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A Formal Approach to the Ontology of Social Beliefs

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Abstract

In this paper we illustrate how the reference problem can be solved in a naturalistic *formal ontology* through a particular interpretation of the theory of truth as correspondence. This is based on the theory of the *mutual saturation* between subject and predicate (against Frege's theory of the simple saturation), in definite descriptions, causally driven by the referential object. Such an approach allows a particular solution of the problem of *individual* and *social* belief because, like Frege's and Searle's ones, separates the truth-condition from consciousness and belief with their "first person" subjective reports, but differently from Frege, does not separate truth from the intentional context of the speech act.

1 Introduction: the reference problem, from formal logic to formal ontology

It is well known Quine's criticism to the use of singular terms for referential aims, like in Frege's definite description, because it supposes the *identification* between a *generic* individual *x* (e.g., "a man"), and a *singular* individual, *a* (e.g. "Antony"), as arguments (subjects) of the same predicate *F,* i.e.:

$$\left(\exists xFx \wedge \left(x=a\right)\right) \rightarrow Fa \qquad (1)$$

At the same time, it is well known also that the solution of the problems of *reference* and of *truth* as "correspondence to facts", cannot be formally found in an *extensional logic* of the first order predicate calculus, because of Tarski's and Gödel's theorems.

Finally, using *the intensional epistemic logic*, it was demonstrated (Galvan, 1991; Basti, 2012) that the truth condition of a cognitive agent *x* as to the proposition *p,* able to transform the simple "*x* believes that *p* is true", **B**(*x,p*), into the "*x* knows that *p* is true", **S**(*x,p*) — where **S** is the intensional operator of "sound beliefs" – consists in a foundation clause **F** , according to the following:

$$\mathbf{S}\left(x,p\right) \Leftrightarrow \left(\mathbf{B}\left(x,p\right) \wedge \mathbf{F}\right) \qquad (2)$$

Where **F** is a *foundation relation,* with the extra-linguistic object, that can be interpreted in different ways according to the different ontologies. Anyway*,* **F** has to be outside the range of **B,** and hence outside the range of *x* consciousness, otherwise we are not dealing with "knowing" but only with a "believing of knowing". From this, the reflexivity property of operator **S** holds. Indeed, simply believing that a given representation of the actual world, expressed in the proposition *p*, is *true*, does not mean that *it is effectively* true, if it is not well-founded, so that:

$$\mathbf{B}\left(x,p\right) \not\rightarrow p$$

While:

$$\mathbf{S}\left(x,p\right) \rightarrow p \qquad (3)$$

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In this paper, using Kripke's relational semantics, we demonstrate that the condition **F,** as *truth-condition* for epistemic intensional contexts, can be formalized in a particular *ontic* interpretation of the modal system **KD45** in *formal ontology***,** able to include both *a naturalistic* and *a social foundation* of the epistemic truth and reference**.**

2 Philosophical logic: from modal logic to a formal ontology of social beliefs

2.1 Kripke relational semantics

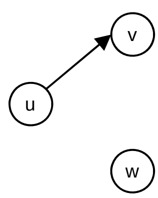
Kripke relational semantic is an evolution of Tarski formal semantics, with two specific characters: 1) it is related to an *intuitionistic logic* (i.e., it considers as non-equivalent excluded middle and contradiction principle, so to admit coherent theories violating the first one), and hence 2) it is compatible with the *necessarily incomplete character* of the formalized theories (i.e., with Gödel theorems outcome), and with the *evolutionary character* of natural laws not only in biology but also in cosmology. In other terms, while in Tarski classical formal semantics, the truth of formulas is concerned with the state of affairs of *one only actual world,* in Kripke relational semantics the truth of formulas depends on states of affairs of worlds different from the actual one (= possible worlds). On the other hand, in contemporary cosmology, it is nonsensical speaking of an "absolute truth of physical laws", with respect to a world where the physical laws cannot be always the same, but have to evolve with their referents (Davies, 2010; Benioff, 2005).

Anyway, the notion of "possible world" in Kripke semantics has not only a physical sense. On the contrary, as he vindicated many times, the notion of "possible world", as syntactic structure in a relational logic, has as many senses as the semantic models that can be consistently defined on it. In Kripke words, the notion of "possible world" in his semantics has a *purely stipulatory character.*

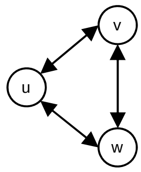
In the same way, in Kripke semantics, like the notion of "possible world" can be interpreted in many ways, so also the relations among worlds can be given as interpretations of the only relation of *accessibility.* In this way, a unified theory of the different intensional interpretations (alethic, ontology included, deontic, epistemic, etc.) of modal logic became possible, as well as a graphic representation of their relational semantics.

