3rd POSTGRADUATE CONFERENCE ON LOGIC AND PHILOSOPHY OF SCIENCE 2016

30 May – 1 June, 2016

Palazzo Albani and Collegio Internazionale

University of Urbino

Book of Abstracts

The conference is organized by the

Italian Society for Logic and the Philosophy of Science (SILFS)

Department of Pure and Applied Sciences (University of Urbino)

Department of Pedagogy, Psychology, Philosophy (University of Cagliari)

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SESSIONS

[BIO]Philosophy of Biology and Health Sciences
chairs: Giovanni Boniolo (Univ. of Ferrara) and Raffaella Campaner (Univ. of Bologna)

[COG SC] Philosophy of Formal and Cognitive Sciences
chairs: Lorenzo Magnani (Univ. of Pavia) and Francesco Paoli (Univ. of Cagliari)

[COMP] Models and Foundations of Computing
chairs: Guido Gherardi (Univ. of Bologna) and Silvio Ghilardi (Univ. of Milan)

[LOGIC] Non-Classical Logics: semantics, proof theory and applications
chairs: Giovanna Corsi (Univ. of Bologna) and Pierluigi Minari (Univ. of Florence)

[PHYS] Philosophy and Foundations of Physics
chairs: Elena Castellani (Univ. of Florence) and Federico Laudisa (Univ. of Milano-Bicocca)

PROGRAM

30 MAGGIO 2016 (PALAZZO ALBANI, room Clemente XI)

09:30 Gino Tarozzi (Univ. of Urbino) and Giovanna Corsi (Univ. of Bologna)
Opening

Memorial lectures honoring Giorgio Sandri (Univ. of Bologna).

9:50 Vincenzo Fano (Univ. of Urbino)

10:20 Claudia Casadio (Univ. of Chieti-Pescara)

10:50 Dolores Sandri

11:10 COFFEE BREAK

11:30 Luke Burke (UCL, Univ. of London) [LOGIC]
Gl-TAG: a non-classical proof-theoretic semantics for natural language quantification

12:10 Tommaso Bertolotti (Univ. of Pavia) [COG SC]
Bridging the gap between niche construction, cognitive niche and cognitive niche construction

13:00 BUFFET

15:00 Carlo Nicolai (Munich Center for Mathematical Philosophy, LMU, Munich) [LOGIC]
Remarks on the role of truth-theoretic and non-semantic patterns of reasoning in non-classical systems of truth

15:40 Francesco Antonio Genco (TU Wien) [LOGIC]
Hypersequents and Systems of Rules: An Embedding

16:20 COFFEE BREAK

16:40 Michele Pra Baldi (Univ. of Padua) [LOGIC]
A n-sided Sequent Calculus for Paraconsistent Weak Kleene Logic

20:00 DINNER

31 MAGGIO 2016 (PALAZZO ALBANI, room Clemente XI)

09:30 Selene Arfini (Univ. of Chieti-Pescara) [COG SC]
Epistemological and Metacognitive Consequences of Cognitive Autoimmunity

10:10 Federica Malfatti (Leopold Franzens Univ. Innsbruck) [PHYS]
Understanding through models. The role of structure.

10:50 COFFEE BREAK

11:10 Emanuele Rossanese (Univ. of Roma Tre)) [PHYS]
Structural Monism: The Case of Algebraic Quantum Field Theory

11:50   Lorenzo Rossi (Univ. of Oxford) [LOGIC]
Irreflexive Validity

13:00 LUNCH

15:00 Davide Romano (Univ. of Lausanne)) [PHYS]
Why Bohmian non-locality is not a problem for us (classical objects)

15:40 Francesco Bellucci (Tallinn Univ. of Technology) [COMP]
Notational aspects of Begriffsschrift and Existential Graph

16:20   COFFEE BREAK

16:40 Bogdan Dicher (Univ. of Cagliari) [LOGIC]
On quantum disjunction and a generality condition in proof-theoretic semantics

17:20 Luisa Peruzzi, Stefano Bonzio, José Gil-Férez, Francesco Paoli (Univ. of Cagliari) [LOGIC]
On Paraconsistent Weak Kleene Logic and Involutive Bisemilattices

18:10 CONSIGLIO DIRETTIVO della SILFS

20:00 SOCIAL DINNER

1 GIUGNO 2016 (COLLEGIO INTERNAZIONALE, Conference Room, P.zza San Filippo, 2, Urbino)

09:30 Anna Maria Dieli (Univ. of Rome "Tor Vergata" – Univ. Paris 1 Panthéon-Sorbonne) [BIO]
Inquiry on Cancer Cells Individuality

10:10 Daniele Chiffi (Univ. of Padua) [BIO]
Knowledge and Belief in Placebo Effect

10:50 COFFEE BREAK

11:10 Stefano Bonzio, Ivan Chajda and Antonio Ledda (Univ. of Cagliari) [LOGIC]

Representing Quantum structures as near semirings

11:50 Davide Fazio [COMP]
Deterministic computations and critical pairs in Term Rewriting Systems

13:00 LUNCH

15:00 Mihail-Valentin Cernea ("Alexandru Ioan Cuza" Univ. of Iași) [BIO]
Supraorganismal selection in Darwin’s "Origin of Species". An avenue for a better understanding

15:40 Federico Boem (Univ. of Milan) [BIO]
Why genes are like lemons

16:20 Luca Rivelli (Univ. Paris 1 - IHPST, Univ. of Padova – FISPPA) [BIO]
Functional and mechanistic explanations are reverse-engineered modular descriptions constrained by computational complexity

17:00 CLOSING

Scientific Committee: The Council of SILFS, Italian Society for Logic and the Philosophy of Science (www.silfs.it).

Organizing Committee: Giovanna Corsi (Univ. of Bologna), Vincenzo Fano (Univ. of Urbino),
Roberto Giuntini (Univ. of Cagliari), Pierluigi Graziani (Univ. of Chieti-Pescara), Eugenio Orlandelli (Univ. of Bologna).

Further information can be found at www.silfs.it
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GL-TAG: A NON-CLASSICAL PROOF-THEORETIC SEMANTICS FOR NATURAL LANGUAGE QUANTIFICATION

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Abstract.
This talk introduces Gl-TAG, a novel proof-theoretic, compositional semantics for natural language quantification developed by the author. Gl-TAG combines linear logic, a non-classical logic invented by Girard (1987), and TAG (Joshi and Schabes (1997)), a tree-based formal grammar. Gl-TAG combines semantic values via the introduction and elimination rules of linear logic, by exploiting the Curry-Howard isomorphism to pair formulas of linear logic with corresponding formulas of the simply-typed lambda calculus.

There are three particularly interesting features of Gl-TAG.

Firstly, it demonstrates a particular linguistic application of substructural logic, of potential relevance to those who follow (Dummett (1991) and Martin-Lof (1996)) in endorsing proof-theoretic approaches to meaning.

Secondly, it embodies a distinctive conception of semantic value, which bears some resemblance to the concept of a continuation, familiar from the semantics of programming languages (Kelsey et al. 1998).

And finally, Gl-TAG derives quantifier scope ambiguities in a distinctive way, applying the TAG operations of substitution and adjunction to the parse trees of linear logic proof trees. Thus syntactic and semantic mechanisms are used to derive scope ambiguities, thus potentially enabling a more equitable division of labour between the syntax and semantics than afforded by some other approaches.

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BRIDGING THE GAP BETWEEN NICHE CONSTRUCTION, COGNITIVE NICHE, AND COGNITIVE NICHE CONSTRUCTION

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Abstract.
Niche theories consist of a theoretical framework that is proving extremely profitable in bridging evolutionary biology, philosophy, cognitive science, and anthropology by offering an inter-disciplinary ground causing novel approaches and debates to crucial issues in all of the aforementioned fields (Tooby & DeVore, 1987; Odling-Smee, Laland, & Feldman, 2003; Pinker, 2003; Clark, 2005, 2006; Magnani, 2007; Iriki & Taoka, 2012; Sinha, 2015; Bertolotti & Magnani, 2015; Wallach, 2015).

Such rapid expansion raises the need for a consistent theoretical consolidation (that is at the same time a clarification) of the theory itself, in the light of its complex origins and outcomes especially as far as human phenomena are at stake. With this respect, we are going to take in consideration a particular niche theory, that is cognitive niche construction. Setting off from the strict relationship between cognitive niche construction and niche construction

theories, the second goal will consist in the attempt to sketch a unified bio-cognitive framework explaining the shift from ecological to cognitive niche construction.

The often advocated and debated human uniqueness is first of all (or naïvely) a matter of ecological evidence. The fact that human endeavors became something special at a certain point in time clearly emerges from human organization and their ability to affect and change their environment. The point this reflection starts from is the acknowledgment that one of they factors that produced this is human beings' ability to continuously delegate and distribute cognitive functions to the environment to lessen their bio-cognitive limits. Also the modifications that seem basically environmental, like building a persistent roof covering oneself from heavy weather, are actually the product of impressive cognitive capabilities. One of the explanations is that human beings create models, representations and other various mediating structures, that are thought to be of aid for thinking: such intense activity of distributing cognition in the environment is described as cognitive niche construction (Magnani, 2009; Clark, 2005, 2006; Iriki & Taoka, 2012; Bertolotti & Magnani, 2015).

Along this paper, I will proceed first by understanding and choosing among the different characterizations of cognitive niches. Then I will draw on the different views in order to offer a consistent definition of cognitive niche construction, on which I will subsequently rely to sketch out the theoretical links connecting ecological and cognitive niche construction.

The definition of cognitive niche I will suggest, elaborating on (Clark, 2005), (Pinker, 2003), and (Tooby & DeVore, 1987), is the following:

> Cognitive niche construction is the process by which organisms modify their environment to affect their evolutionary fitness1 by introducing structures that facilitate (or sometimes impede) the persistent individuation, the modeling, and the creation of cause-effect relationships within some target domain or domains. These structures may combine with appropriate culturally transmitted practices to enhance problem-solving, and (in the most dramatic cases) they afford potential whole new forms of thought and reason.

The aim of this paper will be a reflection about the main niche theories: ecological niche construction, cognitive niche, and cognitive niche construction theory. In particular, the goal will be to understand the theoretical and actual connections between ecological niche construction theory and cognitive niche construction theory, being the latter less evolutionarily informed but of greater interest for philosophers, especially advocates of the distributed cognition and extended mind paradigms.

Acknowledging that cognitive niche construction is more than a theoretical intersection between ecological niche construction and cognitive niche theories, I will set off by analyzing the relationship between these perspectives in order to produce the aforementioned definition, which should be consistent with the different received views.

