



Analysing the Cognitive Effectiveness of the UCM Visual Notation

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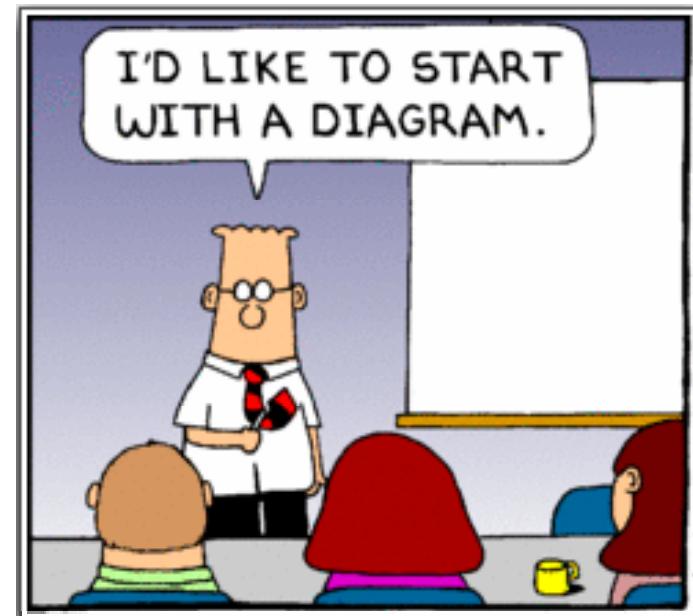


Why Visual Modelling?

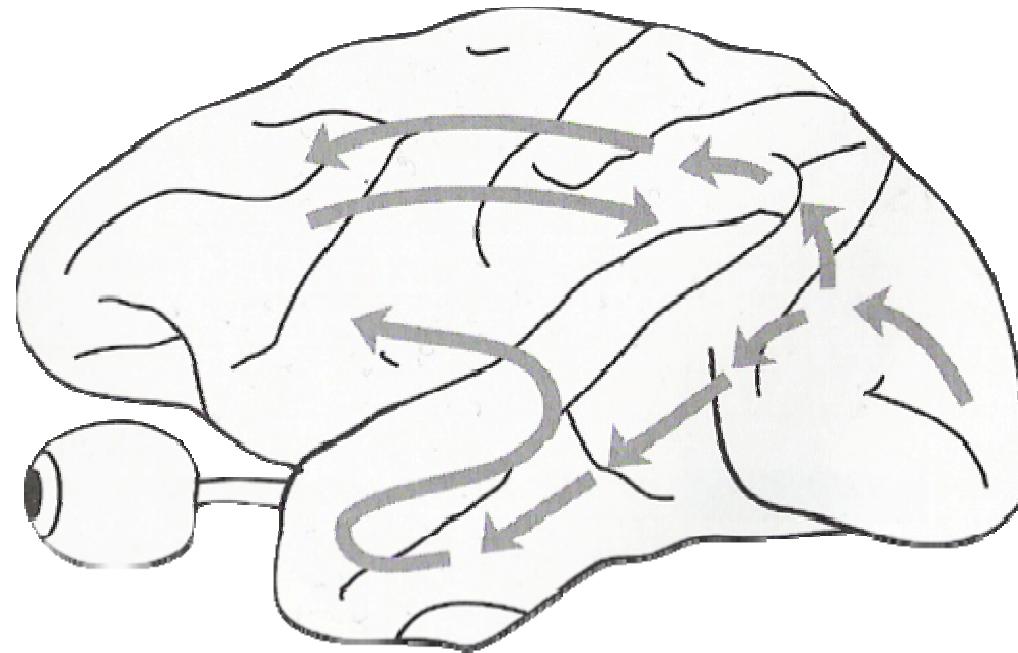
Diagrams play a critical role in discussing, designing and documenting systems

The main reason for using diagrams is to facilitate communication

- assumed to be more effective than text **especially for end users**



What makes a visual notation “good”?



