A core ontology of instruments used for neurological, behavioral and cognitive assessments

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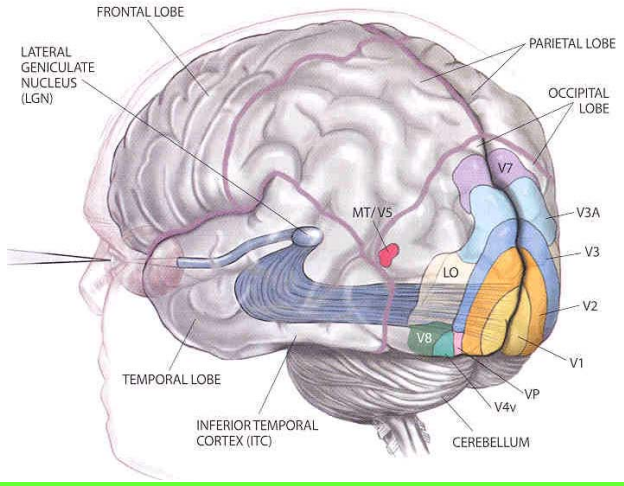
Project motivations

A tool for NeuroSciences

- **Development of an open software architecture:**
  - Management and access to partly structured, heterogeneous and distributed data.
  - Ease resources sharing (data sets and processing tools)
  - Foster collaborative work (multi-centre studies)
- **Design of an application ontology as a conceptualization of reference:**
  - Following a multi- layer and component approach (Temal *et al.*, 2006)
  - A core ontology for images and regions-of-interest is in use (Temal *et al.*, 2008)



Current work objectives

- **Define a model supporting the investigation of correlation between image (MRI) data and neuro-psychology data,** e.g.,
  - "*Find all patients with a low memory score and with T1-weighted images presenting a grey matter loss in the temporal lobes*"
- **Design an ontology of instruments used to assess the neurological state of the subjects as well as their cognitive and behavioral performances**
- **Observation:**
  - No such ontology already exists
  - Its design requires to introduce abstract concepts (e.g., capacities, functions, behaviours, artefacts) whose characterization in formal ontologies is still an open issue

Outline

- Subject data acquisition (SDA) instruments
- Ontological reference framework
- Core ontology of instruments (*per se)*
- Core ontology of scores
- Conclusion

An informal model

We have **measurement situations** with:

- **A measured object**
  - A subject (patient or healthy volunteer)
- **An instrument**
  - A “subject data acquisition” instrument
  - Enables to measure – or assess the subject’s state – along some dimension
- **A measurement**
  - An “instrument-based assessment”
  - Performed by a healthcare professional
- **Results of measurement**
  - Scores (raw, corrected by norms)
  - Structured according to scales

A questionnaire : Beck Depression Inventory

1. Sadness
0 I do not feel sad.
1 I feel sad much of the time.
2 I am sad all the time.
3 I am so sad or unhappy that I can't stand it.

2. Pessimism
0 I am not discouraged about my future.
1 I feel more discouraged about my future than I used to be.
2 I do not expect things to work out for me.
3 I feel my future is hopeless and will only get worse.

3. Past Failure
0 I do not feel like a failure.
1 I have failed more than I should have.
2 As I look back, I see a lot of failures.
3 I feel I am a total failure as a person.

4. Loss of Pleasure
0 I get as much pleasure as I ever did from the things I enjoy.
1 I don't enjoy things as much as I used to.
2 I get very little pleasure from the things I used to enjoy.
3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings
0 I don't feel particularly guilty.
1 I feel guilty over many things I have done or should have done.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

6. Punishment Feelings
0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

7. Self-Dislike
0 I feel the same about myself as ever.
1 I have lost confidence in myself.
2 I am disappointed in myself.
3 I dislike myself.

8. Self-Criticalness
0 I don't criticize or blame myself more than usual.
1 I am more critical of myself than I used to be.
2 I criticize myself for all of my faults.
3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes
0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

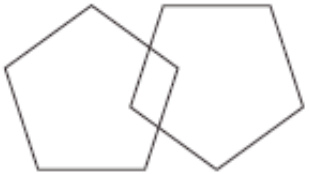
10. Crying
0 I don't cry anymore than I used to.
1 I cry more than I used to.
2 I cry over every little thing.
3 I feel like crying, but I can't.

BDI (Beck, 1996) focuses on depression

Items measure elements related to depression (e.g., self-dislike, suicidal thoughts or wishes)

