

UNAM Workshop

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Cognitive affordances: Theoretical foundations and developments

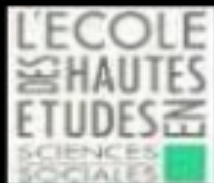
How are cognitive affordances sensed?

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OUTLINE

1. Updating the perceiving/sensing debate
2. Cognitive actions are guided by affordance-sensings
3. How are cognitive affordances sensed ?

I. Pragmatic affordances: updating the perceiving/sensing debate



The concept of affordance: etymology

- Derives from the German **Aufforderung** used by Kurt Lewin, 1935:
- "to perceive an affordance is to recognize an object or a situation as having a *positive or a negative* character, which potentiates an approach or an escape behaviour."
- Lewin's *Aufforderungscharakter*, (literally: "**invitation-character**") was translated by Edward C. Tolman through "valence", now a central explanans in emotion theory.
- For a review : [Colombetti \(2005\)](#).

Gibson versus Lewin on Affordances

- In Lewin's work, behavioural dispositions are *explained by* the phenomenal character of affordance perceptions:
 - A specific "tension" between the phenomenal "self-in-action" with objects is **experienced as supportive or obstructive**, as a function of present goals.
 - Affordances are invitations to act in context as a function of experienced value

Gibson rejects the role of valence as causal in affordance sensitivity

- Positive and negative affordances (benefits, injuries) are not "properties of the *experiences of the observer* "
- An affective mediation would compromise the **direct character** of affordance perception (see also Silberstein & Chemero, 2012).

Le concept d'affordance de J.J. GIBSON



- Gibson : (1979) "The affordances of the environment are what it offers to the animal, what it provides or procures for it, whether for good or ill" (p. 127).
- Affordances are relationships between animal capabilities and environmental characteristics. (Chemero, 2003)
- As relationships, affordances are both real and perceptible, but are not properties of the environment or the animal.

Gibson and his successors are *anti-representationalists*

- They minimize the role of information processing in perception.
- They understand "representation" as more or less equivalent to "belief"
- "Representational conceptions are incompatible with direct perception and erect barriers between the animal and the environment."

Contemporary revisions of Gibsonian affordances



I. Affordances involve information processing

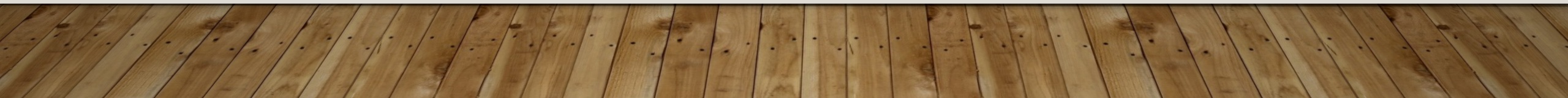
- Gibson believes that the perception of affordances, being "direct", does not go through an information processing process.
- However, neuroscience has shown that perceptual affordances are processed :
 - - **by the dorsal pathway** in the case of **low-level motor affordances** (such as preparing to pick up a glass). (Chong & Proctor, 2020)
 - by the **ventral pathway** for **high-level affordances** (e.g. which fruit to eat first). (reviewed in Jacob & Jeannerod, 2003).

2. It is not true that vision *only* targets affordances:

there are **allocentric** forms of perception where, for example, relations between objects are perceived in relation to each other.

3. Are affordances "directly" perceived?

only in the sense that they potentiate action programs before an object **is consciously categorized and recognized** (Barrett and Bar, 2009).



4. The role of valence in affordance detection and action preparation

- **Prompt detection**

Valence is a key feature for detecting survival opportunities and learning to behave adaptively, i.e. **flexibly and rationally**.

