

Phd Thesis Abstract

A study of the interaction between naive and scientific conceptual systems
by modelling the
Interdisciplinary Species Problem

**Written by
Sándor Soós**

**Budapest
2006**

1. BACKGROUND AND OBJECTIVES

The Species Problem (SP) as the long-standing methodological issue in biology is comprised of two interrelated questions: (1) what is the proper definition for the Species Category and the Species Concept and (2) on what criteria species taxa, the members of the Species Category, could be delineated (HEY, 2001b). In recent decades numerous solutions have been proposed. Characteristic of these approaches is the quest for the factors accounting for the on-going nature of the Problem: most of them attempt to explain why the SP still remains. A branch of these proposals, that have become eminent in recent years, comes from the field of cognitive science. These evaluations tend to conclude that the key for the puzzling persistence of the SP is provided by psychological factors as that of human concept-formation and categorization that influences the organization of folk, naive and expert knowledge as well.

Upon these developments it is possible to formulate what we will call „the cognitive hypothesis” in relation to the Species Problem. According to that, the decomposition of the Species Problem aiming to identify the factors accounting for its persistence results in, or can be reduced to, a cognitive explanation. The cognitive hypothesis is our point of departure.

The main objective of this study is the evaluation of the cognitive hypothesis. The work is divided into three modules.

- (1) The first main part focuses on the analytic decomposition and formal reconstruction of the discourse on the Species Problem. One of the main outcomes of the work is the comprehensive formal model of the SP that explains the critical conceptual relations and dependencies driving the dispute. Therefore, it is capable of specifying and preparing the main issues within the SP for further analysis from our vantage point.
- (2) The objective of the second part is the elaboration of the cognitive hypothesis. It involves the mapping of proposals from cognitive science related to, or accounting for the causes of the SP. The results are formalized in the very same framework that is applied for the modelling of discourse in (1) in order to make them comparable. The main outcome of this section is the logical model of the naive species concept.
- (3) The third part takes (1) and (2) as input for the analysis of their relationship. After the cognitive hypothesis is being specified in terms of the relation between the two models, its plausibility is assessed.

2. SPECIFICATION OF THE SUBJECT: THE INTERDISCIPLINARY SPECIES PROBLEM (ISP)

The XX. century discussion of the SP involves theoretical biology and the philosophy of biology – or biophilosophy – with equal weight, and affected by both. In the sixties and the seventies the biologist Michael Ghiselin and the philosopher of science David Hull formulated the so-called „individuality thesis” (*species-as-*

individuals; SAI) with respect to the ontological status of species, according to which species taxa are not kinds or classes, but, ontologically speaking, individuals (GHISELIN, 1974, HULL, 1978). The critical reception of this thesis induced a broad and still-present controversy among and between biologist and biophilosophers. The controversy has resulted in a huge variety of (biological, ontological, logical, semantic, etc.) arguments for and against the thesis on one hand, and criticism of the program to apply the thesis as a new paradigm that diminishes the problem of the concept of species in a natural way (GHISELIN, 1981a). In addition, a wide range of now-canonic issues have emerged in biophilosophy addressing the dissolution of the SP, focusing on the abundance of species concepts, the reality and objective nature of the Species Category (pluralism—monism, realism—antirealism, etc.)

The closer inspection of the theoretical debate on the concept of species reveals that the relationship between the two conceptual levels, (1) the scientific-methodological aspect and (2) biophilosophy is not purely conceptual. This relationship plays a *causal* role in the development of the discourse. This claim, also hypothetical, serves as the basis for specifying the discourse presently under study, hereafter referred to as the *Interdisciplinary Species Problem (ISP)*. The ISP here is generally described as the theoretical debate on the modern Species Problem from the 1970's to date, incorporating the related philosophy of biology as well. In our work, therefore, an auxiliary hypothesis is that

[ISP] The factors accounting for the Species Problem are to be found in the context of the ISP (so that the ISP is a valid concept).