**Cognitive Effectiveness =
speed, ease and accuracy** [Larkin-87]

Problem

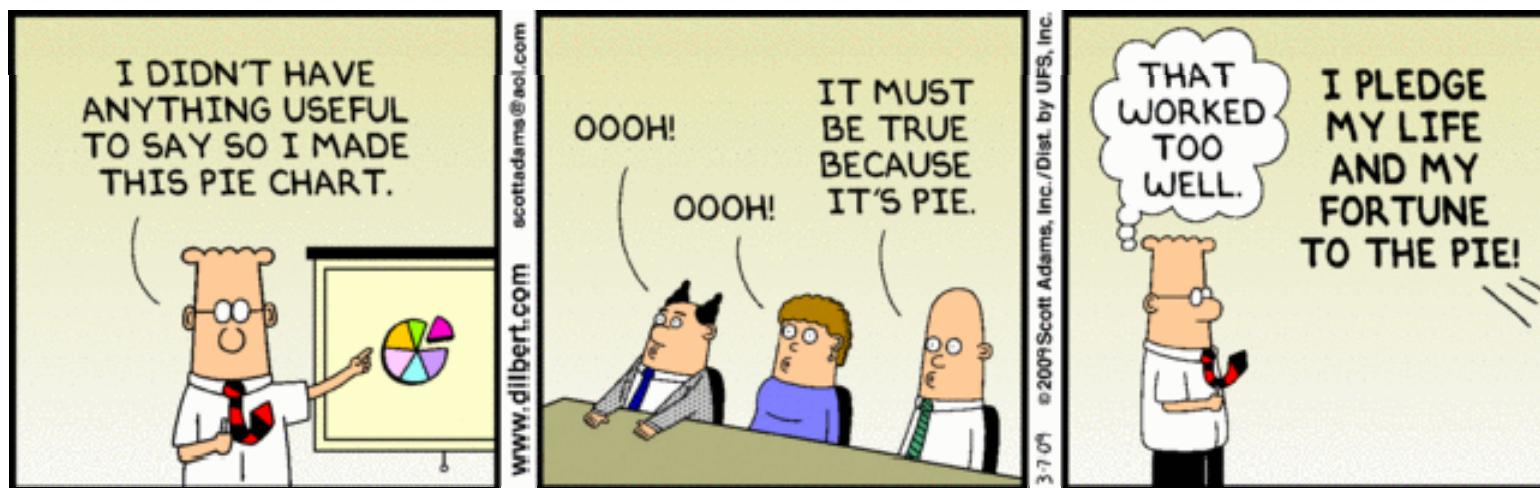
When creating or evolving the visual notation of a modelling language, cognitive effectiveness is not taken into consideration in a systematic way!

- focus is often on abstract syntax and semantics
- visual notation is the “poor cousin” in notation design, and is designed in ad hoc ways
- concrete visual syntax is often thought of as a matter of mere aesthetics

(I'm as guilty as many of you!)

Moreover...

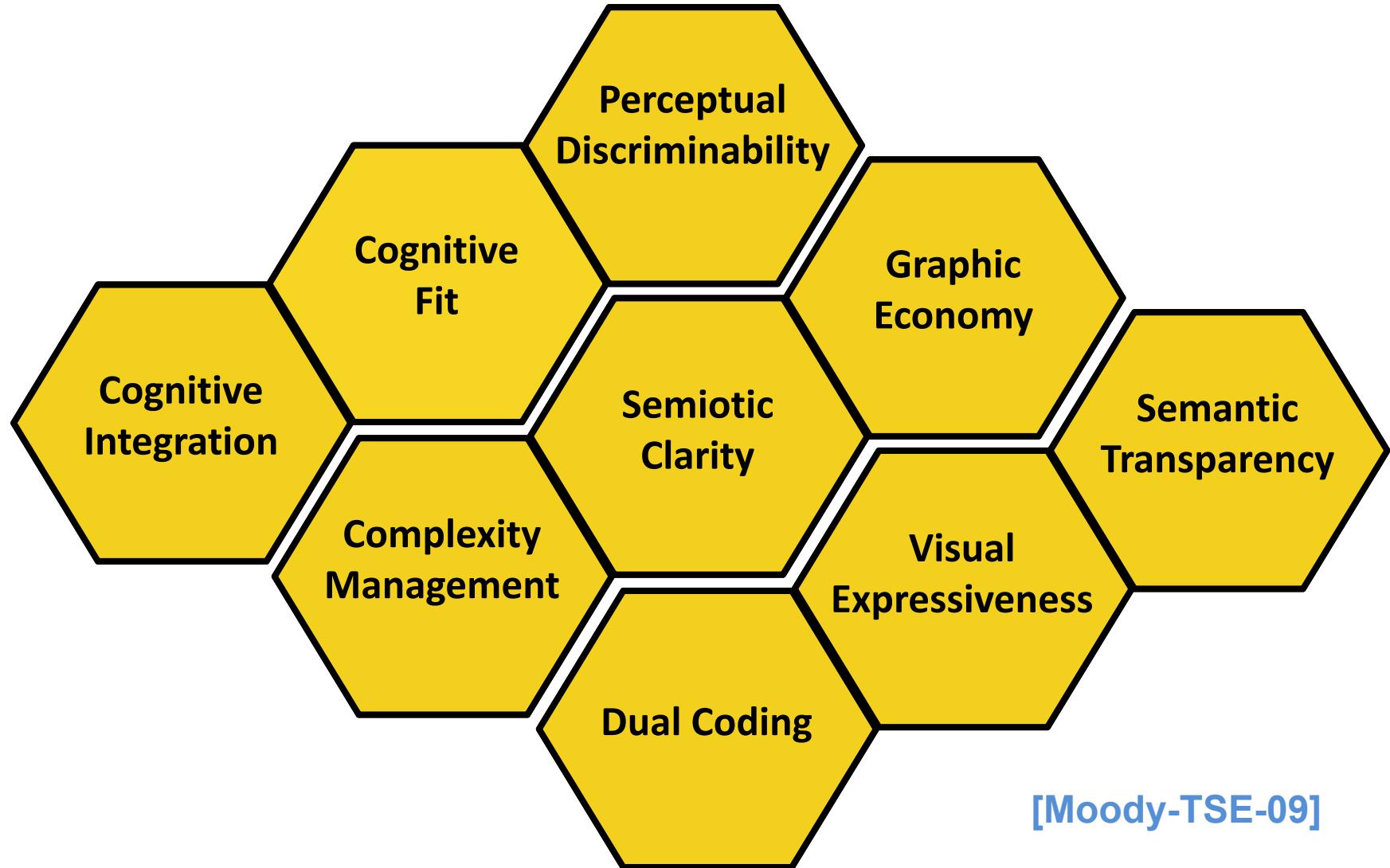
Users often rely (incorrectly) on intuition, leading to suboptimal communication and unintended interpretations



