

Bounded Rationality in Agent Orientation – “Just-in-Time” Visual Pattern Recognition

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Objectives

1. Revisiting thoroughly the concept of bounded rationality, in view of its roles in a post-industrial (service-based) society.

- a) *Choosing a Lingua Franca for holistic approaches able to promote transdisciplinarity (above all as regards psychologists).*
- b) *Expressing bounded rationality in terms of General System Theory.*

Objectives

2. On this groundwork, substantiating the ambivalence of bounded rationality (cognitive limitation and IT guiding principle) within the agent-orientation paradigm, in applications destined to perform in dynamic, and uncertain environment).

- a) Investigating preterminologic BR (mainly the anthropogenetic divergence between optimization and simplicity).*
- b) Exploring the role of BR as “psychological stabiliser” (through negative feedback).*
- c) Extending the analyse to (largely preterminologic) synergy as (boundedly rational) resource amplifier.*

Extensions in **2011**

Objectives

- 3. Instantiating this approach for permanent education, via a framework able to manage educational chaoplexity based on bounded rationality as common denominator of, mechanism for, and connection between the two facets of continuing education: *e-teaching and e-learning*.**

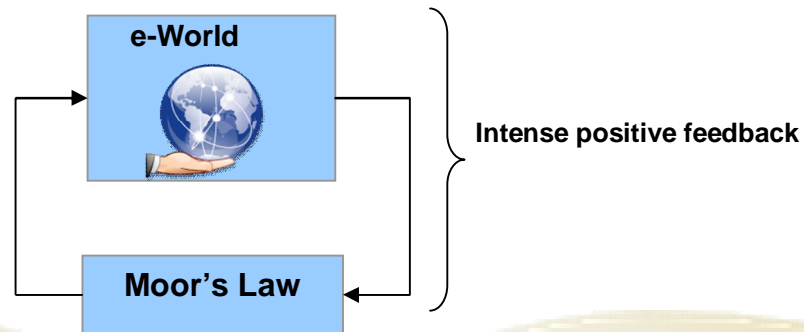
- a) Investigating post-modern “educational chaoplexity”.*
- b) Exploring e-teaching as boundedly rational system.*
- c) Boosting e-teaching via extrapolating lasting topics and behaviours.*

Extensions in **2011**

Objectives

- 4. Validating the approach by carrying out an experimental model of a nontrivial service to be provided (from a holistic perspective, within a user-centred application) by an agent-oriented interface in uncertain and changing environments. To ensure the qualitative validation soundness, the application field chosen is “Visual pattern recognition”.**
- 5. Exploring the paradigmatic shift towards building Computer Science rather on semiotics than on mathematics.**

Context



“Kelvin-Number-Oriented”

Deterministic Environment
(closed, static, known)

Well-Defined Problem
(quantity, precision, certainty)

Optimal Lasting Solution
(algorithmic, apodictic, general)

Solving accurately Problems
(imperative, firm, reliable)

Client-Server Paradigm
(object-oriented, sequential)

**Mental
Rubicon**

“Zadeh-Word-Oriented”

Nondeterministic Environment
(open, dynamic, uncertain)

Fuzzy-Defined Situation
(quality, imprecision, uncertainty)

Suboptimal Temporary Answer
(non-algorithmic, revisable, local)

Managing “Just In Time” situations
(descriptive, flexible, robust)

“Computing as Interaction” Paradigm
(process-oriented, parallel)

Premises



- **Pr1:** In post-industrial (service-oriented) engineering failure is ruled out for vital services (because some of them are vital in the very sense of the word).
- **Pr2:** Post-industrial (service-oriented) nontrivial applications are intended for intense interaction in open, heterogeneous, dynamic and uncertain environments (OHDUE).
- **Pr3:** *Negative feedback* tends to keep parameter values, is corrective, conservative and promotes symmetry, stationariness, stability, reversibility. *Positive feedback* tends to increase parameter values, is evolutive, innovative and promotes chain reactions, ontogenesis, system increase (perhaps catastrophic, leading to system annihilation), instability, irreversibility.
- **Pr4:** Both *decision making* and *learning* are cognition-based, non-deterministic, processes that operate in dynamic and uncertain environments; hence, they cannot be modelled *deterministically* and cannot be described adequately by *algorithms*.
- **Pr5:** Agents are *processes* devised as *interactants* not *objects* devised as tools.
- **Pr6:** Precision is costly (Zadeh).