A test: Mini Mental State

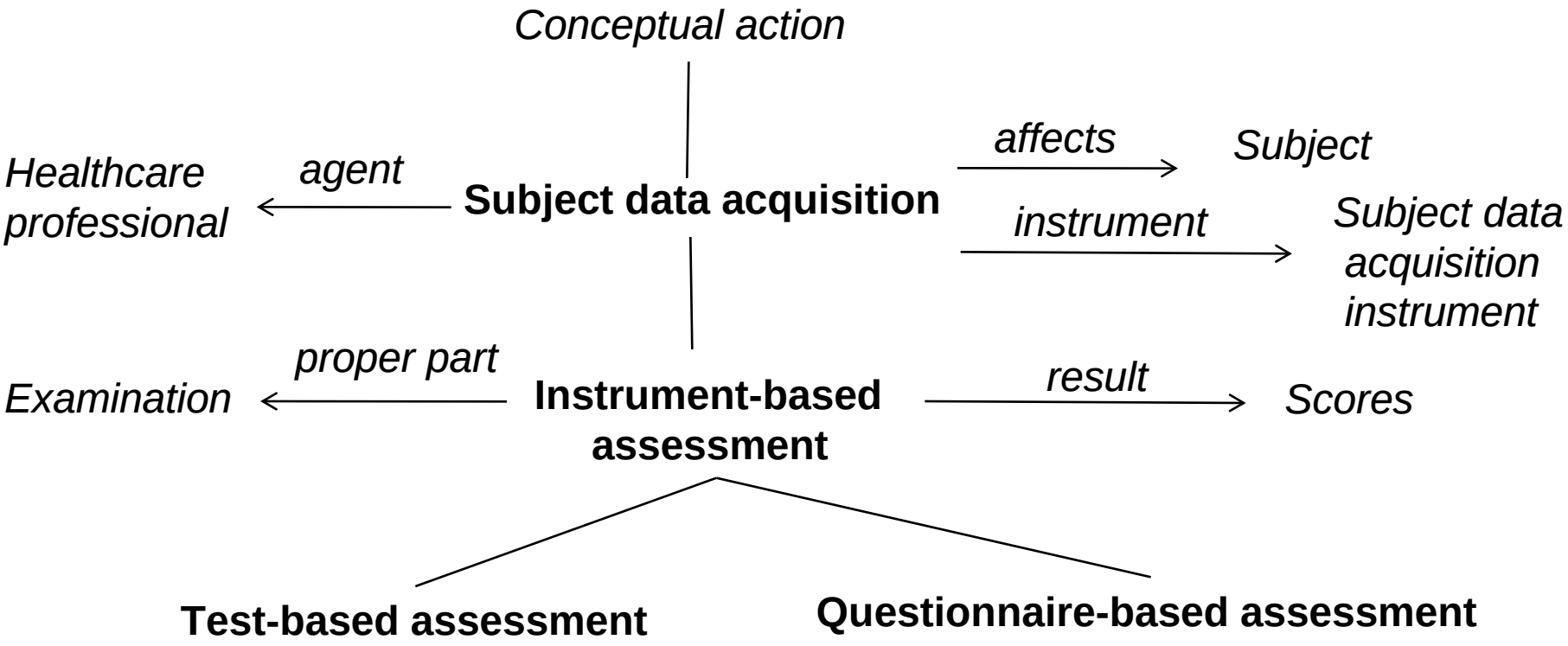
Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward. (Do both and take the best score)
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.



MMS (Folstein, 1975)
focuses on
global cognitive efficiency

