Agents with understanding abilities
and ways to avoid misunderstanding

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Motivations of the author

Software agents

- are already used in many applications

- their usages are increasing

    - including agent-directed simulation

- they are becoming more advanced

    - such as agents with personality and emotions

They can be even more advanced
    - if they can have ability to "understand"
    - …

Motivations of the author

- **Understanding** is

  an **interesting**, **important**, and **challenging** topic:

  - in philosophy

  - in artificial intelligence

- Ability to understand **has pragmatic values**

  in many application areas such as:
  - **program understanding**
  - **understanding human emotions**

Presentations and Publications of Dr. Tuncer Ören on
Understanding

http://www.site.uottawa.ca/~oren/pubsList/understanding.pdf

A software agent:

- is an **autonomous** software module

  - with perception and social ability

- to perform **goal-directed knowledge processing** over time.

- can work

  - **on behalf of** humans or other software agents

  - in software or physical environments.

1. Motivations of the speaker

2. Software agents

3. Understanding: Basic concepts and definitions

4. A taxonomy of understanding

5. Performance factors of understanding systems

6. Examples

7. Misunderstanding and ways to avoid it

Understanding - Dictionary definitions (Webster):

- to seize the meaning of
    <understand relativity>
- to grasp the reasonableness of
    <his behavior is hard to understand>
- to have thorough or technical acquaintance with or expertness in the practice of
    <understand finance>
- to be thoroughly familiar with the character
    <understand children>
- to accept as a fact or truth or regard as plausible without utter certainty
    <we understand that he is returning from abroad>

Understanding - Dictionary definitions (Webster):

- to interpret in one of a number of possible ways
- to form a reasoned judgment concerning (something)
- to have the power of seizing meanings,

  forming reasoned judgments ...

- to believe or infer something to be the case

  <I understand she is not coming>

- to show a sympathetic or tolerant attitude toward

  <his manager understands him>

- to possess a passive knowledge of (a language)

Relationship :

| understanding | ⟷ | meaning |
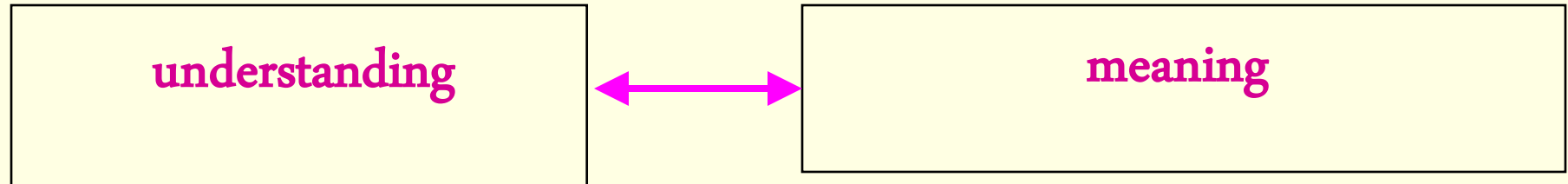
If "A" cannot understand "B,"

"B" does not have a meaning for "A."

A → **B**
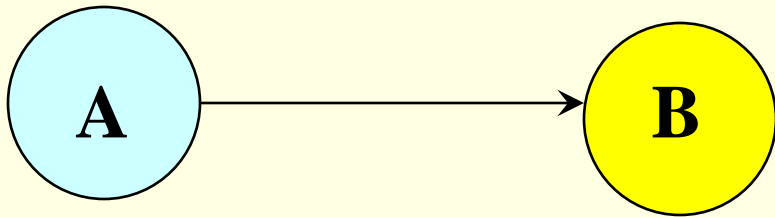
J. Dewey (1910). How we think, D.C. Heath, Lexington, MA.

Relationship

understanding	⟷	knowledge

"We say that a systems "**knows about**" a class of
objects, or relations,

if it has an internal (***knowledge*** *about the*) relations
for the class

which enables it to operate on objects in this class

and to communicate with others about

such operations."

(B.P. Zeigler, 1986)

"Thus, **if a system knows about X**, a class of objects or relations on objects,

it is able to use an (internal) representation of the class in at least the following ways:

- **receive** information about the class,
- **generate** elements in the class,
- **recognize members** of the class and **discriminate** them from other class members,
- **answer** questions about the class, and
- **take into account** information about changes in the class members."

<div align="right">(B.P. Zeigler, 1986)</div>

Zeigler, B.P. (1986). System Knowledge: A definition and its implications. In: Elzas, M.S., Ören, T.I., Zeigler, B.P. (eds.) (1986). Modelling and Simulation Methodology in the Artificial Intelligence Era. North-Holland, Amsterdam, pp. 15-17.

A definition of understanding:

Understanding an entity
(a thing, a concept, an event, or a system)
is a mapping between

the **perceived *knowledge*** about the entity

and

a ***meta-model*** (i.e., a more general
knowledge) of the entity.   (Tuncer Ören)

Understanding Systems :

A can understand B iff 3 conditions are met: 1, 2, 3.