Working Assumptions



- **Wa1:** The very concept of Bounded Rationality involves suboptimality in nontrivial applications.
- **Wa2:** In line with ***Pr1***, decision-making support applications based on conventional algorithmic software are either *unaffordable* (with scarce resources) or *ineffective* (as regards end-user expectations).
- **Wa3:** Analog input is natural (human mind is visual oriented), general (for any usual linguistic variable), effective (fast, robust, ergonomic) and very easy to implement.
- **Wa4:** Cognition is (regarded as) holistic and boundedly rational. (The parenthesis is necessary because an apodictic assertion about the very nature of human cognition is outside the competence of computer scientists and hence unacceptable in a CSITAO thesis). As a result, here only the relationship between cognition and decisional or educational systems seen as *cybernetic* and *intentional* is dealt with.
- **Wa5:** Precision is useless.
- **Wa6:** Precision could be harmful when decision is urgent (“Just-in-Time” decision making).

Thesis kernel. The main paradigmatic shifts

- **Chapter 4** – the new role of bounded rationality in the post-industrial era, focusing on the evolution “From Kelvin to Zadeh”
- **Chapter 5** – choosing General System Theory (GST) as “Lingua Franca” for transdisciplinary communication, focusing on bounded rationality as twofold feedback.
- **Chapter 6** – illustrates the new paradigms by two non-algorithmic mechanisms for word-based modelling: a multifunctional bar for decision input and an abduction-based decision-making simulator.

Bounded Rationality from Hindrance to Excuse, to Mechanism, to Strategy

- “Don’t plan anything in detail” is not an advice from a guru of Economics, but a constituent of a Viking law (i.e., “Be brave and aggressive”



- a) *bounded rationality* has a long-standing and significant pre-Simonian use;
- b) it was organically related to another unborn concept: “*Just in Time*” (there is not enough time to *optimise*);
- c) it was not a purpose for itself, but an ingredient of a *holistic* endeavour.

Pre-Simonian Era. Best Versus Simple

- BR sufficed to finding “Just in Time” solution without having an accurate mathematical proof is the isoperimetric problem (“Dido Problem”) according to Virgil's Aeneid, the first optimisation problem.
- the pre-terminological life of BR shows the intrinsic anthropogenetic / psychological nature of BR due the vital need to manage situations “Just in time”.



Terminological Era. In Search For Time

During its half a century long terminological life, the concept acquired several new connotations including the ambivalence of BR in holistic approaches.



- *Herbert Simon* proposed in 1982 the concept of BR as valuable tool for decision making in economy
- *Ariel Rubinstein* describes “models in which procedural aspects of decision making are explicitly included”
- *Daniel Kahneman* received his Nobel Prize for seeing bounded rationality as a means to improve economic modelling.
- *Gerd Gigerenzer* proposed alternatives for decision making, based on simple heuristics; for instance, priority heuristics

Cognitive Psychology vs. Educational Chaoplexity

- explaining the concept of “educational chaoplexity” via a lingua franca
- focus on BR as mechanism of permanent education, showing how it can alleviate the temporal hiatus intrinsic to permanent education, proposing to teach a *lasting subject matter* as well as a *lasting behaviour*.



GST as Lingua Franca for Holistic Approaches

- educational systems are teaching systems and learning systems

- a) such systems are open, nondeterministic, and operate in dynamic and uncertain environments;
- b) without claiming “the end of reductionism”, cognition can be studied only macroscopically, i.e., holistic, within cybernetic intentional systems;
- c) long-term quasi-stability is preserved through BR acting as negative feedback;
- d) short interludes of creativity can be boosted through BR acting as positive feedback.