Solicits actions from the subject (e.g., repeating names of objects, copying a figure)

Instrument-based assessments



Plan

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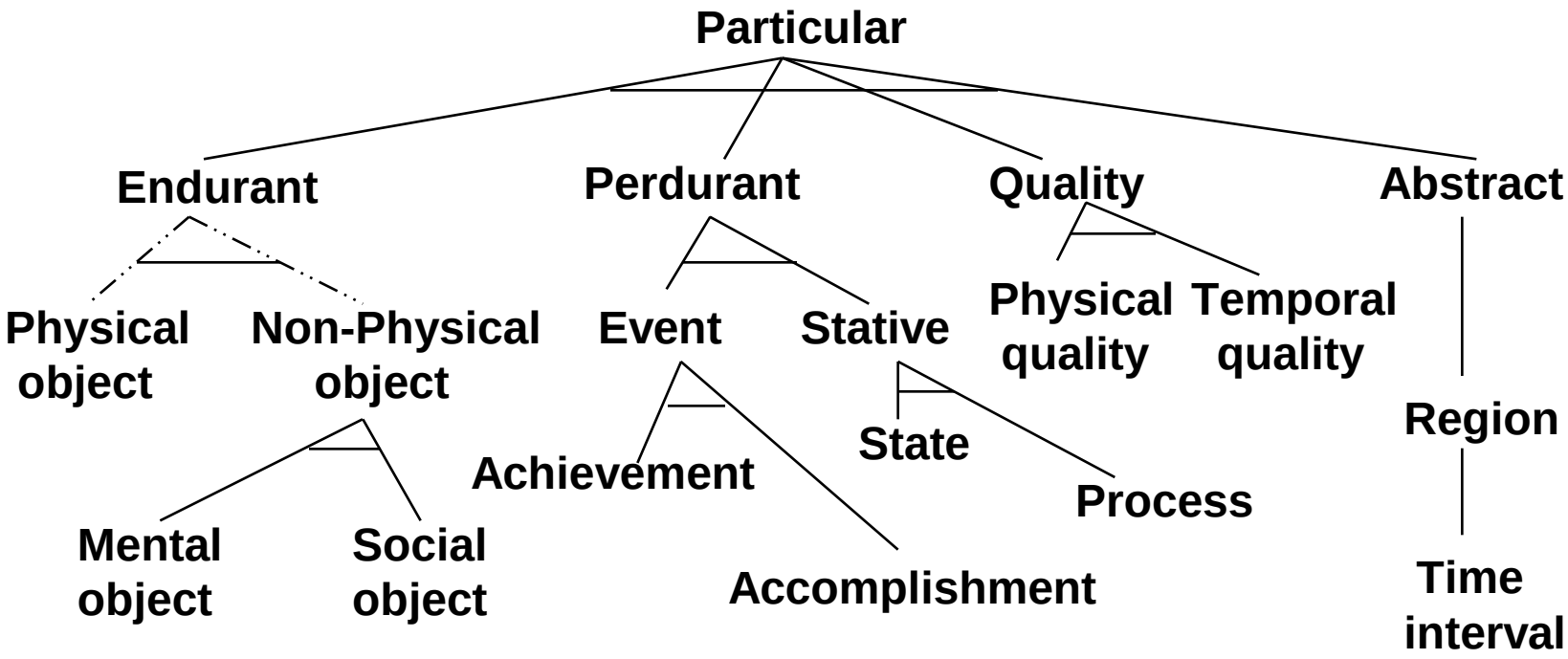
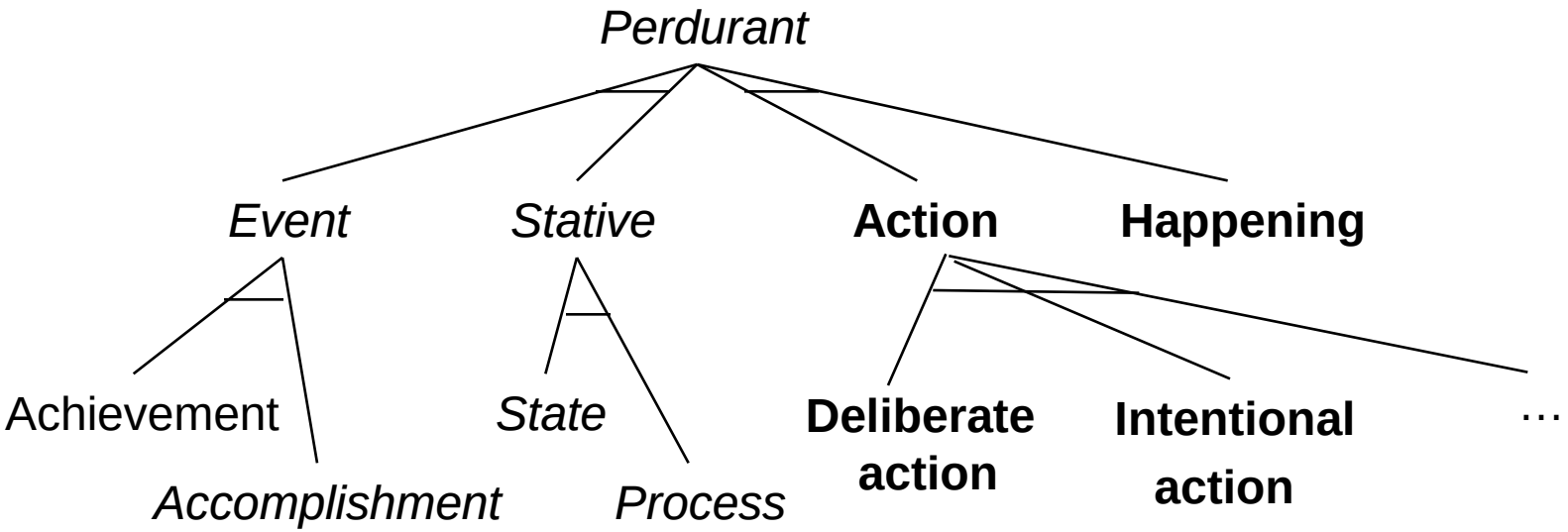
DOLCE: an ontology of particulars

