive action**.
- **No second-order available in this format.**
- **Norm : predictive efficiency, adequate action guidance**

- **Propositional format**

- **first-order: Subsumption** of an **object (reference)** under a concept, and **inferential links between concepts**, generate propositional knowledge.
- **Second order:** a first-order content is **embedded in a higher order** attitude (e.g. a belief, or a desire), generating self/other knowledge.
- **Norms: truth, consistency among representations, deductive power**

Hypothesis 2 : Difference in representational format is reflected in forms of awareness

- **Metacognitive feelings give access to a non-conceptual form of knowledge**

track and evaluate **affordances** (opportunities and risks) from a subjective viewpoint

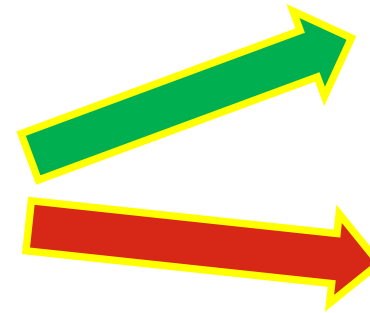
represented by **structured memory schemata** where subjective well-being plays a central role

- **Propositional knowledge**
- Represents facts and regularities **in a detached way** (concepts and objects represented from a third-person perspective)
- **Contains expressive redescriptions of noetic feelings and other nonconceptual forms of subjective experience**

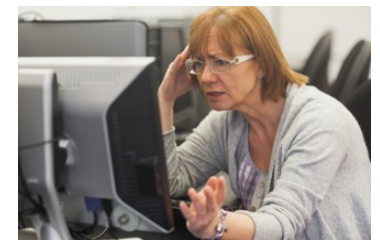
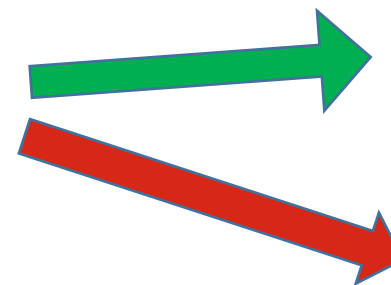
Representations of type 1 metacognition

Acting requires a sensitivity to "affordances"

- **Opportunities & risks** in the environment: **world affordances**



- **Opportunities & risks** in information acquisition/retrieval: **cognitive affordances**



Semantics of procedural metacognition : a proposal

All kinds of affordance sensings, including noetic feelings are specific structured representations stored in memory, that guide decision-making in all kinds of domain.

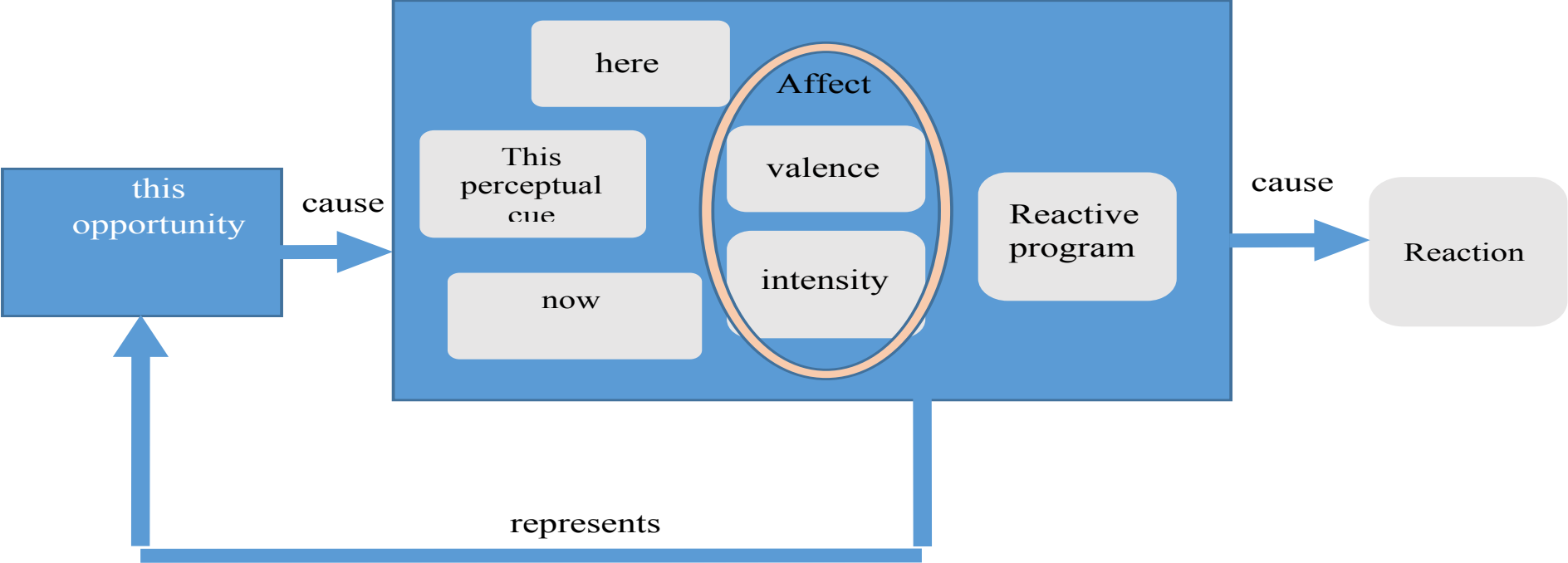
Being **memory schemata**, they have a structure including the following slots:

1. **Intentionality** : target opportunity (e.g. recalling, discriminating)
2. **Subjectivity** (feeling of dis/conformity to agent's own interest or well-being)
3. **Time** : **present** experiencing (or simulation thereof).
4. **Valence gradient** : **positive or negative**
5. **Intensity gradient** (**power to attract attention, impact on bodily markers**)
6. **Action program**

Similar approaches

- Memory research:
 - Silvan Tomkins: Script theory 1978
 - Roger Schank: Schema theory 1990
 - Joseph LeDoux : Preconscious schemata theory 2020
- Psychology:
 - Gawronski & Bodenhausen 2006
- Philosophy
 - Bermudez 2003
 - Cussins 2006
 - Dreyfus & Kelly 2007
 - Gendler 2008
 - Griffiths & Scarantino 2009
 - Strawson 1959

The representational structure of affordance sensings



Examples of cognitive affordance-sensings

Affordance_{familiar/rememberable, clear}, [Time=
present task],

- [Valence_a]_{positive}
- [Intensity_a (on a scale 0 to 1)],
- [motivation to act of degree_d according to action program_a]. Identify! Remember! Accept!
- New predictive cues can be added over time

How is a noetic feeling felt as
being about this task ?

Response

- No conceptual interpretation needed
- Task goal is part of the schema structure for affordance sensings:
 - **The slot "goal" is automatically filled in by a given icon**
 - **In connection to the sensed affordance + action program (along with other slots for valence, intensity, etc.)**

The conscious core of an affordance-sensing

- A motivational **goal-index** (an idiosyncratic imaging **icon**)
- **An evaluative prediction through a subjective experience :**
 - **valence** + or - : *motivational gradient scale* (preparing action type)
 - **intensity**: *intensity gradient scale* (assessing importance and effort regulation)
- **Evaluation is embodied through *markers* produced at time t**
 - **Distributed in various bodily "affective metrics"**
 - **express reactive affects**
 - **pre-select an action type**

The nonconscious parts of an affordance-sensing

The implicit antecedents for goal imagery, felt valence and intensity, for example:

- **Cue familiarity:** elicited by the terms of the question (Reder, 1987, Metcalfe, 2000)
- **Overall accessibility** of pertinent information regarding the target: elicited by the activity triggered by the question (Koriat, 1993)
- **Fluency heuristic:** responses that come to mind quickly are deemed correct. (eg: priming experiments as a source of confidence enhancement: Kelley & Lindsay, 1993)