A system B to be understood; Entities, Relations, Attributes

System B
(E, R, A)

understand

1

C: meta-model of B
(knowledge of A about Bs)

access

System A can

analyse/ perceive

2

D: **a** perception of B by A

map

3

relationships between C and D
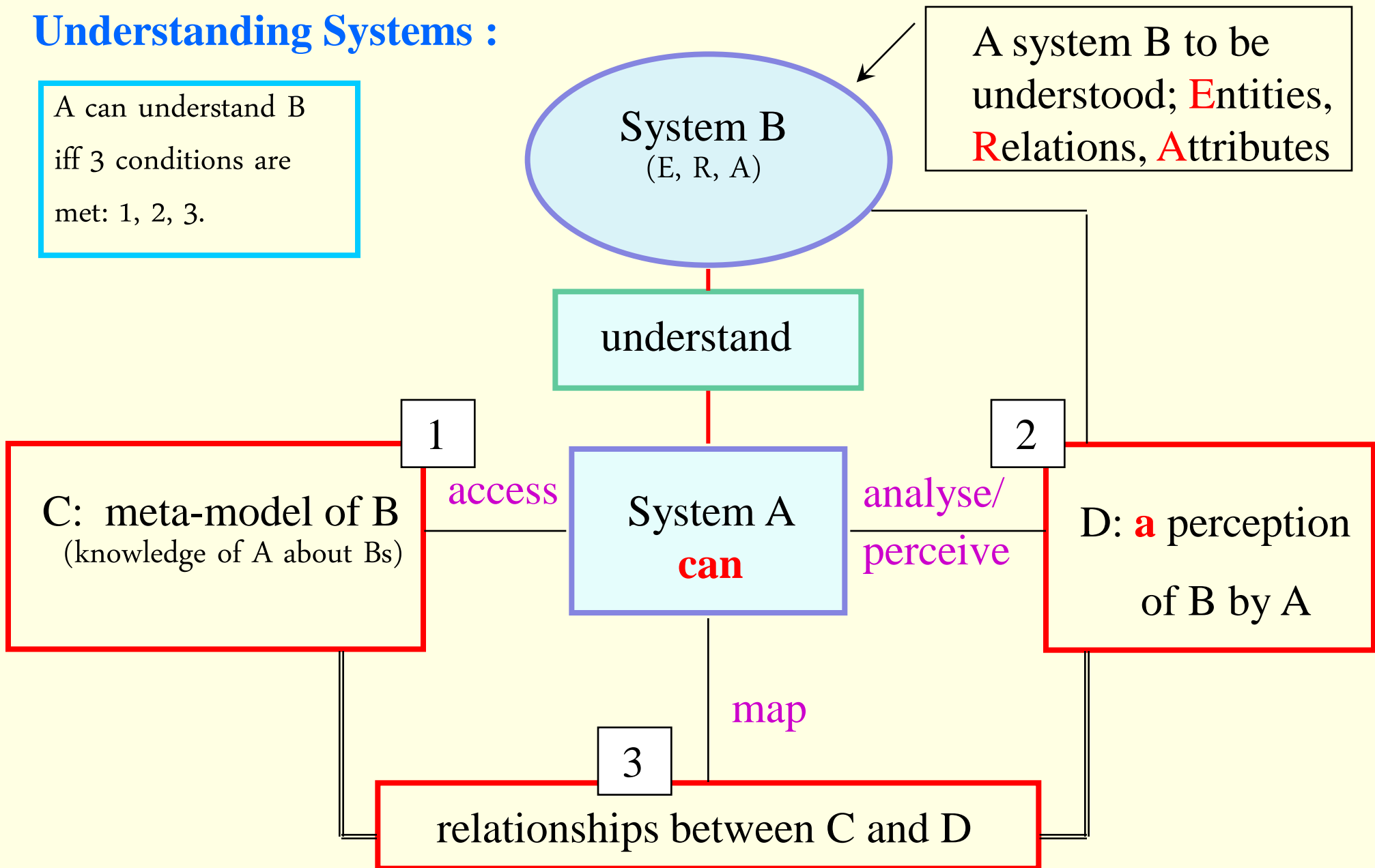
Understanding an entity is a mapping (establishing a relationship):

"B"
entity to be understood

meta-model (knowledge about "B"s)