(Masolo *et al.*, 2003)



A minimal ontology of actions

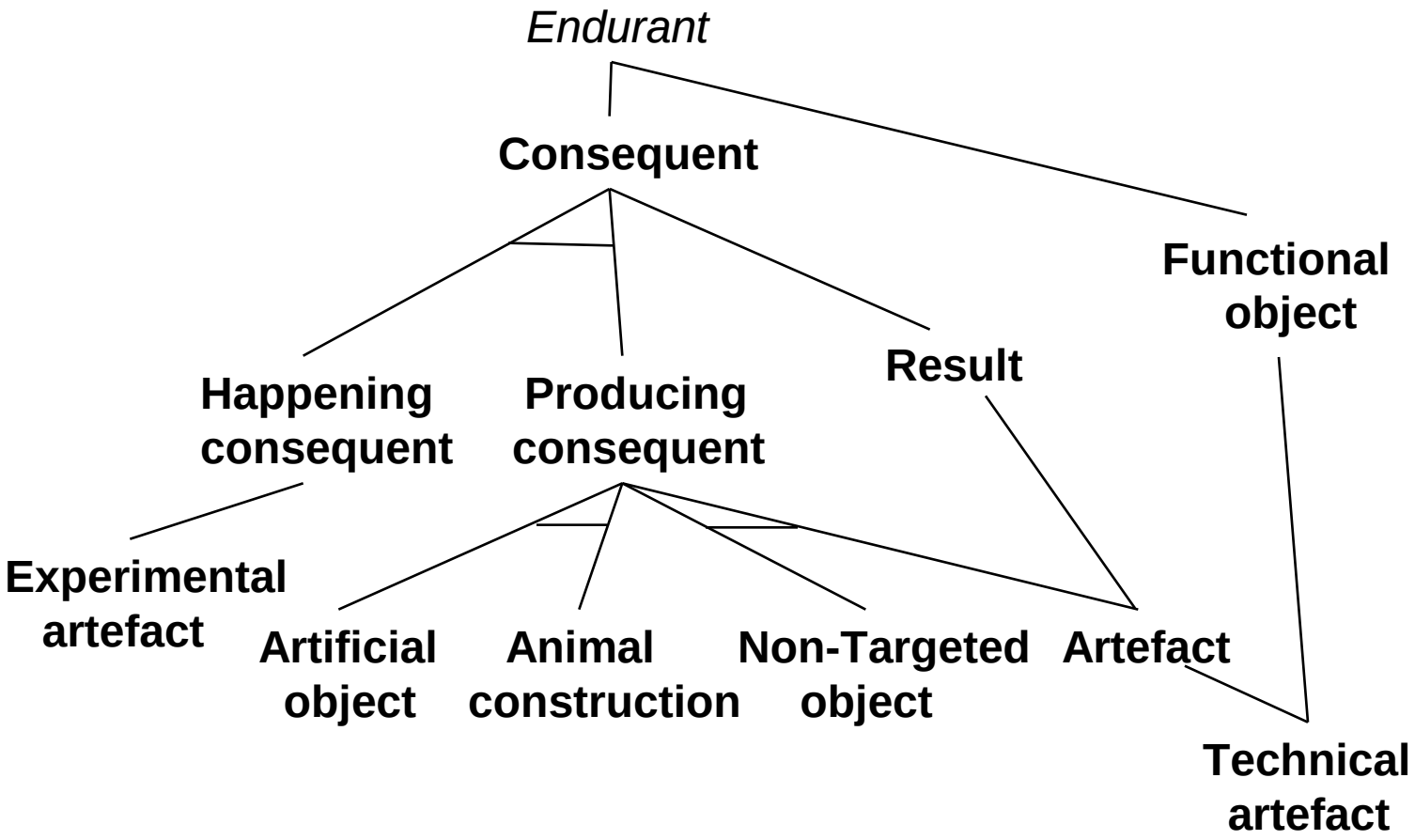


Sources:

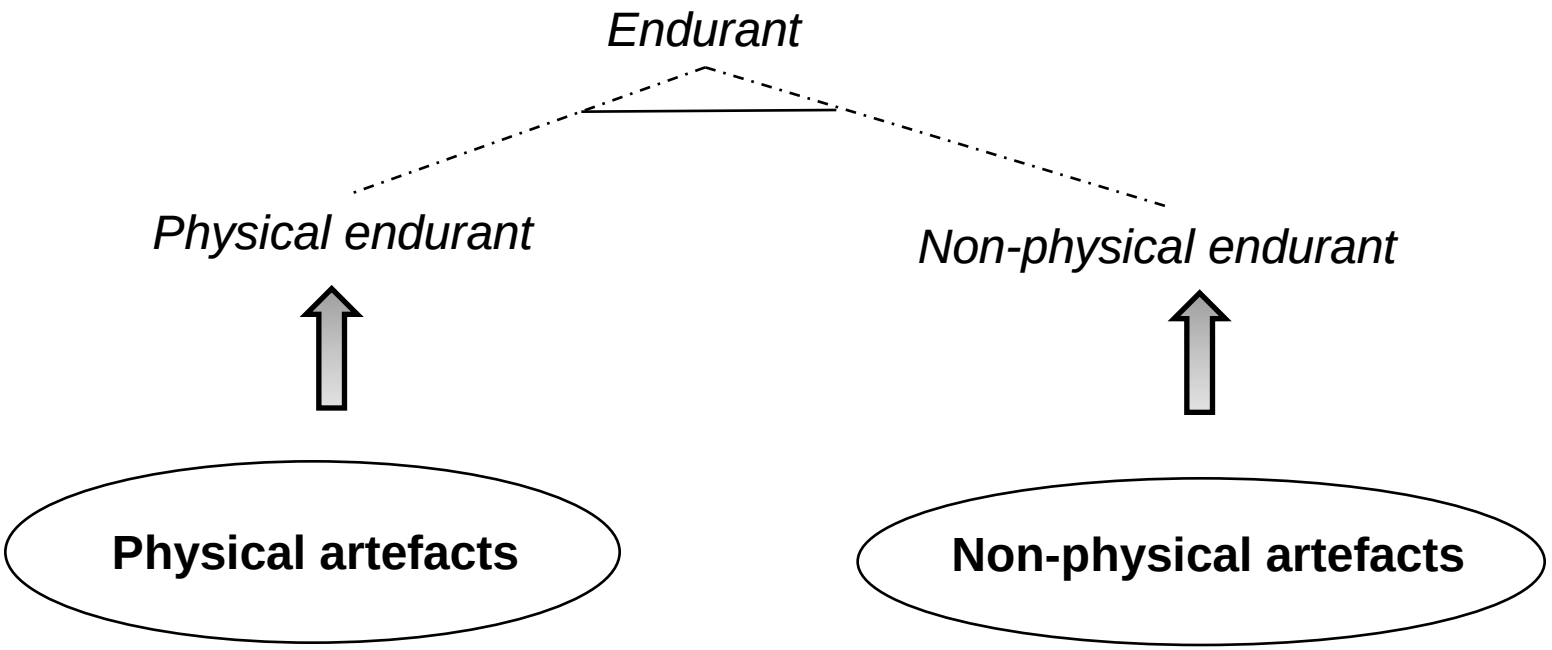
- (Pacherie, 2000): *The content of intention*
- (Pacherie, 2007): *The phenomenology of action...*
- (Trypuz, 2008): *Formal ontology of action...*

An ontology of technical artefacts

(Kassel, 2010, *Applied Ontology*): “technical artefacts have a triple nature”



