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Case Study Analysis of Disturbs in Spatial Cognition: Unified TOGA Approach

Adam Maria Gadomski * , Antonietta Salvatore, Alessandro Di Giulio *****

Address: ENEA, R.C. Casaccia, 00060 Rome, Italy.
(*) ENEA, ECONA, gadomski_a@casaccia.enea.it ,
(**) Univ. of Rome "La Sapienza", anto.sal@katamail.com,
(***) ECONA, lewin@libero.it

ABSTRACT

This work is aimed at contributing to the development of a **computational cognitive architecture**, i.e. a theory for understanding and simulating human cognition. The objective is a conceptualization of spatial cognitive disturbances according to a general, structuralized, top-down systemic framework.
For the test study, two characteristic cases from clinical psychology: **Agoraphobia** and **Claustrophobia** (AC cluster) have been modeled. The analysis has been performed in frame of the TOGA (Top-down Object-based Goal-oriented Approach) theory where human intelligent cognitive processes are represented by an unique modelling frame composed with well distinguished components and functional layers with learning capabilities. Using this approach we identify pathologies as possible conflicts between recognized components and their functioning. Ongoing research results of this study are presented.
The assumed model can also be seen as a basis for the development of a meta-cognition layer for artificial intelligent agents in advanced software engineering.

The Method: TOGA - What is this?

Top-down Object-based Goal-oriented Approach

"The 17th century scientist and philosopher Rene Descartes saved science from religious domination by coming up with the theory of dualism - dividing the body from the mind - but it meant that scientists spent the next two centuries ignoring consciousness." Bill Pheasant,

Top-down means from general concepts to details

Object-based means that everything can be represented as a world of abstract objects.

Goal-oriented Approach controls links between objects of interest and the goal (using the Point of View concept).

TOGA is a theory of goal-oriented knowledge ordering.
It serves for complex problems specification and modelling of cognitive decision making.

TOGA is based on an integrated computational model of an abstract "intelligent" entity (a natural or artificial system).

TOGA is composed of 3 basic Sub-theories:

TAO (Theory of Abstract Objects),
KNOCS (Knowledge Conceptualization System),
MRUS (Methodological Rules System).