Having defined the concept of cognitive niche construction, I will attempt to make sense of its intuitive relationship with the theory it was inspired by, that is ecological niche construction: what still is to be fully explained is the shift from the ecological interaction between organisms and their environment to the cognitive interaction between agents and their environment.

In order to account for this shift, that I understand as continuous and separated by a blurred – if any –border, I will refer to two notions continuously defining the active and "causal" relationship between agents and their environment: enablements and affordances.

The biological notion of enablement (Longo & Montévil, 2014) and the psycho-cognitive one of affordance (Gibson, 1979; Norman, 1988) concern the mutual affecting and peculiar, coupled relationships between parts of a niche. Indeed, a niche can be defined as the result of a set of enablements (from the biological point of view) and as a set of affordances (from a cognitive point of view). I will argue that enablements could be seen as the core concept of ecological niche construction, while affordances are the core of cognitive niche construction.

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REMARKS ON THE ROLE OF TRUTH-THEORETIC AND NON-SEMANTIC PATTERNS OF REASONING IN NONCLASSICAL SYSTEMS OF TRUTH

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Abstract.

1. *A nonclassical system of truth and two main questions.*

Semantic paradoxes force us to question our naïve intuition about truth, encompassed in the schema \`*A*' is true if and only if *A*. Solutions to semantic paradoxes can be classified as following two main strategies: on the one hand, one may give up the naïve truth schema and

retain classical logic; on the other, one may retain our naïve intuition and abandon classical logic.

We focus on the *nonclassical approach*. It relaxes classical logic for semantic vocabulary and maintains rules for truth that are fully transparent: `A' *is true* is fully substitutable with A in any context. Its advocates argue that the relaxation of classical logic applies only to semantic vocabulary, and that classical logic can be retained for the non-semantic portions of the language under consideration. We investigate in particular variations on a specific deductive system in partial logic, known as PKF from partial Kripke-Feferman, first formulated in Halbach and Horsten 2006.

The language L_T of PKF is obtained by expanding the language L of arithmetic with a unary predicate T. PKF is then formulated in a two-sided (context-sharing) sequent calculus containing, besides the genuinely logical sequents, sequents $\Rightarrow A$ with A a basic axiom of Peano arithmetic, an induction rule for arbitrary formulas of L_T and truth-theoretic initial sequents inspired to the clauses of the Strong Kleene version of Kripke's fixed point construction (cf. Kripke 1975, Halbach 2014).

The logic of PKF forces either gaps (sentences with no truth-value) or gluts (sentences that are both true and false), but not both and it is sound and complete with respect to the intended notion of logical consequence; moreover, we will show that PKF and its variants considered below enjoy free-cut elimination in the sense of Buss 2011.

Discussions of nonclassical deductive systems of truth mostly focus on how these systems behave with respect to paradoxical sentences. We opt for a different approach and appeal to concrete formal results to tackle two main questions:

I. Is the purely truth-theoretic part of PKF

II. How does PKF respond to variations of genuinely non-semantic principles such as induction schemata?

The first question may be motivated by the notorious difficulties of performing “sustained ordinary reasoning” (see Feferman 1984) in partial logic. It is therefore natural to wonder whether, following Reinhardt 1986, there may exist classical systems playing the role of manageable tools to uncover the theorems of PKF. This would enable one to sidestep the clumsiness of the partial setting while maintaining the virtues of PKF.

The second question impinges on the analysis of the very role of nonclassical logics in the field of semantics: if routine scientific reasoning, schematic and inductive reasoning in particular, is compromised or severely reduced in a nonclassical theory of truth, as some authors think (McGee 1991, Halbach 2014, Williamson 2016), the adequacy of systems à la PKF is severely in doubt.

2. *Variations on the PKF-theme*

To address both questions, we compare PKF to the truths of Feferman's axiomatization of Kripke's theory of truth in classical logic – in the same language L_T as well – called KF in Halbach 2014. This is a nontrivial methodological move: since we want to compare theories formulated in different logics, there are no straightforward ways to resort to the usual inter-theoretic reductions such as proof-theoretic equivalence or variants of relative interpretability.

2.1 *A completeness theorem*

For question I. we interested in the purely semantic content of PKF. We therefore consider the theories KF| and PKF| obtained by disallowing semantic vocabulary to appear into instances of the induction rules of both theories. In particular, we take into account the internal logics of KF| and PKF|:

IKF| :={*A* | KF| |- T(A) }; IPKF| :={*A* | PKF| $|\!-^{*}$ T(A)}.

Notice that (i) PKF|, featuring an intersubstitutable truth predicate, is identical to its internal logic,[1] and (ii) that we distinguish between |- (classical derivability) and $|\!-^{*}$ (derivability in partial logic). We will prove

Proposition 1. PKF| = IKF|.

Proposition 1 tells us that, if we are interested in the purely semantic principles of the nonclassical theory PKF|, we may avail ourselves of a detour through classical logic. PKF| is without a doubt a nonclassical theory and yet there is a recursively enumerable theory of truth in classical logic whose provably true sentences are exactly the theorems of PKF|.

2.2 Nonclassical logic and transfinite induction

Although Proposition 1 may suggest that the use of systems of truth in nonclassical logic does not lead to any loss, the situation drastically changes when one considers the interaction of semantic vocabulary with principles of open-ended nature such as induction schemata. We already knew in fact that

Lemma 1.

a) KF proves the rule and the schema of transfinite induction for L_T up to any ordinal less than ε_0;
b) PKF proves the rule of transfinite induction for L_T up to any ordinal less than ω^{ω}.

As a corollary, IKF is stronger than PKF. We contribute to this picture by providing conclusive evidence that the interaction of truth with mathematical patterns of reasoning such as induction is indeed responsible for the asymmetry between the provable truths of KF and PKF. In particular, by letting

PKF^{+}:= PKF+ *the rule of transfinite induction up to any* ordinal less than ε_0,

we show that:

Proposition 2. IKF=PKF^{+}.

This result may even suggest that, as soon as semantic vocabulary interacts with patterns of reasoning proper of other areas of scientific or philosophical enquiry, the costs of adopting nonclassical logics may be hardly contained.

1 And the same holds for its versions with full induction.

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HYPERSEQUENTS AND SYSTEMS OF RULES: AN EMBEDDING

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Abstract.
Proof theory provides a constructive approach for the investigation of metalogical and computational properties of a logic through the design and study of suitable proof systems. An essential feature of such proof systems is analyticity. A proof system is analytic if its proofs only contain subformulae of the formula to be proved.

Sequent calculus has been extensively and successfully used in the definition of analytic proof systems since its introduction [7]. Unfortunately it is not powerful enough to capture many non-classical logics. Hence, many variants and extensions of the framework of sequents have been introduced. Prominent examples of formalisms for the proof theory of non-classical logics are the labelled calculus [6, 8] and the hypersequent calculus [1]. The labelled calculus consists of sequent rules acting on labelled formulae and relations on labels. The hypersequent calculus consists of rules acting on multisets of sequents, *i.e.* objects of the form

$$\Gamma_1 \Rightarrow \Delta_1 \mid \dots \mid \Gamma_n \Rightarrow \Delta_n$$

where $\Gamma_i \Rightarrow \Delta_i$, for $1 \leq i \leq n$, are sequents, and the symbol | is usually interpreted in a disjunctive way.

The multitude and diversity of the introduced formalisms has made it increasingly important to identify their interrelationships and relative expressive power. Embeddings between formalisms, *i.e.*, functions that take any calculus in some formalism and yield a calculus for the same logic in another formalism, are useful tools to prove that a formalism subsumes another one in terms of expressiveness or – when the embedding is bidirectional –

that two formalisms are equally expressive. Such embeddings can also provide useful reformulations of known calculi and allow the transfer of proof-theoretical results.

Using propositional intermediate logics as a case study, we present a bidirectional embedding between two formalisms for the proof theory of non-classical logics: hypersequents and two-level systems of rules [5].

Systems of Rules.

The formalism of systems of rules was introduced [9] to define analytic labelled calculi for logics semantically characterised by frame conditions. A system of rules is a set of sequent rules reciprocally related by conditions on their applicability. For example, the system of rules $Sys_{(com)}$ corresponding to the linearity axiom $(\varphi \supset \psi) \vee (\psi \supset \varphi)$ is the following:

$$\dfrac{\dfrac{\begin{array}{c}\dfrac{\varphi, \Gamma_1 \Rightarrow \Pi_1}{\psi, \Gamma_1 \Rightarrow \Pi_1}\,(com_1)\\ \vdots \\ \Gamma \Rightarrow \Pi\end{array}}{} \qquad \dfrac{\begin{array}{c}\dfrac{\psi, \Gamma_2 \Rightarrow \Pi_2}{\varphi, \Gamma_2 \Rightarrow \Pi_2}\,(com_2)\\ \vdots \\ \Gamma \Rightarrow \Pi\end{array}}{}}{\Gamma \Rightarrow \Pi}\,(com_{end})$$

where φ, ψ are metavariables for formulae; Γ, Γ_1, Γ_2 for multisets of formulae; and Π, Π_1, Π_2 for multisets of formulae with at most one element. By this schema we represent the following conditions:

- *(com_1)* and *(com_2)* can only be applied above different premisses of *(com_{end})*,
- the metavariables φ and ψ are shared by the two applications.

System of rules are quite powerful and can be used in labelled calculi to define analytic proof systems for all the modal logics characterised by frame properties that correspond to formulae in the Sahlqvist fragment. The downside of this great expressivity is the non-locality of rules in this framework, which appears at two levels: horizontally, because of the dependency between rules occurring in disjoint branches; and vertically, because of rules that can only be applied above other rules.

The Embedding.

A “possible connection” between hypersequents and systems of rules has been hinted [9]. We formalised in full this intuition defining a bidirectional embedding, w.r.t. intermediate propositional logics, between hypersequents and a proper fragment of the full formalism of systems of rules, *i.e.*, two-level systems of rules. An example of this kind of system is $Sys_{(com)}$ above – indeed only one application of *(com_1)* or *(com_2)* (the rules of the second level) can occur above each premiss of *(com_{end})* (the rule of the first level).

The specific outcomes of the embedding are

(a) a local representation of two-level systems of rules by hypersequent rules (*e.g.*, for intermediate logics characterised by Hilbert axioms within the class P_3 of the substructural hierarchy [4]),
(b) the transfer of analyticity results from the hypersequent formalism to the formalism of two-level systems of rules (this is achieved translating the two-level system of rules into a hypersequent rule, constructing a version of the latter that preserves cut-elimination [4], and translating the rule back),
(c) the definition of new cut-free proof systems with two-level systems of rules,
(d) a reformulation of hypersequent calculi which may be of independent interest due to its close relation to natural deduction systems.

