

Formal Ontology: Lecture One

Intensive Course STOQ 50547

II Semester April 26–30, 2004

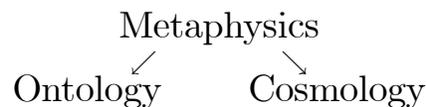
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April 26, 2004, 11.15–12.45

1 Introduction

Formal ontology is a discipline in which the formal methods of mathematical logic are combined with the intuitive, philosophical analyses and principles of ontology. Formal ontology brings together the clarity, precision and methodology of logical analysis on the one hand with the philosophical significance of ontological analysis on the other. Father I.M. Bochenski, for example, has said of ontology that it is a “sort of prolegomenon to logic” in that whereas ontology is an intuitive, informal inquiry into the categorial aspects of reality in general, “logic is the systematic formal, axiomatic elaboration of this material predigested by ontology.”¹

Ontology, which is the study of being *qua* being (Aristotle, *Meta.* 1031a), has been a principal part of metaphysics since ancient times. Metaphysics itself has usually been divided into ontology and cosmology:



where

- ontology = the study of being as such, and
- cosmology = the study of the physical universe at large; i.e., space, time, nature and causality.

Implicit in this division is a distinction between methodologies. In particular,

- the methodology of cosmology is based on:

¹Bochenski 1974.

- the analysis of such categories as space, time, matter, and causality, where
- the goal is to discover by observation and experiment the laws connecting these categories and their constituents with one another, including in particular the natural kinds of things (beings) in nature.
- The methodology of ontology, on the other hand, is based on:
 - the analysis of ontological categories, i.e., categories of being, where
 - the goal is to discover the laws connecting these categories and the entities in these categories with one another.

The particular sciences that are part of cosmology and that are concerned with particular natural kinds of beings may be prior to ontology in the order of discovery—and even in the order of conception. But as an analysis of ontological categories, ontology is a science that contains the ontological forms, if not the specific content, of the ideas and principles of the different natural sciences, and in that sense it is a science that is prior to all of the others. Similarly, logic contains the logical forms, but not the specific content, of the different scientific theories that make up the content of our knowledge of nature, and in that sense logic is a science prior to all others. Thus, when the logico-grammatical forms and principles of logic are formulated with the idea of representing the different categories of being and the laws connecting them, i.e., when ontological and logical categories are combined in a unified framework, then the result, which is what we mean by formal ontology, is a comprehensive deductive science that is prior to all others in both logical and ontological structure.

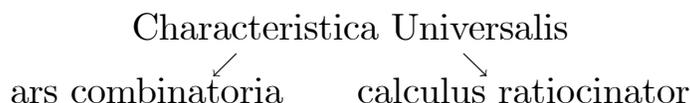
2 Formal Ontology as a *Characteristica Universalis*

A system of logic can be constructed under two quite different aspects. On the one hand, it can be developed as a formal calculus and studied independently of whatever content it might be used to represent. Such a formal system in that case is only a calculus ratiocinator. On the other hand, a system of logic can be constructed somewhat along the lines of what Leibniz called a *characteristica universalis*. Such a system, according to Leibniz, was to serve three main purposes. The first was that of an international auxiliary language that would enable the people of different countries to speak and communicate with one another. Apparently, because Latin was no longer a “living” language and new trade routes were opening up to lands with many different local languages, the possibility of such an international auxiliary language was widely considered and discussed in the 17th and 18th centuries.² There were in fact a number of proposals and partial constructions of such a language during that period, but

²Cf. Cohen 1954 and Knowlson 1975.

none of them succeeded in being used by more than a handful of people. It was only towards the end of the 19th century when Esperanto was constructed that such a language came to be used by as many as eight million people. At present, however, the question of whether even Esperanto will succeed in fulfilling that purpose seems very much in doubt. Ido is another such language, which was constructed in 1907 by a committee of linguists, but it has not been used since about 1930.³ In any case, notwithstanding its visionary goal, the idea of an international auxiliary language is not the purpose of a formal ontology.