Agenda

- The Physics of Notations theory (PoN)
- Use Case Map (UCM) notation
- Analysing UCM with the Physics of Notations
 - Illustration of several guidelines, with results and possible improvements
 - More guidelines discussed in the SAM paper
 - Full analysis available as a technical report
- Related work
- Observations about this theory
- Conclusions and future work

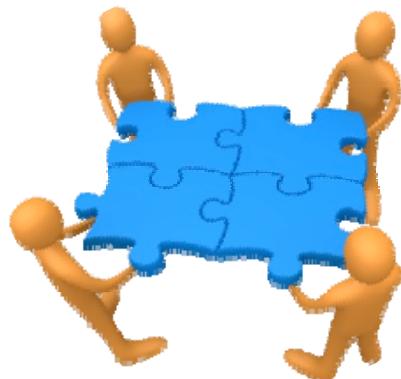
Physics of Notations Theory



Physics of Notations Theory

The principles synthesize **knowledge** and **evidence** coming from various disciplines:

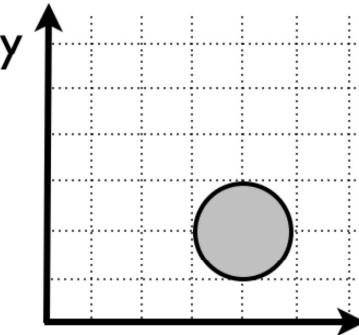
- Cartography
- Cognitive psychology
- Diagrammatic reasoning
- Graphic design
- HCI
- Information visualization
- Linguistics
- Perceptual psychology
- Semiotics
- Typography



Main contribution: defragmentation
and some metrics defined

Visual Variables

Eight elementary **visual variables** that can be used to graphically encode information [Bertin-83]