3. PRELIMINARIES TO THE MODELL: MAPPING THE DISCOURSE OF THE ISP

Methods

Three complementary and interconnected methods are applied in order to reveal the structure and mechanisms of the Interdisciplinary Species Problem, namely

- (A) In a systematic overview of the discourse the main dimensions of the ISP are identified. This first approach is narrative and provides the raw material for further analysis by identifying the basic and central concepts/issues of the ISP, and allocating them along its main dimensions (chapters 1-3).
- (B) In the second step, a representative sample of the (publications constituting the) discourse is analyzed in terms of its constituents identified in (A). The analysis results in individual case studies for each publication in the sample (chapter 4).
- (C) In the third step the same sample is subjected to a special variant of content analysis. The output is the visualization of the conceptual structure of the ISP (network map and MDS) (chapter 4).

Methods (B)–(C) serve as means for the analytic reconstruction of the ISP. Both are based on a modell in the philosophy of science that is best conceived as the operationalization of the so-called semantic view of scientific theories (SUPPE, 1977), as proposed by WILKINS (1998). In this framework, the discourse under study is represented in an abstract multi-dimensional space (*issue-space*), the dimensions of which are the mappings of the main issues setting up the discourse in question. The

dimensions are constituted by *elementary issues*, that is, basic claims/views in relation to the respective issue that are irreducible in the relevant context. The issue space for the ISP is set up by the dimensions and views (elementary issues) identified in chapters 1-3. The issue space of the ISP naturally defines a system of categories/codes that is subsequently used in the content analysis and visualization of the statements and arguments constituting the discourse. To adjust the sensitivity of the analysis to the complexity of the ISP, a relatively small, but representative sample (set of publications) was selected for in- depth evaluation utilizing the categories derived from the issue space. The evaluation proceeds in two phases:

The qualitative approach. In the first phase, each publication in the sample is casted into the issue space by an individual case study. In this procedure the relevant statements and arguments in a publication are mapped into a system of elementary issues, formalized with the aid of the categories of the content analysis. The approach is to reveal the internal conceptual structure of the contributions in the sample („vectors” of the issue space), that is, the micro-level of the discourse.

The quantitative approach. In the second phase, the sample text as a whole is subjected to a special kind of content analysis technique akin to latent semantic analysis. The text items (sentences or coherent series of sentences) encoding elementary issues are assigned to (statement, context) pairs of categories so that the network of (co-occurrences between) the ISP dimensions become visible at the sample level. This relation is then visualized and evaluated with both network analysis and explorative multivariate techniques commonly used in text-mining (hierarchical clustering, MDS). In this case, the resulting conceptual structure is conceivable as the macro-level architecture of the ISP, being the union of the micro-level concept lattices revealed w.r.t. individual publications.

Results.

Dimensions of the ISP. The two levels of description of the ISP, namely, that of defining the Species Category and of species taxa can be characterized by two basic (groups of) dimensions. (1) From a methodological perspective, attempts are aimed at identifying the proper function, the methodological role for the various species concepts proposed so far in order to solve the problem. The other significant set of questions is (2) the ontology of the Category and of taxa. In the ontological dimensions the now-canonical question of the reality and ontological status of species taxa is addressed, where the distinguished and relatively consensual elementary issue is the SAI. Pairs of elementary issues (dichotomies) define the ontological dimensions for the Species Category, including the reality and status of the Category as to being a natural kind, and, most eminently, the monism–pluralism dichotomy. The latter is the debate on whether there is only one true species concept, or more of them are functional. (Since various types of responses can be revealed, despite the seemingly dichotomous nature of the question, more than two elementary issues are stretched along this dimension). The issue space for the species problem is presented in Table 1.