a mapping
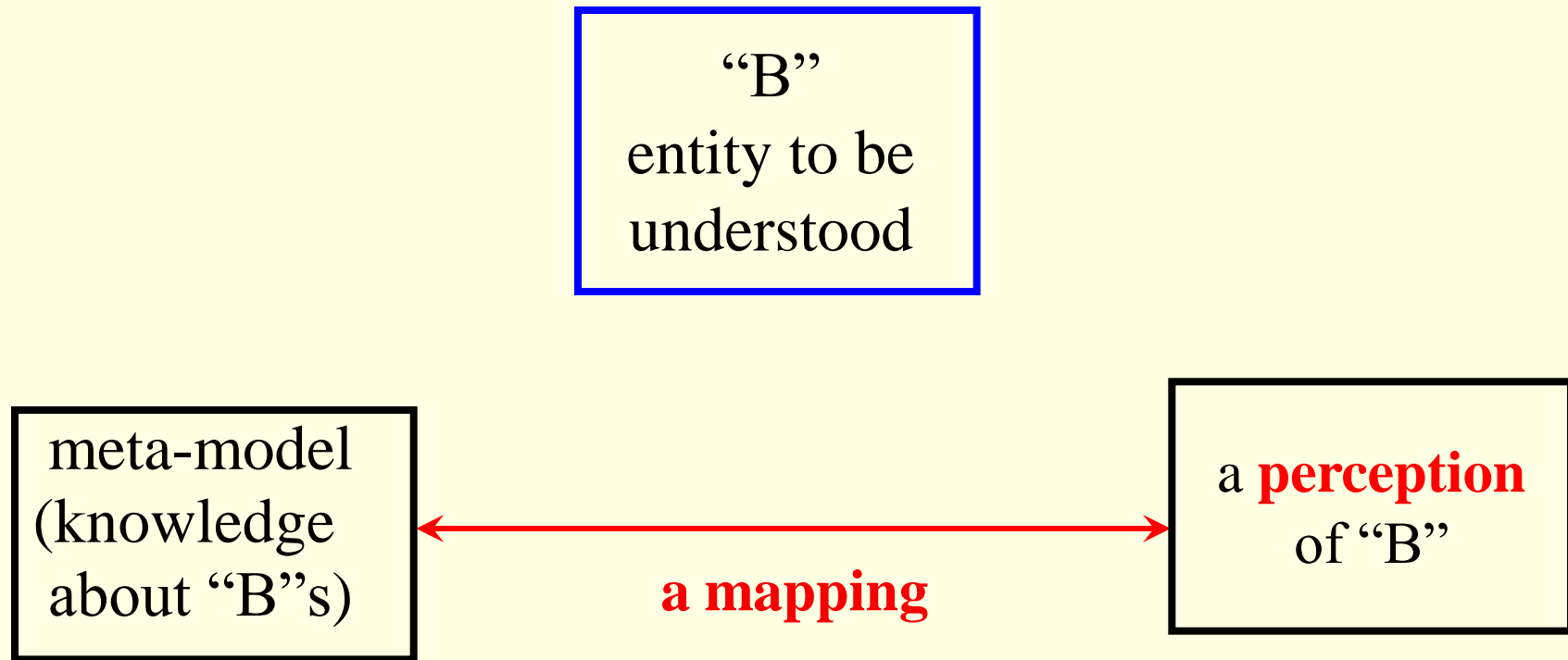
a **perception** of "B"

Ability to understand an entity

requires

knowledge (meta-model) about entity to be understood
and

knowledge processing ability
- **to perceive** the characteristics of the entity &
- **to compare** the perception and the meta-model

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A taxonomy requires identification of **elements** and **criteria**:

Criteria:

- **product** of the understanding process

- understanding **process**

- **meta-model**

- characteristics of the understanding **system**

Criterion - **Product** of the understanding process:

subcriteria:
- domain
- nature
- scope
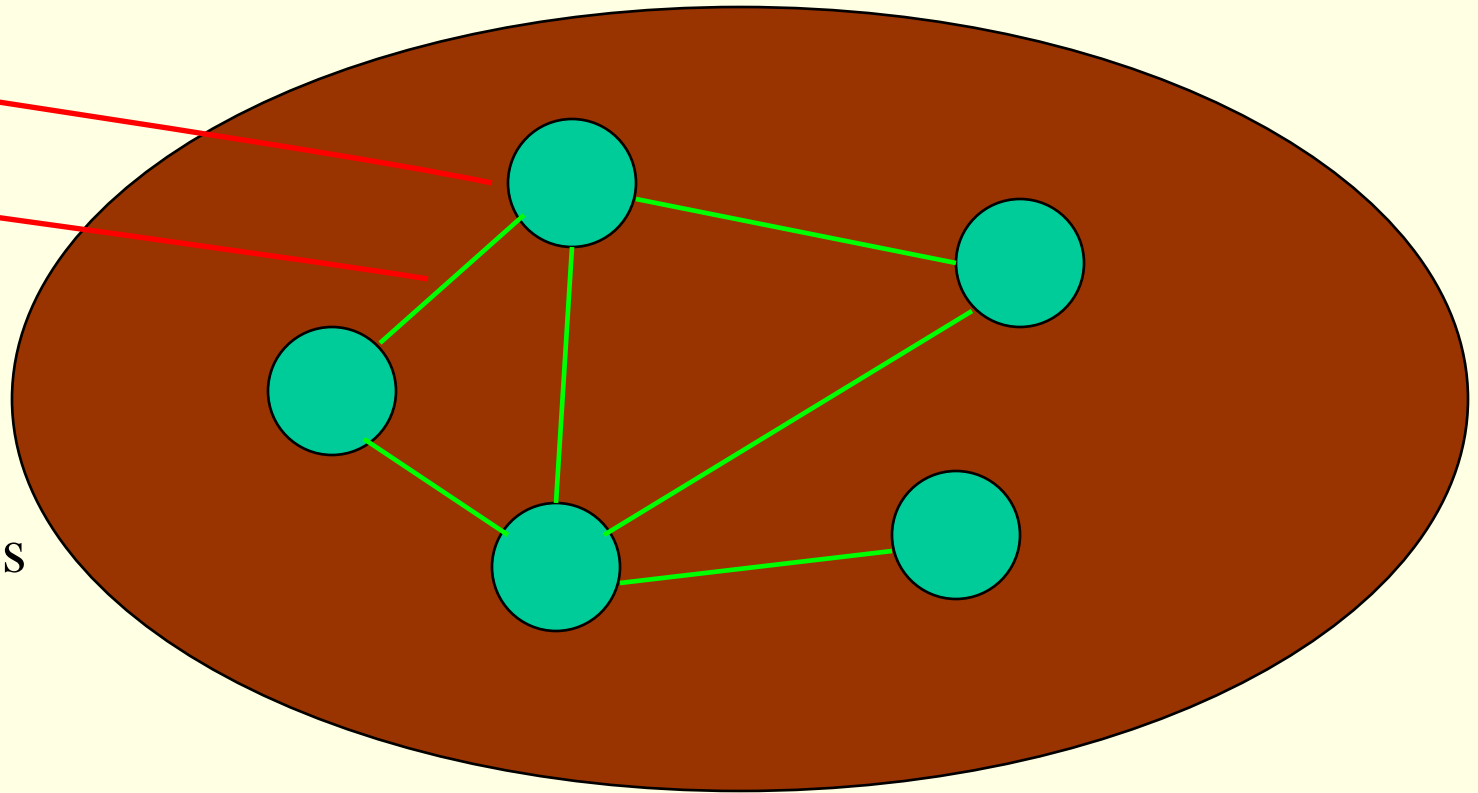- granularity (level of detail)
- reliability