The basic notion for such a graphic representation is the notion of *frame.* This is an ordered pair , <**W**, R>, constituted by a domain **W** of possible worlds {*u, v, w*…}, and a by a two-place *relation R* defined on **W**, i.e., by a set of ordered pairs of elements of **W** ($R \subseteq$ **W**×**W**), where **W**×**W** is the *Cartesian product* of **W** per **W**.

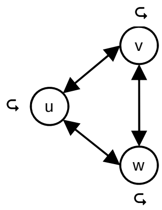
E.g. with **W** = {*u,v,w*} and *R* = {*uRv*}, we have:



According to such a model, the accessibility relation *R* is only in the sense that *v* is accessible by *u*, while *w* is not related with whichever world. On the contrary, if in **W** all the worlds were reciprocally accessible, i.e., *R*= {*uRv*, *vRu, uRw, wRu, wRv, vRw*}, then we would have:



On the contrary, for having R not only included in $\mathbf{W}\times\mathbf{W}$, but $R=\mathbf{W}\times\mathbf{W}$, we need that each world must be related also with itself, i.e.:



(4)

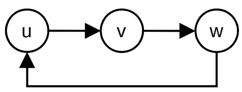
Hence, from the standpoint of the relation logic, i.e., by interpreting $\{u,v,w\}$ as elements of a class we can say that this *frame* represents an *equivalence class.* So, we can formally define an interpretation I on a frame of possible worlds as:

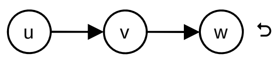
$$I: \mathbf{V}\times\mathbf{W} \rightarrow \{0,1\}$$

Where **V** a set of propositional variables. Hence, $I(p,u)=0$ means that p is false in u, while $I(p,v)=1$ means that p is true in v. So, just like all the interpretations of a propositional calculus are determined as to all the variables, all the interpretations of a modal calculus are determined as to all the pairs in $\mathbf{V}\times\mathbf{W}$.

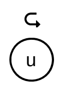
The main relations we can represent in a frame are the following:

R is *serial*: <(om *u*)(ex *v*)(*uR*v)>, where “om” and “ex” are the meta-linguistic symbols, respectively of the universal and existential quantifier. The serial property here means that given whichever world of the frame <**W**,*R*>, there exists always another one accessible from the precedent one. This type of relation is particularly important for formalizing ontology. In fact, the serial property of causal relations among worlds implies that the causal chain is always *closed*, as it is required in physics by the “first principle of thermodynamics”, in physical ontology, and as it is required by the notion of a “first cause” in metaphysical ontology. The following are thus examples of serial relations for finite sets of serial worlds:

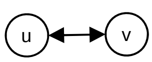




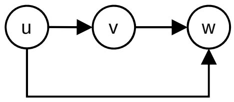
R is *reflexive*, <(om u) (*uRu*)>:



R is *symmetrical,* <(om *u*) (om *v*) (u*R*v $\Rightarrow$ v*R*u)>:



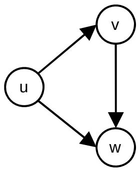
R is *transitive,* <(om *u*) (om *v*) (om *w*) (*uRv* et *vRw* ⇒ *uRw*)>, where "et" is the meta-symbol for the conjunction :



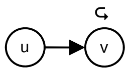
R is Euclidean

The Euclidean property generally in mathematics means a weaker form of the transitive property (that is, if one element of a set has the same relation with other two, these two have the same relation with each other). So, in our case, we have the following:

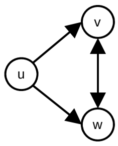
<(om *u*) (om *v*) (om *w*) (*uR*v et *uRw* ⇒ v*R*w)> :



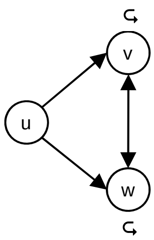
Thus, for seriality, if (*uRv* et *uRw* ⇒ *vRw*) then <(om *u*)(om *v*) (*uRv*⇒*vRv*)>:



Moreover, (om *u*) (om *v*) (om *w*) (*uRv* et *uRw* ⇒ *vRw* et *wRv*):