Table 1. The Issue Space of the ISP

<i>Dimensions and elementary issues</i>	<i>Category/Taxon</i>
ONTOLOGICAL DIMENSIONS	
O1) Ontological status: Individuum vs. set/class	Taxon
O2) Ontological status: Essentialism vs. Population thinking	taxon, occasionally: Category
O3) Ontological status: being/not being a Natural Kind	taxon, Category
O4) Realism vs. Anti-realism/nominalism	taxon, Category
O5) Pluralism vs. Monism	Category
METHODOLOGICAL DIMENSIONS	
M1) Operational vs. Theoretical concept	Category
M2) Methodological role, affiliation: taxonomy/phylogeny/evolutionary biology	Category
M3) Views on the praxis of systematics	Taxon
S) Semantic issues (definitions)	Category, taxon

The overall conceptual structure. Both the argumentation structure derived from the case studies and the relationship between the dimensions of the issue space reveal the following conceptual lattice as the basis of debate. The point of departure is that proper treatment of the SP requires systematics/evolutionary biology to imply that both the Category and taxa are real (objective) entities. The criteria of reality is, in turn, entails certain ontological constraints in both cases. In the case of taxa, the acceptance of the Species-As-Individuals thesis generally follows, while Category-realism is, in most cases, tied to the conceptualization of the Category as a natural kind. Taking the latter position (and the arguments for it), according to the discourse, has immediate consequences with respect to the pluralism–monism dimension. The most significant conclusion is the rejection of pluralism, claiming that it is inconsistent with the constraint of being a natural kind.

According to this conceptual structure, the key for the proper treatment of species satisfying the network of criteria above is the careful selection of one or more species (Category/Concept) definitions from the candidates. A very often re-occurring perspective organizing the positions (issues) on the SP is whether the definition of the Category or the praxis of systematics (for species identification) is 1) in accord with the SAI, and 2) represents the Category as being a natural kind. It can be stated that there is a strong disposition among authors to the effect that choosing a species definition or another fundamentally determines the whole system of ontological positions identified in the issue space of the ISP.

Main implications of the conceptual structure. For the logical modelling of the ISP the following features of the overall conceptual structure are to be pointed out.

- (1) The distinction between the Category problem and the taxon problem as the two main constituents of the discourse is a functional one (i.e. it has a proper role in

describing the factors and mechanisms of the ISP). The subject of the modern SP and the ISP is the Species Category.

- (2) Taking the position w.r.t the validity of a species concept *A* is heavily affected by the ontological implications attributed to the grouping criterion (relation) in the definition of *A*. According to the consensus, valid species definitions represent species as individuals (and, therefore, are in accord with the SAI) (MAYDEN, 1997, 1999).
- (3) The apparent opposition between the reality of the Species Category and species pluralism is to be conceived as the problem of natural kinds, historically identified at the level of species taxa, re-occurring at the level of the Category.

The disciplinary structure of the ISP. The arguments and considerations from philosophy/the philosophy of science are proper factors of the scientific theoretical debate on the Species Problem. They serve as an independent or external stock of criteria against which the biological positions can and should be testified. As such, these claims often enter the dispute as the ultimate confirmation in favour of a chosen species concept, when the available biological arguments underdetermine the choice. The confirmation process is based on the overall conceptual structure explicated above, the philosophical implications of taking a given position on the methodological dimensions of the issue space, or, in particular, on the interconnected ontological implications of choosing among species concepts. These implications, together with the philosophical consensus (SAI), are capable of verifying this choice. This pattern shows that interdisciplinary interactions are crucial for the mechanisms maintaining the Problem, as stated in our auxiliary hypothesis. In sum, methodological (scientific) and ontological (philosophical) arguments are strongly interlinked, which relationship affects the outcome of the discourse in a causal way.

4. THE TWO-LEVEL LOGICAL MODELL OF THE ISP

Guidelines for the logical modell. The fundamental purpose of the formal modell for the ISP is to capture the relevant implications of any given species concept (SC). Since the latter set can be said the ontological import of the concept, a decomposition of the Problem into two modules or levels is done by the modell. The (1) semantic level provides the formalization of species definitions, while (2) the ontological level expresses their ontological implications. The ISP can then be specified as the relation between the two modules.

