

Ontology, step by step

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1. Introduction

The considerable interest in ontology that has developed in recent years may peter out unless at least three problems are addressed *very* seriously:

1. What are the boundaries of ontology; that is, what problems are ontological (rather than, say, epistemological, logical or linguistic, etc.)?
2. What types are there, if any, of ontology?
3. What is the structure of ontology?

2. The Boundaries of Ontology

I shall distinguish (1) between ontological and non-ontological information, and (2) between ontological and quasi-ontological information for both domain and general ontologies.

To put things succinctly, information may be basically organized into at least three dimensions: the semiotic, the semantic and the ontological. Semiotic and semantic information are kinds of non-ontological information.

The semiotic dimension analyses the features of the signs used to convey information, and its main sub-section is the language analysis module (Poli and Mazzola 2000). The semantic dimension analyses forms of classification. Standards and other agreed-upon forms of classification pertain to this module. Cognitive and social categorizations (as for prototype theories) pertain to the semantics module as well.

Besides the distinction between semiotic, semantic and ontological analyses, a further distinction must be drawn between properly ontological information and quasi-ontological information. Ontology should be able to say that a certain object is situated somewhere, or that an event has taken place at a certain moment. But it does not have to say these things using the Gregorian calendar or a particular system of coordinates. We choose a system of measurement for every magnitude, but which system is chosen is purely a matter of convention, and the relative module should be substitutable if for some reason it becomes necessary to use another system of reference (with appropriate adjustments).

3. Types of Ontology

I shall distinguish descriptive, categorical and formalized ontology. Each of these ontologies comes in two guises: domain-dependent and domain-independent.

Descriptive ontology concerns the collection of information about the many items making up the whole world or the specific domain under analysis. In my understanding, the unity and the variety of the world is the outcome of the complex interweaving of dependence connections and forms of independence among its many items. Material things, plants and animals, as well as the products of the talents and activities of animals and humans, are items of the world's furniture. In other terms, the world comprises not only things, animate or inanimate, but also activities and processes and the products that derive from them. It is likewise difficult to deny that there are thoughts, sensations and decisions, and the entire spectrum of mental activities, just as one is compelled to admit that there are laws and rules, languages, societies and customs (Poli 2001a, ch. 5).

Categorical ontology distills, filters, codifies and organizes the results of descriptive ontology (in either its local or global setting). Categorical ontology deals with categories like *thing*, *process*, *matter*, *form*, *whole*, *part*, etc. These are pure categories that characterize aspects or types of reality and still *have nothing to do with the use of any specific formalism*.

Formal codification in the strict sense is undertaken at the level of *formalized* ontology. The task here is to find the proper formal codification for the constructs descriptively acquired and formally purified in the way just indicated. The level of formalized constructions also relates to evaluation of the adequacy (expressive, computational, cognitive) of the various formalisms, and to the problem of their reciprocal translations.

The three levels of ontology are different but not separate. In many respects they affect each other. Descriptive findings may bear on formal categories; formalized outcomes may bear on their twin levels, etc. To set out the differences and the connections between the various ontological facets precisely is a most delicate task (Poli 2003a).

4. The Structure of Ontology

In this section I will try to give an idea of the highly complex structure of ontology. The first step is to distinguish between what we are talking about and its determinations. A number of deep problems are embedded even in this first move, in fact. But let us agree to leave them aside for a while. Resorting to traditional terminology, I shall address the first topic as the problem of "substance", and the second one as the problem of "determinations" (Poli 2001a).

4.1 Substance

My basic tenet is that the theory of substance comprises at least three sub-theories: the theory of particulars, the theory of levels of reality, and the theory of wholes and their parts. Most traditional theories of substance fail precisely because they lack one or more of the above sub-theories. Furthermore, I distinguish an elementary theory of substance, given by the above-mentioned three sub-theories, from a non-elementary or higher-order theory of substance, given by the study of their interactions.

In this paper I only provide a very basic introduction to the elementary theory of substance.