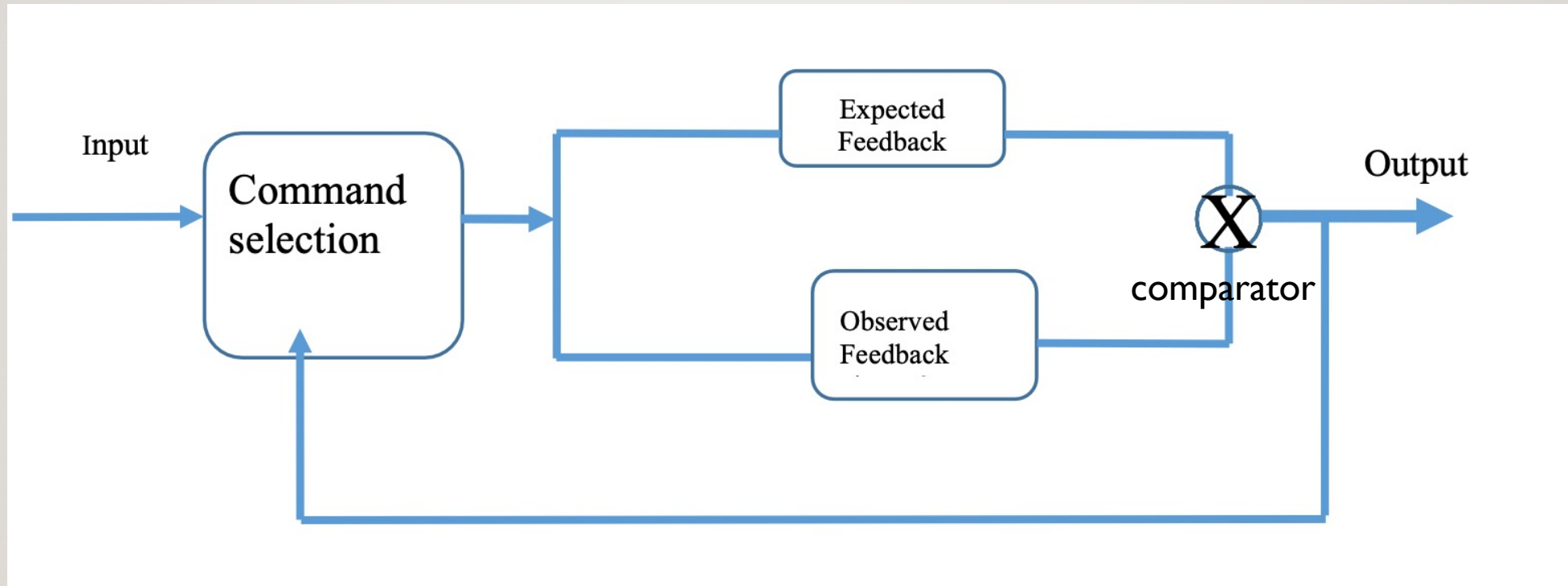
- **Embodied action guidance**

Affordances are expressed in somatic markers and action programs "invited" by the corresponding affordance-sensing (Fanselow, 2018, Sander et al. 2005).

Affordances are now a major construct in adaptive control theory

- Paul Cisek studies the evolution of cognition from simple feedback loops in ancient mobile animals to primate parallel control systems.
- Each of these control systems is dedicated to specifying the affordances for guiding species-typical actions.
- These systems compete against each other

A simple control loop



Two kinds of control and their corresponding affordances

The selection of action (what to do?): "**high-level affordance sensitivity**"

The specification of action, (how to act?) "**low-level affordance sensitivity**"

(Cisek, 2007)

- Pick **this** fruit (ripeness, volume..)
- At **arm-length**

Why two levels ?

Duality is functionally explained by the distinction between two functions of **feedback in a control system**

1. **Goal selection:** What is the most important and promising **action to be selected in this context** ? (High-level affordance sensitivity)
2. **Embodied execution:** **How will this action be best performed** in this context ? (Low-level affordance sensitivity)

Duality is a necessary feature in affordance sensitivity

- Duality derives from a constitutive compromise, in any action, between
 - the utility or reward to be grasped (eg: optimal nutrition)
 - The bodily and cognitive resources to engage to this end. (Eg: effort minimization)
- The structure of motor learning and motor control implements it throughout a hierarchy of decision-making levels.