The key idea for the formalization of the ISP comes from the result of the analysis described above that it is the grouping criterion included in any definition of species *A* which determines the ontological import of *A*. In the logical framework this feature is mirrored by introducing a relational definition schema for SCs (semantic level), and, simultaneously, by characterizing the relations therein with the aid of formal ontology (ontological level).

Theoretical backgrounds and methods

In order both to distinguish between, and appropriately link the semantic and ontological levels, we utilize a relatively new applied field of set theoretical semantics, namely, *formal ontology*. For our purposes, the combination of two branches of formal ontology is best suited, both of which are intensional in nature.

- (1) *The theory of ontological commitment (OC)*. The primary source for the model is the formal concept of *Ontological Commitment* as elaborated by Nicola Guarino et al. (GUARINO et al., 1994, 2004 etc.). An ontological commitment, from the perspective of computer science, is an axiomatized upper-level ontology. Logically speaking it is a modal theory constraining the semantic behaviour of the concepts (terms) of a formal language *L*, thereby identifying the exact set of models by which *L* can be interpreted.
- (2) *The logic of natural kinds (TFL)*. Our model is also based upon the theory of predication invented by Nino B. Cocchiarella (COCCHIARELLA, 1989), a second branch of formal ontology. In particular, the model draws upon the calculus the aim of which is to formalize the classic Aristotelian notion of *natural kinds*. In parallel with the theory of ontological commitment, the TFL puts constraints on the various ways to (formally) interpret the terms occurring in a given language, in that it specifies schema of evaluating predicates referring to natural kinds.

Results

The semantic framework. Upon the combination of the theory of ontological commitment and the logic of natural kinds we defined a new semantic framework (i.e. a family of formal languages together with the corresponding semantics), within which it is possible to account for the ontological import of a relational definition of species with respect to both the Species Category and species taxa. („ontological import”, again, being understood in terms of the SAI, of the problem of natural kinds and the issue of pluralism versus monism). The key features of this semantic framework are the following.

- The logic applied is (1) second-order, (2) modal and (3) sortal logic. It also incorporates (4) mereological components. (1)–(3) serves for the modelling of the notion of natural kinds, while the reason for (3)–(4) is to formalize the SAI.
- Via the sortal semantics and the mereological relation involved this framework is capable of both mapping compound (vs. atomic) individuals and expressing ontological claims on them (e.g. being real or abstract entities etc.).
- A new feature of the system (relative to the theories it is built upon) is the extension of the scope of the concept of ontological commitment to include (diadic) relations as well. In order to formalize the SAI and to model the relationship between species definitions and the the ontology of taxa, we introduced the concept of *material relation*. Predicates enrolled in this category are to build compound individuals out of atomic ones.

The model: the ontological level. The first phase of setting up our model is the specification of the formal language (belonging to the family referred to above) via

which species definitions can be set up and evaluated. This step roughly covers the mapping and enrollment of grouping relations characteristic of the main families of SCs among the non-logical constants of Σ (*Ib*: interbreeding, *Pg*: phylogeny; *Eco*: ecological similarity, *MS*: morphological similarity). Upon this, we define a „maximal” (logical) theory – more precisely, a maximal class of theories – that describes the ontological commitments occurring in the discourse of the ISP. The set of models satisfying this theory (the OC itself) provides the possible interpretations of Σ . The theory T_{OC} of the maximal ontological commitment defines (i) the concept and behaviour of compound individuals, (ii) the concept and properties of natural kinds, and, most importantly, (iii) constrains the ontological behaviour (rules of interpretation) of the relations within the language by allocating them between the categories of material and non-material relations.