The connection between hypersequents and two-level systems suggests a promising approach to the problem of extracting the computational content of logics formalised by hypersequent proof systems. Indeed, translating a hypersequent proof system into a suitable natural deduction system it is possible to establish a Curry–Howard correspondence (see, *e.g.*, [2] for an attempt in this direction with Gödel logic).

Furthermore, the fact that all propositional axiomatisable intermediate logics are definable by adding suitable formulae (*canonical formulae*) to intuitionistic logic [3] points at another research direction. Indeed, these formulae belong to a class which is immediately above the class for which hypersequent can provide analytic rules [4], and therefore three-level systems seem a suitable choice to transform formulae in the higher class into analytic rules.

Finally, the embedding does not essentially depend on the specific rules of the considered calculus and can be naturally extended to other classes of propositional logics, *e.g.*, substructural or modal logics.

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AN n-SIDED SEQUENT CALCULUS FOR PARACONSISTENT WEAK KLEENE LOGIC

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Abstract.
In this work I present an n-sided sequent calculus for Paraconsistent Weak Kleene Logic (PWK), the praconsistent version of the 3-valued Weak Kleene Logic (WK) introduced by Halldén [10]. Recently, many authors have focused on this logic, with special attention to its semantical aspects and on the algebraic structures associated [6, 7]. However, the literature on the proof-theoretical behaviour of the logic is still lacking.

This paper investigates precisely the deductive nature of PWK, by developing a system in 3-sided sequents (PWK_{3n}), a well-known extension of standard sequent calculus due to Rousseau [17]. This framework has been widely used to formalise different non-classical and many valued logics, and it represents a powerful common ground for their comparison.

An exception to the lack of literature on the proof theory of PWK is the work by Coniglio and Corbalán [9], which gave a sequent calculus system (H) for the $\{\neg, \vee\}$-fragment of PWK by introducing appropriate linguistic restrictions on the classical sequent calculus CPL.

Calculus H adopts some linguistic restrictions on classical sequent calculus to get non-classical features. My strategy, on the contrary, is to extend classical sequent calculus to get non-classical features, without restrictions.

The main points I deal with are:

1. An invertible 3-sided sequent calculus that avoids ad hoc (linguistic) restrictions
2. The proof of fundamental theorems for the calculus as soundness, complete- ness and decidability
3. The definition of a method that provides a countermodel for every derivation ending in non-axiomatic sequents
4. Some comments on the proof-theoretic relation between classical logic and PWK.

Points 1-2 are self-explaining and they essentially follow the line of [20], so let us briefly go in some details on points 3-4.

3. Unlike the system H, the calculus PWK_{3n} is particularly efficient for proof searching, since it associates a countermodel in the semantics to every failed deriva- tion. Of course, this aspect is ensured by the invertibility of the rules, which pre- serve validity in the bottom-up procedure. A nice feature is that, thanks to the close connection between truth-tables and n-sided sequents, it is possible to grasp how one of the most distinctive trait of PWK, the contaminating behaviour of the middle value, works in deductions. Indeed, we can always keep trace of the influence the principle of contamination has on drawing inferences.

4. Another characteristic of this framework is that we can investigate the relation between PWK and classical logic from a different point of view. Indeed, sequent calculus for classical logic clearly is a special case of n-sided sequents, i.e. when n= 2. In particular, if we remove the component for the third value from PWK_{3n}, we get exactly the structural and the operational rules of classical logic.

At last, I present some applications of the method, in order to show the proof- theoretic motivation for the failure of some notable inferences in PWK, such as conjunction

simplification (A ∧ B ⊢ A), EFQ (A ∧ ¬A ⊢ B) and a direction of absorption (A ∧ (A ∨ B) ⊢ A, A ∨ (A ∧ B) ⊢ A).

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EPISTEMOLOGICAL AND METACOGNITIVE CONSEQUENCES OF COGNITIVE AUTOIMMUNITY

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Abstract.
The Naturalization of Logic and the Autoimmune Cognitive Agent.
The term autoimmunity has been first applied in the logical and epistemological field in 2005, within the still ongoing project of the "Naturalization of Logic", initiated by logicians Gabbay and Woods [Gabbay and Woods, 2001], which aims at the construction of a more "empirically sensitive logic" to deal with the reasoning that the human agents actually perform. The term autoimmunity follows from the consideration that the cognitive states of belief, doubt, knowledge, and ignorance affect the epistemic status of the agent who experiences them in ways she cannot anticipate nor control. Indeed, cognitive autoimmunity stands for an inescapable condition of the human epistemic status which compromises her ability to recognize her own fallacious reasonings and eliminate her own misconceptions. The autoimmune mechanism also involves the ways the agent adopts in order to make this condition less problematic as possible, in terms of decision making strategies and emotional responses. Considering the cognitive relevance of this concept, I contend that cognitive autoimmunity can be usefully employed beyond the epistemological and logical fieldwork, in order to describe the cognitive mechanism supporting what the philosophical and psychological literature call "epistemic feelings" (tip-of-the-tongue experience, feeling-of-knowing, etc). Pointing at this target, first I will present a definition of cognitive autoimmunity, embedded in the concepts of Epistemic Bubble [Woods, 2005], and Ignorance Bubble [Arfini and Magnani, 2015]. Then, I will relate the structure of autoimmunity to the metacognitive processes that underlie the "epistemic feelings" regarding the confidence of the agent on her own knowledge, [Muñoz, 2014b].

The Bubble Theses.
The first instantiation of Cognitive Autoimmunity is represented by Woods' idea of Epistemic Bubble, which derives from the assertion that belief is not only a fallible condition but also a pleasurable state. Indeed, belief is a mental state that requires cognitive commitment because it solves the irritation of doubt and calms the agent's mind. Moreover, while the achievement of knowledge always entails a state of belief in the agent, the attainment of a belief does not directly imply the gain of knowledge. Thus, whenever the agent knows something, she is compelled to believe she knows it. Consequently, the asymmetry between the states of belief and knowledge determines the fact that the agent has a hard time distinguishing between the epistemological status of belief and knowledge, when she has to deal with her own cognition. As a result, the Epistemic Bubble is configured as a first-person knowledge-ascription, performed by the knowing agent, to whom the difference between knowing something and thinking she knows that same thing is unapparent [Woods, 2005]. Consequently, this mechanism always provides – more or less heavily – an illusion about the truthfulness of the knowledge of the agent's first-person perspective, which allows the agent to act despite her uncertain beliefs.

Starting from similar assumptions, the concept of ignorance bubble has been introduced considering the connection between the agent doubt and ignorance from her first-person perspective, not equivalent from the third-person point of view. While the agent considers her doubt a manifestation of her ignorance, the proper amount of ignorance she possesses lingers beyond the frame of her doubts. Even if she tried to reach her entire ignorance starting from what she doubts, there will still be data, events and information she could not consider. At the same time, doubt is the only "visible part of ignorance" that the agent in first-person perspective can approach. So, exactly as in the epistemic bubble, "albeit there is a solid difference between the epistemological statuses of doubt and ignorance, the agent cannot be aware of this distinction when she has to deal with her own cognition"[Arfini and Magnani, 2015]. Thus, the ignorance bubble is represented by a missing-ascription of ignorance, performed by the agent, to whom the difference between ignoring something and doubting is unapparent. Doubt, as the only tool that permits the agent to investigate a part of her ignorance, also makes impossible for the agent to distinguish the amount of actual ignorance she possesses from what she is just able to recognize.

Both Bubble Theses describe a form of Cognitive Autoimmunity (or self immunization) because they prevent the agent from seeing the defections of her own cognition. At the same time, the naiveness of the agent about her own cognition is directed by the same systems that permit her to attain any type of knowledge or to improve it describing her own ignorance. Even if the agent accepts the concept of the epistemic autoimmunity, the functionality of her cognitive states prevents her from dealing with it.

Metacognitive Implications.

Considering how cognitive autoimmunity has effects on the agent's epistemic dynamics, I will then describe how it can be extended beyond the mere epistemological dimension, affecting the occurrence of what Munõz called "epistemic feelings". Indeed, as different but related phenomena occurring in the human brain during a cognitive performance, epistemic feelings (as feeling-of-knowing, tip-on-the-tongue feeling, feeling-of-uncrtainty) are described as the results of the presence of beliefs or doubts in the agent's cognition [Muñoz, 2014b]. I will contend that, since the agent experiences feelings that depend on her doubts and belief, and not relatively to the information they may carry, the inferential process that an epistemic feeling enacts can be described as subordinate to the cognitive autoimmune mechanism. As a consequence, the autoimmune mechanism can explain how the agent applies a fallacious reasoning when she has to judge, and feel about, her own cognition. In conclusion, I will also discuss why the autoimmunity dynamics should not be understood as an impairment of human cognition, notwithstanding the fact that it may cause some cognitive failures (as misplaced epistemic feelings). Rather, the mechanism enacted between mental states, epistemic feelings, and pragmatical actions will be recounted as a logical and cognitive architecture which mostly benefits our cognitive welfare, preventing cases of pathological indecision and neurotic behavior [Randenborgh et al., 2010]. In comparison with such disorders, the occurrences of misplaced epistemic feelings, as consequences of an healthy cognitive autoimmune mechanism, will just represent evidences of human fallibilism.

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UNDERSTANDING THROUGH MODELS. THE ROLE OF STRUCTURE

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Abstract.
Models, in science, play two deeply interconnected roles: they are representational devices, on the one side, and they promote our understanding of the object or system they represent, on the other. They are not something conventionally staying for something else: they represent an object or a system of the world *in such a way* that they make the object or system in question cognitively accessible to us. So, when we ask ourselves how do models in science represent, how do they depict what they depict, how do they relate to reality, we should also ask ourselves which account of representation offers us the best explanation of how models make epistemic achievement possible. Semantics and epistemology call for a combined answer, so to say, when models are at stake. My aim in my contribution is to investigate the connection between representational capacity and cognitive value of models, and to point to what it seems to be a good candidate account of model representation able to offer, at least tentatively, the epistemological explanation in question.

How do we build models, in science? Usually appealing to a system we already partially understood as the one under study. The two systems in question (the one we grasp to in order to build the model and the one we aim to represent through the model) differ in some substantial respects, but they resemble each other to some extent. They share something – and the fact that something is shared between the two makes the model a representation of the target system. The idea I would like to defend is that what is shared between the source system and the target system is some kind of (partial) structure, and that model representation needs to be therefore conceived as some kind of structural representation: the (partial) structural analogies between the source system and the target system are what makes a model a representation of the target system (Bartels 2005 and Tetens 2013).