The second and third purposes Leibniz set for his *characteristica universalis* are what distinguish it from its precursors and give his program its formal or logistic methodology. The second purpose is that the universal character is to be based upon an *ars combinatoria*, i.e., an ideography or system of symbolization, that would enable it to provide a logical analysis of all of the actual and possible concepts that might arise in science. Such an *ars combinatoria* would contain both a theory of logical form, i.e., a theory of all the possible forms that a meaningful expression might have in such a language, and a theory of definitional forms, i.e., a theory of the operations whereby one could construct new concepts on the basis of already given concepts. The third purpose was that the universal character must contain a *calculus ratiocinator*, and in particular a complete system of deduction and valid argument forms, by which, through a study of the consequences, or implications, of what was already known, it could serve as an instrument of knowledge. These two purposes are central to the notion of a formal ontology.



With a universal character that could serve these purposes, Leibniz thought that a unified encyclopedia of science could be developed about the world, and that, by its means, the universal character would then also amount to a *characteristica realis*, i.e., a representational system that would enable us to see into the inner nature of things and guide our reasoning about reality like an Ariadne's thread.⁴ In other words, in Leibniz's program for a *characteristica universalis* we have an attempt to encompass the relationships between language and reality, language and thought, and language and knowledge, especially as represented in terms of scientific theories. In two fundamental parts of the program, namely, the construction of an *ars combinatoria* and a *calculus ratiocinator*, we also have critical components that are necessary for a formal ontology.

The idea of a *characteristica realis*, i.e., a unified encyclopedia of science, is also important for a formal ontology. That is because a formal ontology, as a logistic system, must be structurally rich enough so that in principle every scientific theory can be formulated within it. Of course, this will be possible only

³Cf. Van Themaat 1962.

⁴Cp. Cohen 1954, p. 50.

by adding to the general framework of a formal ontology appropriate nonlogical constants, axioms, and meaning postulates that represent the basic concepts and principles of a given science. In addition, though this is not required from a strictly scientific point of view, a formal ontology should be sufficiently structured so that with the addition of suitable nonlogical constants and meaning postulates a logical analysis of every meaningful declarative sentence of natural language can be given within it. That is, a formal ontology should be able to contain a semantics for natural language that captures the ontology of our commonsense framework. In that case such a logistic system can be taken not only as a *characteristica realis*, but also as a *lingua philosophica*. Of course, prior to the introduction of such constants and postulates, whether for science or natural language, a formal ontology is essentially just a shell containing the logico-ontological categorial forms and principles of science and of our commonsense understanding of the world.

3 Commonsense Versus Scientific Understanding

Our commonsense understanding of the world is sometimes said to be in conflict with our scientific understanding, which, on this view, is taken as providing the only proper criteria for truth. It is also claimed that the construction of a logistic system as the basis of a unified encyclopedia of science can represent only our scientific understanding, because by its very nature such a system can operate only with concepts and principles that have sharp and exact boundaries, such as the concepts and principles we strive to formulate in our scientific theories. The same cannot be said, according to this view, of the concepts and principles of our commonsense understanding. That is, the concepts underlying our use of natural language do not have sharp boundaries, and do not require the kind of precision of thought that is the goal of scientific knowledge, which alone can provide an adequate criterion of truth. Many of the words and phrases of natural language by which we express our commonsense understanding, for example, are vague or ambiguous, and as such are unsuitable for the kind of logical representation involved in our methodology. Gottlob Frege expressed this view in comparing the difference between his logical system and ordinary language with that between a microscope and the human eye. Even though the eye is superior to the microscope, Frege observed, “because of the range of its possible uses and the versatility with which it can adapt to the most diverse circumstances,” nevertheless, “as soon as scientific goals demand great sharpness of resolution, the eye proves to be insufficient”.⁵

That only our scientific understanding can provide an adequate criterion of truth about the natural world does not mean that our commonsense understanding gives a false picture of the world, or a picture that, for the purposes

⁵Frege 1879, p, 6.

of knowledge, ought to be eliminated.⁶ No doubt, many of our commonsense beliefs and concepts about the natural world have been revised and corrected over the millennia, and probably many will be revised or corrected in times to come. The concept *water*, for example, has been replaced by the concept H_2O in the scientific context of the atomic theory of matter, where the concept H_2O is systematically related to the concept H for hydrogen and the concept O for oxygen.⁷ This does not mean that the concept *water* is somehow misleading and that the role it plays in our commonsense framework is to be eliminated. Indeed, not only has the concept continued to be functionally useful in everyday contexts, but it also continues to serve in scientific contexts as well.