4.1.1. Theory of particulars

Logic-driven thinkers tend to believe that we live in a "world of individuals". "Individual" is a logical concept, not an ontological one. It pertains at most to the ambit of formalized ontology. From the point of view of descriptive and categorical ontology, it should be replaced with richer concepts.

I shall propose adopting "item" as the most generic descriptive term. Subsequent distinctions should consider at least the following concepts: object, process, stuff and group. Each of these has its ontological features and deserves a proper theory. Higher-order items consider items composed by other items (groups of processes, etc).

My own perspective is thoroughly dynamic and thus follows the route opened by such thinkers as Brentano, Husserl, Hartmann, Peirce and Whitehead (see references). Among contemporary ontologists, Brian Cantwell Smith (1996) and John Sowa (2000) defend similar positions. For the time being, we may leave deeper analysis of this more debatable point aside.

4.1.2. Levels of reality

We may distinguish at least three ontological strata of the real world: the material, the psychological and the social (Hartmann 1935, Husserl 1989; on the theory of levels of reality cfr. Poli 1998, 1999, 2001a, 2001b and 2001c).

Specific forms of categorial and existential dependence exist among these strata. For example, a psychological item or event requires an animate physical object as its existential bearer. Should there be no person (and should there be no body of some such person), then neither will there be the correlative psychological states.

A relationship of matter and form holds among many items. In these cases, matter and form are correlative categories, so that any form may be the matter of a higher form, and any matter may be the form of a lower matter. The hierarchy thus constituted is a progressive overforming of matter and form. The nature of the physical world is clearly governed by this embedding principle: the atom is the matter of the molecule, but it is already an entity endowed with form; the molecule is the matter of the cell; the cell is the matter of the multi-cellular organism; and so on.

However, not all the dependences that structure the world are of a matter/form type. When one moves from the organic to the mental plane, one finds a dependence relation that is not reducible to the matter/form relation. One cannot say, in fact, that atoms or cells or organisms are the matter of the mind. Organic reality takes atoms and molecules and assembles them into a new form, consciousness, which is nevertheless not made up of organic forms. In the passage from the material to the mental there arises a *new* series of forms whereby corporeal life with its forms and processes no longer functions as matter. The organic levels are mirrored in psychic life: they influence it, they follow close upon it, but *they are not part of it* (Hartmann 1933). In effect, the life of the mind does not comprise organic processes, nor does it use them as its building blocks, even though it is supported by them and is influenced by them.

One finds another break as far as the social stratum is concerned. In both these cases the dependence relationship is no longer of matter/form type but becomes one of a completely different kind: a bearer/borne relationship. In these cases, the substratum of the higher level is not the matter of the lower level (Hartmann 1952, 68-69; Poli 2001c).

Belonging to the social stratum are all phenomena of communication, and therefore the complex of social phenomena and customs, economic and legal realities, history, language, science, technology and the body of knowledge of every epoch, and morals.

Analysis of the dependences among objects therefore requires us to distinguish at least two fundamental relationships: that among the layers and that among the strata of reality.

A terminological note may be of use here. For the sake of clarity, I shall say that overforming relationships hold among ontological *layers*, while building-above relationships hold among ontological *strata*. Whereas by ‘overforming’ is meant that every category can constitute the ‘matter’ of a higher category, the term ‘building-above’ denotes a very different type of conditioning. In this case, the higher stratum requires the lower one only as its *external basis of existential support*, but not as matter to be supraformed (details in Poli 2001a and 2001c).

Almost all actually existent entities are multi-stratified. Which means that *the levels and strata of reality do not distinguish items. The levels are internal to items but not as their parts!* (Poli 1998, 2001a, ch 8).

4.1.3 Wholes and Their Parts

The theory of wholes and their parts presents a number of different subsections. As to its first-order segment, we may distinguish (1) classification of wholes; (2) classification of parts; (3) classification of boundaries. Section (2) has been widely discussed in the past fifteen years; section (1) has been less intensively discussed; and section (3) has received even less attention. Here I skip analysis of point (2) and (3) and deal briefly with point (1) only.