Why structure? What makes structure more appealing than other notions, like denotation or similarity? I believe that structure (and partial sharing of structure between different systems of objects) is the notion to be preferred, in light of the fact that the concept of *sharing structure* enables us to realize the above mentioned connection between semantics and epistemology: it gives us a plausible answer of how models relate to reality, on the one side, and it is a good basis to develop an account of how models make understanding possible, on the other.

Partial sharing of structure, in a nutshell, refers to the possibility of partially mapping, projecting or preserving of systems of relations holding between different domains of objects. Understanding, generally speaking, [i] has to do with grasping relations, i.e. with seeing how discrete elements relate to one another to build a certain system and [ii] it presents a relevant counterfactual aspect – understanding something, say a situation, involves not just the ability to tell causes and to make factual assertions, but also the ability to say how things *would have gone*, if the situation had been even slightly different (Grimm 2011, Zagzebski 2011). On the basis of this general characterization, I will argue that understanding through models has to do with [i] seeing how and to what extent a mapping of structure is possible among different domains of objects, and [ii] being able to make predictions about how changes in one part of the target system will lead to changes in another part, in light of the above mentioned possibility of partial structural projection.

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IRREFLEXIVE VALIDITY

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Abstract.

(Beall and Murzi, 2013) prompted a lively debate on *object-theoretic* notions of *validity*. They considered the following principles to characterize naïve validity:

(Val-In) If $\varphi \vdash \psi$, then $\vdash Val(<\varphi>, <\psi>)$

(Val-El) $\varphi, Val(<\varphi>,<\psi>) \vdash \psi$

They also give (what they see as) an analog of the (T -Schema):

(Val-Schema) $\vdash Val(<\varphi>,<\psi>)$ if and only if $\varphi \vdash \psi$

Here, I address some questions on object-theoretic validity, and Beall and Murzi's principles.

(1) How can Beall and Murzi's principles be made consistent?

(Val-In) and (Val-El) are inconsistent with classical logic (over a sufficiently strong base theory). A variant of the Curry Paradox, that Beall and Murzi call *V-Curry Paradox*, lets us derive a falsity using essentially Contraction and Cut. One could try to avoid the V-Curry Paradox by weakening (Val-El) as follows:

$(Val\text{-El}^M)$ If $\Gamma \vdash \varphi$ and $\Delta \vdash Val(<\varphi>,<\psi>)$, then $\Gamma;\Delta \vdash \psi$.

This move, however, does not avoid the V-Curry Paradox: we can derive a falsity using (*Val*-In), $(Val\text{-El}^M)$, together with Reflexivity, Weakening, Cut, and Contraction. *Substructural* approaches seem needed.

Some substructural theories are compatible with Beall and Murzi's principles.[2] (Meadows, 2014) investigated substructural *semantic* approaches to naïve validity: he developed a substructural Kripke-style construction that recovers (*Val*-El) and (*Val*-In). The resulting notion of consequence, however, is far from the standard one, since it invalidates Reflexivity, Cut, and Contraction. Can we develop a substructural, semantic Kripke-style construction that improves on these limitations?

(2) What notion(s) of validity results from Beall and Murzi's principles?

Substructural logics have well-known justifications in some contexts (e.g. where resources matter). *But in semantics?* Some substructural logicians argue that the structural rules they reject are invalid *tout court*, on the basis of some metaphysical picture.[3] Can we articulate a purely *logico-linguistic justification* for a substructural approach, and carve out which notion(s) of validity can be modeled in it?

(3) Are Beall and Murzi's principles desirable for validity?

(Field, 2016) raises some concerns about (*Val*-Schema): '*Even on the assumption that* '⊢' *represents a kind of validity and* '*Val*' *the same kind of validity, their schema has a 'double occurrence of validity'* ('⊢ *Val*') *on the left side and a 'single occurrence'* ('⊢') *on the right, making the argument from right to left [...] problematic*.'

Furthermore, he considers this strengthening of (*Val*-Schema):

$(Val\text{-Schema})^+$ $\Gamma \vdash Val(<\varphi>,<\psi>)$ if and only if $\Gamma;\varphi \vdash \psi$

He argues that $(Val\text{-Schema})^+$ is to be rejected, giving the following counterexample:

snow is white, grass is green ⊢ snow is white

snow is white \not⊢ *Val*('grass is green', 'snow is white').

Unfortunately, every theory (I know of) that validates (*Val*-Schema), also validates $(Val\text{-Schema})^+$. Is there a reading of validity that makes sense of both these principles?

In this work, I will address the difficulties raised in conjunction to questions (1), (2), and (3), providing a new semantic construction for naïve validity. In short, I will give an inductive construction *à la* Kripke for *sequents*.[4] The language will then be interpreted by the consistent *fixed points* of the construction.

To give an idea of the construction, let me describe informally how its least fixed point is built. The starting point of the least fixed point is constituted by sequents that have either atomic truths of the base language on the right-hand side, or atomic falsities of the base language on the left-hand side.[5] This starting point, I take it, dualizes the starting point of

[2] E.g. the systems in (Cobreros, Egrè, Ripley, and van Rooij, 2014), or (Zardini, 2014).

[3] E.g. *stability* (Zardini, 2014), *anti-realism* (Tennant, 2015).

[4] I work in the language of Peano Arithmetic, expanded with a fresh binary predicate *Val*(*x*,*y*).

[5] Namely, that have either the form $(\Gamma \Rightarrow s_0 = t_0;\Delta)$, where s_0 and t_0 have the same value, or the form $(\Gamma;s_1 = t_1 \Rightarrow \Delta)$, where s_1 and t_1 have a different value.

Kripke's construction for truth—the main difference being that here we have sequents, not sentences. The construction, then, is described by inductive clauses that provide closure under *all the classical operational rules* and *all the classical structural meta-inferences*—the terminology is from (Cobreros, Egrè, Ripley, and van Rooij, 2014).

This new construction, I argue, addresses the difficulties highlighted above:

- We have a substructural *semantic* construction that interprets naïve validity, recovering Beall and Murzi's principles to a large extent: we recover (*Val*-In), (*Val*-El^{M}), (*Val*-Schema), (*Val*-Schema^{+}). We do not recover (*Val*-El).
- The resulting theory avoids the V-Curry and related paradoxes: there are consistent, and hence paradox-free, fixed points of our construction.
- The resulting theory provides a notion of consequence that improves on the limitations of (Meadows, 2014), and comes very close to the standard, Tarskian account. Our construction validates Contraction, Cut, and Weakening. We only drop Reflexivity.[6] So, we don't recover the restricted substructural rule 'in non-paradoxical cases' or the like (as many substructural approaches do): we have a *genuine substructural rule* that approximates it.
- It seems possible to give a purely logico-linguistic justification for the restriction of the substructural rules operated by the theory, by analogy with Kripke's construction for truth: the least fixed point of our construction models a notion of 'grounded validity', i.e. validity that is grounded in the truths and falsities of the base language. In this reading, Reflexivity should naturally be restricted.
- This construction solves Field's worries about (*Val*-Schema), as it interprets *Val* in a fixed-point construction: whenever one side of the (*Val*-Schema) belongs to a fixed point, the other does too.
- The construction makes sense of (*Val*-Schema)$^{+}$, since this principle becomes unproblematic if we read *Val* as an object-theoretic representation of the notion of 'grounded validity' sketched above.

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[6] (Schroeder-Heister, 2012) is the only work (I'm aware of) where restrictions of Reflexivity, in order to avoid semantic paradoxes, are mentioned.

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STRUCTURAL MONISM: THE CASE OF ALGEBRAIC QUANTUM FIELD THEORY

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Abstract.
The main aim of this paper is to define and develop the notion of *structural monism*. According to this proposal, the fundamental element of our ontology should be a *whole* (for instance, the *whole universe*) that is however defined in structuralist terms. This idea would then merge together a *structuralist interpretation* of our best physical theories with a *monist position à la* Schaffer (2010). I would try to defend this position in the specific context of algebraic quantum field theory (AQFT).

Schaffer claims that the "cosmos is a one vast entangled system" (Schaffer 2010, 52). Schaffer's idea is in fact to consider that in the very first moments after the Big Bang there was a highly entangled physical system and from that moment onward the Schroedinger evolution of quantum systems had preserved the entanglement. Thus, Schaffer goes on and suggests that perhaps there exists one unique wave-function of the universe that is, in a certain sense, similar to the "unbroken wholeness" that Bohm and Hiley (1993, 352) mention in their book. It is here interesting to note that the problem of the entanglement has been considered in quite the same terms also by Lam (2013), who in fact starts from these kind of considerations in order to justify his structuralist interpretation of AQFT.

We can try to apply Schaffer (2010)'s proposal to AQFT and formulate an argument in favor of a monist interpretation of this theory as follows.

(1) In a pluralist account of our physical world, there should be a *democritean* account for entanglement relations;
(2) Such an account should be spelled in terms of particles *plus* entanglement relations;
(3) In AQFT, there are no (ontologically fundamental) particles;
(4) Thus, we would have only entanglement relations;
(5) But, such entanglement relations are spread over all the universe;
(6) Hence, entangled systems are fundamental wholes;
(7) Since the cosmos is an entangled system, then the cosmos is a fundamental whole.

One of most important assumptions of the argument is (3). As a *Received View*, the particle interpretation of AQFT seems to be ruled out by three main arguments. A particle should be a *countable* and *localizable* entity. Furthermore, we would like to have an ontology that does not depend on the choice of the frame of reference. However, these three requirements seem to be violated in the context of AQFT. This means that particles cannot be considered as ontologically fundamental in AQFT. This seems therefore to justify our assumption (3) in the argument sketched above. In other terms, particles can be considered only as *epiphenomena* of a more fundamental entity, namely the *fundamental whole*, that is, *the universe as a whole physical entangled system*.