Pezzulo & cisek's 2016: affordance competition

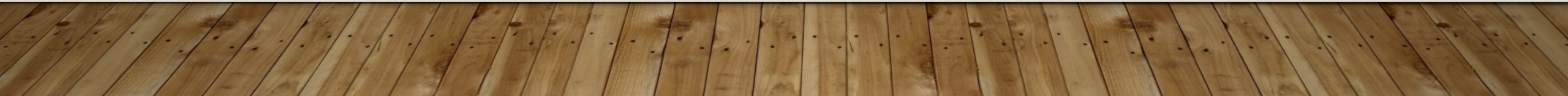
- On a **control view** of cognition, affordances do not describe the world, but predict ways of interacting with situations
 - **Multiple competitions occur in parallel** at different processing layers: the lower-layers may revise control decisions in higher layers and vice versa.
 - This competition occurs at **a hierarchy of time scales**
- this competition allows **situated and embodied aspects of action to enable behavioral flexibility.**



INTERIM CONCLUSIONS

1. Given that affordance sensitivity depends on **predicting** how to act on opportunities, the associated control episode should rather be characterized as an "affordance-**sensing**" ([Dreyfus & Kelly, 2007](#))
2. Sensing an affordance consists in assessing gradients of valence and intensity in embodied situated contexts of action
3. Integrating affordances is a major evolutionary pressure on the evolution of cognition: a common "affordance currency" is a key to adaptive control.

2. From pragmatic to cognitive affordances



AFFORDANCE SENSINGS = FEEDBACK

PRAGMATIC AFFORDANCES

COGNITIVE AFFORDANCES

Control of **motor** activity in anticipation of environmental opportunities and risks

Control of **cognitive** activity to obtain knowledge and prevent error.

THEORETICAL ISSUES

- How are cognitive affordances sensed? The structure of cognitive agency
- Is individual cognitive affordance sensitivity a developmental matter?
- Are individual cognitive affordances soluble in social cognitive affordances?

How are cognitive affordances sensed ?



DEFINING ACTION

An action consists in **using compensatory mechanisms** to maintain a trajectory **toward a goal**

From Harry Frankfurt "The problem of action"

(1978)



- Prior intentions are no longer a **defining** feature of action.
- This view is consistent with the fact that agents select informational goals
 - without having formed a conscious intention to engage in them (see verbal communication, error correction, etc.)
 - Without representing their informational goal in words (infants, nonhuman animals)

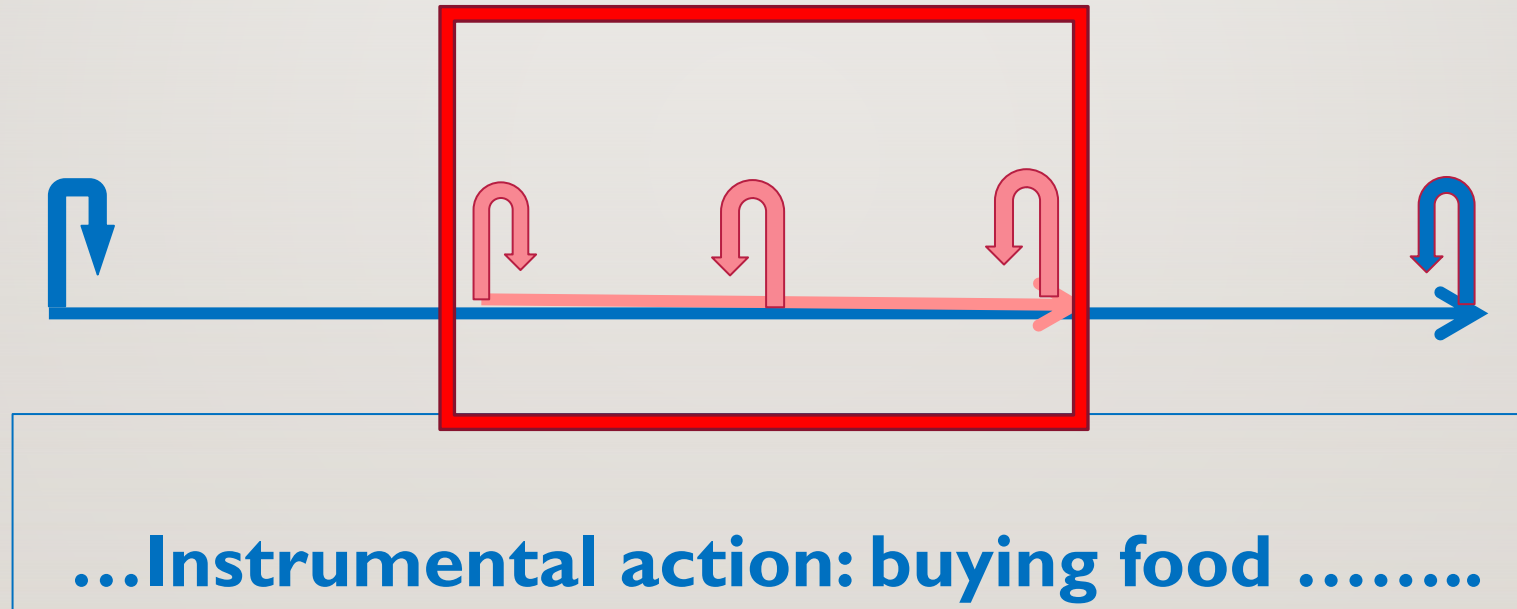
Cognitive affordances control cognitive actions