I distinguish three kinds of wholes: aggregates, wholes in the proper sense and systems. The following table provides a way to distinguish among them:

Table 1

| | unity by proximity | unity by solidarity | dynamic unity |
|-----------|--------------------|---------------------|---------------|
| Aggregate | yes | no | no |
| Whole | yes | yes | no |
| System | yes | yes | yes |

Aggregates consist of proximate parts. Wholes in the proper sense comprise parts "which go together" (recall Uexküll's motto: an object is that which moves together). Systems require a dynamic exchange between the whole and its parts.

Unity by solidarity is stronger than unity by proximity. This means that only some items that are aggregates are also (integral) wholes, and that some of the latter may be systems. Needless to say, the most difficult task is furnishing an adequate characterization of the dynamic components of systems. For the moment I merely point out that it is possible to determine various forms of dynamic unity, ranging from those that obtain in material systems of a physical nature to those that obtain in systems which, like living and social systems, are able to produce the elements of which they are composed.

In general, what is it that characterizes wholes? Exemplification of whole as something connected may be acceptable for items of the physical or biological world. But, what about sociological wholes (like ‘family’ or ‘community’), or institutional ones (like ‘university’ or ‘city’)? These too are wholes, they have their history, properties, parts, and so on, but they are not connected *in the same way* as material items are. This observation highlights how close the interplay is between the theory of wholes and the theory of levels.

The above classification can be further clarified by adding that aggregates are characterized by relations among their parts. Wholes require both part-part relations and parts-whole relations, whereas a proper characterization of systems requires information on

three kinds of relations: part-part relations, part-whole relations and whole-part relations (Poli 2001a, ch 7).

4.2 Determinations

Determinations can be classified according to different criteria. Two major criteria are the determinable/determinate opposition and the intensive/extensive opposition. Having already analyzed them in some detail, I refer interested readers to Poli 2001a, ch. 6 and 2003b.

5. Again on Levels

There are general categories that apply to all the ontological strata: for example, the category of part. However, the fact that this is a general category does not entail that it is a univocal category. In effect, the concepts of part that apply to the material stratum differ substantially from the concepts of part typical of the mental or social strata. Note the deliberate use of the plural here: concepts of part are not only different from stratum to stratum but they may also be different from layer to layer. We are therefore in need of both an extremely general characterization of part and specifications of part for each ontological level.

However much the various top-level categories may assume different values in the different strata of the ontology, they must nevertheless have something in common. Although part differs as regards inanimate and animate items, in both cases we always speak of parts and distinguish part from the other categories.

Each ontological level is characterized by the presence of a group of categories typical of that level. The first task, therefore, is to find the most general categories typical of that level. There will then be groups of categories that mark out particular sub-levels.

Two important points require making as regards the use of this approach. The first is that one always talks of groups of categories. There are no real domains characterized by one single general category. In general, a domain is characterized by complexes of categories which interact with each other. The second point is that domain ontologies are not solely the outcome of the way a particular ontological stratum is sliced up. Domain ontologies, in fact, are often the result of a complex combination of local realms belonging to different ontological layers and strata.

Consider for example the case of artifacts. These are at minimum objects of the inanimate material world. To characterize their ontology, however, we must examine other dimensions as well, like the 'design', 'manufacture' and 'marketing' of artifacts, and these are dimensions of the social world. The ontology of artifacts is therefore an ontology that operates crosswise to the sequence of the ontological layers and strata. It is this 'transversality' that makes the categorization of many domain ontologies such a complex undertaking.

6. Methodology of Domain Analysis

From an ontological viewpoint, at least two major aspects should be addressed: (1) The universal basic structure of a domain, and (2) The basic scheme of the domain's prototypical items. Let us look at these separately.

6.1 A Domains' Basic Structure

I shall distinguish among a domain's external, internal and mixed dimensions. To aid understanding, I shall exemplify my proposal by considering two different complex domains, namely those of sport and of literary works of art.

The first two dimensions are by far the most relevant. I therefore start with their analysis. The internal dimension concerns information related to the concrete performance of any sport, whereas the external dimension regards everything related to the organization, the regulation, and the study of sports. Internal dimensions for the domain of literary works of art comprise the writing down of the work, whereas external dimensions are linked to its fruition (copyrights, publication, etc.). For both domains, mixed dimensions concern areas of systematic overlapping with other domains.