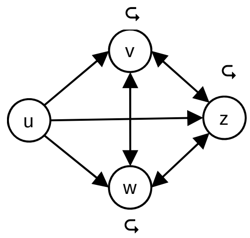


Finally, if we see at the last two steps, via the Euclidean property, we are able to justify *secondary* reflexive and symmetrical relations, so that we have the final frame of a *secondary equivalence* relation among worlds based on an Euclidean relation with a third one:



(5)

Of course, this procedure of equivalence constitution can be iterated indefinitely:



(6)

To conclude this part, it is important to emphasize that frame (4) and frame (5) are a graphic representation in Kripke's approach of **S5** and **KD45** modal systems respectively. If we see at these frames, we can understand immediately, why, from one side, **S5** is the only axiomatic system in modal logic, since all its elements constitutes one only equivalence class. On the other side, we can understand immediately also why **KD45** is named also "secondary **S5**". In fact, <*v,w*> in (5) and <*v,w,z*> in (6)constitute two equivalence classes via their Euclidean relations with <*u*>. If **S5** is thus the common structure of all possible metaphysics in a rationalistic, absolute, sense, **KD45** is the common structure of all metaphysics with a foundation axiom.

2.2 From formal ontology to formal epistemology

As we know, the contemporary notion of "formal ontology" as distinguished from "formal logic" derived from Edmund Husserl research and teaching. Indeed, he in his "Third Logical Research" (Husserl, 1913/21), distinguishes between:

1. *Ontology* as a discipline studying relationships between *things* (like "objects and properties", "parts and wholes", "relations and collections", etc.); and
2. *Logic* as a discipline studying relationships among *truths* (come "consistency", "validity", "conjunction", "disjunction", etc.).

On the other hand, Husserl continues, both disciplines are *formal* in the sense that they are "domain independent". So, for instance, for the formal structure "part-whole" in ontology, limitations for the type of objects that might enter the relation "part-whole" do not exist, just like for the formal relation of "conjunction" in logic, limitations for the type of proposition that can be connected in such a way do not exist (Smith, 2005). Husserl and his school developed the formal ontology analysis using the phenomenological method. Today, however, in the scientific and philosophical realm, when we speak about formal ontology, we intend generally the "formalized ontology", i.e., the formal ontology developed according to the axiomatic method, using the formal means of modal and philosophical logic.

Of course, there exist several interpretations of formal ontology since ancient age, according to the different ontological values we assign to predicates and predication, even though all the ontological schools agree in not reducing the predication relation to the simple membership relation of mathematical logic.

So, partly following Nino B. Cocchiarella (2007), we can distinguish among different ontologies, according to the different *truth conditions* they assign to predicates:

Nominalism: the predicates exist only in the language that, through its *conventional rules,* fully determines the *truth conditions* of the predicative formulas (Sophists, Quine, …)

Conceptualism: the predicates exist in mind that through its *rules of reasoning* fully determines the *truth conditions* of the predicative formulas (Kant and transcendental philosophers).

Realism: the predicates are expressions of *properties and relations,* existing independently of language and mind, and determining with their rules, the *truth conditions* of the predicative formulas. So we can have:

a. *Logicism* (or *logical realism:* Plato, Frege…)*:* predicates refer to logical entities existing in the *logical realm.*
b. *Naturalism*: predicates refer to properties and relations founded in the physical reality, according to two main different truth conditions:

- *Logical atomism* (Democritus, Wittengstein, …): according to an isomorphism between elementary predicative formulas and elementary world facts.
- *Ontical modalism* (*or Essentialism:* Aristotle, Kripke,…): according to a fundamental distinction between *natural properties* and *natural kinds,* both *causally founded* in the physical realm, and expressed through two distinct modalities of predication, respectively *necessary* — i.e., true in all possible worlds[1] — and *contingent* — i.e., true only in some of them.

Of course, what characterizes the naturalistic formal ontology with respect to formal logic is the inclusion in its formalism of *pragmatic* relations, beside the syntactic and semantic ones of formal logic.

This is particularly significant in the modal ontic version of the naturalistic ontology because it is possible to formalize in it also the *causal* relation as a "transitive and serial" relation, as opposed to the *equivalence* relation as a "transitive, symmetrical and reflexive" relation, so to distinguish clearly between *causal* and *logical* determinism (against Leibniz and Kant identification of them). But it is possible also to formalize their dependence relationship, that is in the opposite direction of the modern one (causal necessity based on the logical necessity: Kant), namely in a dependence of the logical necessity of law on the ontic relation of causality, as the contemporary cosmology, biology and neuroscience are re-discovering (see below).