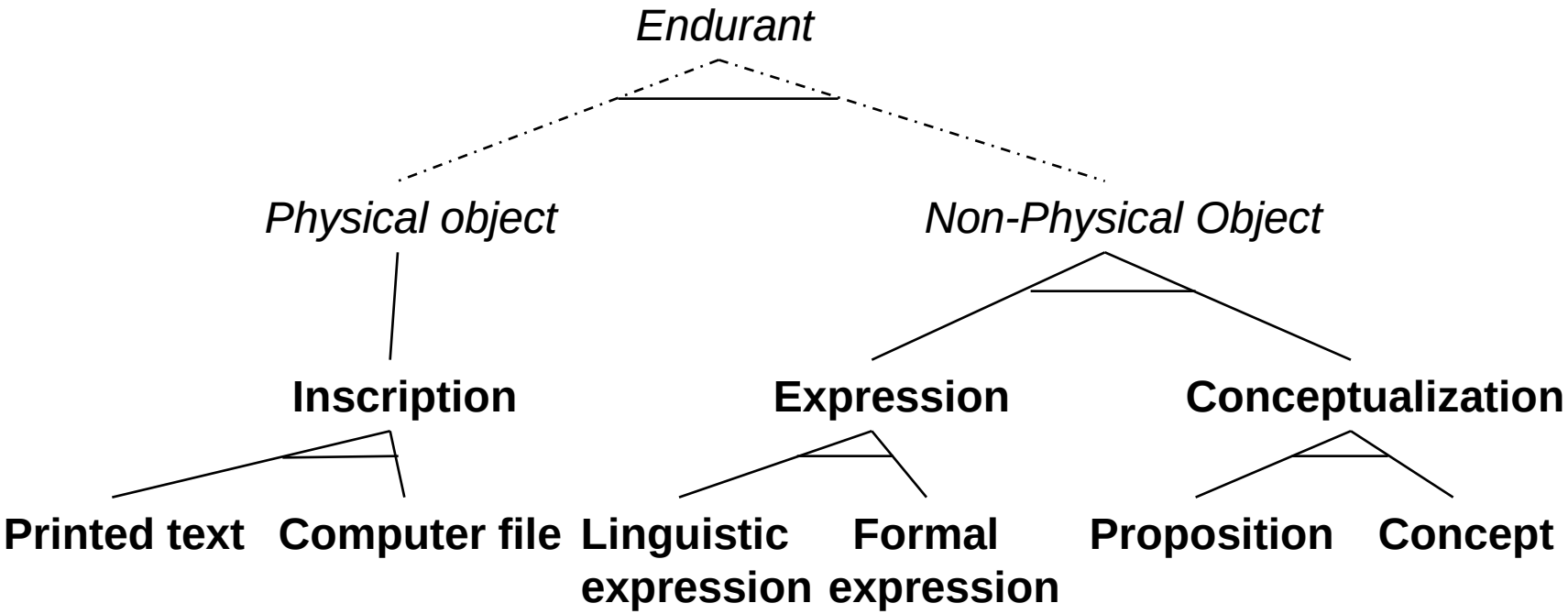
Physicality and artefacts



(e.g., chair, screwdriver, computer, thermometer, measuring-rod)

(e.g., ontology, computer program, scale questionnaire, test, exam subject)

A minimal ontology of information content objects



Sources:

- (Pease & Niles, 2002): *Practical Semiotics...*
- (Masolo *et al.*, 2003) -> define *Information objects* and *Descriptions*
- (Fortier & Kassel, 2004) -> define *Inscriptions*, *Expressions* and *Conceptualizations*

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SDA Instruments' triple nature

- **SDA instruments are:**
  - **Intangible artefacts, complex propositional contents**
    - **including** « clearly defined methods and instructions for administration or responding, a standard format for data collection, and well-documented methods for scoring, analysis, and interpretation of results » (CDISC Glossary, 2007)
  - **Intentionnally produced (and therefore have authors)**
  - **Functional entities which enable the exploration of some class(es) of entities related to the subject's state (their *domain(s)*)**

More about instruments' structure

- **Some (*`composite`*) instruments have for parts *`sub-instruments`* (exploring sub- or related domains)**
  - (e.g., the MMS (Mini-Mental State) Test is composed of the MMS orientation Test, the Registration Test and Language Tests)

- **Instruments have *`variables`* as atomic parts, which:**
  - "explore" domains (like instruments)
    - *`Main variables`* explore the same domain as their instrument
    - `Secondary variables` explore near domains to provide additional information