The model: the semantic level. The subsequent step in setting up the model was the formalization of the various species definitions drawn from the discourse. Since the crucial feature of any SC with respect to the ISP is the grouping criterion the SC is based on, the concept SPECIES was reconstructed the following way.

$$\begin{aligned} \text{(1)} \quad S_R(x) &\leftrightarrow_{def} \forall y \forall z (y, z < x \rightarrow yRz) \wedge \varphi, & \text{(3)} \quad S(x) &\leftrightarrow_{def} S_{Ib}(x) \vee S_{Pg}(x) \\ \text{(2)} \quad S_R(F) &\leftrightarrow_{def} \forall y \forall z (F(y) \wedge F(z) \rightarrow yRz) \wedge \varphi, & \text{(4)} \quad S(F) &\leftrightarrow_{def} S_{Ib}(F) \vee S_{Pg}(F) \vee S_{Eco}(F), \end{aligned}$$

where R is the grouping criterion, and φ is the so-called ranking constraint, which is to specify the boundaries of the groups identified by R . Parametrization, that is, the substitution of R with particular relation symbols, results in Σ -definitions of species relativized to the relations introduced above, that appropriately capture the four families of SCs in the ISP, namely, the biological, the phylogeny-based, the ecological and the morphological definitions. (1) translates SPECIES into a first-order predicate, while (2) translates it into a second-order predicate applicable to taxa. Accordingly (1) is suited to express the SAI, on the contrary, (2) is for demonstrating the Species-As-Classes thesis. (3) and (4) are the results of the parametrization of the corresponding schemas combined into the pluralist definitions of species drawn from the ISP.

Testing the model. The bedrock in assessing the model is the capacity of this structure to account for the conceptual dependencies behind the ISP revealed in the analysis of the discourse. In the final section of this chapter, therefore, we examine the relations between the semantic and ontological level of the model. The main goal is to confirm the implications of species definitions for the ontological status (1) species taxa and (2) the Species Category, the latter involving the connection between Category realism and species pluralism. The evaluation of the model the justified the following.

- The applicability of the second- vs. the first-order definitions (schemas) of SPECIES is a function of two factors: (1) the grouping criterion involved and (2) the choice among ontological commitments (primarily in terms of

the selection of material relations). Through this dual dependence the model explains a fundamental connection characteristic of the ISP, that ties its ontological and semantic dimensions. This connection is embodied in the set of arguments for and against particular SCs based on whether the SC in question can be conceived as a „class concept” or an „individualist concept”.

- The Species Category defined via alternation, that is, by the pluralist scheme does not meet the criteria of natural kinds within the set of models characterized by T_{OC} . Since being a natural kind is a consequence of Category Realism in the model, this feature mirrors the claim that the issue of (Category) realism-antirealism, together with that of pluralism-monism results in a „new” problem of natural kinds on the level of the Species Category. Also present in this feature is the main statement of the ISP on the status of the Category, according to which pluralist definitions yield a heterogenous, non-real Species Category.

5. THE COGNITIVE APPROACH AND THE MODELL OF THE NAIVE CONCEPT OF SPECIES

The aim of the chapter is to „translate” the cognitive hypothesis to the language of the ISP in order to render the two commensurable, and to analyze their relationship. This aim is achieved via the formal characterization of the so-called *naive species concept* within the same semantic framework that was applied to the ISP.

Specifying the cognitive hypothesis. The point of departure in reconstructing the cognitive hypothesis is the identification and systematization of the various interfaces between cognitive science and the ISP. The two main dimensions along which to allocate those, as emerging from the overview, are (1) the direction of the link (reference) between the two, and (2) the degree of closeness of the two. The latter relation is understood in terms of the extent the ISP and cognitive science is related in the particular case, one option being the immediate, explicit reference to the issues of other, another is the conceptual path between approaches in cognitive science and the ISP through mediating issues such as studies of categorization etc. In this framing we distinguished between three main cases (Table 2), from which group (3), i.e. the explicit efforts to account for the species problem from cognitive science, is our main interest.