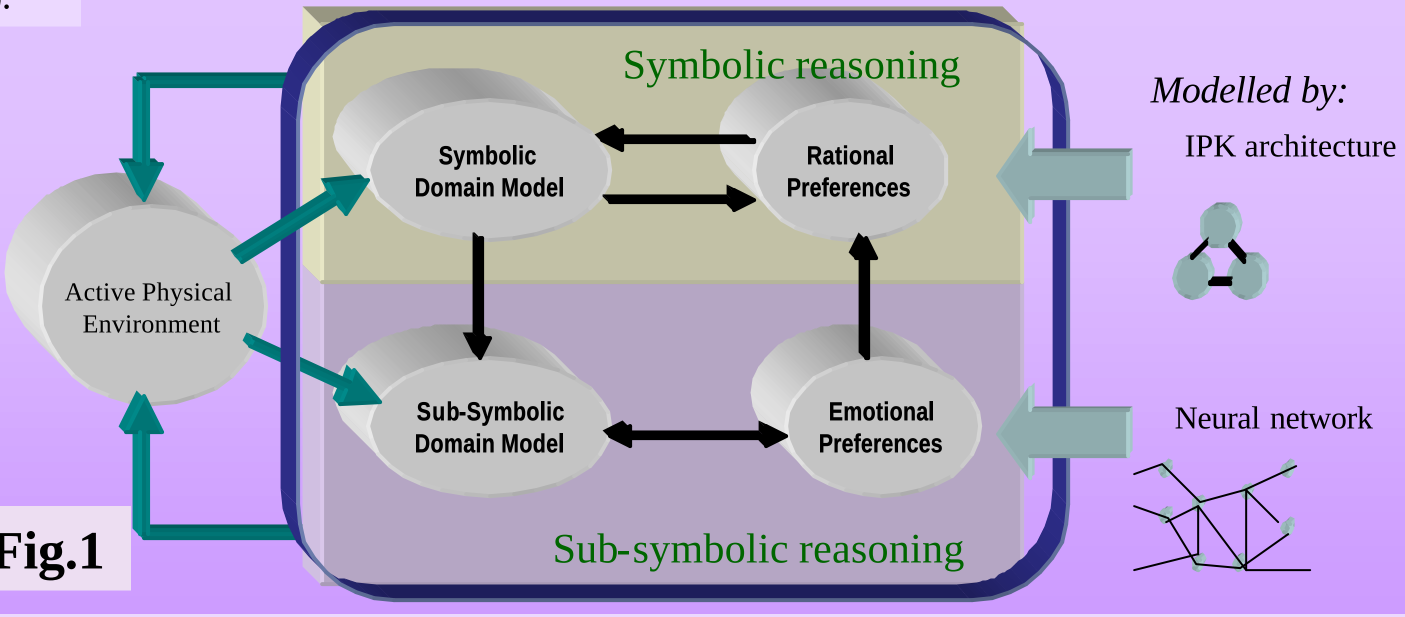


Fig.1

Top **TOGA** vision on **an intelligent entity** the **two main reasoning layers are distinguished**

Work Objectives & Initial Definitions

The objective of this initial studies is an approach to the conceptualization of spatial cognitive disturbances in terms of a general, structuralized, top-down systemic framework.

The modelling is based on the TOGA (Top-down Object-based Goal-oriented Approach) theory [1], [2]

Possible Applications: Using an unified terminology and computational formalism, developed models should improve detailed diagnosis of spatial cognitive disturbances. Results of the analysis should provide a base for cognitive simulation experiments, and contribute to the development of emotional components for Intelligent Agent Technology [4], in Intelligent Decision Support Systems [1], [3], [4].

Test study (**AC cluster**), two characteristic cases of spatial cognitive disturbances from clinical psychology, Agoraphobia and Claustrophobia [5], [6], are analyzed. We initially assume that:

-**Agoraphobia** typically results from the fear of having a panic attack in specific situations "from which escape might be difficult (or embarrassing) or in which help may not be available in the event of having an unexpected or situationally predisposed Panic Attack or panic-like symptoms" (DSMV-IV). Literally, "**fear of open spaces** or of being in crowded, public places like markets" [5], [6]

-**Claustrophobia** is usually described as a fear of closed places. A more accurate description might be 'a fear of not having an easy escape route' because for anyone who experiences this phobia this is the predominating feature - you feel a need to be able to get out or get home, quickly.[7]

Modeling Framework: IPK Personoid Architecture

Key concepts (simplified definitions):

Intelligent entity (personoid), his **Domain of Activity** (D-o-A) and their **Interactions.**

Personoid thinks about D-o-A and himself using:

Information:
How situation looks like.
Present states of D-o-A.

Preferences:
An order of hypothetic states of D-o-A.
What is more important.

Knowledge:
How situation can be modeled (Descriptive),
What is possible to do (Operational)

Goal: What state of D-o-A should be achieved

All these concepts are subjective and functional, do not exist in separate manner, but they are independent. They serves for the definition of: I systems (**DS**), P systems (**PS**) and K systems (**KS**).

Personoid *does not need any human-like physical body, it realizes* ***functions of human mind*** *considered fundamental for any goal-oriented intelligent system.*[2].

Basic Two Steps Reasoning Scheme (TSRS):

Information1 **-> Preferences ->** *Goal* **-> KnowledgeA**

Information1 **-> KnowledgeA ->** *Information2* **-> Action**

The above processes are realized by **IPK monad**. It is **repeated on meta-levels** where lower level PS and KS became new abstract Ds-o-A.