- By definition, a cognitive action is an action whose goal is information-
 - acquisition (learning)
 - categorisation (judging)
 - retrieval (remembering)
 - integration (understanding, reasoning, inferring, explaining)

Predictive evaluations are functional constituents in cognitive actions

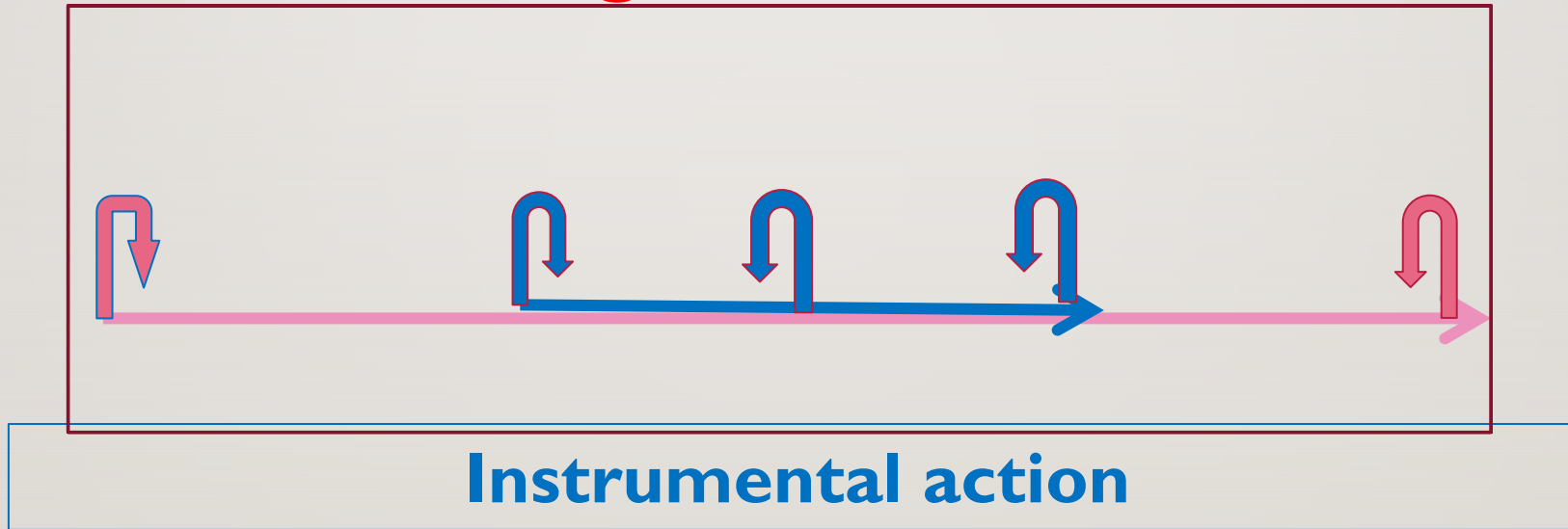
Example: **reconstructing a shopping list**