It is not just our commonsense concepts that are important for an understanding of the world, however, but also how we structure our thought in our commonsense framework as well. How we reason and argue in this framework are preconditions of scientific knowledge and theorizing. Scientific understanding depends, in other words, both conceptually and pragmatically upon our commonsense understanding, including the way the world is categorially structured, and the way we reason in terms of that structure. In this regard, the representation of our scientific knowledge involves more than the representation of a large number of facts or beliefs about the objects in a given domain of scientific inquiry, regardless of whether those facts or beliefs are in conflict with what is believed by common sense. In particular, it involves the criteria for valid reasoning that we bring to bear on our commonsense arguments, and the way those arguments are structured in terms of the categorial structure of our commonsense understanding.

It is precisely the formal representation of the categorial structure of our commonsense framework, as well as the criteria for valid reasoning within that framework that is one of the goals of formal ontology. The arguments that we find in natural language and in terms of which we articulate our reasoning can be evaluated as valid or invalid only with respect to a logical theory, and in particular one that provides an adequate formal representation of the basic categories of natural language and the commonsense framework expressed in its use. The adequacy of such a theory is judged on the basis of how well it agrees with our commonsense intuition of which arguments are valid and which invalid.

We are not claiming here that the ontology of our commonsense framework, based as it is on perceptible objects and their qualitative features, is also fundamental to science. Certainly, our commonsense framework is prior in the order of conception, but it is not necessarily prior in the order of being. That is an issue that, among other things, involves the mind-body problem and the way consciousness and the mind are described in terms of a formal ontology as both a *characteristica realis* and an *intensional logic*. In such a formal ontology, the mind-body problem divides into at least two different sub-problems:

- (a) the study of the relations between physiological states

⁶See, e.g., "Philosophy and the Scientific Image of man", in Sellars 1963, for a account of the eliminativist view.

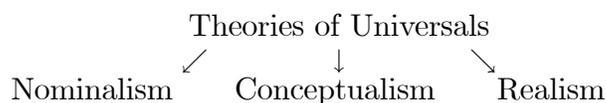
⁷Cf. Fodor 1993, p.86.

- and certain states of consciousness, and
 (b) the study of the emergence of consciousness, meaning,
 and the self and its relation to its body.

The first problem, the study of the relations between physiological states and certain states of consciousness, is a problem that is studied by experts in neuropsychology and other neurosciences, and as such it is a proper part of a *characteristica realis*. The second problem, i.e., the problem of the emergence of consciousness, meaning and the self can be solved, on the other hand, only by taking natural language, intentionality, and our commonsense framework into account, which means the inclusion within formal ontology of an intensional logic that can be used to represent our commonsense understanding and the contents of our beliefs and theories, including the fables and stories that are part of our culture and of our individual mental spaces. Such an intensional logic will provide an account of the ontology of fictional objects in terms of the contents of our concepts, and it will contain a logic of our various cognitive modalities, including a logic knowledge and belief.

4 The Nexus of Predication

Leibniz’s own ideography for his *characteristica universalis* was algebraic and did not deal with the central feature of either a conceptual or ontological theory of logical form—namely, the nexus of predication. How predication is represented in a formal ontology depends on different theories of universals, where by a universal we mean that which can be predicated of things (Aristotle, *De Int.* 17a39). Traditionally, there have been three main theories of universals: nominalism, conceptualism, and realism.



The difference between these three types of theories depends on what each takes to be predicable of things. In this regard, we will distinguish between:

- predication in language (nominalism),
- predication in thought (conceptualism), and
- predication in reality (realism).

All three types of theories agree that there is predication in language, in particular that predicates can be predicated of things in the sense of being true or false of them. Nominalism goes further in maintaining that only predicates can be predicated of things, that is, that there are no universals other than the predicate expressions of some language or other:

Nominalism: only predicates are true or false of things; there are no universals that predicates stand for.