GST as Lingua Franca for Holistic Approaches



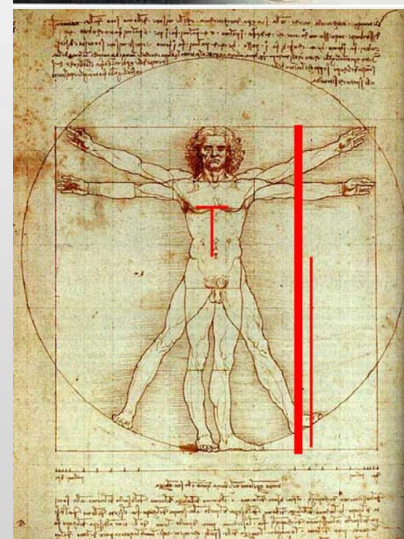
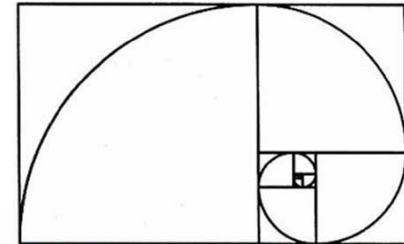
- Why is BR crucial?



- *Because* it is a psychological – hence, lasting – feature.

Most Lasting Topics. The Golden Ratio

- has inspired thinkers of all disciplines like no other number in the history of mathematics
- often, authors refer to this number as expression of “beauty of our world”
- “its interdisciplinary nature combined with rich mathematical relationships make it attractive for teachers and students as it helps in building multiple connections between mathematics and other subjects and real-life applications”



Most Lasting Behaviours. The Damascus Blade

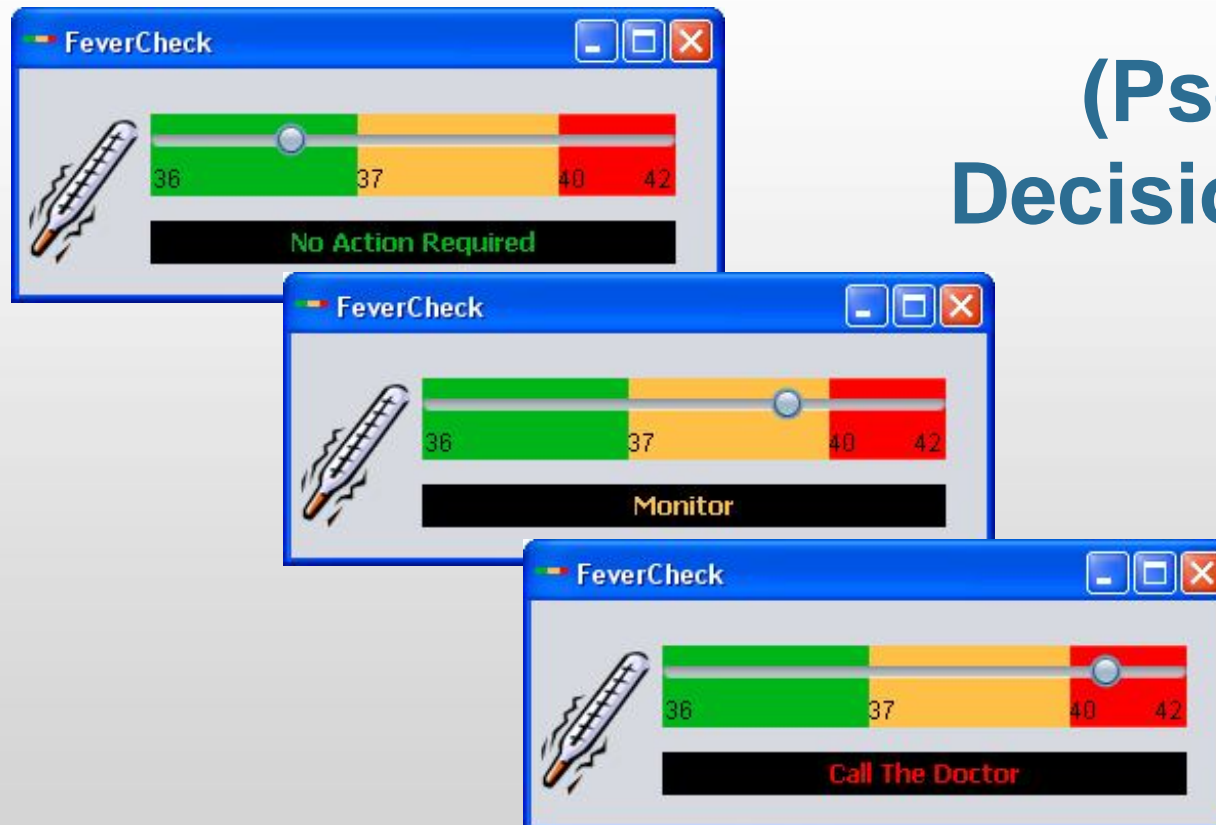
Five reasons why it is relevant for BR as mechanism