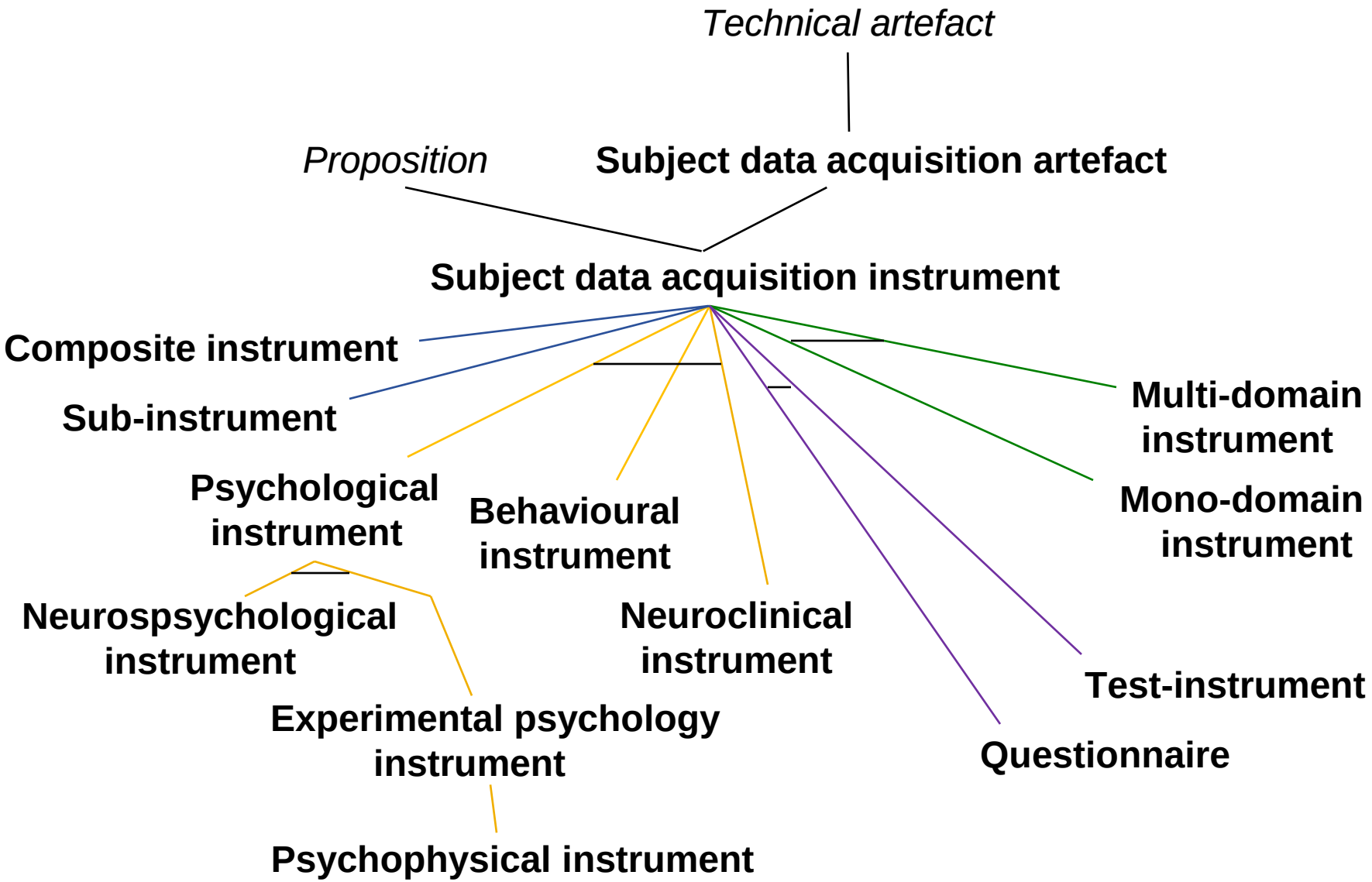
More about instruments' creation

- **Two types of produced entities must be distinguished:**
  - kinds of instruments
  - instances of instruments
- **Kinds of instruments undergo adaptations (variants) and are revised to create standards:**
  - (e.g., Wechsler Adult Intelligence Scale: WAIS-I (1955), WAIS-R (1981), WAIS-III (1997), WAIS-IV (2008))
- **It is crucial to model knowledge about kinds of instruments (and not only about instances) to enable data sharing:**
  - (e.g., the conventional name of the variables)