Cognitive action



Predictive evaluations are functional constituents in cognitive actions

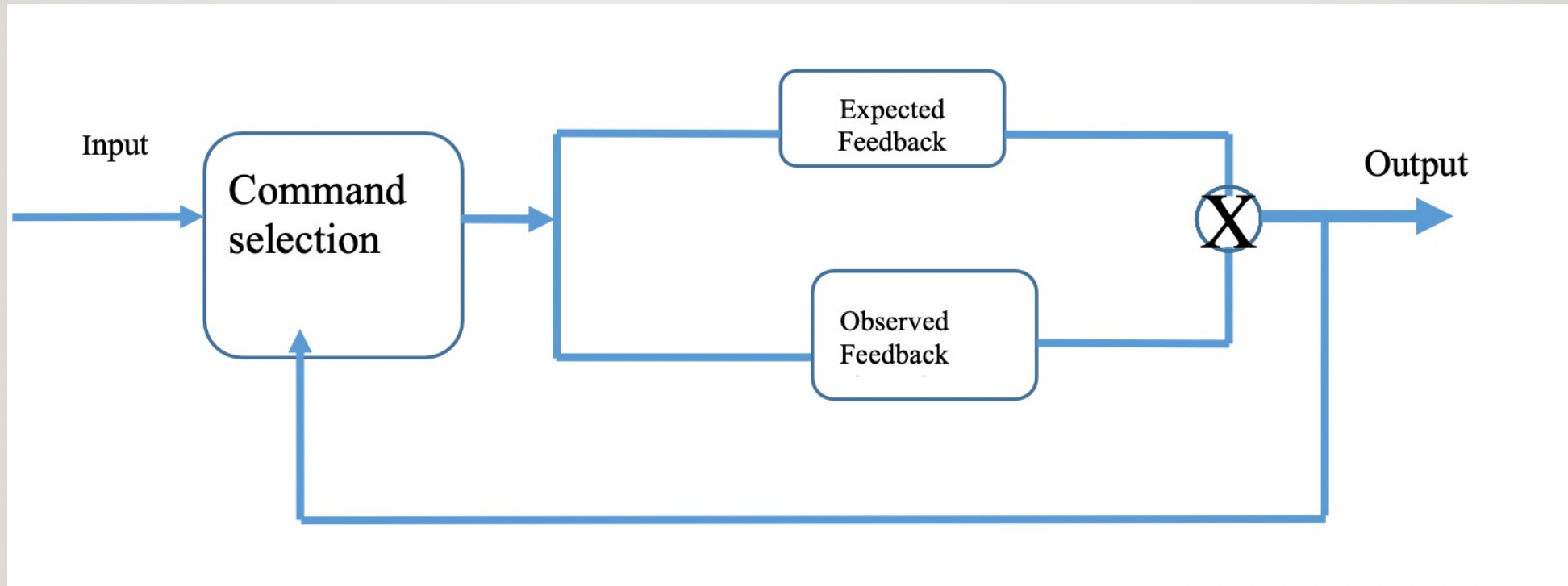
-----Cognitive action-----



Example: learning biology by drawing a
conceptual map



= evaluation conducted in the currently active forward model

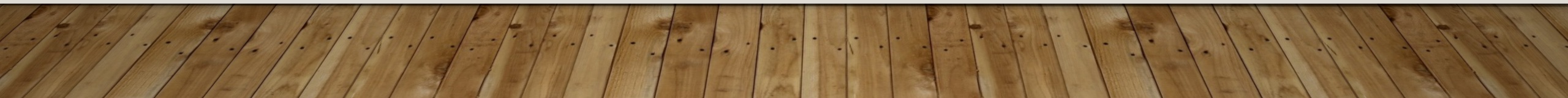


3 main kinds of comparators

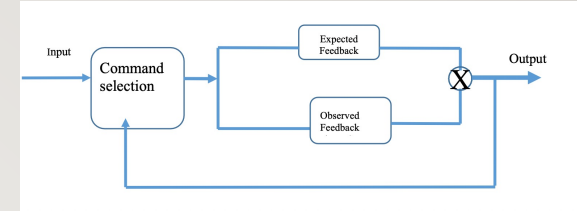
- ❖ **Before acting:** by selecting **the most promising informational targets**, given current resources and needs
- ❖ **While acting** : by detecting **error**, efficiency/time ratio, stalling, confusion, or unexpected progress to goal
- ❖ **After acting:** by evaluating **likely success** of informational output.