1. an informal experiment showed that even **bright** students have cognitive problems as regards the relationships between “scoring”, “comparing”, “measuring” etc.
2. it is independent on technology: both the ancient blacksmith and the present-day oncologist just compare colours;
3. moreover, both use their eyes as precision equipment in evaluating hue after transducing;
4. corollary: is it another example of shifting from myth to meme?
5. it opens significant transdisciplinary niches towards semiotics in at least two directions: nonverbal communication and psycholinguistics



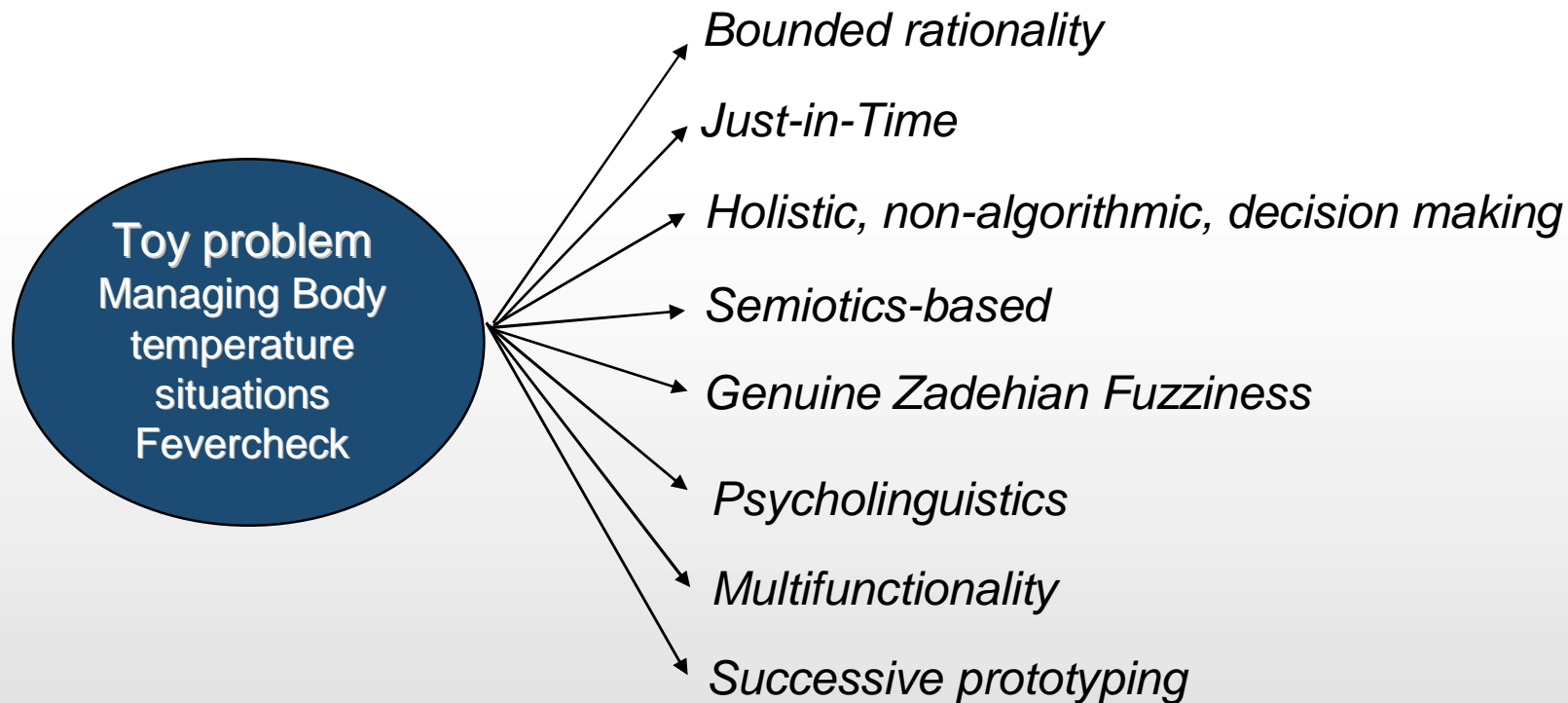