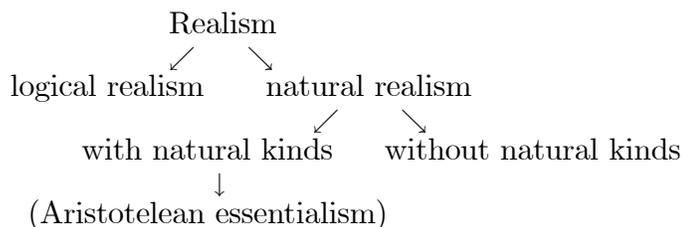
Conceptualism opposes nominalism and maintains that predicates can be true or false of things only because they stand for concepts, where predicable concepts are the cognitive capacities—intelligible universals—that underlie predication in thought and our rule-following abilities in the use of the predicate expressions of natural language.

Conceptualism: predication in thought underlies predication in language; predicable concepts are rule-following cognitive capacities regarding the use of predicate expressions.

Realism also opposes nominalism in maintaining that there are real universals, namely, properties and relations, that are the basis of predication in reality.

Realism: there are real properties and relations that are the basis of predication in reality.

There are two distinct types of realism that should be distinguished; namely, various forms of logical realism as modern forms of Platonism, and various forms of natural realism, with at least one being a modern form of Aristotle's theory of natural kinds.



Both forms of realism are compatible with conceptualism, but natural realism, especially Aristotle's theory of natural kinds, is closely connected with the kind of conceptualism we will describe in later lectures. That is because, natural realism as a formal ontology presupposes some form of conceptualism in order even to be articulated; and the kind of conceptualism that we will later defend depends in turn on some form of natural realism as its causal basis. How conceptualism is compatible with logical realism, and how natural realism and a certain modern form of conceptualism are intimately connected are issues we will take up later in our discussion of what we call conceptual realism.

Corresponding to these different theories of universals, there are different formal ontologies containing different formal theories of predication, each representing some variant of one of these alternatives. That means that there will be different comprehensive systems of formal ontology. Each formal ontology,

of course, will view itself internally as the final arbiter of all logical and ontological distinctions. But the study of different possible formal ontologies, their consistency, adequacy, and relative strength with respect to one another, and, similarly, the study of the alternative subtheories that might be realized in the different branches of a comprehensive formal ontology, may together be called *comparative formal ontology*.

A comprehensive system of formal ontology will in general have different branches or subsystems within which different ontological tasks can be carried out. One such branch, for example, might be a theory of parts and wholes, which would include a relation of foundation regarding how some parts are founded or dependent upon other parts or wholes.⁸ There might also be a theory of extensive and intensive magnitudes, i.e., a measurement theory, and a theory of continuants and of the existence of the latter in space and time.⁹

5 Univocal Versus Multiple Senses of Being

One important distinction between different systems of formal ontology is whether *being* is taken as univocal or as having different senses. It will have different senses when different types or categories of expressions are understood as representing different categories of being, in which case there will also be different types of variables bound by quantifiers having the entities of those different categories as their values. Such is the case in both conceptualism and some variants of realism. Where being is univocal, on the other hand, i.e., where there is just one ontological category of being (being *simpliciter*), only one type of quantifiable variable will have semantic significance. This does not mean that there are no different “kinds”, or sorts, of being, but only that in such a framework being is a genus, and that the different kinds of being all fall within that genus. In a formal ontology for *nominalism*, for example, there will be no ontological category corresponding to any grammatical category other than that of singular terms (logical subjects), and in particular there will be no ontological category or mode of being corresponding to the grammatical category of predicate expressions. Only objectual variables, i.e., the category of variables having singular terms as their substituents, will have semantic-ontological significance in such a formal ontology. Predicate variables, and quantifiers binding such, if admitted at all, must then be given only a substitutional and not a semantical interpretation, which means that certain constraints must be imposed on the logic of the predicate quantifiers in such a formal ontology.

Most nominalists in fact eschew even such a substitutional interpretation of predicate quantifiers and describe their ontology only in terms of first-order logic where there is but one type of bindable variable, i.e., where, as in W.V.O. Quine’s phrase,

to be = to be the value of a bound objectual variable.

⁸Cf. Husserl 1900, Volume 2, Investigation III, and Barry Smith 1982.

⁹Cf. Brentano, 1933.

It should be noted, however, that, unlike traditional nominalists, some contemporary nominalists (e.g., Nelson Goodman), take abstract objects (e.g., qualia) as well as concrete objects to fall under their supposedly univocal sense of being.¹⁰ This means that although there is but one ontological category of being in such an ontology, there may still be different “kinds” of being. That is, in such a system being is a genus, which is not at all the same as being multivalent.