Table 2. Interfaces between cognitive science and the ISP

	<i>Indirect relationship</i>	<i>Direct relationship</i>
<i>Cognitive science > ISP</i>	(1) models of categorization, the models of natural kind concepts	(3) cognitive explanations for the SP
<i>ISP > Cognitive science</i>		(2) models of categorization, philosophy of biology

Explanations based on models for naive and folk biology. The further analysis of group (3) shows that this set of approaches is dominated by two accounts. Jody Hey and Scott Atran explains the long-lasting nature of the SP on the basis of the theories of naive (HEY, 2001a,b), and folk biology (cf. ATRAN, 1999), respectively. In the core of both approaches is the demonstration of cognitive universals in human categorization and their biasing effect on the scientific species concept. The outline of Hey's argument is as follows:

- (P1) The term „Species” is ambiguous, as it simultaneously refers to mental categories and evolutionary groups.
- (P2) The boundaries of mental categories and evolutionary groups cannot coincide.
- (C) The mapping between the two group of entities are not feasible (which results in the SP, as this result is hardly recognized).

Atran evaluates the SP utilizing the results of his work in cognitive anthropology, namely, folk biology, which he identifies with *folk taxonomy*. According to Atran's definition, folk taxonomy is an innate conceptual domain („module”) of the domain-dependent human categorization operating on the living world exclusively. It's characteristic features are (1) concept-formation according to psychological essentialism, and (2) taxonomic categories ordered in a ranked hierarchy. Since, as Atran argues, folk taxonomy is universal, its distinguished levels (ranks) must be part of *naive biology* as well, including the rank of *Generic Species* (GS). The main claims of Atran (relevant for us) are that folk taxonomy fundamentally contributed to the historic development of scientific taxonomy (systematics), and that the naive concept of generic species affects numerous elementary issues of the ISP. In particular, it is argued that GS interferes with pluralism, and implies Category Realism, both being important factors in maintaining the SP.

T_{GS} – a modell of folk taxonomy (NT). We conducted the study of the core explanations for the SP through the reconstruction of the theory of folk taxonomy elaborated by Atran. The main reason for this method is that the account of Atran can be conceived as „maximal” in the sense of integrating most elements of cognitive approaches related to the ISP, so that the arguments of Hey can be expressed in this framework as well. Additionally, the most relevant notion of our cognitive hypothesis, that of generic species is best conceptualized in the context of folk taxonomy. The most important role of the model built in this chapter is to allow the evaluation of the cognitive explanation against the logical reconstruction of the ISP. Upon these requirements, and taking into account the the studies of NT in cognitive anthropology, our model of folk taxonomy had the following characteristics.

- In our model, folk taxonomy was casted into the semantic framework defined for the ISP. The theory of folk taxonomy was formulated as an *alternative ontological commitment* with respect to Σ (the language of the ISP model).

- The ranked hierarchy of taxonomic categories was formally approximated by the concept of *well-formed ontological commitment*, a key concept in the source theory of OC by Guarino. The concept of taxonomic rank was formally modelled by that of ontological category (as in the former case of material relations).
- The *theory* T_{GS} describes (the behaviour of) distinguished taxonomic ranks, primarily the rank of generic species, and allocates the predicates in Σ that refer to taxa among taxonomic ranks (i.e. ontological categories).

The concept of generic species (GS) in our model. The naive conception of species, that is, that notion of generic species was formalized in T_{GS} as an ontological category, i.e. a second-order predicate constraining the semantic behaviour of first-order predicates referring to taxa (classes). The distinguished nature of the rank GS is expressed via two steps in T_{GS} : (1) first, most of the ranks of folk taxonomy is modelled by the „weakened” version of the concept of natural kinds as elaborated for the model of the ISP. The definition of the weak version lacks the scheme for inductive potential. Second, (2) the rank *GS* is modelled as standing for „strong” natural kinds, distinguished from other ranks/ontological categories by bearing the property of inductive potential. In the frame of this model, this distinction sufficiently captures the distinctive feature of „maximizing the inductive potential” imposed on generic species by the theory of folk taxonomy/biology.