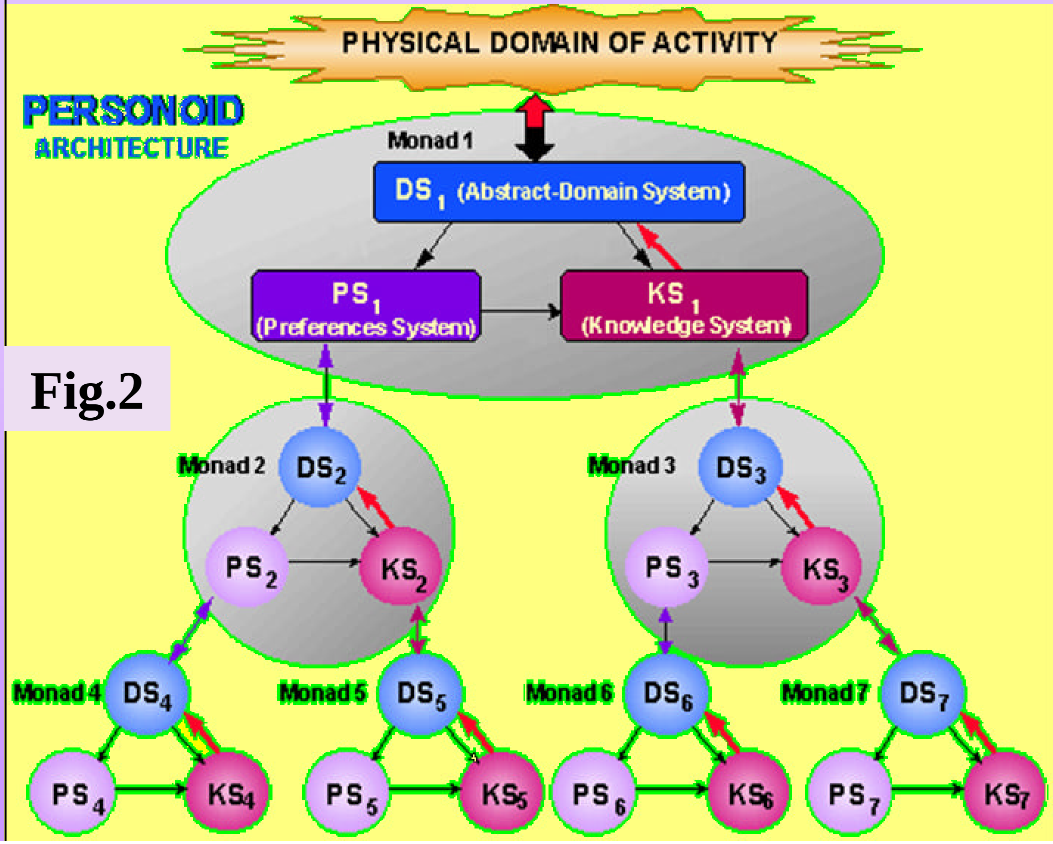


Fig.2

The Application: Disturbs in TOGA

According to some psychologist [9], [10], [11] an application of precise models for a unified cognition theory building is required. For the purposes of this study we have had to introduce a few initial functional assumptions:

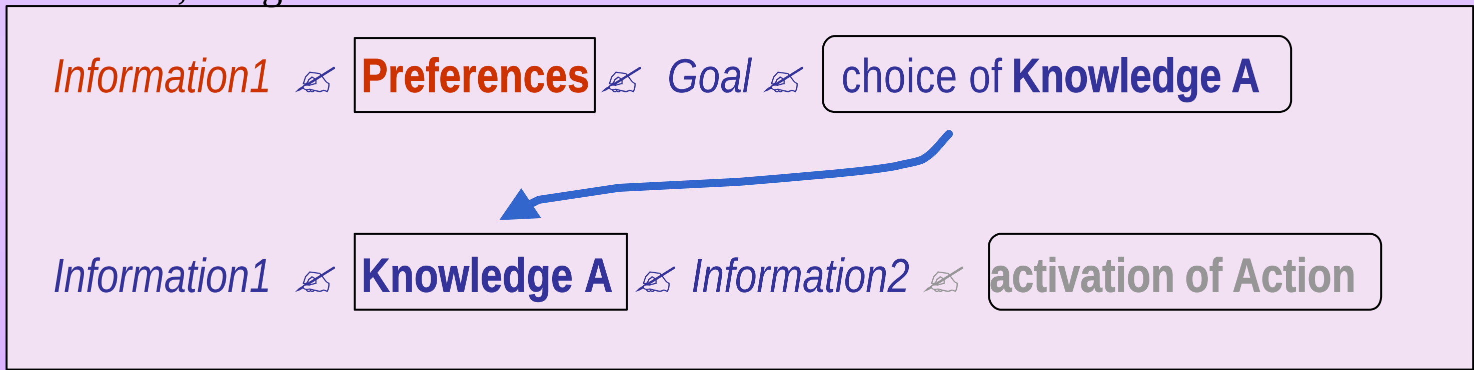
- the **AC cluster** (Agoraphobia and Claustrophobia symptoms Cluster) is

fear of either open or closed spaces with the visible dominated **tendency of a flight/escape**.

- **cognitive information processing** which leads to the AC symptoms is modelled as an activation of a sequence of **cognitive functions** relying on the repetition of **TSRS** (realized by the monad units) in sub-symbolic and symbolic layers , and on the meta-reasoning levels (evidenced on Fig 2).

In normal conditions, the generic functional scheme:

Fig.3



Requires the acquisition of proper information base, proper preferences base, proper knowledge bases and properly working reasoning process.

If adequate information is processed by not adequate PS or KS then, finally, activated Actions will be incorrect/pathological.

These mentioned bases are obtained either by not conscious learning (sub-symbolic layer) or by conscious observation & communication processes (symbolic layer).