Product of the understanding process

• **Domain** of understanding:

    - **internal understanding**

    - **external understanding**

Internal understanding :

- elements
- relationships
- attributes
  - elements
  - relationships

Internal understanding :

involves:

- **elements** of a system,

- **relationships** of the elements, and

- the **attributes** (time invariant / time varying) of

  the elements and

  the relationships.

In systems and software engineering terminology

the system is considered as a **glass box**

External understanding :

involves:

 - **relationship** of a **system** and its **environment**.

  (time invariant / time varying)

In systems and software engineering terminology the system is considered as a **black box**

Product of the understanding process

- **Nature** of understanding:

  - lexical understanding
  - syntactic understanding
  - morphological understanding   (structure)
  - semantic understanding   (meaning)
  - pragmatic understanding   (intention)

Product of the understanding process

• **Scope** of understanding:

    - **focused understanding**

    - **broad understanding**

      (understanding several or all aspects)

Product of the understanding process

- **Granularity** (level of detail) of understanding:

  - **coarse understanding**
  - **detailed understanding**
  (**in-depth understanding**)

Product of the understanding process

- **Reliability** of understanding:

    - **reliable understanding**

        - valid understanding

        - verified understanding

    - **unreliable understanding**

        - invalid understanding

        - unverified understanding

Criterion - understanding **process** :

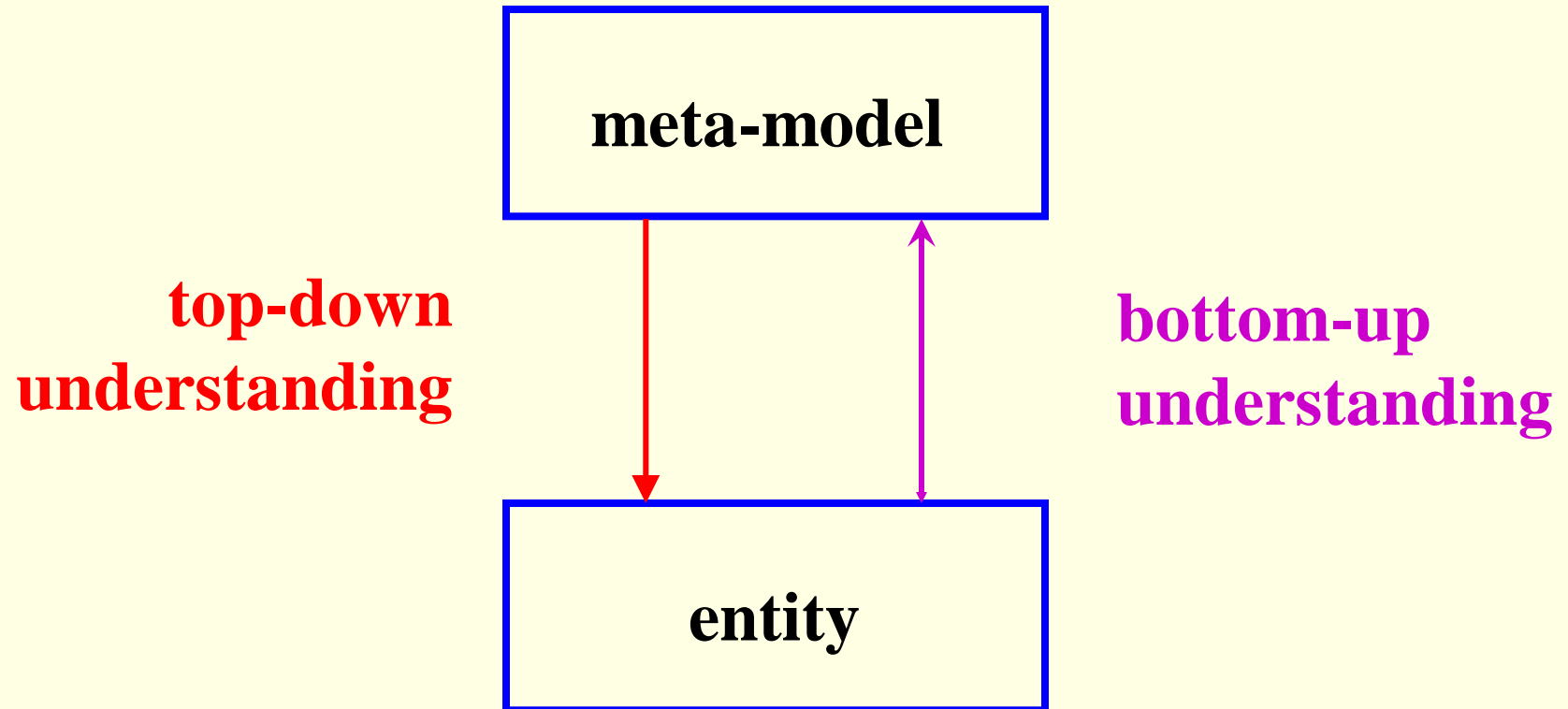**subcriteria**:

- - direction of the understanding process

- - directness of the understanding process

- - accumulation of knowledge

Understanding **process**

- **Direction** of understanding:

  - **top-down understanding**

  - **bottom-up understanding**

understanding process: direction

top-down understanding

meta-model

entity

bottom-up understanding

Understanding **process**

• **Directness** of understanding:

- **direct understanding** - **apprehension**
  (intuitive understanding)

- **indirect understanding** - **comprehension**
  (logical understanding)

Logical understanding: (comprehension)

- **Access a *meta-model***

    - given (rote learning),

    - known and located,

    - searched and located

        (on the Internet, for example),

    - developed (!)

- For further details:

    - attempt to **refine / improve** the meta-model

Criterion -
characteristics of **meta-model**:

subcriteria:
- **fixed**
- **evolvable**
- **replaceable**

Understanding **meta-model**

- **Fixed** meta-model:

  - **single vision understanding**
    - dogmatic understanding

Understanding **meta-model**

- **Evolvable** meta-model:

  - **Learning understanding**

Understanding **meta-model**

- **Replaceable** meta-model:

  - **multivision understanding**
    - **switchable** understanding

Criterion -
characteristics of understanding **system**:

subcriteria:
- **initiative** of the understanding system
- **number** of understanding system
- **knowledge sharing** features of understanding system
- **mechanism to disseminate** the result of
  understanding process

Understanding **system**

- **Initiative** of the understanding system:

  - **autonomous understanding**
  - **delegated understanding**
    - **remote understanding**
      (with mobile software agents, for example)

Understanding **system**

- **Number** of the understanding system:

  - **individual understanding** (1 understanding system)
  - **group understanding** (several understanding systems)
    - collective understanding
    - distributed understanding

Understanding **system**

- **knowledge sharing features**

  - **repetitive understanding**
  - **cooperative understanding**

Understanding **system**

- **Dissemination mechanism**

  - **understanding per command**
  - **understanding for subscribers**
  - **broadcasted understanding**
  - **blackboard understanding**
  - **legacy understanding**

Ören, T.I., Ghasem-Aghaee, N., and L. Yilmaz (2007).
An Ontology-Based Dictionary of Understanding as a Basis for Software Agents with Understanding Abilities. Proceedings of the Spring Simulation Multiconference (SpringSim'07). Norfolk, VA, March 25-29, 2007, pp. 19-27. (ISBN: 1-56555-313-6)

http://www.site.uottawa.ca/~oren/pubs-pres/2007/pub-ADS-07-understanding

Criteria related with the characteristics of the		**types of understanding**
product of the understanding process	domain	- internal understanding - external understanding
	nature	- lexical understanding - syntactic understanding - morphological understanding (understanding the structure) - semantic understanding (understanding the meaning) - pragmatic understanding (understanding the intention)
	scope	- focused understanding - broad understanding (understanding several or all characteristics) - multiaspect understanding
	granularity (level of detail)	- coarse understanding - in-depth understanding (detailed understanding)
	reliability	- reliable understanding - valid understanding, - verified understanding