6. TESTING THE COGNITIVE HYPOTHESIS: CONCLUSIONS

The comparative analysis of the two models. The elaboration of the theory T_{GS} of generic species allows us to compare the naive and the professional conceptualization of species as revealed with respect to the ISP. Also involved in this analysis is the comparison of the theories T_{OC} and T_{GS} , as the latter can, technically speaking, be conceived as the theory of an alternative OC relative to T_{OC} . This view is further motivated by the methodological point that, given the hypothesis on the role of T_{GS} as being a crucial factor in the professional evaluation of SCs, the effect of T_{GS} on professional attitudes can be shown by the interrelations of the two ontological commitments and the alternative definitions of species.

The comparison of the conceptions of species present in T_{OC} and T_{GS} was implemented based on the mapping in Table 3. According to this, the concept of scientific species (predicate S with T_{OC}) is contrasted with the rank of generic species (the ontological category GS), and scientific taxa (the elements of S) are contrasted with particular generic species (i.e. predicates of the type GS , t_x^{GS}). This mapping is to convey the main claim in the cognitive hypothesis, i.e. that the scientific conceptualization of both the concept of species and taxa is biased by the corresponding naive notions.

Table 3. Mapping between the two models

	ISP – S(T_{OC})	NT – (GS) T_{GS}
<i>Species</i>	S	GS
<i>Category/Concept</i>		
<i>Species Taxa</i>	$\{x : S(x)\}$	$\{t_x^{GS} : x = 1, \dots, n\}$

The formal relationship of the two models. The naive notion of species (*GS*) has definite implications for the ontological level of the ISP model, as it yields structures diverging from that implied by the scientific concept *S*. The systematic assessment of the differences involved resulted in the recognition of three fundamental issues.

- (i) the ontological status of species taxa is different in the two models; generic species are always classes, while scientific taxa are, according to the standard OC, individuals.
- (ii) In the naive case, the feature of inductive potential is attributed to individual (generic) species, while it is assigned to the Species Category in the scientific case.
- (iii) The naive conception is inconsistent with species pluralism (the „conceptual version”, in particular).

As to the semantic level of the ISP model, it is showed with respect to the definitions that

- (iv) the theory T_{GS} requires taxa to be categories with clear-cut boundaries. For the scientific positions influencing the ISP (and describing the relation of the semantic and ontological level) this constraint is indifferent.

The consequences of divergence: predictions of the analysis for the interplay between cognitive forces and the ISP. The crucial question to be addressed with respect to the cognitive hypothesis is that whether the differences between the two models revealed can be related to the main factors of the ISP. The question was examined in the last section of our work. The evaluation proceeded along the lines of the specific proposals behind the cognitive hypothesis:

- a) Folk taxonomy as ontology. With respect to the elementary issues in the ontological dimensions of the ISP that are assumed to be in conflict with the naive model, namely, Category Realism and pluralism, we derived that those elementary issues cannot be defeated on the sole grounds of folk taxonomy (NT), even after successfully „translating” those issues into the formal model of NT (i.e. after making the ISP model and the NT model comparable in this respect). Within the context of the ISP, these issues are claims on the (ontology of the) *Category*, and deductively related to such issues. The constituents of folk taxonomy assumed to contradict both are claims on species *taxa* constraining the categorization of living organisms. The latter constraints, nevertheless, are not related the ontology of the *Category as it is*

debated in the professional discourse. In both the cases of pluralism and realism, the basic problem is the status of the Category as being or not being a natural kind (in the context of the ISP) versus the capacity of species taxa to partition the living world (in the context of the NT). We showed that these two aspects are not conceptually related.

b) Folk taxonomy as taxonomy. The other main cognitive bias, according to the cognitive hypothesis, is that the psychological disposition to have clear-cut boundaries between taxa compels the (scientific) definition of species to result in such a Species Category. This assumption pictures the effect of folk taxonomy on the ISP as a problem of categorization: Psychology controls the choice among SCs through their taxonomic implications. Result (iv) referred to above shows, however, that this is also not the case: the taxonomic implications of SCs are not crucial to the discourse of the ISP.