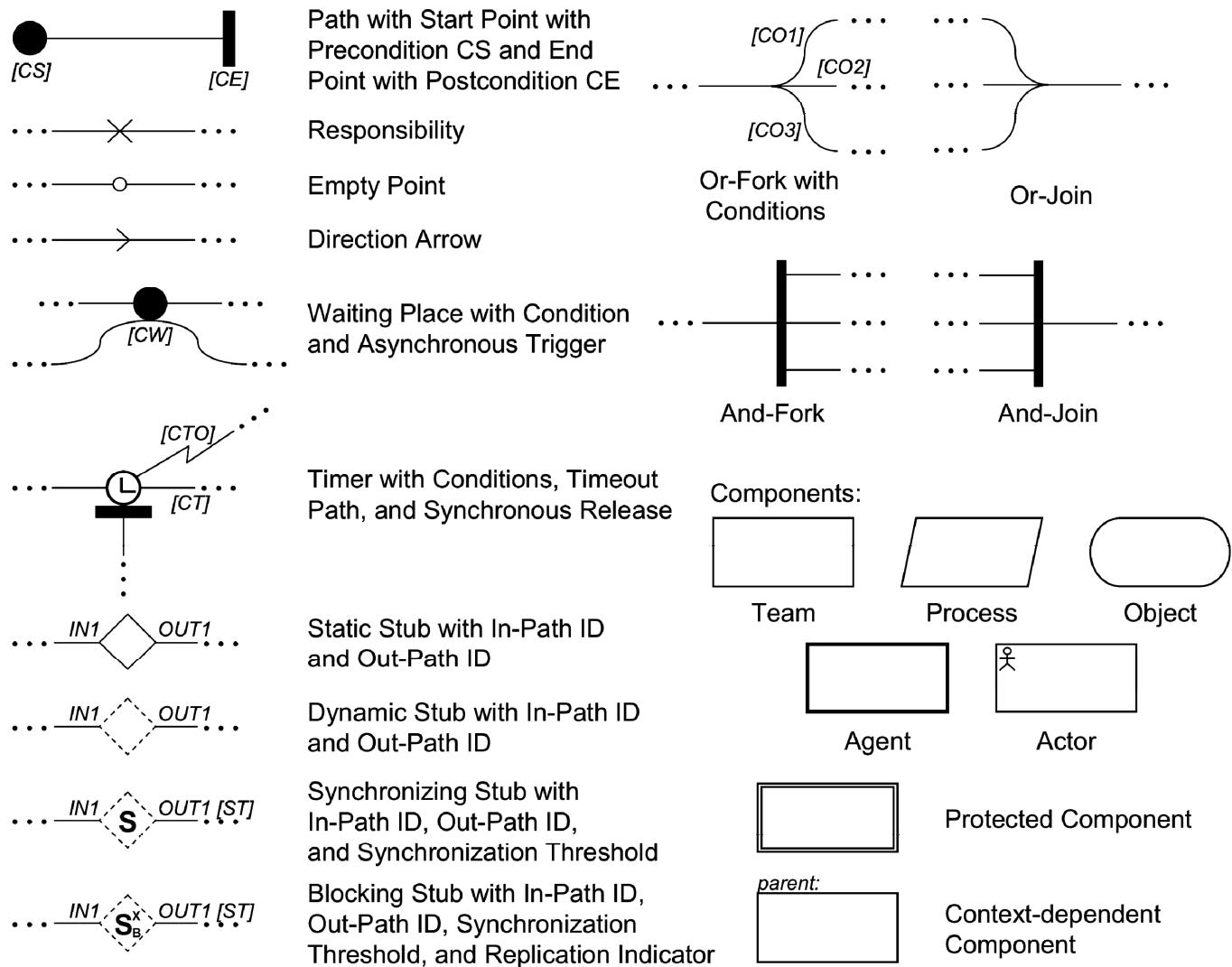
PLANAR VARIABLES	RETINAL VARIABLES			
 (x,y) coordinates	Shape	Colour	Size	Brightness

Use Case Maps

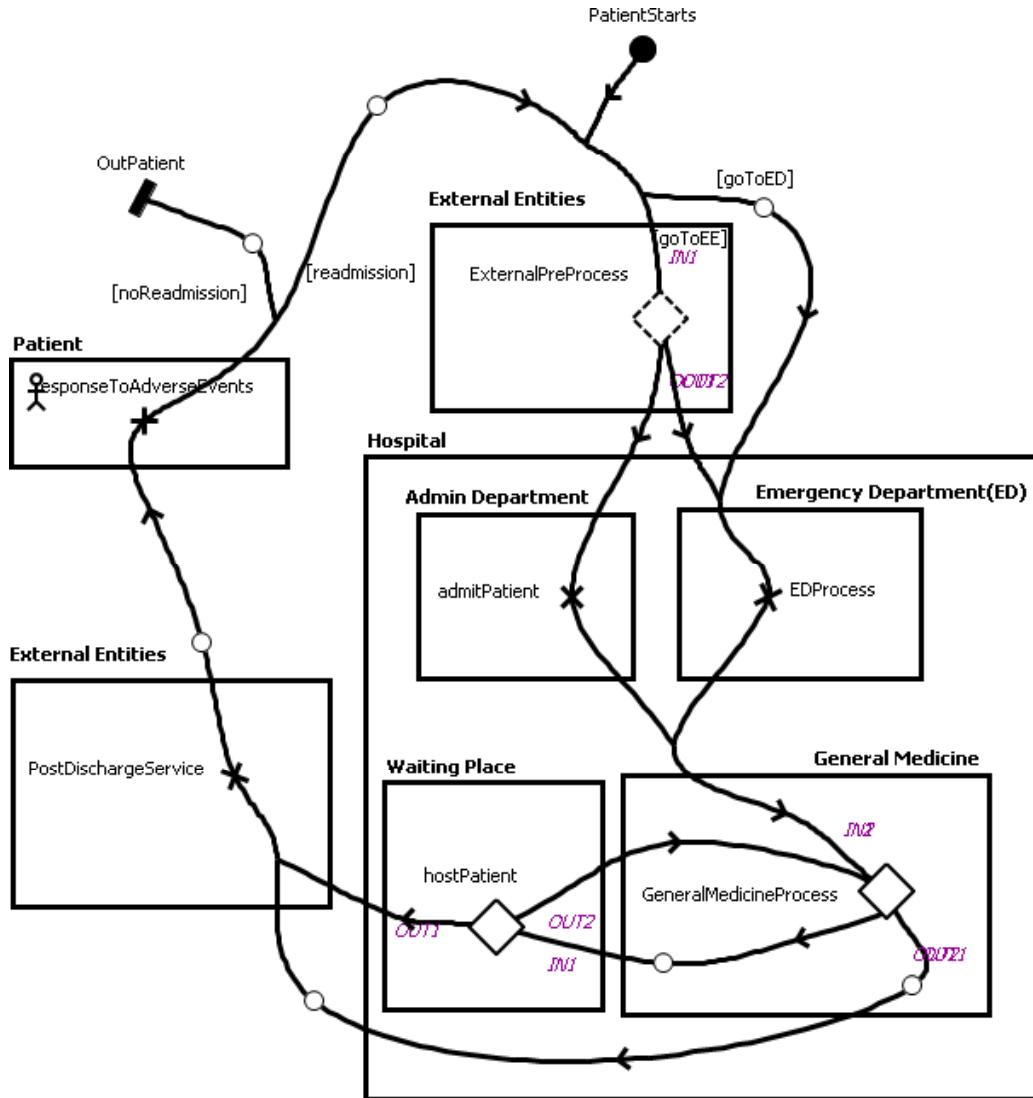
- Introduced by Buhr *et al.* in the early 90's
- Part of ITU-T's User Requirements Notation
 - Rec. Z.151, November 2008
 - Goal modelling with GRL
 - Scenario modelling with UCM
- The standard includes
 - Metamodel
 - Visual notation
 - XML-based interchange format