French (2010) too seems to suggest something along the same lines: "A 'global' bounding of the relevant polyadic properties will yield the blob as structure of the world, with a 'local' bounding of the relevant properties giving us the putative 'objects'." (French 2010, 105) Here the *blob* is what Schaffer calls cosmos. Another interesting example is given by Levy-

Leblond, who is quoted in Ghirardi (2013, 44): “I would like to remind you that there is a universal correlation of the EPR type which we do not have cleverly set up, it is simply the antisymmetrization of a many fermion state that which does correlate the electrons of my body with those of any inhabitant of the Andromeda galaxy.” It is worth noting that also Horgan and Potrc (2000) defend a position that is similar to what Schaffer and French suggest. They write: “Our own world, in all its glorious complexity and spatiotemporal variation, dose not have any real parts. Indeed, this is a conceptually coherent ontological framework for physics, especially if one focuses on broadly field-theoretic formulations of physical theories.” (Horgan and Potrc 2000, 253)

In AQFT the main objects of study are the local algebras of observables associated with bounded regions of space-time. The physical content of AQFT is encoded in the net of relations among these local algebras. It seems therefore that the algebra structure contains all the information that we need in order to describe quantum field phenomena. Another important feature of AQFT is the *fundamental entanglement structure*. The Reeh-Schlieder theorem in fact shows that the vacuum state is highly entangled across many space-like separated regions. The technical reason is that the local algebras in AQFT are type III von Neumann algebras and in this framework any global state (like the vacuum state) is entangled across any diamond or double-cone region of space-time and its causal complement. Any state in a type III von Neumann algebra is *intrinsically mixed* and cannot be regarded as a probability distribution over pure states (that is, type III von Neumann algebras do not contain (one-dimensional) finite abelian projectors). The fundamental entanglement of all quantum field systems shows the *relational-structural character* of AQFT.

If we accept the arguments against the particle interpretation of AQFT that we have mentioned above and if we also accept Baker (2009)'s generalization of those arguments to the field interpretation of the theory, then we might find a possible solution by adopting a structuralist interpretation of AQFT. It is in fact possible to show that Baker's generalization holds also for other interpretations of the theory, such as, for example, the trope ontology proposed by Kuhlmann (see Rossanese 2013). It is therefore possible to claim that the structuralist interpretation seems to emerge *by elimination* from the other alternatives as the best intepretation in the context of AQFT. Moreover, the algebraic structure of AQFT suggests that there is a *fundamental entanglement structure* that seems to be the *technical counterpart* of what we have said before in the brief discussion of Schaffer's position. Given this aspect of the formalism, a *structural monist interpretation* appears to be an interesting proposal in order to provide an interpretation to AQFT. A *structural monism* would in fact give a clear philosophical account of the *non-separability* of the physical systems described by this theory and, at the same time, it allows to explain why local pysical systems cannot be considered as ontologically fundamental.

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WHY BOHMIAN NON-LOCALITY IS NOT A PROBLEM FOR US (CLASSICAL OBJECTS)

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Abstract.
Bohmian mechanics is a realistic interpretation of quantum mechanics, that is, it supplies the standard mathematical framework with a clear ontology. Within Bohmian mechanics we can tell a physical story about the actual behavior of the quantum systems, while within the standard framework we can mainly calculate the predictions for the measurement outcomes. A Bohmian system is described by a configuration of particles and a wave function. As time evolves, the particles follow continuous trajectories in physical space, whose motion is guided by the wave function (evolving itself according to the Schrödinger equation).

The basic ontology of Bohmian mechanics is, thus, rather simple: particles that follow continuous trajectories in space through time. This seems to be ideal if we want to recover the classical world of everyday experience, whose basic ontology also reduces to particles that follow trajectories in space. However, Bohmian trajectories have a striking and novel feature respect to the classical ones: they are highly non-local, i.e., given a non-factorized N-particle system, the velocity of one particle depends from the positions of all the other particles in the configuration. This fact permits to account (together with the quantum equilibrium hypothesis) for the predictions of quantum mechanics, but brings with it an image of the world that is quite different from the classical one, where different systems seem to behave independently each other. It has been argued, indeed, that this novel feature of Bohmian mechanics cannot be compatible with the ordinary experience of the physical world, and that the non-local Bohmian trajectories have to be rejected if we want to maintain a realistic interpretation of nature.

I shall argue, on the contrary, that Bohmian non-locality is a crucial ingredient for explaining the transition from a holistic dynamics (quantum world) to a local dynamics (classical world).

The scheme is the following one: in a realistic situation, a Bohmian system interacts with an external environment, that is, an external particle (e.g., an air molecule, a photon, a cosmic ray, …). This leads to entanglement between the system and the external particle, which in turn creates a superposition of spatially separated channels in the total wave function (system + environment). However, the system particle (X) and the external particle (Y) will enter just one of these channels. If the different channels have disjoint supports in configuration space (which is the Bohmian condition to have an "effective decoherence") then the dynamics of X (Y) will be guided just by the corresponding branch of the wave function in which the particles has entered before (say, ψ_S (ψ_E)). Under these conditions, we can call ψ_S the effective wave function of the system and ψ_E the effective wave function of the external particle. So, the wave-function of the system and that one of the environment have been "effectively factorized": the dynamics of X is only guided by ψ_S and the dynamics of Y only

by ψ_E. It is worth noting that this is not a real factorization: the total wave function is still represented by a superposition of different states, but all these branches (the ones different from the effective wave functions of the two systems) do not affect anymore the dynamics of the particles X and Y. We, thus, have entered a local dynamical regime, since the trajectory of X does not depend from any external particle or any external branch of the wave function (and the same for Y).

The emergence of the effective wave functions for Bohmian subsystems is, thus, the turning point for the quantum to classical transition, and the Bohmian non-locality (mathematically expressed in the entangled state) is exactly what we need in order to accomplish that.

The idea to recover an effective factorization through the interaction with environment dates back to Bohm & Hiley (1987), and it is now investigated in decoherence theory. Finally, we will seek to clarify the relationship between Bohmian mechanics and decoherence, finding out how the latter can be of a great help to the former in the quantum to classical connection and the former of great help to the latter in providing a clear interpretation of the formalism.

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NOTATIONAL ASPECTS OF BEGRIFFSSCHRIFT AND EXISTENTIAL GRAPHS

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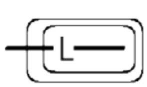
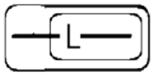
Abstract.

It is widely accepted that some notations for first order logic are diagrammatic while others are not. Frege's Begriffsschrift (BS) and Peirce's Existential Graphs (EGs) are commonly considered diagrammatic. But what it is that makes BS and EGs diagrammatic, precisely speaking?

No satisfying answer is available. Some hold that these notations, like the Euler circles and the Venn circles used to represent the logic of classes, are 'visual languages' (Hammer 1995; Shin 2002; Shin & Hammer 2014), but fail to explain what 'visual' is intended to mean in this context. Take the sentences of (1a-2a) in standard notation and (1b-2b) in EGs and ask how, e.g., the dependence of quantifiers is represented in the two cases.

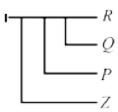
(1a) ∃x∀y L(x,y)
(2a) ∀x∃y L(x,y)

(1b) 

(2b) 

In EGs, if one line/quantifier is less enclosed than the other, then the former has larger scope than the latter. In standard notation, linear concatenation does the job. But the fact that in EGs a line is less enclosed than another is a ‘visual fact’ in exactly the same sense in which the fact that ∀ occurs at the right of ∃ in (1a) is a visual fact. An algebraic formula is a fact concerning certain configurations just as a geometric diagram is a fact concerning certain other configurations. Until ‘visuality’ is defined, nothing distinguishes EGs from the language of (1a-2a) under the supposed ‘visual’ aspect, because *all notations are visual* in the trivial sense that you need to ‘see’ a formula to interpret it.

Some claim or suggest that BS and EGs are diagrammatic because their formulas are capable of multiple equivalent readings (Macbeth 2005). For example, the BS formula (3) can be multiply read as 3.a, 3.b, 3.c and 3.d.

(3) 

(3a) $Z \supset (P \supset (Q \supset R))$
(3b) $(Z \,\&\, P) \supset (Q \supset R))$
(3c) $Z \supset ((P \,\&\, Q) \supset R)$
(3d) $(Z \,\&\, P \,\&\, Q) \supset R$

The same is claimed by Shin (2002), Shin & Hammer (2014) and Moktefi & Shin (2012) to apply to EGs. But it is evident and trivial that a BS or EGs formula is capable of ‘multiple equivalent readings’ in a target language Lt only if Lt has more primitive operators than the BS or EGs. In fact, the so-called ‘multiple readings’ of a formula are only *translations* of a formula of a notation Ls into several equivalent formulas in a notation Lt which has a richer logical vocabulary than Ls, so that to several equivalent configurations of primitive signs in Lt there correspond one single configuration of primitive signs in L. Since nothing more is meant with ‘multiple readings’, *any* notation is capable of multiple readings in other notations that are richer in logical primitives. Multiple readings do not capture salient notational aspects of either the BS or EGs, but simply and trivially determine classes of languages equivalent in the set of primitives.

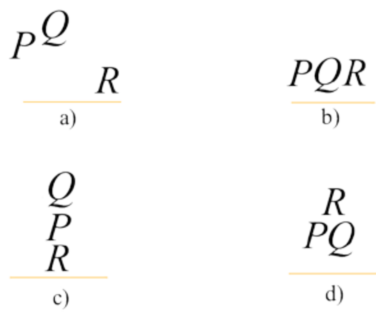
Neither visuality nor multiple readability explain why BS and EGs are different kinds of notations. My idea is that that which distinguishes BS and especially EGs from standard notations is that these notation abandon the linear arrangement, i.e., their fundamental syntax is not linear. Consider the following pairs of sentences (example from Howse et al. 2002):

(4) $P \land Q$
(5) P ⋀Q

(6) $P \land Q$
(7) $Q \land P$

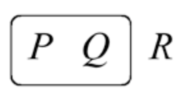
The difference between 4 and 5 is a difference in font and size, which is ignored at the syntactic level because font and size are not representing facts. Therefore, 4 and 5 are sentence *tokens* of the same sentence *type*. By contrast, the difference between 6 and 7 is a difference in ordering which is not ignored at the syntactic level because order is a representing fact. Therefore, 6 and 7 are not two sentence tokens of the same sentence type, but two distinct sentences types (which are semantically equivalent). Thus a *linear language* is one that, in general, *produces types by permutation*.

EGs (and to some extent to be discussed BS) abandon linearity. Each of 8a-d is a distinct graph token of the same graph type; they are not different graph types.