(GOUPIL & PROUST, *COGNITION*, 2023)

Goal-related predictive feelings: Prospective MC	Process-related evaluative feelings Data-driven MC	Result-related evaluative feelings Retrospective MC
Feelings of curiosity	Feelings of error	Feeling of being right/wrong
Feelings of familiarity	Feelings of incomprehension	Feeling that one learned ("judgement of learning")
Feelings of knowing	Feelings of incoherence	Eureka feeling
Feelings of prospective confidence	Feelings of interest/boredom	Feelings of retrospective confidence
Tip-of-the tongue	Feelings of confusion	



Example of memory control: before acting



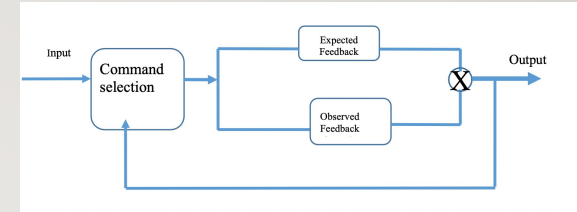
- **You forgot your shopping list.**

Before deciding what to do: you ask yourself whether you **can remember** what was written on it **accurately**, or even maybe **exhaustively**. **The resulting confidence level is a cognitive affordance that guides your decision.**

How do you evaluate your confidence?

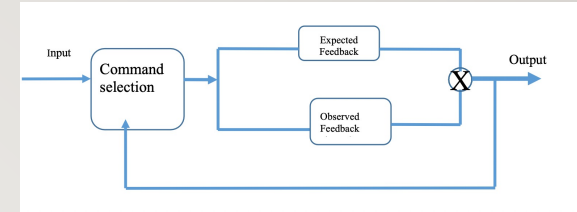
- Based on a few memory samplings, an overall feeling of ability to remember is produced.
- If affordance of remembering is sensed, the act of reconstructing the list is launched.

Example of error detection: during the action



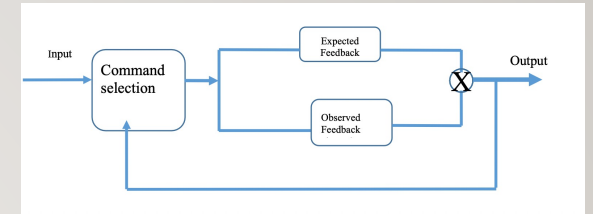
- for example: You discover that you lack **a crucial information** to solve a given problem
- This activates repair-affordance-sensings (e.g. internet explorations)
- This qualifies as a low-level kind of affordance (related to how to act)

Affordance-sensing for action correction






- Once a cognitive goal is reached, it is crucial to evaluate outcome correction
- Is my computation correct?
- Did I learn/understand/ the document?

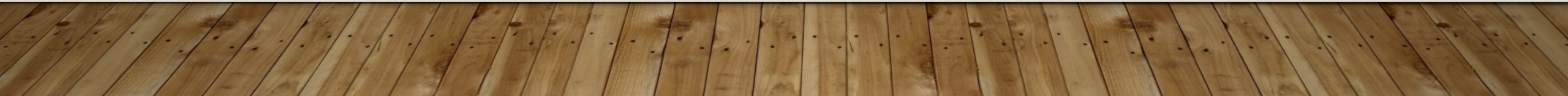
Affordance-sensing for action correction is sensitive to low-level affordances



The subjective confidence experienced at the end of an action has been shown to depend on low-level features of the activity, e.g.