Internal dimensions concern the effective playing of sport. Actual performances, training, analyses of basic and complex movements, intentions sustaining performed movements (attack, defence, feint) are all proper aspects of internal dimensions. Generally speaking, sports are based on movements that we all are able to perform (running, jumping, throwing, etc.). These ground movements are possibly linked to or enhanced by specific tools (weight, javelin, racket, foil, etc.). Basic or ground movements depend on our biological constitution.

As a consequence they cannot gainsay the results yielded by the anatomical and physical study of the human and animal body. In reality, however, the basis of sport is neither medical nor biological but phenomenological. What truly counts is our experience of movement (running, for example, or jumping), the pleasure or satisfaction that we gain from it, and perhaps our desire to enhance the experience as much as possible. Medical, physiological and biochemical knowledge comes into play only afterwards as sources of information enabling us to achieve certain goals more efficaciously.

The grounding of sport in the experience of our elementary movements is then augmented by the more complex forms of experience that have accumulated historically (duelling, etc.). Both the elementary forms of movement and the more sophisticated ones tied to subsequent historical developments undergo a process of refinement and stylization that leads to codification of explicit rules (permitted movements, etc.). All professional sports, and the majority of amateur ones, are governed by explicitly formulated rules.

The purpose of training is to transform natural movements into movements codified by the rules and to acquire the automatisms necessary for adequate and efficient performance of those movements.

The structure of a sports contest is not limited to the more or less successful execution of certain movements; it also involves classification of the contestants according to their performance. This aspect introduces a further dimension: besides enjoyment of the movement (whether natural or conventional) there is enjoyment of the competition and of possible victory. Which means that the various movements must be coordinated so that a positive outcome is achieved. For example, in the case of two-sided contests in which an individual or group must counter the moves of an opponent, the latter must be attacked, perhaps by resorting to forms of deception (feints, etc., within the bounds set by the regulations). Other types of sporting contests may display a different phenomenology of the actions involved.

Unlike the inner dimension, the external one is a social dimension which is closely related to institutional structures (rules, regulations, associations, tournaments) and the material facilities that enable the sport to be played (stadiums, sports arenas, various types of facility).

Although the internal dimension is also social in nature, it emphasises the intentional aspects of sport. Unlike purely mental intentions, the physical ones of sport are mostly externalized and are expressed in specific movements and combinations of movements. Of course, also involved are the athlete's directly subjective intentions (determination and will to win) as well as intermediate ones tied to the dynamic of the contest (the fear of winning typical of certain phases of tennis matches).

Note that the external and internal dimensions are also distinguished by their different ontological characterization: most of the external items are objects, while the internal ones are processes (events).

The case of literature is very similar. A literary work of art can be viewed as the concrete product of its author's intentions. Because it is reified, a literary object is independent of its author and has its own existence. While sport is based on movements, their codification, and their coordination to achieve victory, a literary work is based on words, phrases and other linguistic structures which convey the author's intentions. Thus, just as a single movement is not a sport, so a single word is not a literary work. A set of movements and a set of (written) words may respectively become sports events and literary objects. In both cases there are amateurs and professionals, and in both cases the professional is someone able to perform the activity to the maximum extent.

The main difference between the domain 'sport' and the domain 'literary works of art' is the following. In the case of sport, the inner dimensions concern structural and functional analyses of *doing sport*, while in the case of literature they concern structural and functional analysis of (particular) *objects*. This difference springs from the unit of reference, which in the case of sport is an event, while in the case of a literary work of art is an object. Information about this aspect (whether we are dealing primarily with objects or events or some other category) is provided by the next structure: the basic scheme of the canonical item of a domain.

6.2. Basic scheme of the canonical item of a domain

I shall exemplify the schemes relative to sport and a literary work. Both sport and literary works are social realities. Which means that they have a stratified structure characterized by a directly social nucleus with two fringes: below they require material bearers that bring social phenomena into existence; above they require meanings.