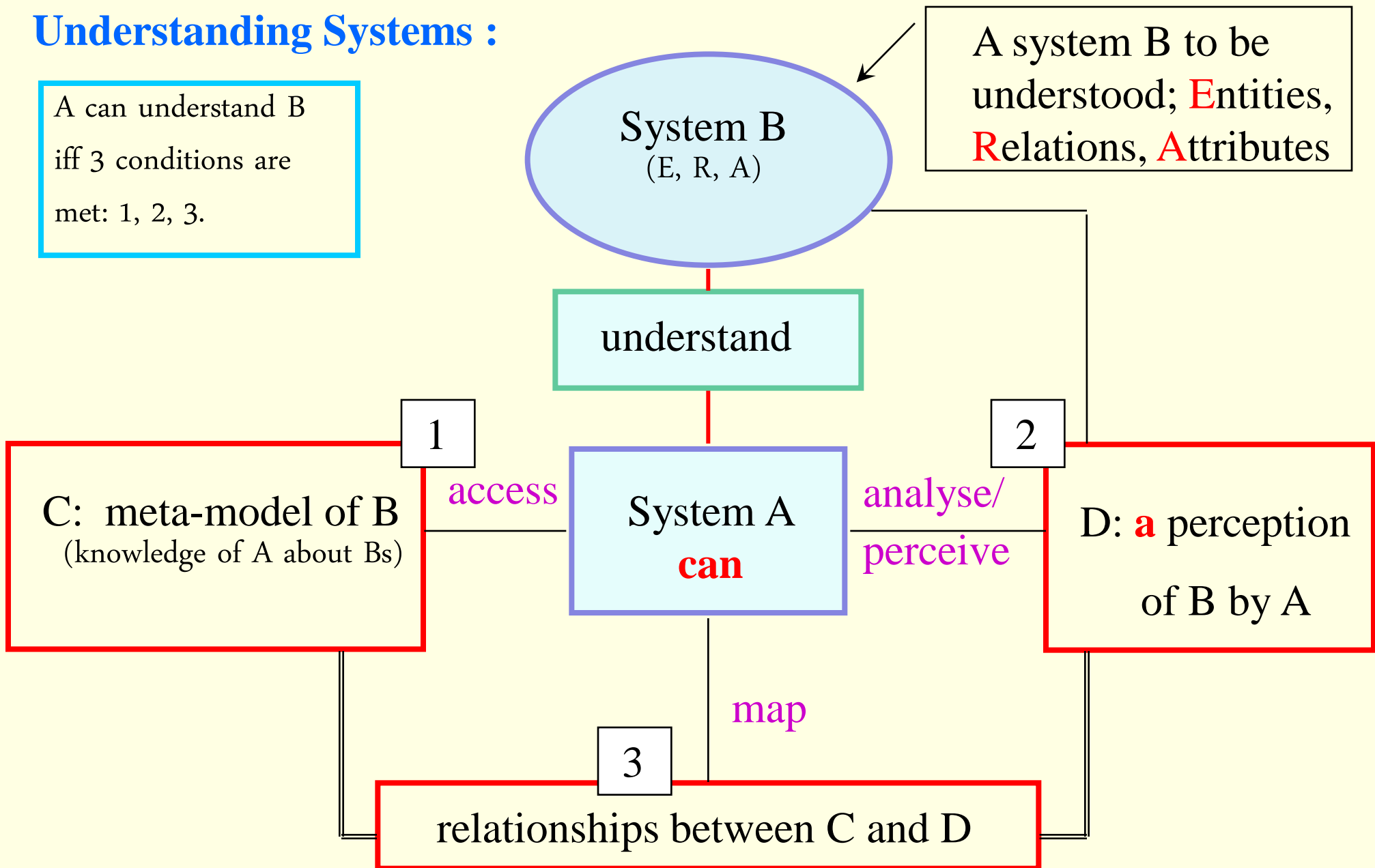| Criteria related with the characteristics of the		types of understanding
understanding **process**	direction	- top-down understanding - bottom up understanding
	directness	- apprehension (direct understanding) - comprehension (indirect understanding, mediated understanding) - logical understanding)
	accumulation of knowledge	- re-initialized understanding (tabula rasa understanding) - cumulative understanding

Criteria related with the characteristics of the		types of understanding
meta-model used	fixed	- single vision understanding - dogmatic understanding
	evolvable	- learning understanding
	replaceable	- multivision understanding (switchable understanding)
understanding **system**	*initiative* of the understanding system	- autonomous understanding delegated understanding - remote understanding
	number of understanding system	- individual understanding - group understanding - distributed understanding
	knowledge sharing features of understanding system	- repetitive understanding - cooperative understanding
	mechanisms to *disseminate* the result of understanding process	- understanding per command - understanding for subscribers - broadcasted understanding - blackboard understanding - legacy understanding -

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5. **Performance factors of understanding systems**

6. Examples

7. Misunderstanding and ways to avoid it

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map

3

relationships between C and D

A's ability to understand B:

depends on

the restrictions of the three conditions; i.e.,

- **meta-model**
- **perception / analysis**
- **mapping**

For a system, another system can be

intelligible or **unintelligible;**

i.e., intelligibility of a system often depends on the abilities of the perceiving system.

Performance Factors
1. **Meta-model**: A's knowledge about Bs

- A system that does not have basic knowledge (meta-model) about another system cannot understand it.

- The scope of understanding is bound by the types of knowledge in the meta-model.

- Superiority of *understanding-based learning* over rote learning.

- **Access time** to the meta-model affects the *speed of understanding*.

- The **granularity** (the level of details) of the meta-model determines the **discrimination ability** of the understanding system.

- The **content and granularity** of the meta-model **depend on**:

  - the types of knowledge required from the understanding system.
    (**the types of questions it should be able to answer**)

Performance Factors
2. **Perception**

"B" (the system to be understood)
   can **be submitted** to "A".
   - In this case, "A" needs to analyse "B" with
      respect to "C" (a meta-model of "B"s)
"A" may need to **perceive** "B"
   - In this case, A needs to keep track of some
      external / internal events, and
      recognize, classify, and filter them.

- The level of details (**granularity**) of the perception / analysis determines the **granularity of understanding**.

  (**What is not perceived or discriminated in the analysis cannot be understood**.)

- The speed of perception / analysis affects the **speed of understanding**.

Performance Factors
3. Relationship

- To understand a system "B," a system "A" needs
   to perform a mapping between:
   - a meta-model "C" of "B"s, and
   - "D:" a perception of "B"
           or a result of the analysis of "B."
- The types of relationships affect
   the **limits of understanding**.
- The speed of mapping affects
   the **speed of understanding**.