The relative independence of the two models can be formulated the following way: in the context of the ISP the „bottleneck” for any concept of species is its ontological nature, while the theory of folk taxonomy constrains the taxonomic behaviour of the corresponding naive notions.

Conclusions. To sum up, we can state that our results do not support the cognitive hypothesis *in its present form.* According to the comparative analysis of the two models, the naive and professional conceptualization of species implies different ontologies. The discrepancies involved are relevant to their relationship, but do not in themselves explain the background of the causally effective disputes within the ISP. It was shown, based on the models, that (1) the naive and expert conceptual networks cannot be matched in the sense that the conceptual interdependencies of the latter are not sensitive to that of the former: the „implicature” of the ISP and that of folk taxonomy are different. As to the issues of categorization, the structure of the ISP leads us to the conclusion that (2) the Interdisciplinary Species Problem cannot be traced back to cognitive psychology and human categorization. The capacity of the definition to categorize resulting in species taxa does not have a significant role in the discourse. As to the capacities at the level of the Species Category, the problematic nature of proposed definitions is better explained with the favoured relation between the semantic and ontological level of the model, in particular, the need for having the Category that is a natural kind. This feature, in turn, supports an explanation of the ISP from the sociology of science, rather than the cognitive solution (which is, in itself, tied to the study of individual epistemic agents). In the final section we provided a brief outline of such a future work, that, based on our results, seeks for a macro-level explanation of the ISP, incorporating cognitive factors in a more realistic way.

REFERENCES¹

- ATRAN, S. (1999): The universal primacy of generic species in folk biological taxonomy. In Wilson, R (szerk.): *Species: New Interdisciplinary Essays*. Cambridge: MIT Press. 229–261.
- COCCHIARELLA, N. B. (1989): Philosophical Perspectives on Formal Theories of Predication. In Gabbay, D.O, Guenther, F. (szerk.): *Handbook of Philosophical Logic. Vol. IV*. Dordrecht: D. Reidel.. 253–326.
- GHISELIN, M. T. (1974): Radical solution to species problem. *Systematic Zoology*, 23(4), 536–544.
- GHISELIN, M. T. (1981a): Categories, life, and thinking. *Behavioral And Brain Sciences*, 4(2), 269–283.
- GUARINO, N. (2004): Helping people (and machines) understanding each other: The role of formal ontology. *On The Move To Meaningful Internet Systems 2004: Coopis, Doa, And Odbase, Pt 1, Proceedings*, 3290, 599–599.
- GUARINO, N.; CARRARA, M.; GIARETTA, P. (1994): Formalizing Ontological Commitments. In (szerk.): *Proceedings of the 12th National Conference on Artificial Intelligence (AAAI'94)*. Seattle, Washington. 560–567. <http://www.loa-cnr.it/Papers/AAAI94.pdf>
- HEY, J. (2001a): *Genes, Categories, and Species: The Evolutionary and Cognitive Causes of the Species Problem*. Oxford: Oxford University Press.
- HEY, J. (2001b): The mind of the species problem. *Trends In Ecology & Evolution*, 16(7), 326–329.
- HULL, D.L. (1978): Matter of individuality. *Philosophy Of Science*, 45(3), 335–360.
- MAYDEN, R. L. (1997): A Hierarchy of Species Concepts: The Denouement in the Saga of the Species Problem. In Claridge, M.F.; Dawah, H.A.; and Wilson, M.R. (szerk.): *Species: The Units of Biodiversity*. London: Chapman and Hall Ltd.. 381–424.
- MAYDEN, R. L. (1999): Consilience and a hierarchy of species concepts: Advances toward closure on the species puzzle. *Journal Of Nematology*, 31(2), 95–116.
- SUPPE, F. (1977): Afterword - 1977. In Suppe, F (szerk.): *The Structure of Scientific Theories*. Second edition, Chicago: University of Illinois Press. 615–730.
- WILKINS, J. S. (1998): The evolutionary structure of scientific theories. *Biology & Philosophy*, 13(4), 479–504.

¹ In this section the references included in the present text are listed exclusively.