The nonconscious parts of a metacognitive affordance-sensing

- **Predictive neural dynamics:** (Kepecs & Mainen, 2012).
- **Predictive interoceptive cues** from the respiratory, circulatory, digestive, and endocrine systems: (Barrett & Symons, 2015, Park & Tallon-Baudry, 2014).
- **Proprioceptive (postural, facial) cues** (corrugator/zygomaticus): (Stepper & Strack, 1993)

Type 2 metacognitive awareness

The conscious core of predicative thought

Option 1: predicative thought has its own form of conscious awareness

- **Consciously perceived phonology of concepts indexes nonconscious semantic networks** (Jackendoff, 1987)

Option 2: Phonology might index **non-conscious/preconscious simulations** that activate relevant components in **episodic memory**, including **affordance sensings** (Barsalou 2005, for "convince", "arithmetic",)

- In conversation, valence is **redescribed** through specialized expressive "**evaluative concepts**" and through **intonation**

Janus-faced emotional communication expresses affordance-sensings inside propositional thought

- Expressive communication: **points**
 - **inward**, to the psychological state it expresses
 - **outward**, toward the object or event at which the state is directed and ensuing behaviors. (**Dorit Bar-On, 2013**)
- Expressive (emotional) communication is the intermediate step between **non-propositional and metarepresentational** forms of communication. (**Richard Moore, 2017**)
- Affordance sensings provide the semantic underpinnings of primate communication and metacommunication. (**Proust, 2016**)

The representational status of self: not confined to a conceptual level

- The representation of a self becomes explicit when a thinker can refer to him/herself through autobiographical memories.
- This includes a capacity to keep track of one's own former social commitments (Proust, 2003)
- However subjectivity is experienced through affordance sensings in a non-conceptual way early on in life (Rochat & Striano, 2000)

Summary of the present proposal

1. Conscious feelings in the narrow sense of affective signals belong to a **larger representational structure, called affordance sensing.**
2. **Affordance sensings occur at the evaluative junctures of cognitive actions.**
3. **Because they include an action program motivated by felt valence and intensity, they are experienced as being about the indexed task (goal, situation) not about the somatic markers of their affective value.**
4. They are **entertained even when no reference to mental concepts is available.** Concept-based simulations, when available, **can be associated** with their conscious core.

Conclusion: Educational
implications

Learning how to learn is a matter of detecting cognitive affordances, and acting on them

- Cognitive affordance-sensings can serve learning or block it, as a function of felt valence and associated cognitive programs.
- It is well documented that affective attitudes towards mathematics, for example, depend on implicit evaluations
 - associated with gender or social origin (Huguet & Régner, 2007)
 - difficult to fight with concept-based representations.

Appropriate scaffolding is experience-based

- Propositional, declarative metacognition redescibes, enriches and revises information delivered by noetic feelings, **but the latter are a precondition of metacognitive knowledge**
- Educational forms of self-regulation need to focus on students' own subjective experience as learners,
- " Indeed **manipulations** that improve learners' monitoring accuracy result in a more effective regulation of study and, in turn, in overall better test performance" (Koriat et al 2009)."

Examples of implicit, testable manipulations for helping students calibrate their effort through internal feedback

- Provide students with learning materials
 - corresponding to their **region of proximal learning** (Metcalfe 2009)
 - Having a level of **semantic coherence** appropriate for autonomous inferential decoding and understanding (McNamara et al, 1996)
- Provide schoolers with a "**confidence tool**" (set of 5 smileys) enabling them to compare, in a given task type, their anticipatory confidence, their post-decisional confidence, and their performance.

Examples of implicit, testable manipulations for helping students calibrate their effort through internal feedback

- Offer students plenty of occasions to gain **autonomous** feedback concerning their own learning progress through short individual or collective "intercalary" quizzes, summarizings, rephrasings.

General recommendation

Try to align, through **implicit** interventions, **school children's affordance sensings related to their**

- ✓ cognitive actions at school
- ✓ Social affiliation and related self identities (families, peers)

Avoid **misaligned "extrinsic" affordance sensings**, such as **social visibility** – favored by summative grading.