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6. **Examples**

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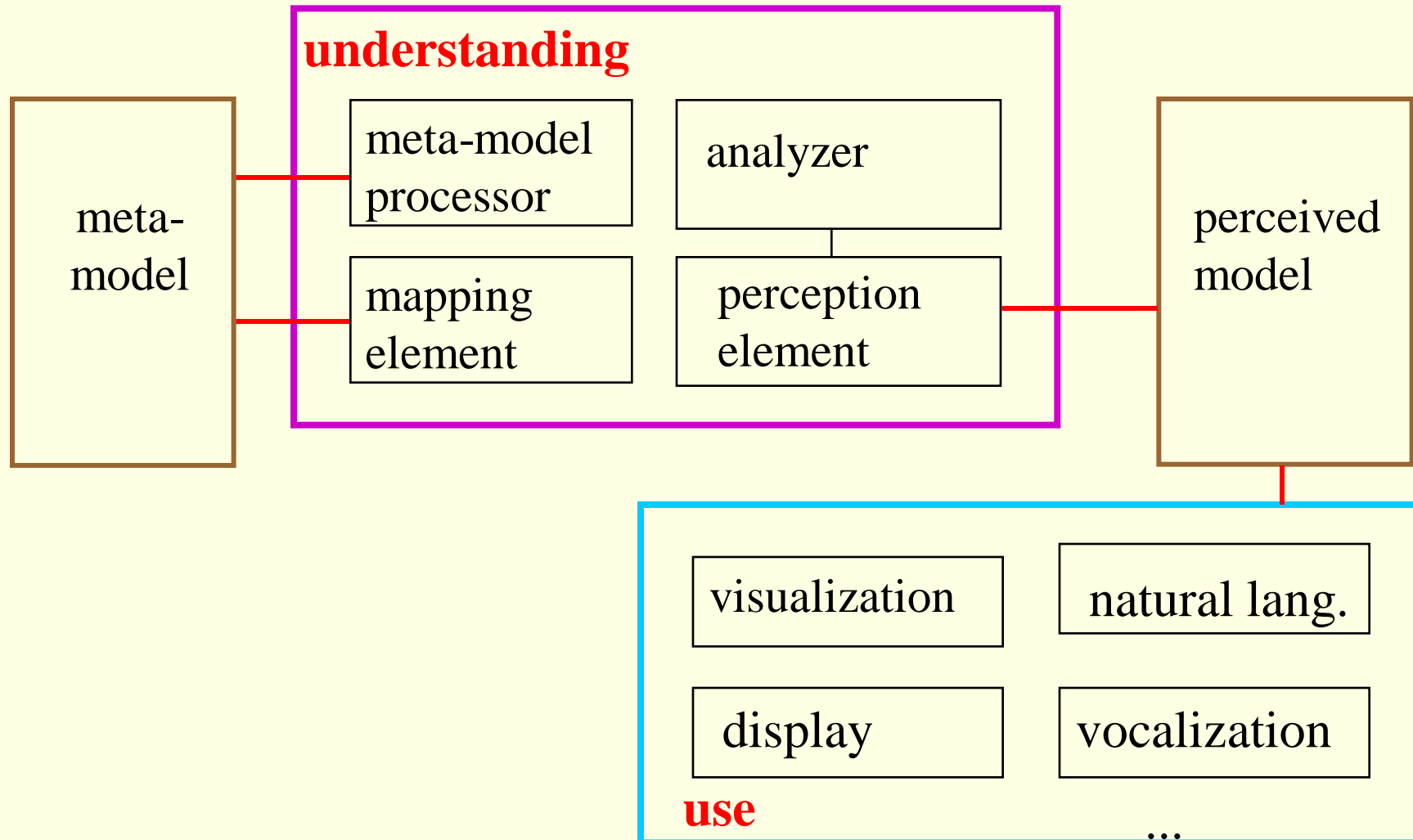# Types of **program understanding** systems:

1. **Static**

    - analysis of the program without running it.

2. **Dynamic**

    - observing the program while it is running.

Elements of program understanding systems:

Applications of program understanding systems:

1. **Automatic documentation**
   of software:
   - **display**
     - **text**
       - annotation
       - categorization
       - natural language doc.
     - **visualization**
       - data structures
       - control structures
       - object-oriented
   - **sonorization**
     - **speech** synthesis
     - **voice** annotation

2. **Answering questions** about a software
    (for maintenance)

   This ability requires the following abilities:
   - abstraction
   - generalization
   - filtering
   - communication in natural language
     (both ways)

3. **Certification** of the existence or lack of some properties.

4. **Computer aided** verification and validation of software.

5. **Critique** of user programs

   (One uses the perceived image "D" and the

   meta-model 'C.")