Finally, another character of the conceptual naturalism — recently emphasized by Cocchiarella (2001; 2007) and myself (see (Basti, 1995) and (Basti, 2007; 2011; 2012)), but dating back to Middle Age — is the so called theory of the "double signification", *conceptual* and *natural*, of the same predicate. This theory was defined, for the first time by Aquinas (1225-1274) in the Middle Age, as the theory of the *double intention,* "natural" or *first intention,* and "conceptual" or *second intention,* of a predicative judgment, against the otherwise unsolvable epistemological dichotomy between subject and object deriving by the Abelard (1079-1142) theory of the double predication *natural* and *conceptual*.

The theory of the double signification of the same predicate is the ontological core of any *natural theory of intentional realism* in epistemology, because by formal ontology it is possible to demonstrate that, both the causal foundation of natural kinds, in the physical and biological realms, on one side, and the foundation relation of truth and of definite descriptions in epistemic logic, on the other side, share the same modal structure **KD45**, as we see after.

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[1] This means that a natural kind predication is true (e.g., "water is H_2O"), both in the world(s) where the beings denoted by the predicate arguments actually exist (e.g., on Earth today), and in the world(s) where these beings do not actually exist (e.g., on Mars surface), and even, also in those worlds where they never could exist (e.g., on Sun), but nevertheless, if there existed, they ought be connoted by such a predicate, i.e., they would belong to that natural kind. The causal foundation of natural kinds makes this position perfectly reasonable — whereas in a conceptualist foundation, after Quine criticism, it is not , because it means that there exist a given causal concourse (texture) on which the existence of a given kind of beings necessarily depends, just like in quantum mechanics the different kinds of fundamental particles (fermions) exist only as nodes of given Feynman diagrams.

However, before discussing this final point of our paper, it is useful to introduce the ontological formalism of our approach that we take essentially from Cocchiarella, even though with a fundamental difference, as we see. Before all, the core of formal ontology as to formal logic is its capability of formalizing a notion of "being" not reduced to the simple "existence". So in the "conceptual naturalism" of formal ontology we distinguish among:

1. $\{\exists x, \exists F; \forall x, \forall F\}$: what <u>*is*</u> (not "exists") *potentially* and not *actually.* I.e., past/future beings (x), and properties (F) as to thinking selves (logical, fictional beings); or as to natural, causal concourses (natural beings, natural properties, natural kinds for which we use the index n (natural), for their quantifiers, so to distinguish what is "natural" from what is "mental": $\{\exists^n x, \exists^n F; \forall^n x, \forall^n F\}$).
2. $\{\exists^e x, \forall^e x; \exists^e F, \forall^e F\}$: what <u>*is*</u> (not "exists") *actually* as a generic, abstract individual x, or as a natural property or kind F.
3. $E!(a) := (\exists^e y)\ (y = a)$: what properly *exists* as a concrete, singular individual a, and never as an abstract, generic individual x, and never as a property or kind, i.e. $(\forall^e F)\neg E!(F)$, where, as we see, for "existing" we are using the existence *predicate E* and not the existence *quantifier* $\exists$, limiting the E argument only to singular, concrete individuals a, i.e, $E!(a)$.

As it is evident from Cocchiarella formalism, in the last formula, we are newly faced with the core problem of any consistent solution of the reference problem the identification between a generic individual y and a concrete singular individual a, i.e., $y=a$. This emphasize that it is not possible to speak rigorously about a "formal" ontology if we do not solve in a consistent way the reference problem.

Anyway, for concluding the necessary premises of our proposal, let us follow another time the Cocchiarella formalism, this time for characterizing symbolically the *natural* predication of properties (e.g., "being white") and kinds (e.g., "being a cat"), as far as both are *causally* and not *mentally, ontologically* and not *logically,* constituted. As anticipated, for the *conceptual* predication of properties we use the quantifiers — having for argument predicate variables (we are in a predicate logic of higher order than the first one) — in the usual, logical way without indexes, i.e.:

$$\left(\forall F^{j}\right)\left(\exists x_1\right),\ldots,\left(\exists x_j\right)F\left(x_1,\ldots x_j\right) \tag{7}$$

On the contrary, for the corresponding *natural* predication of properties we use quantifiers with index n, i.e., we use the quantifier in an *ontological* way, i.e.:

$$\left(\forall^{n} F^{j}\right)\Diamond_C\left(\exists^{e} x_1\right),\ldots,\left(\exists^{e} x_j\right)F\left(x_1,\ldots x_j\right) \tag{8}$$

Where the index C applied to the possibility operator means that we are speaking of causal power and not of logical possibility.