(8)

EGs have a symmetric syntax, because the basic mode of junction of simple and complex graphs is juxtaposition on the sheet, and this is a symmetric mode of junction. Graphs juxtaposed on the same area are thus conjunctively asserted but *nothing is implied about their ordering*. Only negation brings anti-symmetry in the system. The relation between '*P* & *Q*' and '*R*' in the Alpha graph of Fig. 9



(9)

is anti-symmetric, and thus is expressed by anti-symmetric mode of junction (juxtaposition on different areas); by contrast, the relation between '*P*' and '*Q*' is symmetric, and thus is expressed by a symmetric mode of junction (juxtaposition on the same area). In other words, *EGs represent order only where it is necessary to represent order (anti-symmetric relations), and leave the rest to be represented as unordered (symmetric relations).* In this way EGs *dispense with the standard rules of commutativity and permutation*. In linear notation, permutation produces different sentence types; in EGs, permutation and any other movement on the sheet do not produce different graph types but different graph tokens of the same graph type (Dipert 2006; Hammer 1996). Another way of saying this is that the laws of commutativity and associativity are only the product of the linearity of the notation. They *say* nothing about logic, they only *show* that the notation is linear. By the same token, one might say that the fact a formula of a notation L is capable of multiple readings says nothing of L; it only shows that notations exist which are richer in primitives.

According to Shimojima, a graphical system has some 'natural constraints' that prevent it from expressing certain information in a particular way without expressing certain other information, while a linguistic systems has no such natural constraints (Shimojima 1996). In order to account for BS' and EGs' abandonment of linearity I distinguish two kinds of constraints projection on the basis of what gets represented; if a constraint projects information decoded as logical consequence I speak of *calculative constraint*; if a constraint projects information decoded as logical equivalence I speak of *analytic constraint*. The fact that in the space of Eulerian diagrams space inclusion is transitive acts a calculatory constraint in drawing syllogistic conclusions; the fact that in EGs the sheet is unordered acts as an analytical constraint in representing logical conjunction. In Euler diagrams, the constraint allows us to dispense with rules of inference, in EGs the constraint allows us to dispense with rules of commutativity and associativity. Certain properties of space are exploited in Euler diagrams for calculus' sake, while certain other properties are exploited in EGs for analysis' sake.

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ON QUANTUM DISJUNCTION AND A GENERALITY CONDITION IN PROOF-THEORETIC SEMANTICS

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Abstract.

Weak disharmony. Famously, Michael Dummett (1991) argued that a logical constant is endowed with a coherent meaning if and only if it is harmonious: if, that is, the inferential strength of the rules which govern the constant's introduction matches that of the rules

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governing the elimination of the constant. This is the desideratum of harmony. Given the introduction rules (I-rules) for a logical constant there are two ways in which its elimination rules (E-rules) may be defective: they may be too strong or they may be too weak. Conversely, given the E-rules, the I-rules are defec-tive if they are either too strong or too weak. Too weak E-rules (or too strong I-rules) generate weak disharmony (Steinberger 2011). (Henceforth, I shall refer to I/E pairs as ‘intelims'.)

While somehow neglected in the traditional debate, weak disharmony recently became a prominent topic in proof-theoretic semantics, where much effort is devoted to finding suitable ways of dealing with it (Steinberger (2011); Tennant (forthcoming); Francez and Dyckhoff (2011)). Particularly challenging is substructural weak disharmony. This is the type of intelim mismatch that occurs when the weakness of the E-rules ensues from structural restrictions affecting them.

Quantum disjunction. The connective of choice to illustrate substructural weak disharmony is quantum disjunction or, for short, qor. Qor has the same I-rules as ‘standard' disjunction, but its E-rule is subject to the restriction that the subderivations originating in the disjuncts cannot use supplementary assumptions. Qor is weakly disharmonious: qor-E validates the ∨-I rules, which in turn validate ∨-E. (Here ∨ stands for ‘standard' disjunction, i.e. a disjunctive connective that is not subject to lateral constraints.) Is qor defective? As it turns out, qor is a hard nut to crack. The intuition that qor is somehow defective is hard to confirm once the informal notion of harmony receives suitable formal elucidation. In general, such elucidations fall in two categories, depending on how they rely on, respectively, global properties of the (various) logical systems or local properties of the intelim pairs. However, neither account manages to identify qor as deficient.

I show that this is true for the most fashionable local accounts of harmony—Read's ‘general elimination' harmony Read (2015), Tennant's ‘deductive equilibrium harmony' Tennant (forthcoming), Dyckhoff and Francez's local intrinsic harmony Francez and Dyckhoff (2011) (and some variants thereof like that in KUrbis (2013)).

Likewise, (I show that) the same result holds for the global accounts of harmony, in particular, Dummett's ‘complementation' and Belnap's conservativeness and uniqueness (Belnap 1962).

The generality condition. However, and despite these results, there is still something to be said against qor. Its defining rules fail to obey a certain generality condition which—so the argument goes—defining rules should obey. The condition in question, i.e., the context generality condition, has it that:

Context variables should be present in every premise and conclusion, ranging, (...), over arbitrary language contexts. (Francez, 2015, 47)

Clearly, qor fails to obey this constraint, as its E-rule places (context) restrictions on the context variables of its subordinate deductions. The bulk of my talk concerns the justification (recte: the lack of justification) for this condition.

Substructurality. A first reason to doubt the usefulness of the generality condition is that it is eo ipso prejudicial to any attempt to account proof-theoretically for the meaning of the logical constants as they appear in sub-structural logics (Hjortland 2009).

Meaningfulness. More importantly, the context generality condition ill fits some known (proof-theoretic) facts pertaining to the distinction between additive and multiplicative connectives. Properly understood, such a distinction would discard the additives (governed by rules which can be interpreted as sub-ject to context restriction) in favour of the multiplicatives. However, the two classes of connectives are different in any but the fully structural context which also has Weakening and Contraction (Paoli 2007).

Misdiagnosis. Moreover, accepting the condition leads to grave misunderstandings of the type of situation generated by having qor in the system. I argue that if qor is to be criticised, this is not on account of its rules per se but rather on account of these rules being able, in certain specific situations, to sureptitiously modify what Belnap called the 'antecedently given context of de-ducibility'. When qor is used in derivability contexts that are more generous than it itself requires, there is the potential for structural instability: that is, structural restrictions may collapse. This, however, doesn't have anything to do with qor, but rather with the manner in which the context of derivability is managed. In particular, unrestricted cuts are shown to have damaging effects.

An inverse generality condition. To substantiate the claims of the last paragraph, I introduce an inverse generality condition. According to this, the logical constants are to be defined via their most restrictive rules. A rule counts as most restrictive when it carries no more structural information than required for the definability of the constant. I show that such a condition naturally fits a well-established test for harmony, i.e., Belnap's dual criterion of conservativeness (sometimes localised as cut-inductiveness) and uniqueness. Moreover, applying this criterion for harmony under the inverse generality condition doesn't have any of the disadvantages presented by the generality condition.

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On Paraconsistent Weak Kleene Logic and Involutive Bisemilattices

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Abstract.
In his "Introduction to Metamathematics" [7] S.C. Kleene distinguishes between a "strong sense" and a "weak sense" of propositional connectives when partially defined predicates are present. Each of these meanings is made explicit via certain 3-valued truth tables, which have become widely known as "strong Kleene" tables and "weak Kleene" tables, respectively. If the elements of the base set are labelled as {0, 1\2 , 1}, the strong tables for conjunction, disjunction and negation are given by $a \wedge b = \min\{a,b\}$, $a \vee b = \max\{a,b\}$ $\neg a = 1 - a$. The weak tables for the same connectives, on the other hand, are given by:

∧	**0**	**1\2**	**1**
0	0	1\2	0
1\2	1\2	1\2	1\2
1	0	1\2	1

∨	**0**	**1\2**	**1**
0	0	1\2	1
1\2	1\2	1\2	1\2
1	1	1\2	1

¬	
0	1
1\2	1\2
1	0

Each set of tables naturally gives rise to two options for building a many-valued logic, depending on whether we choose to consider only 1 as a designated value, or 1 together with the "middle" value 1\2 . Thus, there are four logics in the Kleene family:

- Strong Kleene logic [7], given by the strong Kleene tables with 1 as a designated value
- The Logic of Paradox, LP [10], given by the strong Kleene tables with 1, 1\2 as designated values
- Bochvar's logic [2], given by the weak Kleene tables with 1 as a designated value
- Paraconsistent Weak Kleene logic, PWK [6, 11], given by the weak Kleene tables with 1, 1\2 as designated values

The first three logics have all but gone unnoticed by mathematicians, philosophers, and computer scientists. In terms of sheer impact, PWK is the "ugly duckling" in the family of Kleene logics. Essentially introduced by Halldén [6] and, in a completely independent way, by Prior [19], it is often passed over in silence in the main reviews on finite-valued logics. Most of the extant literature concerns the philosophical interpretation of the third value [1, 3, 5, 6, 12] and PWK as a consequence relation [4].

It has also been noticed early on that the (2,2)-reduct of the 3-element algebra WK defined by the weak Kleene tables is an instance of a distributive bisemilattice, a notion on which there is a burgeoning literature. Yet, despite this intriguing connection to algebra, virtually no paper has viewed PWK in the perspective of Algebraic Logic.

Our aim is to give a contribution towards filling this gap. Firstly, we give a Hilbert-style system for PWK. Next, we introduce some algebraic structures for PWK, called involutive bisemilattices, which are algebras $\langle A, \wedge, \vee, \neg, 0, 1\rangle$ such that $\langle A, \wedge, 0\rangle$ and $\langle A, \vee, 1\rangle$ are a meet

and a join semi- lattices with lower and upper bound, respectively, and ¬ is an idempotent operation, satisfying the De Morgan identities, and moreover the equation

$x \wedge (\neg x \vee y) \approx x \wedge y.$

Among other results, we show that involutive bisemilattices are always distributive as bisemi-lattices and that WK generates the variety IBSL of involutive bisemilattices.

Finally, we use the algebraic construction of Plonka sums, introduced in [8, 9], and prove a representation theorem for involutive bisemilattices. As a consequence, we obtain that the equations satisfied by all the involutive bisemilattices are exactly the regular equations satisfied by all the Boolean algebras. We then axiomatise relative to IBSL its nontrivial subvarieties, namely, Boolean algebras and lower-bounded semi-lattices.

We study then PWK by recourse to the toolbox of Abstract Algebraic Logic. It is not inappropriate to wonder whether the variety IBSL is the actual algebraic counterpart of the logic PWK. Such a guess stands to reason, for PWK is the logic defined by the matrix PWK with WK as an underlying algebra, and IBSL is the variety generated by WK. We show though that IBSL is not the equivalent algebraic semantics of any algebraisable logic, and furthermore, PWK is not algebraisable, since it is not even protoalgebraic. We also show that PWK is not selfextensional either.

Further, characterising the Leibniz congruence of the models of PWK, allows us to prove that the class Alg*(PWK) of the algebraic reducts of the reduced models of PWK is a subclass of IBSL.

Finally, we fully characterise the deductive PWK-filters on members of IBSL and the reduced matrix models of PWK.