- the number of errors revised tends to reduce final confidence in one's performance 
- in problem solving, a fast execution tends to be interpreted as a sign of correctness. 
- In learning, spending deliberately more time on an item subjectively predicts learning failure. 

3. How are cognitive affordances sensed ?



Complicating the picture: trade-offs

- Just as pragmatic affordances, cognitive affordances **compete for goal selection** in a context: this is a consequence of affordances providing a common currency in decision making.
 - Levy & Glimcher, (2012). The root of all value.
 - Proust, J. (2015). Time and action
- Because the competition can be kindled by low-level affordances, from beginning to the end of an action, there may be instability in goal selection and strategies

Affordance competition & trade-offs

Cognitive affordances **compete** to gain control of cognitive actions, e.g.

- **Accuracy** versus informativity
- **Speed** versus accuracy
- **Informativity** versus ease of processing
- **Learning need** versus learning effort
- **Exploration** versus exploitation

A given trade-off is a compromise between two or more cognitive affordances, aimed to regulate a cognitive action



Trade-off is the key to flexibility

- Performance, efficiency, robustness, and flexibility are the key properties of all functional systems, including natural and artificial cognitive systems.
- Trade-offs between these properties, or between different aspects of each property occur both at evolutionary level as at the individual cognitive level to maintain the best possible level of performance (efficiency) given time, energy, external stability.
- See Basic Functional Trade-offs in Cognition: An Integrative Framework, Del Giudice & Crespi *Cognition*, 179, 56-70 (2018).

The case of curiosity

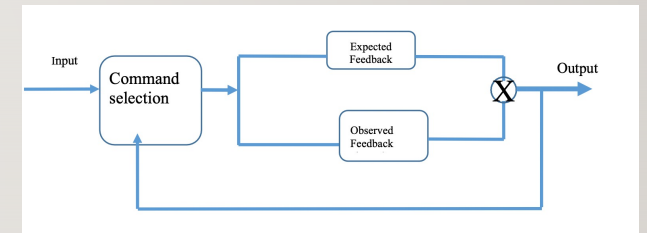
Curiosity is a metacognitive feeling, that was first theorized as expressing a need to repair a knowledge lacuna.

- Curiosity was initially claimed to reflect the sensitivity to a **cognitive affordance of informativity** (knowledge gain).
- However, curiosity was found to combine **two cognitive affordance-sensings**:
 - An evaluation of the **internally available** information
 - An evaluation of the **potential information gains afforded** by the environment (Kang et al., 2009, Kidd et al., 2012)

For a review: **Goupil & Proust, (2023)**

What curiosity teaches us about cognitive affordances

- Each metacognitive feeling is the conscious output of **several comparators** in the control of a cognitive action.
- These comparators reflect **multi-scale affordance-sensings**, based on the multiple types of past feedback associated to the target goal
- Success/failure, social reinforcement/ self-consistency, etc.



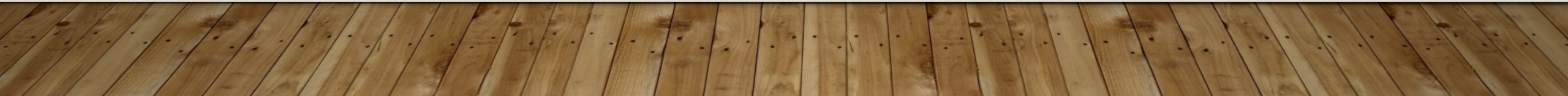
Metacognitive feelings express trade-offs between multiple affordances

- Cognitive affordances are the evaluative components **that are integrated to produce a conscious** metacognitive feeling in a given context.

Sensing a cognitive affordance versus experiencing confidence

- Metacognitive feelings **are experienced**: agents are conscious of their overall motivation
- However, the efficiency of metacognitive feelings depends on the **underlying sensitivity to multiple cognitive and social affordances**.

Is individual cognitive affordance sensitivity a biological or a cultural matter?