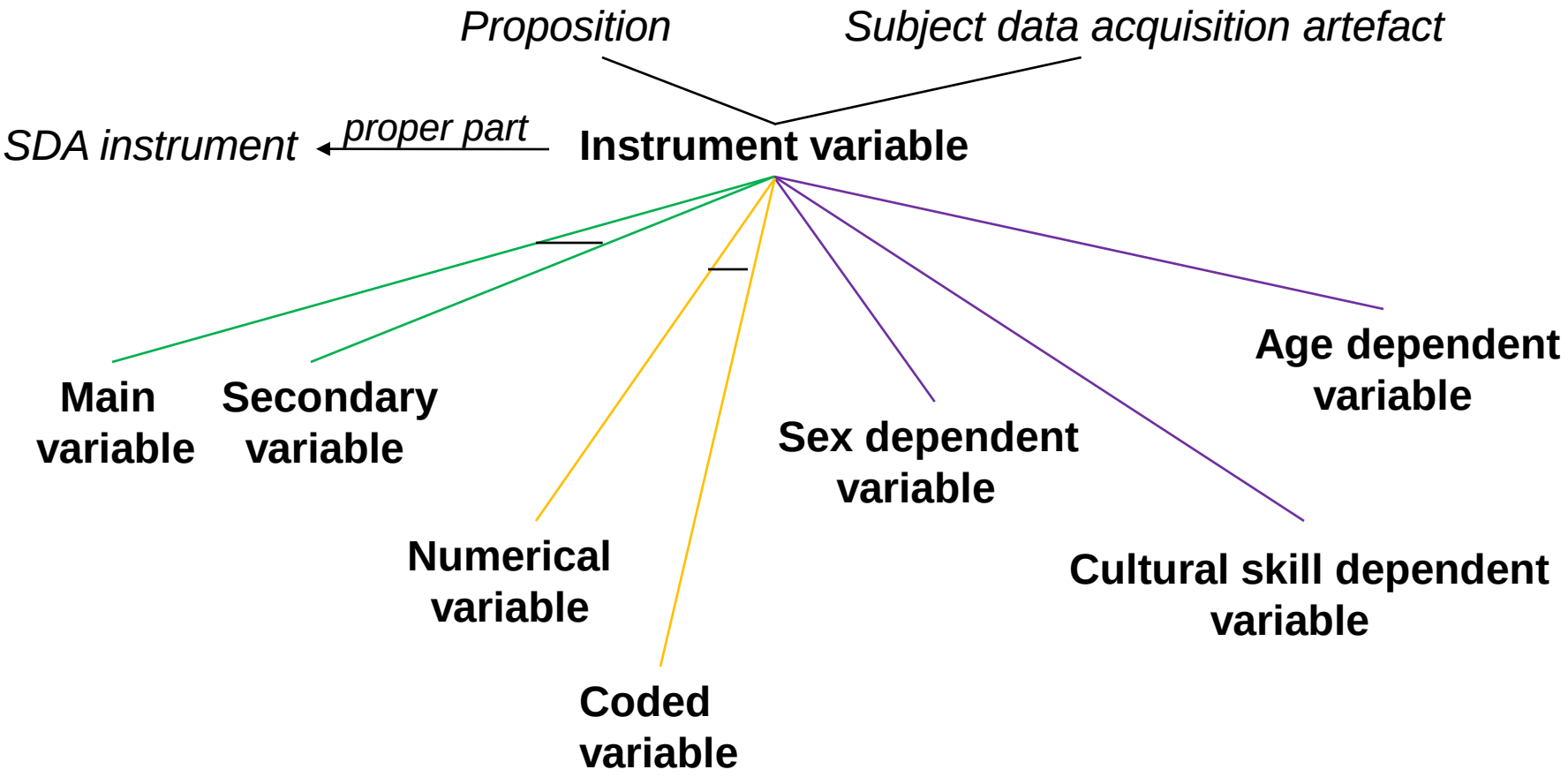
More about instruments' function

- **Two kinds of *domains* must be distinguished:**
  - Capacities/Functions (e.g., language, memory, motricity)
  - « Traits », i.e. pathological states (e.g., depression, anxiety, dementia)
- **Depending on the kinds of *domains*, *variables* measure:**
  - Performances of the subjects on the realization of an action
    - (e.g., performance on naming of two objects, performance on repeating a sentence)
  - Intensity/severity of traits
    - (e.g., intensity of depression, severity of dementia)

Ontology of SDA instruments



Ontology of variables



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what variables measure... in reality

Entities and their properties

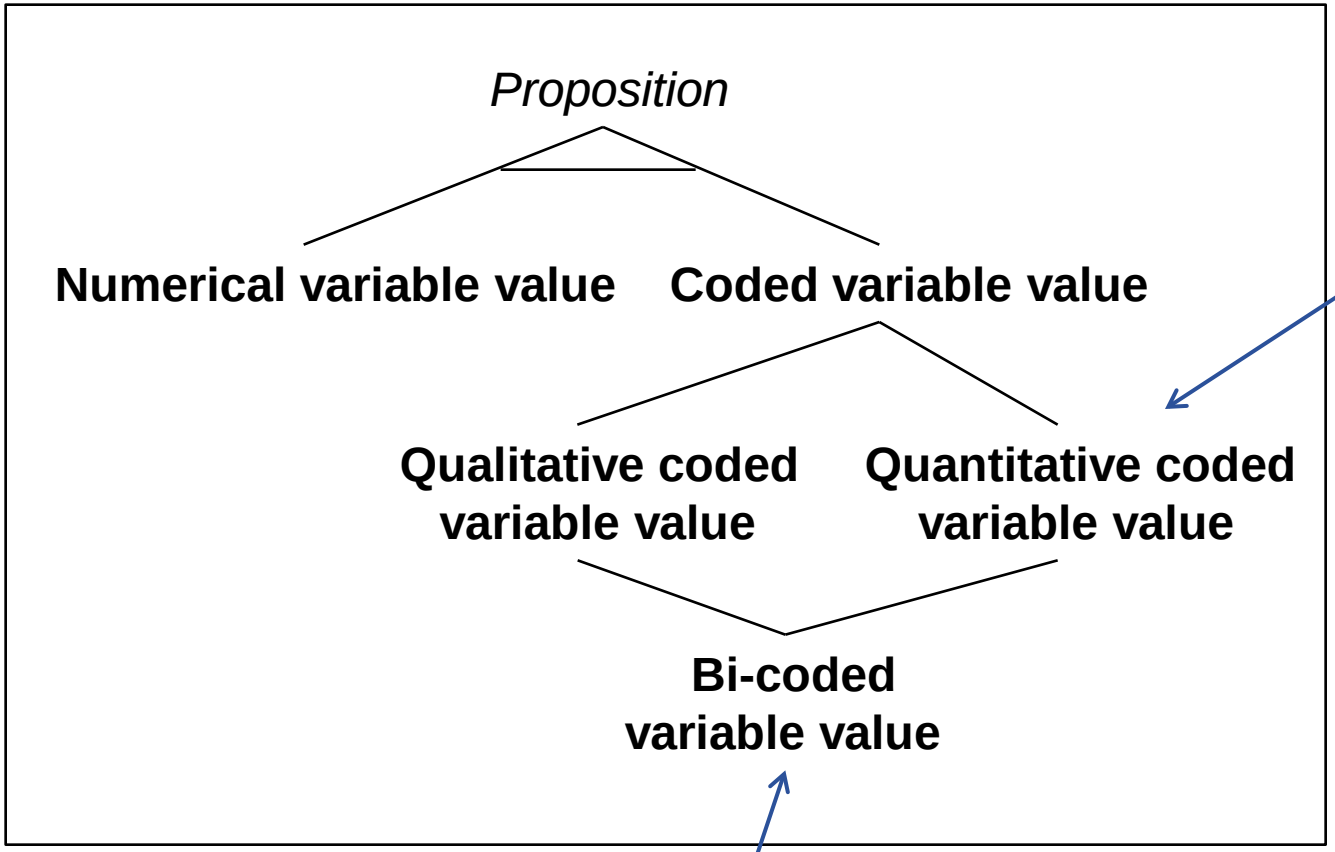
- « Performance » in the realization of actions:
  - Great diversity of actions: counting backwards by 7, figure recopy, walking a 500-meter
  - Collections of successfull actions: number of items correctly recognized during a test
- « Intensity » of « traits »:
  - Great diversity of qualites: Frequency, severity, gravity, impact on the entourage, impact for the subject
  - Great diversity of traits: capacities, loss of capacities, aberrant behaviors, pathological states, dispositions, feelings, wishes, delusional ideas, hallucinations
  - Collection of states: depression, most of the day or nearly every day for the past two weaks