Nominalism: being is univocal; i.e., being is a genus.

Being is also univocal in some forms of realism (regarding universals). This would appear to be the case, for example, in the ultra-realism of certain early scholastic philosophers for whom the realm of being is the realm only of universals (as in the teachings of John Scottus Eriugena and Remigius of Auxerre). It is certainly univocal in the case of certain contemporary forms of *logical realism*, where properties, relations, concrete objects, and perhaps states of affairs as well, are different kinds, as opposed to, categories of being. A formal ontology for such realists is developed today much as it is in nominalism, namely, as an axiomatic first-order logic with primitive predicates standing for certain basic ontological notions. Indeed, except perhaps for the distinction between an intensional and an extensional logic, there is little to distinguish realists who take being to be univocal from such nominalists as Goodman who include abstract objects as values of their objectual variables and who describe such objects axiomatically (e.g., in terms of a mereological relation of *overlap*, or of *part-to-whole*). This is particularly true of those realists who, in effect, replace the extensional membership relation of an axiomatic set theory by an intensional relation of *exemplification*, and, dropping the axiom of extensionality, call the result a theory of properties.¹¹

Logical realism: being is univocal (i.e., being is a genus) if predication is based on a relation of:

- (a) membership (set theory), or
- (b) exemplification (in first-order logic), or
- (c) part-to-whole (mereology).

Formal ontology, in other words, for both the nominalist and that kind of realist who takes being to be univocal and who has abstract as well as concrete objects as values of their object variables, i.e., for whom being is a genus, is really no different from an applied theory of first-order logic. That is, it is no different from a first-order logic to which primitive “nonlogical” (descriptive?) constants and axioms are added and taken as describing certain basic ontological notions. In such a framework, it would seem, the dividing line between the logical and the nonlogical, or between pure formal ontology and its applications, has become somewhat blurred, if not entirely arbitrary.

¹⁰Cf. Goodman 1956, p. 17.

¹¹Cf., Bealer 1982.

6 Predication and Preeminent Being

Beginning with Aristotle, the standard assumption in the history of ontology has been that being is not a genus, i.e., that there are different senses of being, and that the principal method of ontology is categorial analysis. This raises the problem of how the different categories of being fit together, and of whether one of the senses or category of being is preeminent and the others somehow dependent on that sense or category of being. The different categorial analyses that have been proposed as a resolution of this problem have all turned in one way or another on a theory of predication, i.e., on how the different categories fit together in the nexus of predication, and they have differed from one another primarily on whether the analysis of the fundamental forms of predication is to be directed upon the structure of reality or the structure of thought. In formal ontology, the resolution of this problem involves the construction of a formal theory of predication.

Aristotle's categorial analysis, for example, is directed upon the structure of the natural world and not upon the structure of thought, and the preeminent mode of being is that of concrete individual things, or primary substances. Aristotle's realism regarding species, genera, and universals is a form of *natural realism*, in other words, and not of logical realism. Also, unlike logical realism, Aristotle's realism is a *moderate realism*, though, as we indicate below, a *modal moderate realism* is better suited to a modern form of Aristotelian essentialism.

Moderate realism = the ontological thesis that universals exist only in rebus, i.e., in things in the world.

Modal moderate realism = the ontological thesis that universals exist only in things that, as a matter of a natural or causal possibility, could exist in nature, even if in fact no such things actually do exist in nature.

Predication is explained in Aristotle's realism in terms of two ontological configurations that together characterize the essence-accident distinction of Aristotelian essentialism. These are the so-called essential predicative nexus between an individual and the species or genera, i.e., the natural kinds, to which it belongs, and the accidental, or nonessential, predicative nexus between an individual and the universals that inhere in it. A formal theory of predication constructed as an Aristotelian formal ontology must respect this distinction between essential and accidental predication, in other words, and it must do so in terms of an adequate representation of the two ontological configurations underlying predication in an Aristotelian ontology.

Aristotle's moderate natural realism with two types of predication:

- Predication of species, genera (natural kinds)
- Predication of properties and relations

As a formal ontology, Aristotelian essentialism must contain a logic of natural kinds. In addition, as a form of moderate realism it must impose the constraint that every natural kind, property or relation is instantiated (i.e., that every natural kind, property or relation exists only *in rebus*). This constraint leads to Aristotle's problem of the fixity of species, according to which members of a species cannot come to be except from earlier members of that species, and that therefore there can be no evolution of new species.