The unit of reference is the sporting contest. This has a material base (stadium, gymnasium, ring, swimming pool, etc.) and instantiates contents (the idea of competition, challenge, etc.). The event has outcomes (at minimum a result).

The category *match* is a complex involving numerous participants which, as shown by the following table, can be divided into active and passive (*vis-à-vis* the contest):

Table 2

| | |
|------------------------|--------------------------------------------|
| active participants: | internal (contestants) |
| | external (referees) |
| | auxiliaries (technicians of various kinds) |
| passive participants : | supporters |

The category *match* pertains to the category *process*, as discussed in the previous section. Each of the participants is a social actor with specific properties, etc.

We may now turn to the case of literature. Literature is a social phenomenon (a social product) which can be described on the basis of the following structure:

1. The agent (author) produces an object (literary work) which instantiates (exemplifies, concretizes) his/her intentions. A literary work is therefore firstly an *intentional object*.
2. Secondly, once produced, a literary work has its own existence independently of the author. It is therefore a *reified intentional object*.
3. A literary work necessarily requires a material bearer, a support which enables it to take concrete form (manuscript, book, journal, CD-Rom, videotape, etc).
4. Equally necessarily, a literary work instantiates (exemplifies, concretizes) meanings (which are ideal objects).

The first feature to note is that each of the categories used is defined with respect to more primitive ontological categories. In all cases we have an *object* (and not, for example, a process or a group). The various objects are distinguished with respect to the levels of reality that characterize them: the bearer is *material*, the literary work is *reified intentional* (one of the forms of the social level), the meaning is *ideal*, the agent (author) is a complex reality which for the moment we may take to be *mental* (this is the aspect that interests us because it is the source of the intentional acts that give rise to the intentional object reified in the literary work). In reality, also the agent is multistratified in its structure, but for the moment we may ignore this.

The next step is to articulate the various categories that make up the scheme just seen.

Leaving *agent* and *bearer* aside, the main problem is the articulation of *meaning* and *literary work*. These two levels are connected as genus and instance: like, for example, 'poetry' and 'Faerie Queene'. Besides analysis at this highly general level, numerous more sectoral ones are conducted: of the relationship among the notions of honour, love, pain, pleasure, etc., and the specific ways in which these are expressed in literary works. In their turn, these various modes are grouped into historically determined styles (i.e. as schematic, prototypical ways to express content: the essential references on the relationships between ontology and aesthetics are Ingarden 1973, 1989 and Hartmann 1933, 1950; cf. Poli 1998 and 2002).

7. Standard Template Library

It is entirely obvious that ontology *qua* technology is still in its early stages. At the moment, the research community seems to have reached broad agreement only on the fixing of *formal* standards. This is certainly an important development, but it is one that can be called authentically ontological only by illegitimate extension of the concept of ontology. Formal languages are part and parcel of formalized ontology, but they cannot be extended to cover the fields of either descriptive or categorical ontologies.

In other words, what we really need is a Standard Template Library for *ontological categories and constructs*: for use, for example, in structuring analysis of the LEVELS of objects and their forms of dependence and independence, in the analysis of categories like PROCESS, OBJECT, GROUP, PART and WHOLE. Moreover, we need semiotic and semantic frameworks. Indeed, it would be extremely useful to have templates for analysis of the categories used to recognize and classify reality, just as it is essential to have sophisticated tools for the analysis, construction and organization of lexical fields. All this, however, still seems a long way off. And this is no accident: we have far to go because,

amongst other things, there is still no general consensus even on the general features of an ontology and on the features of whatever should accompany ontological analysis.

For this reason the most urgent task is to continue with the work of conceptual clarification of categories and their organization. In effect, it is plain that each of the topics addressed in the various sections of this paper calls for further inquiry, and that several areas of ontology have yet to be explored. If we look at the literature we soon realize the extent to which analyses have lacked systematicity. For instance, whereas in the last fifteen years there has been an enormous burgeoning of interest in the concept of PART, this is certainly not the case of the correlated and ontologically more important concept of WHOLE.