For denoting that we are speaking about natural *kinds* — i.e., about something that the individual *is* in its totality ("is human"), and not about something that the individual *has* in some of its parts ("is white (in her/his skin)") — we use the index k. In fact, despite in the Western natural languages they are denoted by (common) names — a problem on which, during the Middle Age, whole libraries of books were written, and on which, during the last century, the Polish logician S. Leśniewski concentrated his ontological resarch — , they do not denote individuals but *relatively stable nodes of the casual structure* of the cosmological/biological evolution of nature.

For instance, in the case of organisms, until the causal — genetic, epigenetic and environmental — concourse is *stable,* it is possible to grant the *identity in time* of a given species (e.g., dinosaurs), by the succession of individuals whose existence is fully determined by this concourse, and hence "belong" to such a species. In symbols:

$$\left(\forall^k A\right)\Diamond_C\left(\exists^e x\right)\left(\exists yA\right)\left(x=y\right) \tag{9}$$

Where *A* is a predicate symbol for a natural kind, and the inversion of the position between the predicate and its argument is indicating that the predicate in **NL** is denoted by a "sortal name" ("the individual is a…") and not by an adjective like for properties ("the individual is…). Of course, the classical objection that we can always transform an adjective in a pronoun, and hence in a name, has an obvious response. E.g., if we strongly assert that "John is *a* white", means only that we are racists, i.e., we are affirming that humans, to be truly humans in all possible worlds, must be white. In other terms, the classical modal distinction between necessary predication of kind and contingent predication of properties, can be easily justified in a natural ontology, by distinguishing between causal concourses that are *necessary* or not for the existence of a given individual. Finally, we can say that ontological belonging to a natural kind is the foundation of membership to a class, in symbols:

$$\left(\forall^k A\right)\left(\forall yA\right)\Box_C\left(E!\left(a\right)\rightarrow\left(a=y\right)\wedge\left(\left(a\vee y\right)\in\mathbf{A}\right)\right) \tag{10}$$

Of course, we are newly faced here with the logic nightmare of the identification between a generic individual and a singular one, the same problem constituing the core of the reference problem, when we consider it from the standpoint of Fregean theory of the definite descriptions and/or descriptive functions.

The novelty is that here we are in ontology and no longer in logic, so that it is natural to see at the so called *causal* theory of reference (Donnellan, 1966; Kaplan, 1978), particularly in Kripke's version related to proper names as "rigid designators" (Kripke, 1980), as an alternative to Fregean *descriptive* theory of reference . However, our approach to the causal theory of reference is deeply different from all of them, and in some sense it is in the meadway between them, because it can profit in an original way of Searle's suggestion of founding the descriptive definition through an intentional interpretation of the speech acts (Searle, 1983, p. 231-261).

The originality of our proposal depends on the emerging naturalistic formal ontology discussed till here, allowing us to reinterpret in it, Searle's suggestion according to which when we have sentences containing "that" clauses, they do not have the so called "direct Bedeutung" but they have "indirect Bedeutung". In other terms, the truth-value can be assigned only to the second thought i.e. the thought of the subordinate sentence, as far as it can be analyzed in terms of extensional logic (e.g., "Rossella is an Irish Setter"), whereas to the first one, containing the "that" clause, no truth value can be assigned, because it is analyzable only in terms of intensional logic.

We saw before, in discussing the epistemic logic, that this Frege limitation of truth-value assignments only to extensional sentences does no more hold, as far as we are able to give a satisfactory justification of the foundation clause **F,** defining the truth-condition for intensional epistemic sentences. Namely, in the formula (2), as already remembered, **F** is outside the range of the belief operator **B**, but it is also independent of the extensional proposition *p.* On the contrary, through the reflexivity property of the operator **S** (see formula **(3)),** the constitution of *p* (the existence of *p* in the actual world) as a true formula, is inside the power of **S,** the operator of the sound (true) belief.