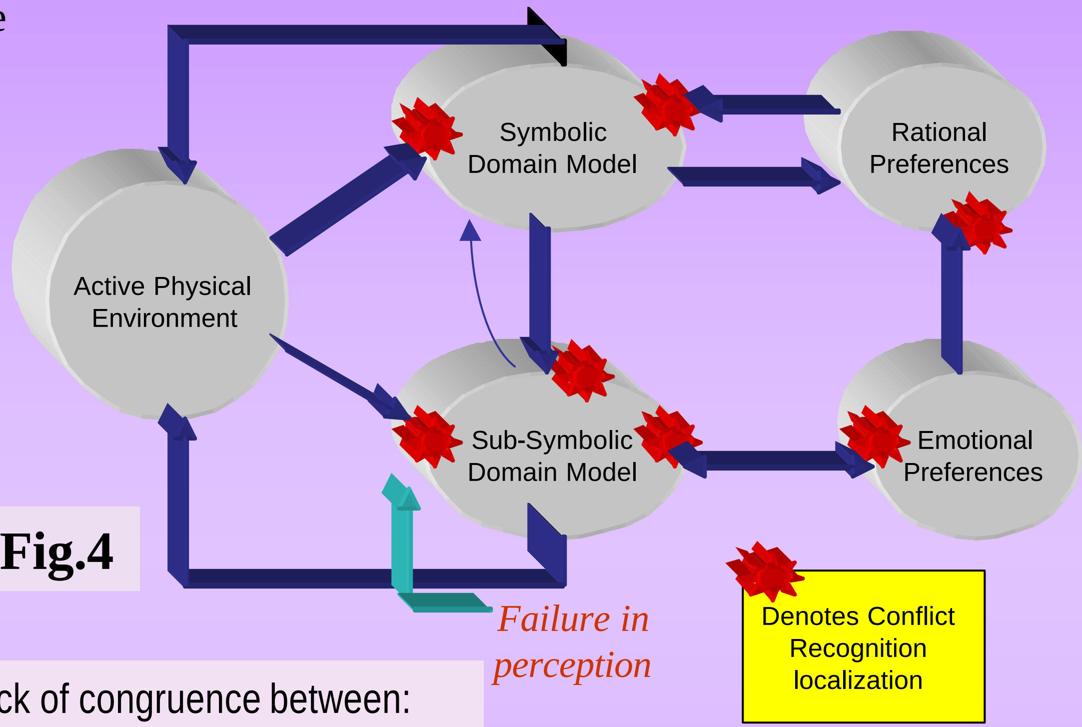
Localization of Possible Conflicts

For the allocation of **TSRS** to the cognitive architecture (fig.1) the following functional layers have been evidenced and employed:

1. neural network based sub-symbolic layer;
2. symbolic reactive reasoning layer;
3. symbolic meta-cognitive layer and
4. emotion-based layer.

The **symbolic layers** are organized according to the IPK meta-levels architecture.

Fig.4



In this frame we may modelling conflicts and lack of congruence between:

1. Spatial information perceived from the active physical environment (D-o-A) and sub-symbolic cognitive domain models currently available to the human subject;
2. Sub-symbolic space interpretation and symbolic domain model-knowledge;
3. Available domain symbolic models and meta-cognitive preferences, and finally;
4. Rational preferences and emotional preferences.

The key components and data flow of the employed conceptual model are roughly illustrated in the next figures.

Here we use the following definition of Emotional factor.

It is a common name of all influences and modifications of symbolic rational reasoning caused by the processes on the subsymbolic level (unconscious).

Pathology Dynamics and Treatment (Examples)

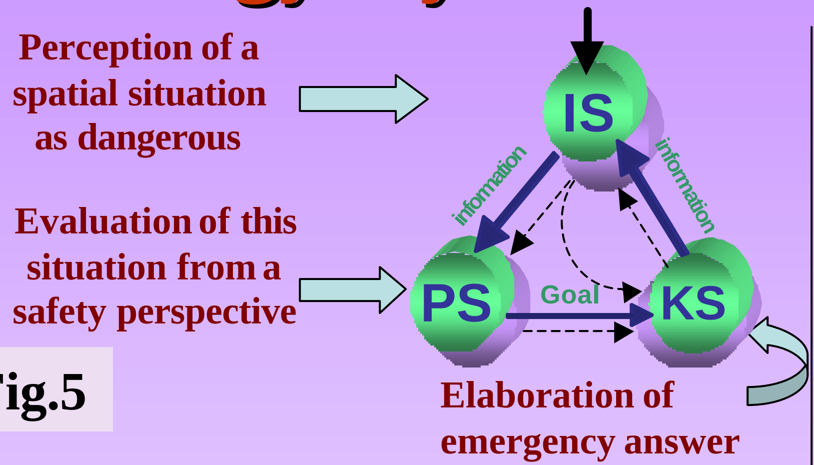


Fig.5

Goals conflict and its symptoms.

Information from the domain arrive in parallel to the symbolic and subsymbolic PSs, both generate their own behavioral goals. The conflict between them is one of possible causes of the spatial pathology. It may be observed as an irrational reaction of the subject with his consciousness of this irrationality.