8. Filterings and Extensions

The picture thus outlined does not offer easy short cuts. On the other hand, only a unitary picture such as this may enable the study of the multiple relations of dependence and autonomy among the various ambits of reality, without having to reduce reality to some form or other of gratuitous existential autonomy.

In cases where ontology is used for particular applications – NLP or databases, for example – the framework described must both be suitably *filtered* or *frozen* (with respect to suitable parameters) and *extended*.

The ‘freezing’ will enable calibration of the various sections of general ontology to the specific intended application. For example, one can ‘reduce’ the problem of temporality by separating the time dimension from other dimensions and assigning it an ordering structure (linear, branching, discrete, continuous, differentiable, etc.). In this way, time becomes an external parameter, and the dynamic operates internally to a qualitative phase space $T \times Q$.

Obviously, different freezing procedures may give rise to different sub-ontologies or to different forms of ontology.

On the other hand, the ‘extension’ procedure will add semiotic and cognitive components. Consider, say, conceptual lexica and linguistic corpora. It is a well-known fact that terms can be categorized at several levels. This means that every term should be accessible by default only in its generic sense (infarct = heart attack), while its generic meanings are made explicit when general ontology is activated and its special meanings are only made explicit when specific domain ontologies are activated. On the other hand, both general and domain ontology contain categories which do not have analytical correspondences in generic knowledge. Knowledge of general ontology provide extended and deeper structure to generic knowledge, whereas knowledge of the domain fills or saturates it.

9. Cooperations

From what I have written, it is clear that ontology needs the contributions of mathematicians, logicians, linguists, psychologists, social scientists and philosophers. Collaboration with philosophers is possibly the most difficult. Years ago, McCarthy noticed that "Either no one in AI, including retreated philosophers, understands philosophical theories well enough to program a computer in accordance with their tenets, or the philosophers haven't even come close to the required precision. Actually it seems that some of the empiricist philosophies may be precise enough but turn out to be inadequate when one attempts to use the most modest computer programs" (Lifschitz 1990,

244). The situation is even worse than that because the two most influential philosophers of the last fifty years – Wittgenstein and Heidegger – rejected the alliance between science and philosophy. One can only hope that contemporary philosophers will come to realize that they have blundered into a blind alley and revert to a more natural standpoint.

On the other hand, if philosophy is naturally allied with science, the philosophers to whom we refer can only be philosophers who have acknowledged the alliance between philosophy and science. For this reason, both analytic philosophy and continental philosophy are unsuited to our purposes. We must accordingly take a step backwards and see whether immediately previous philosophy has something useful to offer. And, in fact, we find in German-speaking philosophy of the late nineteenth and early twentieth centuries a group of thinkers who defend the two principles of alliance with science and the autonomy of ontological problems. The latter principle states that ontological problems cannot be reduced to those of the theory of knowledge. This position was first set out by Franz Brentano, who declared that "the genuine method of philosophy is none other than that of natural science" (Brentano 1968), and it was developed in numerous directions by Brentano's pupils: most notably Edmund Husserl and Alexius Meinong, or Roman Ingarden, who studied under Husserl. Another German thinker who, although he studied neither under Brentano nor under his pupils nevertheless reflected their doctrines, and Husserl's especially, is Nicolai Hartmann, *perhaps the most important ontologist of twentieth century* (see references. The only available English introduction to his thought is Werkmeister 1990). Philosophers in the English-speaking world who have argued substantially similar positions – although not directly influenced by the above authors – have been Charles S. Peirce and Alfred N. Whitehead.

10. Conclusion: who knows something about ontology?

Ontology needs the achievements of all the sciences if it is to accomplish its aims. Even if we accept the Philosopher's claim that, by virtue of the problems it addresses, ontology is *philosophia prima* (first philosophy), because of the answers it proposes, ontology can be only *philosophia ultima* (last philosophy). In between there is science.

Broadly speaking, the variously articulated research communities of philosophers, linguists, psychologists and engineers have still not found a way to relate to each other systematically.