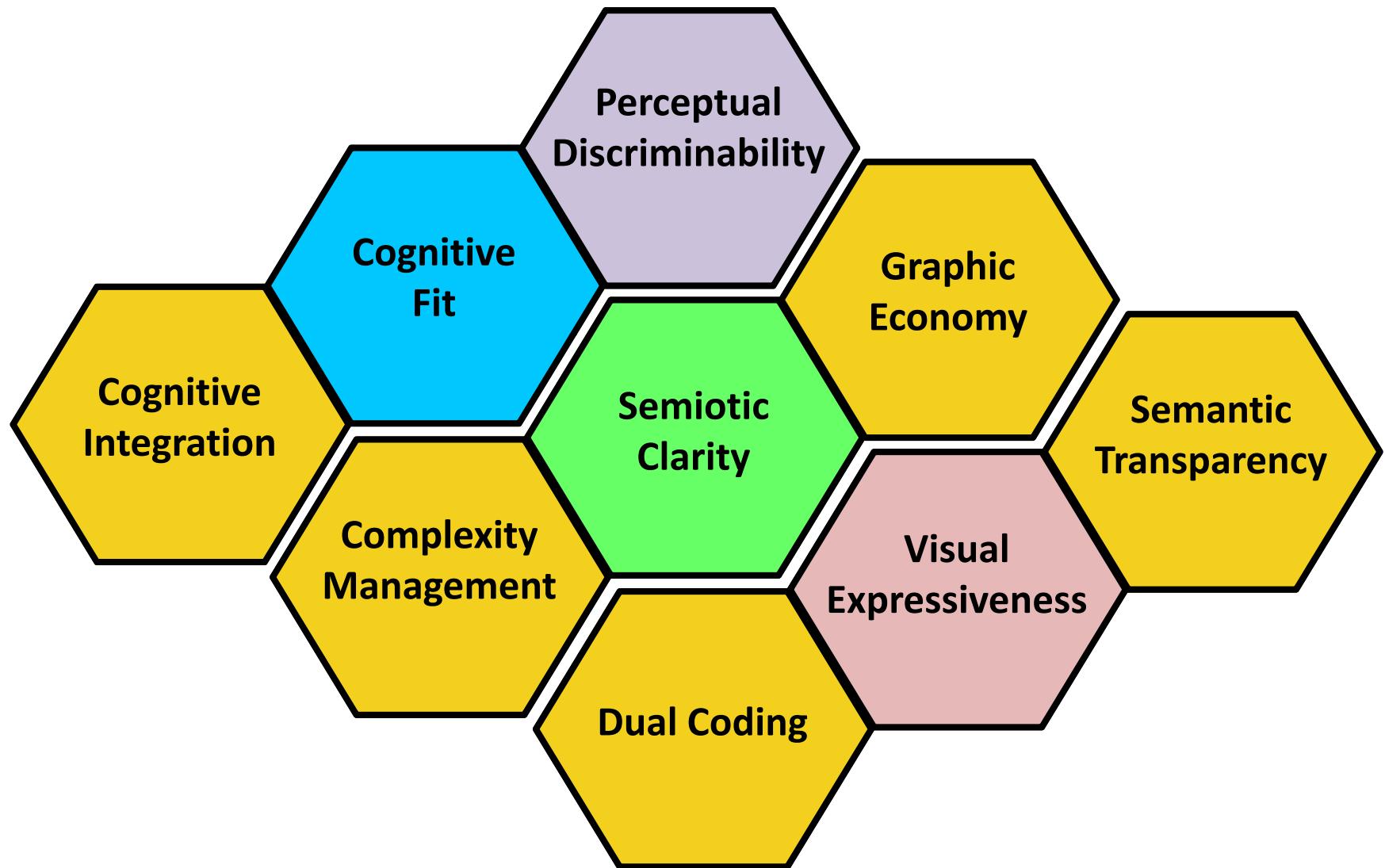
The full analysis is available in a technical report [\[Genon-UCM\]](#)