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Inquiry on Cancer Cells Individuality

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Abstract.
Cancer, also known as malignant tumour, is a disease involving aberrant proliferation of cells and the ability to invade other tissues. In cancer, cells grow out of control and become invasive: therefore, it is usually described as a cell disease. Mutation, competition and natural selection between cells are thus the main components of the phenomenon of cancer (Nowell 1976). Cancer cells fulfil the criteria for Darwinian evolution by natural selection, which is heritable variation in fitness: the rising of cancer can be described as a Darwinian process occurring among cells. This framework has become very popular in the last decades: investigating cancer in a Darwinian perspective has generated new insights into disease aetiology, pathogenesis and treatment.

This talk aims to analyse whether the Darwinian framework is useful to understand cancer cell identity. It will be maintained that it is correct – to some extent – to describe cancer cells as Darwinian individuals; notwithstanding that, cancer cells identity cannot be understood through this framework. Cancer cannot be considered just as a cellular disease. In regarding cancer as a phenomenon which is understandable only at the cellular level, the importance of interaction between levels gets lost.

Firstly, it could be inquired if cancer cells satisfy the formal requirements for being Darwinian individuals (Germain 2012). According to Godfrey-Smith (2009), Darwinian individuals are identified thanks to a list of characteristics: fidelity of heredity, abundance of variation, continuity of the fitness landscape, dependence of reproductive differences on intrinsic character, reproductive specialization and integration. If a cancer cell population has all these characteristics – at least to some degrees – it can be considered as a Darwinian population. According to Germain (2012), cancer cell cannot be considered to be a paradigmatic Darwinian individual: it is re-darwinized, that is, selection acts again at cellular level. Cancer cells are no more subjected to the organism constraints. Natural selection acts on cancer cells as it acts on autonomous entities in nature; and the action of natural selection at cellular level destroys the integration of the organism. Therefore, because of the strong dependence of fitness differences on intrinsic characters, cancer cells are not paradigmatic Darwinian individuals.

Secondly, cancer can be analysed as a multi-level selection phenomenon (Lean-Plutynski 2015). It is too narrow to focus only at the cellular level: rather, cancer has to be analysed as a dynamic that involves multiple levels. Through this analysis, cancer can be understood as both a subject to selection and a by-product. Cancer is both an example of multi-level selection 1 and multi-level selection 2: in fact, selection acts both among cancer cells and among tumour masses. At the same time, cancer is a by-product of natural selection: it uses micro-environment to grow and proliferate successfully. Therefore, for example, cancer cells acquire their phenotype thanks to the signals they both send and receive from the surrounding tissue. Cancer coopts signaling that is usually needed for the organisation of the upper level.

A tumour should thus be described as a pathology which involve the disruption of hierarchical organization of metazoan. Cancer was originally considered to be a deregulation of the normal growing program of the cell. The default state of a cell was thought to be quiescence: therefore, a cell that replicates too much becomes cancerous. However, this is a simplistic view: the Darwinian explanation of cancer has given a big contribution in

understanding that cancer is not only a cellular pathology. Nowadays, cancer is seen as derived from a deregulation of the connections between the tissue and the cell. However, a big work still has to be done to describe the cancer cell within a larger context.

The analysis of cancer cell is particularly important because it suggests both epistemological and ontological implications on the analysis of levels of organization in biology.

First of all, there might be epistemological implications. Levels of organization are characterized in compositional terms by a high number and inter-actions of parts; they have a hierarchical organization and the identity of parts depends on their interactions and on higher levels' effects. The core issue is thus to clarify how the dependency of identity of parts and their interactions on higher levels' effects has to be understood. The organizational integration among parts makes the identity of the whole (Bertolaso 2013).

Secondly, there might be ontological implications. The notion of identity might be somehow more fundamental than the notion of individuality: something has to be identical to itself, to possess an identity, in order to be individual e to be distinguished from everything else. Therefore, the debate should focus more on what makes the identity of an aggregate of biological parts then on what count as a unit of selection. This is a reductionist view that does not help understanding the specificity of biological systems.

In conclusion, the evolutionary description of cancer has become more and more popular because of the consequence it can have on the etiopathology as well as on the therapies of cancer. It is correct – to some extent – to describe a tumour as a population of cells which evolve under the pressure of natural selection, at the expense of the whole organism. However, this picture is misleading: a cancer cell cannot be understood individually, without any reference to its context. A cancer cell has to progress into a normal tissue in order to be considered as pathological. When put "in vitro", a cancer cell is not distinguishable from any other cell: it is just a cell which replicates. For instance, it has been proved that transplanting a cancer cell in a normal tissue not always gives rise to a tumour. A tumour arises from the interaction between cells, tissues, organs and the whole organism. The microenvironment has a role in the development of cancer which cannot be underestimated.

To conclude, it should be argued that a simplistic vision of Darwinian individuals at multiple levels should be rejected: rather, cancer shows that biological phenomena cannot be understood without referring to multiple levels simultaneously.

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KNOWLEDGE AND BELIEF IN PLACEBO EFFECT

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Abstract.
The present talk focuses on the interplay between the epistemic dimension of beliefs associated with the notions of “placebo” and “placebo effect” and their therapeutic value. My aim is to analyse the use of these notions in the construction of important examples for the analysis of knowledge (Nozick, 1981; Kripke, 2011) and to challenge the common view for which placebo beliefs are self-fulfilling, i.e. the view stating that the patient P is cured simply because P believes to be cured.

Placebo based beliefs have been recognized by Nozick himself and by Kripke as particularly problematic for Nozick’s analysis of knowledge (NAK).

NAK is defined in the following way:

A subject *S* knows the proposition *p* if and only if

(1) *p* is true
(2) *S* believes that *p*
(3) If *p* weren’t true, *S* wouldn’t believe that *p*
(4) If *p* were true, *S* would believe that *p*

When the above conditions hold, then we may *track* the fact that *p*. Conditions 3 and 4 make use of subjective conditionals, that is conditionals using verbs not in an indicative mood but in a subjective mood, e.g., “If *p* were true, *q* would be true”. This conditional is evaluated as true when *q* is true in the *p-neighbourhood* of the actual world. The *p-neighbourhood* is the set of those possible worlds considered close to the actual world. However, Nozick (1981) does not fully explicate the concept of closeness among worlds.

Some counterexamples to NAK (and its reformulation expressed in terms of the indication of the knowing method) come from “self-fulfilling beliefs”. A belief that *p* is self-fulfilling when it turns out to be true *just* because an individual believes it. Let us imagine a patient who believes she will recover and therefore does recover. Suppose that condition 3 is fulfilled, i.e. if it were true, the patient would believe it (there is no other way of regaining health except by holding such a belief). In this case, it is unclear whether condition 3 holds or not; that is, if the proposition stating if the patient will recover were not true, would the patient not believe it? Nozick (1981) states that this seems to be a case of truth’s tracking a belief, not of a belief’s tracking the truth. In this example, according to Nozick, it seems more likely that believing *p* implies *p*, rather than its converse. In the case of self-fulfilling beliefs, Nozick (1981, 196) leaves open the possibility that (i) both 3 and 4 do not hold, or (ii) we may add to NAK the following condition: “not-(not believing $p \rightarrow$ not-*p*)”, or (iii) it is not the case that 3 or 4 hold solely: at least one condition between 3 or 4 must hold. Condition 4

seems not to be particularly problematic, because if I can recover *only* by holding a placebo-based belief, then my recovering is completely due to my believing it. In Nozick's example, in fact, there is no other *method* of recovering except by holding such a belief. Instead, what may be problematic in the case of self-fulfilling beliefs is condition 3, since from not-*p* does not seem always intuitively valid to conclude to not-believing *p*. For instance, if *p* means "I will recover", from the fact that I will not recover does not seem to follow *in any case* my disbelief that I will recover.

I will point out that the standard self-fulfilling account of placebo beliefs may be misleading in a multi-agent context. In this type of context, placebo-based beliefs are justified by higher-order beliefs for which the clinical context in which (even "dummy") treatments are administered is essential.

Specifically, I will analyse Nozick's disjunctive argument NAPB which he assumes to hold for (placebo based) self-fulfilling beliefs:

(NAPB 1) truth is usually different from what we believe about it, whereas believing that a placebo effect is efficacious helps to make it so. Given this fact, there might be a different account of truth (and therefore of knowledge) for those truths which are belief-dependent or, alternatively (Nozick, 2001, 47)
(NAPB 2) we might base our concept of truth as simply independent of our beliefs (Nozick, 2001, 318, n 64).

In NAPB, belief-dependent truths seem to require a different account of truth; alternatively, we must base our notion of truth as simply independent of our beliefs. The denial of the self-fulfilling dimension of placebo-based beliefs implies an interplay between both external and internal epistemic factors. I will argue that neither of the options contained in NAPB can make sense of placebo-based beliefs. Placebo-based beliefs are, in fact, contextual, since they are instantiated in a specific clinical setting composed of the environment, doctor-patient beliefs, interaction and communication. Their nature is not merely internal because they also require interaction with the external world and the justification of beliefs according to internal or external methods is a key issue in epistemology. In light of this, I will endorse Lewis' (1975) perspective for which self-fulfilling beliefs require higher-order beliefs for their justification and, ideally, common knowledge between different epistemic agents. I will show that such conditions are normally violated in case of placebo-based beliefs. Therefore, placebo-based beliefs can hardly be considered self-fulfilling.

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REPRESENTING QUANTUM STRUCTURES AS NEAR SEMIRINGS

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Abstract.
It is a long-dated result, due to Marshall Stone [12], that the theory of Boolean algebras (the algebraic counterpart of classical logic) can be framed within the theory of rigs, through the concept of Boolean ring. More recently, in the last decade, the relations between prominent algebraic structures from many-valued logics and (semi)ring theory have stirred a renewed attention (see, e.g., [9, 1]). It was shown by Belluce, Di Nola, Ferraioli [2] and Gerla [9] that MV-algebras (the algebraic semantics of infinite-valued Lukasiewicz logic) can be viewed as particular semirings: MV-semirings.

We will show in this paper that this approach can be raised to a considerably general level. Indeed, we will see that a number of algebraic structures of major importance to non classical logics, and in particular to quantum logics, are representable as semiring-like structures. This paper will be mainly focused on basic algebras and orthomodular lattices. Basic algebras were introduced by R. Halǎs, J. Kühr and one of the authors of this paper as a common generalization of both MV-algebras and orthomodular lattices (the interested reader may consult [4] and [5] for details) and orthomodular lattices – the algebraic counterpart of the logic of quantum mechanics (for an extensive discussion we refer to [3, 10]). Basic algebras can not be represented as semirings since they do not satisfy both distributivity laws, but right-distributivity only; in addition, multiplication need not to be associative in general. These observations suggest that a substantial weakening of the concept of semiring would be required to embrace such algebras. An appropriate generalization can be found in [6, 7] where H. Länger and one of the present authors discuss the concept of near semiring. Taking up ideas from [2] and [8], in order to pro- vide a semiring-like representation of basic algebras, we specialize the concept of near semiring and introduce the notion of Lukasiewicz near semiring and orthomodular near semiring.