   - explanations of the critique

   - recommendations to improve user software

6. **Explanations** of programs

7. Extraction of **re-usable components**

8. **Tools for automatic testing** of software

Currently working on Understanding Emotions:

http://www.site.uottawa.ca/~oren/pubsList/HBS.pdf

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Inabilities and filters that can induce misunderstanding

Ability (inability)
to understand

meta-model

perception

interpretation

Filters for
misunderstanding

context

biases

fallacies

Inabilities that can induce misunderstanding

A system cannot understand

without an **appropriate**

Ability (inability) to understand

meta-model

perception

interpretation

Role of **meta-model** in misunderstanding

Meta-models can have:

- knowledge unfit for the goal of understanding (e.g., *erroneous, incomplete, inconsistent, irrelevant, or corrupt meta-model*).
- **cultural and cognitive biases** (sometimes implicitly; due to the corresponding biases of its developer). (e.g., *erroneous understanding, incomplete understanding, inconsistent understanding, irrelevant understanding,*
- as well as (1) effects of **deliberate use** of unfit meta-model in understanding, and (2) effects of corrupt meta-model in understanding

Role of **perception** in misunderstanding

An understanding system needs the ability to analyze characteristics relevant to the goal of understanding. Some sources of problems:

- focus on an irrelevant aspect
  (domain, nature, scope, granularity, modality)
- lack of appropriate ability to analyze
- lack of appropriate ability to discriminate

Misperception (as well as *misinterpretation) of motivation* and perceptual confusion are also causes of misunderstanding.

Perception component should be able to discriminate *deception.*

Role of **interpretation** in misunderstanding

- Misinterpretation is a source of misunderstanding.
- It may be caused lack of pertinent knowledge processing ability in interpretation
- *Misinterpretation of motivation* is also a cause of misunderstanding.
- *Illusion* is a *misinterpretation of a true sensation.*
- *Schizophrenic understanding* –as an aberration– leads to *misinterpretations of reality* and
- *hallucinations in the absence of stimulus.*

Filters that can induce misunderstanding

Filters for
misunderstanding

context

biases

fallacies

Filters that can induce misunderstanding: (1) **Context**

Context (proper / improper):
- context-sensitive understanding
  (context-dependent understanding)
  (double standards in understanding)

Filters that can induce misunderstanding: (2) **Biases**

- Group bias
- Cultural bias
- Cognitive bias
- Emotive bias
- Personality bias
- Effects of dysrationalia and irrationality

Filters that can induce misunderstanding: (2) Biases

- **Group bias** in misunderstanding
  The group can be limited by a family, company, institution, region, nation, interest or affinity, and/or religion.

Filters that can induce misunderstanding: (2) Biases

- **Cultural bias** in misunderstanding
  Values and symbols differ for various cultures; hence a same entity may be interpreted differently based on the cultural background.
  (*culture-induced misunderstanding*)

Filters that can induce misunderstanding: (2) **Biases**

- **Cognitive bias** in misunderstanding
  Cognitive bias is a "common tendency to acquire and process information by filtering it through one's own likes, dislikes, and experiences."
  -*Dunning-Kruger effect* "*those with limited knowledge in a domain*: (1) they reach mistaken conclusions and make errors, but (2) their incompetence robs them of the ability to realize it."
  - *High cognitive complexity individuals* differ from low cognitive complexity individuals not only in knowledge processing abilities in general but in understanding, in particular

Filters that can induce misunderstanding: (2) **Biases**

- **Emotive bias** in misunderstanding
  Certain types of emotions affect reasoning abilities
  to cause misunderstanding.
  e.g., anger affects reasoning negatively; hence
  understanding ability.
  Effect of anger in misunderstanding leads to
  anger-induced misunderstanding.

Filters that can induce misunderstanding: (2) **Biases**

- **Personality bias** in misunderstanding

- Some personality types are prone to anger; hence their understanding ability can easily be affected to lead misunderstanding.

• Effects of **dysrationalia** and **irrationality**

- *Dysrationalia* is the inability to think and behave rationally despite adequate intelligence [Stanovitch].
- It affects ability to properly understand.
- *Irrationality* is common in cognition [Ariely].
- Irrationality may have two types of effects in misunderstanding:

  (1) *lack of ability to understand properly* and
  (2) *ability to distort understanding of others* to cause *distorted understanding*.

- Fallacy is misconception resulting from incorrect reasoning.
- A logical fallacy is an element of an argument that is flawed, essentially rendering the line of reasoning, if not the entire argument, invalid.
- Fallacies in *information distortion* as well as *deliberate misperception* and *misinterpretation* are sources of misunderstanding.

Filters that can induce misunderstanding: (3) Fallacies

Two categories of fallacies:
- *Paralogism* is *unintentional* invalid argument in reasoning.
- *Sophism* is a *deliberately* invalid argument displaying ingenuity in reasoning in the hope of deceiving someone.

Some recent techniques in lie detection in text analysis can also be used to detect sources of attempt to misguide in understanding

Misunderstandings due to fallacies:

- Deliberate misunderstanding
  - *giving the illusion of not understanding*
- Induced misunderstanding
- Mutual misunderstanding

Filters that can induce misunderstanding: (3) Fallacies

- Induced misunderstanding
  Data and evidences may be tempered or doctored.
  The individuals (or their representatives, such as software agents) need to notice that their understanding is being tempered.
  Hence, recognizing why a reality is presented in a certain way is helpful not to be trapped in misunderstanding.

Filters that can induce misunderstanding: (3) Fallacies

- Mutual misunderstanding

  Avoiding mutual misunderstanding is very important to find reconciliatory solutions at different levels of relationships.

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Challenges

- Designing architectures and realization of advanced agents with **different types of understanding** **for several types of applications**

- Agents **"searching** on Internet**"** metaknowledge(s)

- Using **high speed computers** (supercomputers) for delegated understanding

Thank you for your attention!

Q & A