Use Case Maps



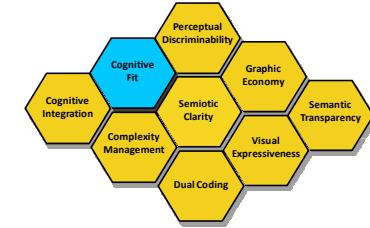
Use Case Maps





Cognitive Fit

Use different visual dialects when required.



3-way fit:

1. Audience (customers, users, domain experts)
2. Representation medium (paper, whiteboard, computer)
3. Task characteristics

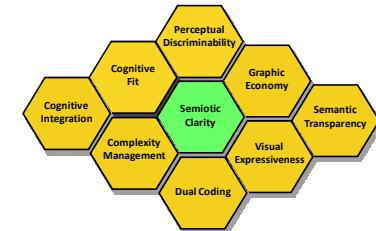
Cognitive Fit helps determine which audiences, media and tasks notation improvements will target

In our analysis of UCM, we considered

- notation experts ...
- ... working mainly on computer tools, and sometimes on whiteboards and paper...
- ... for modelling and discussing advanced scenarios

Semiotic Clarity

There should be a 1:1 correspondence between semantic constructs and graphical symbols



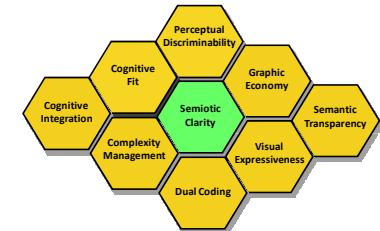
UCM:

- 55 semantic constructs
- 28 symbols

Anomaly types	Description	UCM	%
Symbol deficit	Construct not represented by any symbol	23	42 %
Symbol overload	Single symbol representing multiple constructs	3	7 %
Symbol excess	Single construct represented by multiple symbols	2	4 %
Symbol redundancy	Symbol not representing any construct	1	2 %

Semiotic Clarity

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Anomaly types	Description	UCM	%
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UCM:

Essentially:

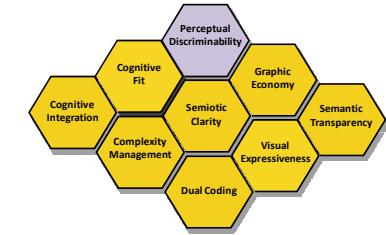
- Variable definitions
- Plug-in bindings
- Performance annotations
- Others (concerns, singleton, metadata)



- Associate symbols to these concepts
- Choose not to represent and make it explicit in the standard
- Remove these concepts

Perceptual Discriminability

Symbols should be clearly distinguishable.

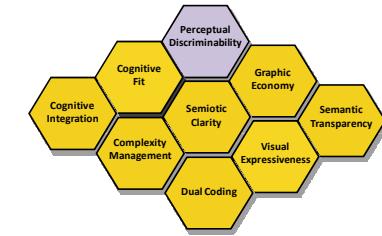


Symbol discriminability in UCM

- Shape
 - 50% of symbols are icons
 - the others use conventional shapes
- Grain (border style)
- Colour (black & white)
- Size

Perceptual Discriminability

Symbols should be clearly distinguishable.