Our modeling strategy

- **Modeling the subject, taking into account information acquired by an instrument-based assessment, is a too difficult task...**
  - Ontological resources accounting for `capacities`, `behaviours`, `dispositions`, `collections`, `etc.` are not yet on the shelves!
- **All what we need is to share scores as symbols having a conventional meaning**
  - We don't need to explicitly represent this meaning

➢ **We therefore model results of instrument-based assessments as *`information`* (propositional content) coded by numbers**

Information associated to variables



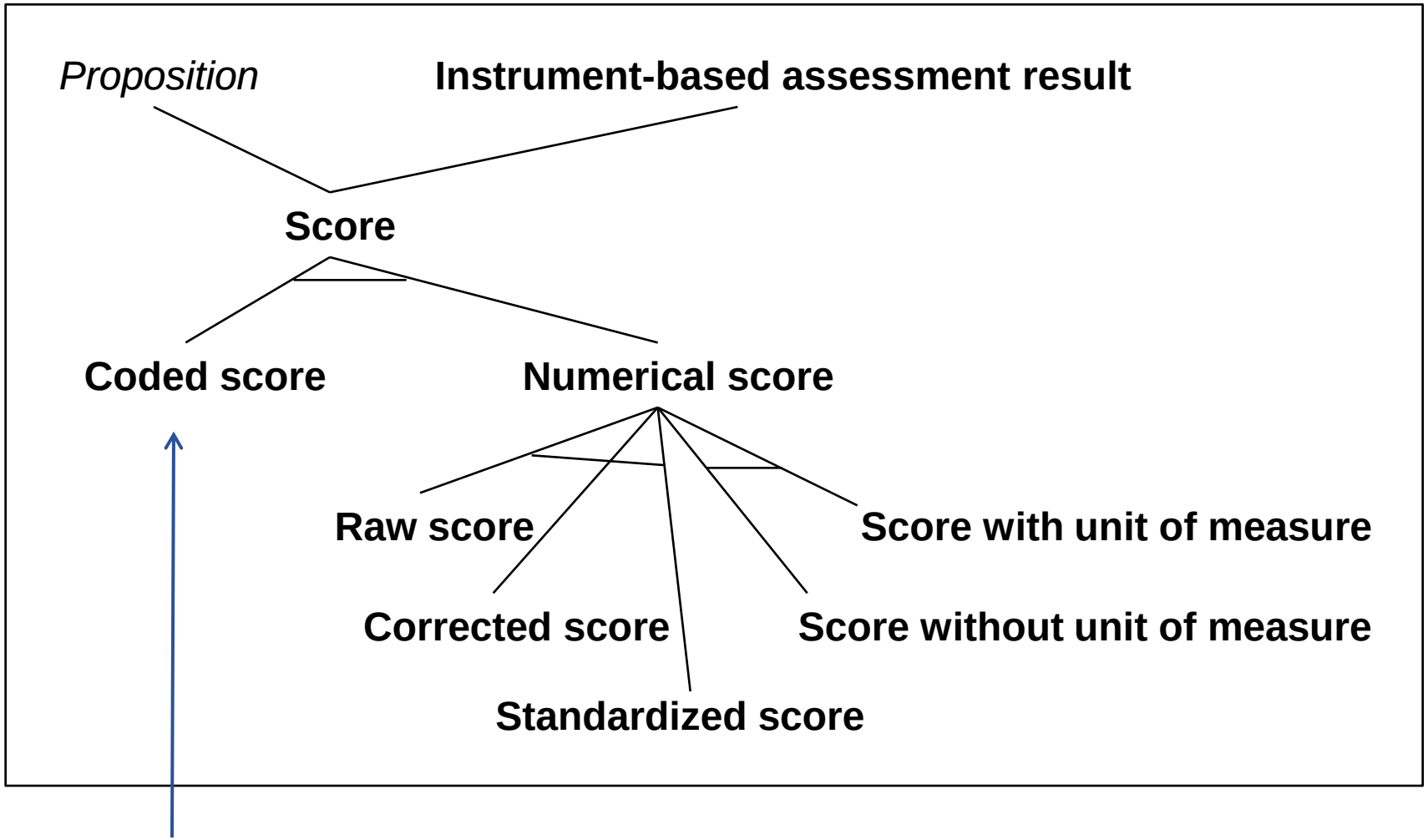
"The subject has fluctuating ideas of failure as measured by the MADRS pessimistic thought variable"

Code = 2

"The subject sleeps somewhat more than usual as measured by the DBI sleeping variable"

Codes = 'minimal' ; '1a'

Scores: information resulting from a specific i-b assessment



"During one MADRS assessment, subject X has no pessimistic thoughts as measured by the MADRS Pessimistic Thought variable"

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Summary and perspectives

- **We designed a core ontology of instruments to assess the neuropsychological state of subjects**
- **This core ontology:**
  - Extends a set of existing foundational and core ontologies (Particular (*DOLCE*), Actions, Functions and Artefacts, Inscriptions, Expressions & Conceptualizations (*I&DA*))
  - Is currently specialized to conceptualize (a dozen of) standards instruments
- **A version encoded in OWL is used to query image and neuropsychological data (project NeuroLOG)**
- **Our short-dated objectives:**
  - modeling brain functions which play the role of instruments' domains, as a first step towards sharing knowledge about instruments