Affordance-sensings & extended-cognition GALLAGHER (2013)

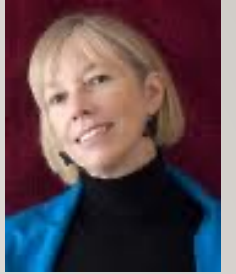
- If we think of the mind not as a repository of propositional attitudes and information, or in terms of internal belief-desire psychology, but **as a dynamic process involved in solving problems and controlling behavior and action** – in dialectical, transformative relations with the environment – then we extend our cognitive reach by engaging with tools, technologies, but also with institutions.
- We might start with the idea that family is ontogenetically the first institution, and ask how basic embodied and situated **processes of primary and secondary intersubjectivity pull the infant into cognitive habits that shape all further learning**, and that become linguistic (and narrative) practices that are further educated in all other social institutions encountered by the child (p. 7)

Preverbal children are sensitive to cognitive affordances

- **Preverbal 20-month-olds can nonverbally ask adults for help strategically, in order to decline choices they assess as too difficult. (Goupil, Romand-Monnier & Kouider, 2016, Goupil & Kouider 2019)**
- **Error-related negativity brain signals are triggered when (preverbal) children make an incorrect choice (Goupil & Kouider 2016).**
- **Infants can correctly assess the confidence of their decision, monitor their errors and use these metacognitive assessments to regulate their behavior, without yet having a theory of mind.**



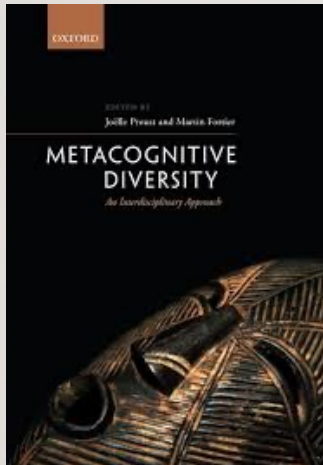
SENSING MEMORY AFFORDANCE



- In verbal testing, 3-year-olds fail to report what they don't know or have forgotten.
- However, when tested with a non-verbal choice-of-task paradigm, they perform in the same metacognitive way as rhesus monkeys, choosing to perform the trials they can perform correctly. (Balcomb & Gerken, 2008).

-
- Sensitivity to cognitive affordances may be in part constructed through the feedback provided in primary intersubjectivity (face to face interaction with infants), which is not a universal feature of children's early social interactions

Development of metacognition is culturally diverse



Proust & Fortier
(eds.), 2018

- In Mayan traditional culture, interactions with infants do not have the Western "face-to-face" structure (Gaskins, 2006)
- Maya people tend **to restrict the amount of information they deliver to others**, which includes the facial gestures related to expressing uncertainty. (Le Guen, 2018)

Finding: 4yr old children overestimate what they know, **even in a "facilitating" context** when they are invited to inform another person. (this context is facilitating for Japanese and German children).

Kim, S., Le Guen, O., Sodian, B., Proust, J. (2021) « Are children sensitive to what they know? An insight from Yucatec Mayan children, *Journal of Cognition and Culture*, 21, 226-242

Institutional trade-offs: cognitive versus social control



Social institutions, such as schools may have conflicting goals, such as:

- Enhancing learning in children independently of their social background
- Assessing students's qualifications through grades (sommative evaluations) to adjust their curriculum to predicted professional abilities.

Even very young students adjust their cognitive affordances to implicit or explicit social/gender stereotypes

- 3 types of social affordances compete with cognitive affordances in the control of students' behavior:
- **Social visibility** in peers' group (grades, disruptive behavior)
- **Social affiliation** in relation to self-concept: family, birth place, ethnic group seen as compatible or incompatible with disciplinary aptitudes or objects of study
- **Gender-based self-concept**: particularly harmful because students' lowered confidence determines their disengagement from specific learning activities and their career choices.

General conclusion

- It is still partly unknown how children's minds are shaped by social institutions in interaction with our genetic "landscape" of affordance sensitivity and the new environments we are confronted with (Pezzulo & Cisek, 2016).
- Metacognitive research, both experimental and philosophical, only begins to work on issues such as polarized thinking. Much more remains to be done.

THANKS FOR YOUR ATTENTION!

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<https://joelleproust.org>