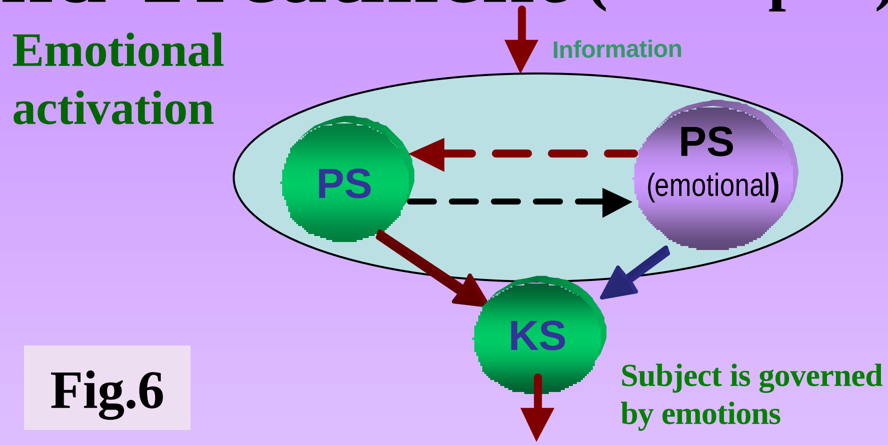


Fig.6

Subsymbolic PS governs subject's symbolic (rational) reasoning. In this case, pathological emotional preferences, previously learned by neural network, are dominating. They do not modify the input information about D-o-A but produce top-preference rules for the symbolic PS.

In consequence, the reasoning of the subject is rational but subordinated to irrational needs.

Patient-Therapist

interaction is illustrated

The cognitive pathological behavior of the subject depends on what **neural network** has been learned and which rules contain **IPK bases** (obtained by learning, communication, experience).

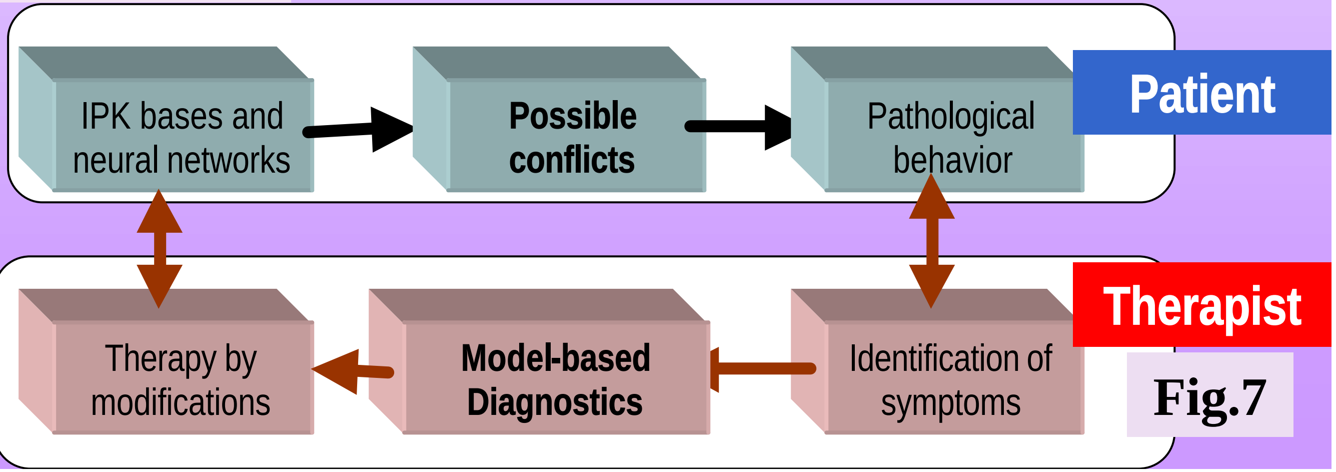


Fig.7

Conclusions

The presented work is a proposal of the study and development of an ontology and a conceptualisation tool for the diagnostics of spatial cognition and for the monitoring of its therapy. In order to be applied, the model has to be carefully experimentally tested and validated according to the criteria of clinical psychology. On the other hand, the formalization of the problem enables to use the obtained results for various computer simulations in cognitive engineering and, as well as, in intelligent agent technologies for the development and testing, so called, intelligent decision support systems (IDSS) and future intelligent autonomous robots [13]. The applicability of the presented model for the study of cognitive pathologies, and especially, for the descriptions of phobic disturb scenarios, will be presented in the thesis of A. Salvatore and in our article (in preparation).

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