Decision-Input Bar

- **Decisional choices** are entered into the system expressed as *pixel segments* on (scrollbar-like) bars. The *segment length* represents the *choice variable value*.



(Pseudo)Linear
Decision Input Bar

Toy problem – relevant as regards



Other (possible) DIB instances

- **Logarithmic**
- **Exponential**
- **Sigmoidal**

Decision making. Toy problem: Fevercheck

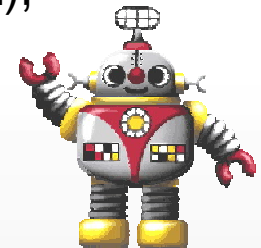
DECISION DOMAINS WHERE DECISIONS ARE FOR *SIMPLE SITUATIONS*

Simple situations

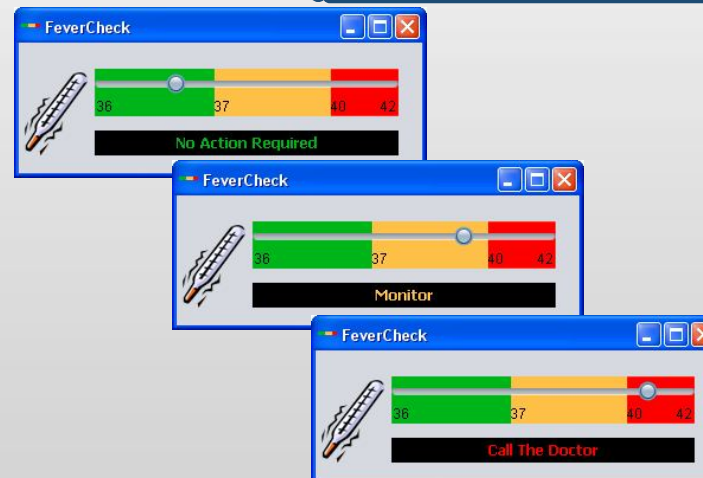
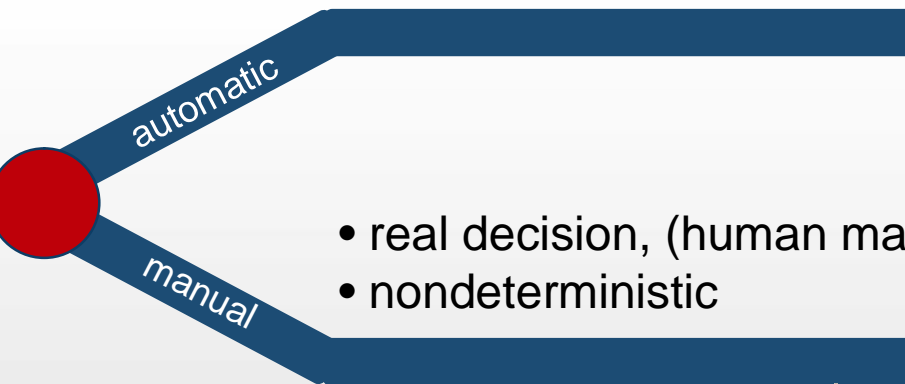
Managing Situations