Suggestions for improvement

1. Use multiple visual variables (especially colour)



Team



Actor



Agent



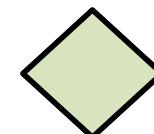
Protected component



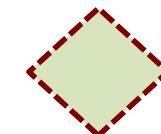
Process



Object



(Static) Stub

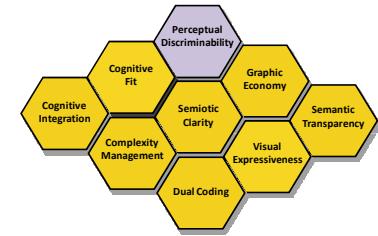


Dynamic Stub



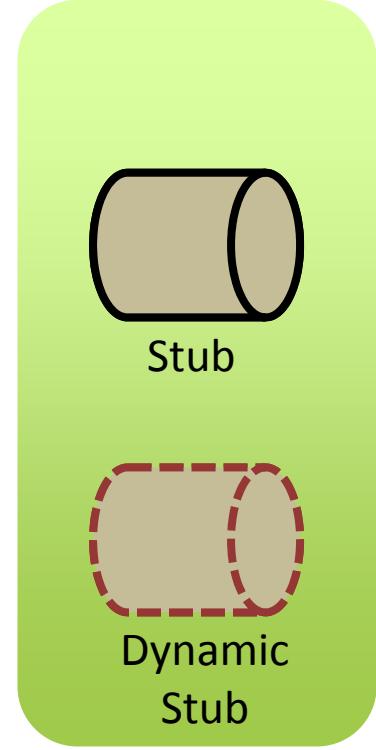
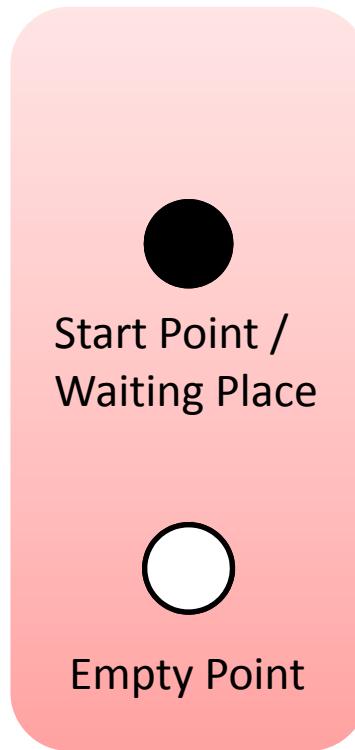
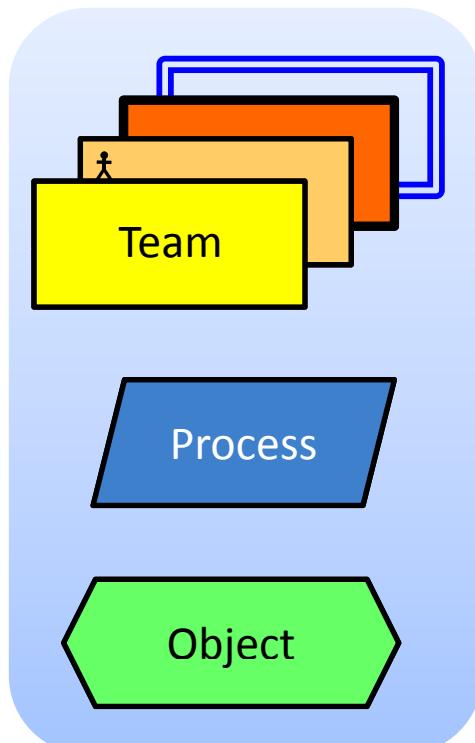
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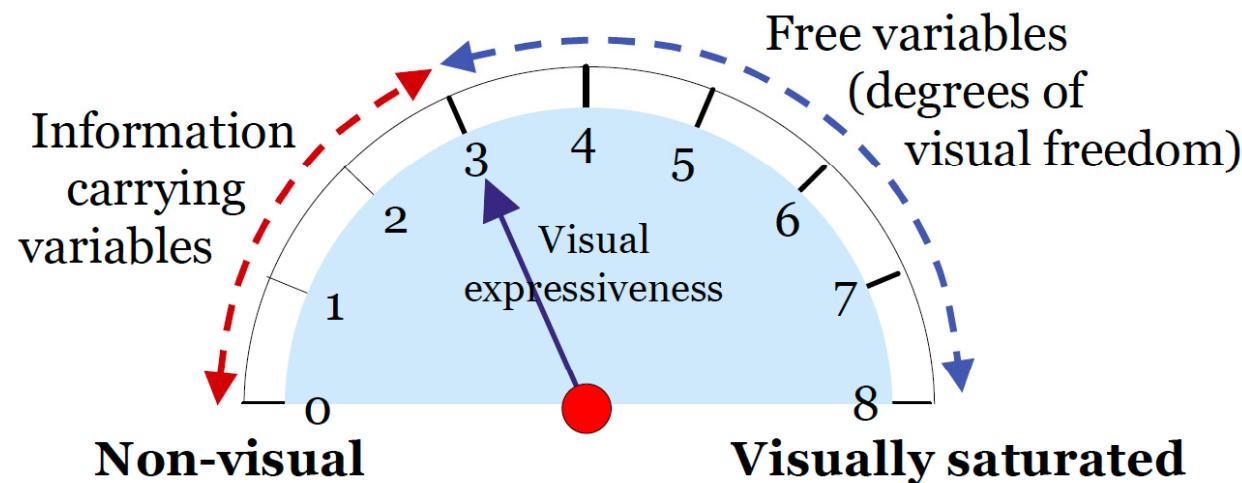
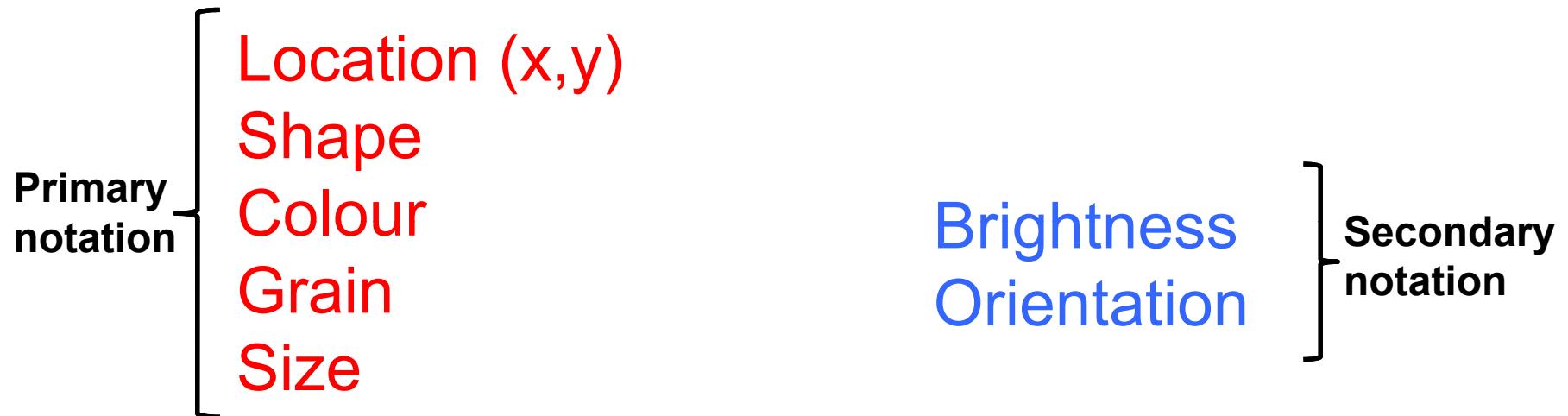
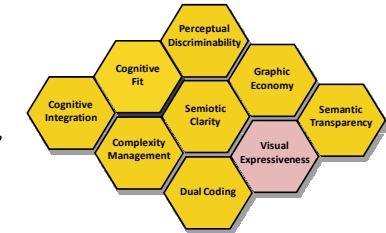
Suggestions for improvement