In the first part of the talk, we introduce the notions of near semiring, near semiring with involution and Lukasiewicz near semiring and discuss some basic properties of these three classes. Afterwards we show that basic algebras can be represented by Lukasiewicz near semirings and we discuss several universal algebraic properties of Lukasiewicz near semirings: congruence regularity, congruence permutability and congruence distributivity.

In the second part of the talk, we introduce the concept of orthomodular near semiring, and we show that orthomodular lattices can be represented by of these algebraic structures. Finally, we claim that the variety of involutive integral near semirings is a Church variety [11]. This yields an explicit description of central elements and, consequently, a series of direct decomposition theorems.

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DETERMINISTIC COMPUTATIONS AND CRITICAL PAIRS IN TERM REWRITING SYSTEMS

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Abstract.
Rewriting theory deals with syntactical properties of rewrite systems in which computations are represented as finite paths of manipulations of symbols by applying (instances of) rewrite rules. In particular, type-free first order term rewriting systems (TRS) framework embodies a simple environment in which computations can be put into relationship with syntactical properties of rules they are performed by. However, althought this format is simple, defining a deterministic TRS in terms of its syntactical properties is hard. In fact, one has to prove it enjoys a well known property called confluence, since it grants that final outcomes of rewrites are uniquely defined. Hence, obtaining a notion of "determinism" corresponds to find sufficient and necessary syntactical conditions for confluence.

The main task of this talk is showing, by a brief survey on several results concerning sufficient criteria as well as the possibility of weakening or eliminating them, the existence of sufficient and necessary conditions for confluence. In particular, it will turn out that syntactical critical pairs joinability as well as convergence into-finitely-many-steps are sufficient and necessary conditions for confluence of left-linear TRSs. Unfortunately, eliminating left-linearity entails an extension of the notion of critical pair as well as adding further requirements. Hence, in order to state that (extended-) critical pairs joinability and finiteness of convergences still "capture" the notion of "determinism", a natural question arises: may those additional hypotheses be eliminated? This problem is still opened.

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SUPRAORGANISMAL SELECTION IN DARWIN'S *ORIGIN OF SPECIES*. AN AVENUE FOR A BETTER UNDERSTANDING

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Abstract.
One of the most disputed notions in the contemporary philosophy of biology is "multi-level selection". More precisely, there continues to be widespread disagreement regarding the units of natural selection: whether they are genes, individual organisms, kinships, groups, even species or all of the above, with natural selection actually operating on multiple levels. Interestingly enough, a very important factor in this contemporary debate is Darwin's original view on the subject. As Elliot Sober puts it, rather bluntly: "Darwin casts a long shadow, and many evolutionists have sought shelter in his penumbra". There is considerable difficulty in showing exactly what Darwin thought on this subject. On the one hand, for long stretches in the "Origin of Species", Darwin seems to be committed to a strict organismal selection, in other words, the idea that natural selection operates only at the level of the individual organism. On the other hand, Darwin needs to explain what has been called "altruistic" behavior in biological organisms: why do members of certain species (like ants or bees) develop traits that do not increase fitness for their own being, but that of their group? Many authors have maintained that, in explaining this kind of phenomena, Darwin seems to use notions that may be attributed to a kind of supra-organismal natural selection, be it group selection, kin-selection or something else. The conclusions drawn from this apparent paradox have been diverse: while some believe that Darwin thinks strictly that the individual is the only unit of selection (Ghiselin 1974, Ruse 1980, Kottler 1985, Cronin 1991, Gould 2002), the remaining levels being reducible to this organismal level, others have argued that Darwin is at least struggling with the notion of group selection and that there is evidence that he seems to accept it, albeit rather tacitly (Borrello 2010, 2013, Richards 2009, Sober 2011).

The aim of this talk is to try to bring something new to the table on this debate about Darwin's view on what we call today "multi-level natural selection", insofar as it informs the more general discussion of this notion on contemporary biology. The biggest difficulty that I try to deal with is historical. Darwin's theory of evolution through (mainly) natural selection has not come about through some spontaneous revelation, but it is, at least in one way or another, a product of the climate of ideas that populated Darwin's time. As Stephen Jay Gould famously thought, the theory of evolution has an origin in its originator's exposure to the Scottish brand of 18th century Enlightenment (Gould 2002). Thus, I believe that we could obtain a better understanding of what Darwin thought of the relation between an individual and the larger community by putting his views on this subject in the historical context they belong in. Specifically, I am referring here, among other things, to Adam Smith's ideas about how interactions between selfish agents at the level of individuals generate higher levels of social organization that are benefit all members of society. Comprehending the general view of his age on this subject might well give us a key to understanding the kind of interactions and relationships he envisaged in the natural world. We clearly cannot find a perfect correspondence between "invisible-hand" explanations of an arising social order, common to Darwin's age, and evolutionary explanations of what happens in the natural world, mainly due to the ontological differences of the objects involved in these types of theories. But I think we may be able to surmise that Darwin, at least, thought that selection on an individual level influences what on goes at higher levels of organization of living organisms. This is not

enough to conclude that Darwin accepted any kind of selection regarding groups of biological organism, as the group traits emerging from the individuals' natural selection in "the struggle for survival" may be considered epiphenomena of that process. Having this in mind, I think we can show that Darwin, in the "Origin of Species", accepted a kind of autonomy that groups have from the individuals. That autonomy is related to the number of offspring that groups of organisms may bring in to the world. Thus, while many Darwin scholars may be right about the central role that organismal selection plays in evolution, we cannot discount the notion that he accepted the fact that some version of the principle of natural selection is at play between groups of organisms, at least when it comes to their comparative rate of descendant production and survival.

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WHY GENES ARE LIKE LEMONS

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Abstract.
In the last few years, the lack of a unitary notion of gene across biological sciences has troubled the philosophy of biology community. However, on the one hand the debate on this concept has remained largely historical. On the other hand it has been focused on particular cases presented by the scientific empirical advancements. Moreover, despite the abundance

of such theoretical analyses, it seems there are no explicit and reasonable arguments, in the literature, on why a philosophical clarification of the concept of gene should be needed, especially for scientific practice. In this talk, we claim that a philosophical clarification of the concept of *gene* is as much relevant for scientific practice as the concept of *lemon* could be. This is not to say that philosophy is useless for science. Rather the contrary. Indeed, in some cases, philosophy can help to set up and prioritize different questions and drive empirical research providing a classification, which distinguishes those ones that could be directly contributing to scientific endeavor from others that are more exquisitely philosophical. For example, if we have a look at the debate on “biological function” we can observe that different philosophical accounts of function (mainly causal role vs. selected effect) have definitely an impact on how scientific research is thought and pursued. In this case, the controversy cannot be settled just by accumulating evidence even if we could collect data on all biological entities on our planet. It rather requires conceptual clarification, because the epistemic and semantic account of function adopted drives the way we accumulate evidence. In other words, in this case we claim that the real problem – the philosophical one – is that supporters of historical and ahistorical notions do not understand each other when they talk about functions, because they point to different things. On the contrary, we argue that, unlike the question "What is a biological function?", the question "What is a gene?" could be mainly answered by means of empirical research, in the sense that biologists' labor is the only way to shed light on it. With regard to this, we adopt the Putnam’s semantic account of natural kinds to show that, conceptually, the notion of *gene* is not different from the concept of *lemon*. By adopting this perspective, we do not embark ourselves in longstanding metaphysical debate on natural kinds. Our position is fundamentally epistemological. Indeed, we show that, from a practical point of view, scientists refer to genes as if they were natural kinds and not theoretical terms unlike other non-observable entities (such as electrons). In our opinion this is the case because, in this situation, only empirical research contributed to the meaning of a notion like the one of *gene*. Indeed, we show that different subfields of the life sciences, such as transcriptomics, structural biology/proteomics and network biology, equally contributed to the establishment and development of the notion of gene despite the lack of a prior theoretical account shared by all of them. Moreover, as a matter of fact, the notion of gene is constantly updated and revised, due to continuous and new contributions of empirical approaches.

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FUNCTIONAL AND MECHANISTIC EXPLANATIONS ARE REVERSE-ENGINEERED MODULAR DESCRIPTIONS CONSTRAINED BY COMPUTATIONAL COMPLEXITY

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Abstract.
Expanding on Herbert Simon's original conception of near decomposability, I propose a generalized view of modularity, applicable to descriptions of complex systems. Embracing an epistemic (as opposed to an ontic) point of view which sees scientific explanation as an essentially epistemic and communicative task, I argue that both functional and mechanistic explanations are basically constituted by modular descriptions, and that the possibility of obtaining hierarchical, multi-level modular descriptions is the condition, in case of large enough complex systems, for the intelligibility of their explanation: actual absence of

modularity in the system or our inability in obtaining valid, explanatory relevant, high-level hierarchical modular descriptions would hinder the understandability of mechanistic explanations of large complex systems, and would render low-level, purely functional explanations, due to their sheer complexity, unintelligible, and thus devoid of explanatory power.

I argue that the computational complexity of certain reverse-engineering tasks, namely algorithmic detection of hierarchical modularity under a variety of forms, exerts a pragmatic constraint on the possibility of obtaining intelligible functional, computational or mechanistic explanations of large complex systems: even approximate algorithms for detection of hierarchical modularity, when sufficiently precise for the explanatory purposes of the explainer, show in general a significantly high, possibly excessive computational cost, which could severely hinder a high-level modular redescription of the system. This would compel the observer to resort to a very low-level modular description, which, because of its sheer complexity possibly overcoming human cognitive capacities, could damage the possibility of explaining the system, functionally or mechanistically, in a human-understandable way.

The occurrence of this difficulty in obtaining an intelligible hierarchical modular description, a circumstance which I call "antimodularity", could possibly damage real-world scientific explanation of large enough complex systems, for example in systems biology, where the size of the system's low-level description (as in the case of genetic regulatory networks) could prevent the algorithmic identification of higher-level structural and/or functional modules constituting a high-level functional explanation of the system, leaving the observer with only a very low-level description, whose size and complexity could overcome human cognitive resources, rendering such an explanation unintelligible.

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