The fixity of species: Members of a species cannot come to be except from earlier members of that species. Therefore, there can be no evolution of new species.

This problem can be resolved, however, in a modified Aristotelian formal ontology of *modal natural realism*, where the modal category of natural necessity and possibility is part of the framework of the formal ontology. On this modified account, instead of requiring that every natural property or relation actually be instantiated at any given time, we require only that such an instantiation be within the realm of natural possibility, a possibility that might arise in time and changing circumstances and not just in other possible worlds. Such a formal ontology, needless to say, will contain a modal logic for natural necessity and possibility, as well as a logic of natural kinds that is to be described in terms of that modal logic.¹² Natural necessity, we will later argue, is a causal modality based on natural kinds and the laws of nature, and as such it is not the same as logical necessity. As modalities, logical necessity and possibility, we will later argue, can be made sense of only in an ontology of *logical atomism*, an ontology in which there are no causal relations and no natural necessity as a causal modality.

Plato's ontology is also directed upon the structure of reality, but the pre-eminent mode of being in this framework is not that of concrete or sensible objects but of the Ideas, or Forms. This leads to the problem of how and in what sense concrete objects participate in Ideas, and also to the problem of how and in what sense Ideas are "things" or abstract objects separate from the concrete objects that participate in them. A Platonist theory of predication in contemporary formal ontology is the basis of logical realism, where it is assumed that a property or relation exists corresponding to each well-formed predicate expression (or open formula) of logical grammar, regardless of whether or not it is even logically possible that such a property or relation have an instance. When applied as a foundation for mathematics (as was Plato's own original intent), logical realism is also called *ontological logicism*. The best-known form of logical realism today is Bertrand Russell's theory of logical types, which Russell developed as a way to avoid his famous paradox of predication (upon which his paradox of membership is based), a paradox not unrelated to Plato's problem of the separate reality of Ideas. Whether and to what extent Russell's theory of logical types can satisfactorily resolve either of Plato's problems and be the

¹²Cf. Cocchiarella 1976 and 1996.

basis of an adequate realist formal ontology is an issue that belongs to what we have called comparative formal ontology.

7 Categorical Analysis and Transcendental Logic

Kant’s categorical analysis, unlike Aristotle’s, is directed upon the structure of thought and experience rather than upon the structure of reality. The categories function on this account to articulate the logical forms of judgments and not as the general causes or grounds of concrete being. There is no preeminent mode of being identified in this analysis, accordingly, other than that of the transcendental subject, whose synthetic unity of apperception is what unifies the categories that are the bases of the different possible judgments that can be made. What categories there are and how they fit together to determine the concept of an object in general is determined through a “transcendental deduction” from Kant’s table of judgments, i.e., from the different possible forms that judgments might have according to Kant. It is for this reason that the logic determined by this kind of categorical analysis is called *transcendental logic*.

The transcendental logic of Husserl in his later work is perhaps one of the best-known versions of this type of approach to formal ontology. According to Husserl, logic, as formal ontology, is a universal theory of science, and as such it is the justifying discipline for science. But even logic itself must be justified, Husserl insists, and it is that justification that is the task of transcendental logic. This means that the grounds of the categorial structures that determine the logical forms of pure logic are to be found in a transcendental subjectivity, and it is to a transcendental critique of such grounds that Husserl turns in his later philosophical work. On the basis of such a critique, for example, Husserl gives subjective versions of the laws and rules of logic, such as the law of contradiction, the principle of excluded middle, and the rules of *modus ponens* and *modus tollens*, claiming that it is only in such subjective versions that there can be found the *a priori* structures of the evidence for the objective versions of those laws and rules.¹³ Husserl also claims on the basis of such grounds that every judgment can be decided¹⁴, and that a “multiplicity,” such as the system of natural numbers, is to be “defined, not by just any formal axiom system, but by a ‘complete’ one”.¹⁵ That is, according to Husserl:

the axiom-system formally defining such a multiplicity is distinguished by the circumstance that any proposition ... that can be constructed, in accordance with the grammar of pure logic, out of the concepts ... occurring in that system is either true—that is to say: an analytic (purely

¹³Husserl 1929, §§75-8.