In other terms, such developments of the intensional logic as a rigorous modal calculus, can give an original evidence to the other famous Searle assert about the natural brain ability of performing intensional calculations, differently from classical Turing-Machine-like computer, able to perform only extensional calculation (Searle, 1980). As we see below, today, we start to understand what is the core of this brain ability, related to the complex (chaotic) dynamics of the brain, giving it quantum-like capabilities of information processing at the mesoscopic and macroscopic level (Freeman & Vitiello, 2006; 2008; 2009). This suggests, from one side, which are the neural basis of intentional behavior (See (Basti & Perrone, 1995; 2001; 2002; Basti, 2009); (Freeman, 2001; 2007; 2008)), and, from the other side, it opens at the possibility of artificial simulations of intentional behavior via a new class of artificial neural networks able to implement complex and even chaotic dynamics (Kozma & Freeman, 2009; Kozma, 2010).

All this means that the classical "triangulation" of cognitive neurosciences (Gardner, 1984) – having:

a. At the first vertex, the "first-person (both singular and plural) belief sentences", expressed in intensional (epistemic) logic propositions (=belief statements);

b. At the second vertex the neuroscience statements, describing the neural correlates of the "first-person" intentional states, and expressed necessarily in extensional logic propositions;

c. It will have now, at the third vertex, not only the computational simulations implementing an extensional calculus, that can refer only indirectly to the intentional states. The cognitive science triangle will have at its third vertex also simulations implementing "third-person" *intensional computations*, that can refer more directly to the "first-person" ones (Goldblatt, 2006; Girle, 2009). The problem is that this "third-person simulations" cannot reduce to themselves the "first-person" ones, against what D. Dennet stated (1992, p. 66-100).

The implementation of intensional computations thus allows the possibility of an *artificial simulation* of semantic tasks, as the program of the so called "semantic web" or "Web3 revolution" exemplifies. In everyday contexts — as I like to explain it to my students, by updating Searle's "Chinese Room" metaphor, so to include also machines able to perform intensional computations —, such a "third person" intensional simulation of an intentional task, is like when a student answers correctly the questions during the examination, simulating a "first person" comprehension of the topics, without having understood anything. If the simulation is well suited, he could be convincing, nevertheless he did not understand anything.

Joking apart, the core of the problem consists thus in analyzing the **F** clause of epistemic logic of formula (3) above, in the context of a naturalistic ontology. As we demonstrated elsewhere, the solution is that the singular predicative statement, for denoting a singular object, must be characterized by a *mutual redefinition* between the subject *S* and the predicate *P* *causally* driven by the referential object itself (Basti & Perrone, 1999; 2001; 2002). In terms of Frege's descriptive definitions, they must be characterized by a "double saturation" between subject and predicate, in opposition of classical Frege's theory of simple saturation in which the predicate is saturated by its arguments (Cocchiarella, 2001). Intuitively, we can synthesizing this idea as a procedure of *mutual modification* between subject *S* and predicate *P,* for the *best matching* of the modifications Δ of the referential object *O* according to some optimization criterion, i.e:

$$\Delta O \propto \frac{\Delta S}{\Delta P} = const \tag{11}$$

Where "$\propto$" is the symbol for proportionality. This procedure is always convergent to some constant (stable) value, when defined on the finite, as it is the case of physical systems, and so it is always effectively computable, as A. L. Perrone first demonstrated (See (Perrone, 1995), (Perrone, Basti, Messi, Paoluzi, & Picozza, 1995), (Basti & Perrone, 2001)).

It is evidently an idea very close to that more recently developed by Benioff (2002; 2005), Davies (2010), and the Nobel Laureate George Smoot (Smoot, 2011), in their search for a physical (causal) foundation of mathematical laws of nature. In this sense, it is evident that truth as "correspondence to facts" has to be intended not in the terms of an abstract identity, an "equation" (*aequatio*), but as a progressive, intentional "adequation" (*adaequatio*) (Freeman, 2008).

This can help to exorcize definitely our nightmare of definite descriptions, i.e., the identification between generic and singular individuals of referential formulas like (1) in terms of a *dynamic identification* among them, according to the naturalistic ontology of mathematics in natural sciences and based on the mutual re-definition between numbers (predicates) and processes (Perrone, 1995; Benioff, 2002) illustrated throughout this paper. So, by using the new symbol "$\leftrightarrows$" for denoting the *concrete* dynamic identity between generic and singular individuals, instead of the *abstract* static identity denoted by the usual "=", we can consistently substitute "=" in any occurrence both of definite description formulas in semantics, and in any occurrence of the existence predicate in ontology, because of the actually *finite* and virtually *infinite character* of the procedure . E. g., in formal ontology, instead of (10), we have:

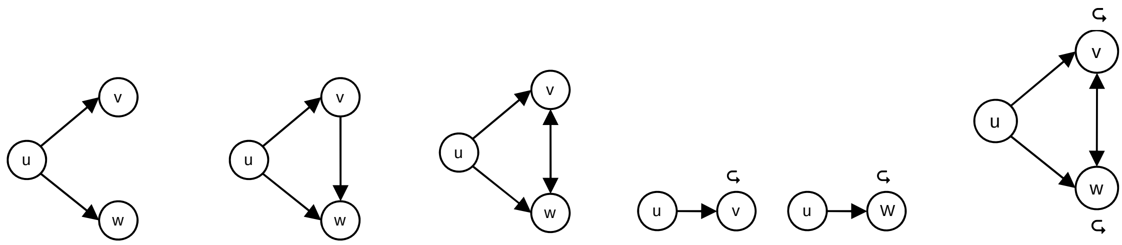
$$\left(\forall^k A\right)(\forall y A)\square_C\left(E!(a) \rightarrow (a \leftrightarrows y) \wedge \left((a \vee y) \in \mathbf{A}\right)\right) \tag{12}$$

And in reference formulas like (1), we have:

$$\left(\exists x F x \wedge (x \leftrightarrows a) \rightarrow F a\right) \tag{13}$$

Of such a modal, recursive, and hence dynamic interpretation of the definite descriptions, making the causal reference a sort of procedure of dynamic locking onto the modifications of the object (target) via a proportional, dynamic self-adpatation of the related definite description, it is possible to give an ontological model, using the Kripke grafic representation of the modal structure **KD45,** introduced in §2.1.

Namely, let us take a **KD45** structure with three worlds, $\{u,v,w\}$, where *u* represents the referential object, and *v, w* represent, respectively, the subject and the predicate of the same object descriptive definition, implemented in a cognitive agent (ontology includes pragmatics and not only semantics and syntax), and where the whole structure **KD45** emerges as the result of the Euclidean relation that it is possible to define among the three worlds. For clarity, we report here only the graphic representation of the different steps of such a relation.



Genetc scheme of KD45, via the development of an Euclidea relation starting from a set of fondational transitive relations (in our case: *uRv*e *uRw*) explained above in §2.1

Now, by interpreting such a scheme of relations according to Aquinas theory of dynamic descriptive definitions just illustrated, starting from two causal relations (transitive and serial) *uRv* e *uRw*, it is possible to found the following *secundary* relations: *transitive* (*vRw, wRv*), *symmetrical* (*vRw* = *wRv*), and *reflexive* (*vRv, wRw*). Practically, from a *causal* (transitive-serial) relation we have founded a *logical* (equivalence) relation, without any reference to consciousness, but only to a *communication agent*.

In our *ontological* interpretation, this means that an identity relation, *S* = *P,* between subject and predicate of a definite description of the referential object *O,* is consituted by the causal relation from *O* itself. In the consequent *epistemological* interpretation (formal epistemology), the foundational *clause* **F,** defining the truth condition of epistemic (*belief*) statements illustrated in formula (2) of §1, is an original synthesis among Kripke's causal theory of reference, and Frege's descriptive one, according to Searle's intentional interpretation of it.

The **F** clause interpreted in such a way can solve also another typical limitation of Kripke's theory, i.e., its inability to justify the so-called trans-world identity and/or the trans-world rigid designation. Namely, if we give a spatio-temporal index *n,* to the elements of our frame, i.e. $\{u_n, v_n, w_n\}$, and to all their relations, i.e., $\{u_n R_n v_n, u_n R_n w_n, v_n R_n w_n, \ldots\}$, the "euclidean" procedure can be easily made iterative, so to make recursive the reference as a sort of "locking" on the object modifications, i.e.:

$$\Delta O_n \propto \frac{\Delta S_n}{\Delta P_n} = const \qquad (14)$$

Finally, by discussing the **KD45** epistemic model as a naturalistic implementation of the foundation clause **F** (truth-condition) of intensional epistemic logic, according to the epistemic scheme (2):

$$\mathbf{S}(x, p) \Leftrightarrow (\mathbf{B}(x, p) \wedge \mathbf{F})$$

It is easy to show that this naturalistic foundation clause does not affect at all the belief operator **B** and hence it leaves irreducible to any extensional/intensional computation the "first personal" belief reports, both in the singular (individual belief) and in the plural (social belief) cases. In the same time, it demonstrates that beliefs and consciousness, both individual and social, are absolutely *irrelevant* as to the truth foundation of the relative knowledge **S**, both in individual (wisdom) and in social (science) senses.