Decisions that can be made by human decision makers as well as by automatic decision maker

- automatic decision (if allowed),
- deterministic



- real decision, (human made, free will)
- nondeterministic



Paradigm shift in decision making

- **The old paradigm is valid for “*automatic control*”.**
Decisions are focused on *precision* and are made by *robots*. They are mathematics-based, algorithmic, and carried out mainly through object-oriented IT.
- **The new paradigm is valid for “*manual control*”.**
Decisions are focused on *bounded rationality* and are made by *humans*. They are semiotics-based, non-algorithmic, and carried out mainly through agent-oriented IT.

Experimental model – Visual Pattern

- Here BR is *not related to a product* – deliver “Lena” at pixel level precision – but rather to providing information about Lena for everyone who needs them.
- Every service is performed by a live entity,
 - if biological – human
 - if virtual – agent
- Apply BR to simplify visual complexity to be able to transmit only what’s needed
- Focus on user, level of granularity, feature – relevance to the target

Experimental model – Visual Pattern

Dialog

Features of the interest area (technical variables)

- location of the interest area
- precision for the interest area
- imprecision for the complementary area

```
switch(client) {
```



```
  case of: client_1
```



```
  case of: client_2
```

```
  .  
  .  
  .
```

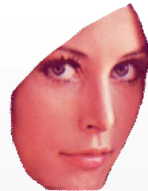


```
  case of: client_n
```



```
  default:
```

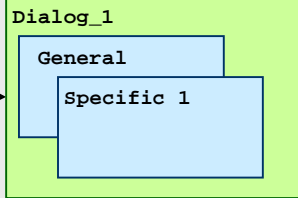
```
}
```



```
switch(CLIENT)
```

```
case: CLIENT_1
```

```
call(CLIENT_1)
```



Service specifications

```
if (dlg_result == 0) then  
call_PROCESSING (Specifications)
```

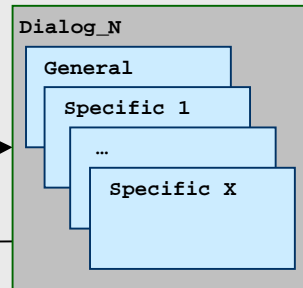
```
foreach( requirement from Specifications)  
do_number_crunching(image, requirement)
```

```
if (processing_result == 0) then  
send_to(CLIENT_1)  
else  
notify_service_provider()  
else  
complain_about_failure()
```

```
...
```

```
case: CLIENT_N
```

```
call(CLIENT_N)
```



Service Specifications

```
if (dlg_result == 0) then  
call_PROCESSING (Specifications)
```

```
foreach( requirement from Specifications)  
do_number_crunching(image, requirement)
```

```
if (processing_result == 0) then  
send_to(CLIENT_N)  
else  
notify_service_provider()  
else  
complain_about_failure()
```

```
case: OTHERWISE
```

```
[do_defaults()
```

Algorithmic problem solving
Product/Object oriented (industrial era)

Non-Algorithmic service providing
Process/Agent oriented (post-industrial era)



Conclusions

- By extending to several accomplished subobjectives, the thesis objectives have been more than fulfilled.
- Precision is against nature and the opposite of precision is fuzziness.
- Ever more services have to be provided in line with the “just in time” (JIT) paradigm;
- Developing applications for JIT services implies both bounded rationality as fact of life and artificial intelligence as powerful IT instrument.
- BR was systematically revisited from psychologic feature to subconscious approach and from conscious hindrance to legitimate excuse for incoherent decision-making
- BR was linked organically to “Just-in-Time” setting up its main role in a post-industrial society: *fighting cognitive chaoplexity*