However, in dynamic terms, one can easily foresee mounting social and institutional pressure for tools able to model fragments of reality in terms that are both adequate and efficient. And from this point of view, we are all at fault. Those colleagues who concern themselves with artificial intelligence seemingly pay closer attention to manipulation and technique than to knowledge. Likewise, those who concern themselves with general issues suffer from the reverse problem, that of navigating in a sea of theories for which the rationale is sometimes unclear.

For my part, I grow increasingly convinced that the same problems will force the former to address general theories, and the latter to address the limitations of our current capabilities. Provided, that is, that both sides have the will, the ability, the desire and the courage to do so. If they decide to tackle these problems, it becomes reasonable to identify and systematically develop those areas of convergence and contact now existing.

References

- Brentano, F. (1968). *Habilitationsthesen (1866)*, in F. Brentano, *Über die Zukunft der Philosophie*. Hamburg, Meiner.
- Hartmann, N. (1933). *Das Problem des geistigen Seins*, Berlin, De Gruyter.
- Hartmann, N. (1935). *Zur Grundlegung der Ontologie*, Berlin, W. de Gruyter.
- Hartmann, N. (1950). *Aesthetik*, de Gruyter, Berlin, 1950.
- Hartmann, N. (1952). *The New Ways of Ontology*, Chicago.
- Husserl, E. (1970). *Logical Investigations*, London, Routledge & Kegan Paul 2 vols.
- Husserl, E. (1989). *Ideas Pertaining to a Pure Phenomenology and to a Phenomenological Philosophy*, Dordrecht, Kluwer.
- Ingarden, R. (1973). *The Literary Work of Art: With an Appendix on the Functions of Language in the Theater*, Evanston, IL, Northwestern University Press, 1973.
- Ingarden, R. (1989). *Ontology of the Work of Art*, Athens, OH, Ohio University Press, 1989.
- Lifschitz 1990. V. Lifschitz (ed.). *Formalizing Common Sense. Papers by John McCarthy*. Norwood, New Jersey, Ablex Publishing Corporation, 1990.
- Poli, R. (1996). Ontology for Knowledge Organization. In R. Green, Ed. *Knowledge Organization and Change*, Frankfurt/Main, INDEKS Verlag, pp. 313-319.
- Poli, R. (1998). Levels. *Axiomathes*, **9**, 1-2, 1998, pp. 197-211.
- Poli, R. (1999). Framing Ontology (<http://www.formalontology.it>).
- Poli, R. (2001a). *Alwis. Ontology for Knowledge Engineers*, PhD thesis, Utrecht, 2001.
- Poli, R. (2001b). Foreword. *Axiomathes*, **12**, 1, 2001, pp. 5-9.
- Poli, R. (2001c). The Basic Problem of the Theory of Levels of Reality. *Axiomathes* **12**, 3-4, pp. 261-283.
- Poli, R. (2002). Ontological Methodology. *International Journal of Human-Computer Studies*, 2002, **56**, pp. 639-664.
- Poli, R. (2003a). Descriptive, Formal, and Formalized Ontologies. In D. Fisette, ed., *Husserl's Logical Investigations Reconsidered*, Kluwer, Dordrecht, pp. 183-210.
- Poli, R. (2003b). W. E. Johnson's Determinable-Determinate Opposition and his Theory of Abstraction. *Poznan Studies in the Philosophy of the Sciences and the Humanities* (forthcoming).
- Poli, R. and Mazzola, G. (2000). Semiotic Aspects of Generalized Bases of Data. In E. Kawaguchi, H. Kangassalo, H. Jaakkola, I.A. Hamid (eds), *Information Modelling and Knowledge Bases XI*, IOS Press, Amsterdam, 2000, pp. 1-11.
- Smith, B.C. (1996). *On the Origin of Objects*, MIT Press, Cambridge MA.
- Sowa, J.F. (2000). *Knowledge Representation: Logical, Philosophical, and Computational Foundations*. Brooks/Cole Publishing Co., Pacific Grove, CA, 2000.
- Werkmeister, W. (1990). *Nicolai Hartmann's New Ontology*, Tallahassee, Florida State University.
- Whitehead, A.N. (1978). *Process and Reality*, corrected version ed. by D.R. Griffin and D.W. Sheburne. The Free Press, New York and London, 1978.