2.3 Toward a formal ontology of social beliefs

Finally, the necessity of a chaotic neural implementation of an intentional epistemology emphasized above depends on the evidence that only a chaotic neural dynamics can implement the continuous variation of the connection topology among the elements of the net — effectively it has to be implemented in a dynamics onto the neuron thresholds and not onto the only neural statistical weights, like in classical connectionist architectures (Basti & Perrone, 1999; 2001; 2002). In other terms, an intentional state is constituted by motor, sensory and emotional components, supposing the interaction in real time (second tenths) of neurons very distant among them located in different parts of the cortex, as well as in subcortical structures. The classical synaptic pathways, modeled by connectionist architectures, cannot implement in principle such complex dynamics. On this regard W. Freeman often quotes the visionary statement of Karl Lashley:

> Generalization [stimulus equivalence] is one of the primitive basic functions of organized nervous tissue. … Here is the dilemma. Nerve impulses are transmitted from cell to cell through definite intercellular connections. Yet all behavior seems to be determined by *masses of excitation*. (...) What sort of nervous organization might be capable of responding to a pattern of excitation without limited specialized paths of conduction? The problem is almost universal in the activities of the nervous system (Lashley, 1942, p. 306).

Contemporary research found the response to this question in the *complex dynamics* of the brain. Particularly, Freeman concentrated his research on the analysis of the basal activity of the brain, often confused by researchers with a background noise to be filtered. On the contrary, the refined statistical analysis of Freeman and of his colleagues, especially by multi-electrode EEG and ECoG registration, directly on the cortex of animals, demonstrated that this signal is not noise but "high dimensional stochastic chaos".

This is the effect of collective behaviors propagating like complex waves of activation among neurons, so to connect in real time very far cortical and sub cortical zones. The subjective instantaneous perceptions of intentionally significant stimuli corresponds thus to the activation/de-activation, fusion/separation of *attractors* of the overall dynamics, each of them corresponding, with their basins, to as many categorizations of the same stimuli. Such attractor activations effectively correspond to real time activation of coherent behaviors, relatively low-dimensional, with respect to the high-dimensional chaotic background. It is like — the example is of Freeman himself — the spontaneous sudden formation/dissolution, fusion/separation of small drops over a surface covered of mist, under fast temperature variations.

This is the neural equivalent of the so-called *dissipative structures,* stable far from equilibrium, studied during last 60's by I. Prigogine. It is easy, then to interpret ontologically the "possible worlds" of our formal semantics as implemented in the metastable states (attractors) of such complex neural dynamics, in a relation of continuous and reciprocal modification, driven by external/internal inputs, till the formation of invariant **KD45** categorization structures.

Finally, recent studies on intentional inter-subjective experiences/communications, having similar complex collective dynamics as their neural basis, demonstrate that such an approach of intentional behavior can be easily extended to the formation of *social beliefs* (Ortigue, Thompson, Parasuraman, & Grafton, 2009; Ortigue, Sinigaglia, Rizzolatti, & Grafton, 2010), till the constitution of the new discipline of the "social neuroscience" (Cacioppo, Bernston, & Decety, 2010). A more complex **KD45** structure of people sharing the same "world of experience", can thus constitute a new class of equivalence of shared beliefs/behaviors, and of shared true knowledge (science).

3 Conclusions

In this paper we present an ontology of social beliefs, within a more general naturalistic approach to ontology, routed in the contemporary physics and cosmology, as well as in the related theory of complex systems in biology and neuroscience.

This result has been reinforced by using the strong modal formalism of the contemporary philosophical logic, mainly the formal ontology and the formal epistemology. By this formalism it became possible to present an original solution of the reference problem based on the idea of the "mutual saturation" between subject and predicate for constituting the unity of a proposition, in opposition to the Fregean well-known theory of the simple saturation of the predicate by its arguments. We showed the Middle Age roots of this idea of double saturation in Aquinas naturalistic theory of intentionality, as well as its power for a finitistic and hence computable solution of the reference problem.

It was easy to show that this naturalistic foundation clause does not affect at all the belief operator **B,** and hence it leaves irreducible to any extensional/intensional computation, the "first person" belief report, both in the singular (individual belief) and in the plural (social belief) cases. In the same time, it demonstrates that beliefs and consciousness, both individual and social, are absolutely *irrelevant* as the truth foundation of the relative knowledge **S**, both in individual (wisdom) and in social (science) senses.

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