Conclusions

- In the challenging environment of post-modern educational chaoplexity, BR was substantiated as both cognitive limitation and IT guiding principle.
- History and psychology show that “simple” was always paramount, whereas “best” became arguable when mathematics became (too) complicated
- The role of BR as “psychological stabiliser” was proved in three steps: b1) choosing an interesting topic or a pervasive habit; b2) investigating memetic stability that assure their usability; b3) proposing a boundedly rational way to exploit simplicity in e-teaching via extrapolating similar topics and behaviours.
- To achieve inter-paradigmatic synergy, modelling requires innovative (i.e., nondeterministic, noncategorical, agent-oriented) software.

Conclusions

- The framework able to manage Educational Chaoplexity (EDCHA) based on BR as common denominator of, mechanism for, and connection between the two facets of permanent education was carried out only for e-teaching since no research started yet as regards service-oriented e-learning.
- It was shown that BR can tackle EDCHA and that it is able to alleviate the temporal hiatus intrinsic to permanent education.
- Exploring the possibility to build Computer Science rather on Semiotics than on Mathematics seems to be more than a single paradigmatic shift.
- Certain openings to be substantiated within the EU2020 research strand came out clearly at least in two directions: *transdisciplinarity* and *osmotic interference*. Thus, shifting the transdisciplinary focus from psychology to semiotics, endorses the claim about the deep relationship between BR and all kind of signs other than numbers. In both directions using GST as Lingua Franca was very useful.

Conclusions

- BR, is much more than an excuse for poor decision making and becomes vital for permanent education because – as key psychological feature – it is the most stable dimension involved.
- To be sustainable in the long run any educational endeavour should be modelled based on BR. In permanent education, to overcome the temporal hiatus between teaching and learning, this educational strategy will become *a must*.
- Any metamodel of teaching should be based on psychosomatic features (first of all on bounded rationality) and can be validated so far through convincing – albeit circumstantial – evidence.
- Helplessness in managing situations too complex for our BR can be lessened investigating the real world according to the huge potential of BR itself.

Open problems – EU2020

Question – Supposition

- **Q1:** *Linguistics (as part of Semiotics).*
- **S1:** *Learning the mother tongue is obviously boundedly rational; teaching babies seems to be too. Moreover, the methods seem pervasive, language-independent, and almost unchanged since anthropogenesis.*
- Hence, teaching metamodels should find out the methods mothers use and should focus on.

Open problems – EU2020

Question – Supposition

- **Q2:** *Logarithms are natural no matter the base.*
- **S2:** *Decomposing CSITAO, logarithms are paramount for all parts: CS (binary logarithm for hardware), IT (common logarithm for conventional software), AO (natural logarithm for anthropocentric applications).*
- Hence, teaching metamodels should shift the focus from conventional mathematics to modern, human-centred (non-numeric and even non-verbal) mathematics.

Open problems – EU2020

Question – Supposition

- **Q3:** *Bounded rationality as positive feedback.*
- **S3:** *Since BR is a – maybe THE – main cognitive mechanism and cognition involves inventiveness (e.g., “Eureka”-like effects) it is likely that BR could boost creativity (via positive feedback).*
- Hence, a GST based and cybernetic-oriented investigation should be carried out starting from the idea of local feedback loops within simulated discernable educational subsystems.

Open problems – CSITAO

- Is the archetypal yin-yang symbol (suggesting both sigmoid and linear nonseparability) just a metaphor or is it mathematically significant?
- What is the relationship between BR, synergy and psycholinguistics?
- Why are so many exact trigonometric formulae or infinite series to express the golden ratio when no user cares about them?
- Why is “Innumeracy” a much newer concept than “Illiteracy” and what is their relationship to BR?

A grayscale photograph of a hand placing a puzzle piece into a larger puzzle. The puzzle is composed of many interlocking pieces, with one piece missing in the center. The hand is holding a single puzzle piece and is about to place it into the gap. The background is a light gray color with a subtle pattern of puzzle pieces.

Thank You!