2. Choose shapes from different families



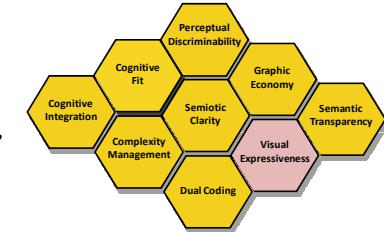
Visual Expressiveness

Use the full range and capacities of visual variables



Visual Expressiveness

Use the full range and capacities of visual variables



Check « if form follows content »

Visual variables	Power	Capacity	UCM values	Saturation
Location (x,y)	Interval	10 – 15	3	20 – 30%
Shape	Nominal	Unlimited	15	–
Colour	Nominal	7 – 10	1	10 – 14%
Size	Interval	20	3	15%
Grain	Nominal	2 – 5	5	100%

Related Work

Cognitive Dimensions of Notations [Green et al., 2006]

- 13 dimensions for cognitive artefacts [7].
- Not for visual notations, no guidelines, vague empirical foundation, not falsifiable

Semiotic Quality (SEQUAL) Framework [Krogstie et al., 2006]

- Comprehensive ontology of quality concepts
- Wider in scope, with similar limitations as above, but provides measurable criteria and guidelines

Guidelines of Modeling [Schuette et al., 2006]

- Language quality framework with 6 principles
- More about using languages, with rules of thumbs

Seven Process Modelling Guidelines [Mendling et al., 2006]

- At the instance (diagram) level. Complementary.

Moody's Framework used on ArchMate, UML, *i**, and BPMN

Observations about the PoN Theory

- Time-consuming exercise (~2 persons/month)
- Training is essential
- Availability of metrics is uneven
 - Perceptual Discriminability: the visual distance between symbols should be “large enough”
- Many principles represent conflicting goals
 - Need to understand the solution’s trade-offs
- Finding the semantic constructs is key
 - Yet it is not straightforward
 - However, once they are known, PoN becomes the most accomplished theory to analyse and improve the cognitive effectiveness of visual modelling languages

Conclusions

- Be aware of the problem, and of the Physics of Notations theory!
- Analysis of the strengths and weaknesses of UCM, with a few ideas for improvements
- Applicable to new languages and extensions
 - UCM exception handling, time, aspects...
- Need for validation phase
 - Empirical experiments implicating real UCM users
- Should this be standardized?
 - Rec. Z.111: Notations to define ITU-T languages?

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