¹⁴Ibid., §§79-80.

¹⁵Ibid., §31, p. 96.

deducible) consequence of the axioms—or ‘false’—that is to say: an analytic contradiction—; *tertium non datur*.¹⁶

Unfortunately, while such claims for transcendental logic are admirable ideals, they are nevertheless in conflict with certain well-known results of mathematical logic, such as Kurt Gödel’s first incompleteness theorem.

8 The Problem of the Completeness of Formal Ontology

The transcendental approach to categorial analysis, as this last observation indicates, raises the important problem of the completeness of formal ontology. It does this, moreover, not in just one but in at least two ways: first, as the problem of the completeness of the categories; and, second, as the problem of the completeness of the laws of consequence regarding the logical forms generated by those categories.

Two problems of the completeness of formal ontology:

- (a) the completeness of the categories; and
- (b) the completeness of the deductive laws with respect to those categories.

For Aristotle, for whom the categories are the most general “causes” or grounds of concrete being, and for whom categorial analysis is directed upon the structure of reality, the categories and their systematization must be discovered by an *inductive abstraction* and reflection on the structure of reality as it is revealed in the development of scientific knowledge, and therefore the question of the completeness of the categories and of their systematization can never be settled as a matter of *a priori* knowledge. This is true of natural realism in general.

Natural realism: the categories of nature and their laws are not knowable *a priori*.

For Kant and the transcendental approach, however, the categories and the principles that flow from them have an *a priori* validity that is grounded in the understanding and pure reason respectively—or, as on Husserl’s approach, in a transcendental phenomenology—and the question of the “unconditioned completeness” of both is said to be not only practical but also necessary. The difficulty with this position for Kant is that neither the system of categories nor the laws of logic described in terms of those categories can be viewed as providing an adequate system of formal ontology as we have described it above.

¹⁶Ibid.. Cf. also Husserl 1913 §72, pp. 187f.

Kant's description of logic, for example, restricts it to the valid forms of the syllogism (which can in no sense account for the complexity of many intuitively valid arguments of natural language, not to mention the complexity of proofs in mathematics). Husserl, unlike Kant, does not himself attempt to settle the matter of a complete system of categories, nor therefore of a complete system of the laws of logic or formal ontology; but he does maintain that such completeness is not only possible but necessary, and that the results achieved regarding the categories and their systematization must ultimately be grounded on the *a priori* structures of the evidence of a transcendental subjectivity.

Transcendental logic: the categories and their laws are knowable *a priori*.

The transcendental approach in general, in other words, or at least the *a priori* nature of its methodology as originally described, leaves no room for inductive methods or new developments in either logic or categorial analysis, especially in the way both are affected by new results in scientific theory (e.g., the logic of quantum mechanics¹⁷ and the way that logic relates to the logic of macrophysical objects) or in theoretical linguistics, (e.g., universal grammar and the way that grammar is related to the pure logical grammar of a formal ontology), or even in cognitive science (e.g., artificial intelligence and the way that the computational theory of mind is related to the categorial and deductive structure of logic).

Some categorial analyses not knowable *a priori*:

- (1) The logic of quantum mechanics and how that logic relates to the logic of macrophysical objects.
- (2) Theoretical linguistics: is there a universal grammar underlying all natural languages? And, if so, how is that grammar related to the pure logical grammar of a formal ontology?
- (3) Cognitive science and artificial intelligence: are there categories and laws of thought that can be represented in formal ontology? And, if so, how are these categories and laws related to the categories of nature? And can they be simulated (duplicated?) in artificial intelligence?

Despite the difficulties with the problem of completeness of the *a priori* methodology of the transcendental approach, it does not follow that we must give up the view that an analysis of the forms of predication is to be directed primarily upon the structure of thought. There are alternatives other than the transcendental idealism of either Kant or Husserl that such a view might

¹⁷Cf. Putnam 1969 and Dummett 1976.

adopt. Jean Piaget's *genetic epistemology* with its "functional" (as opposed to absolute) *a priori* is such an alternative, for example, and so is Konrad Lorenz's biological Kantianism with its evolutionarily determined (and therefore nontranscendental) *a priori*.¹⁸

Some non-transcendental approaches:

- (a) Jean Piaget's genetic epistemology (a non-absolute "functional" *a priori*).
- (b) Konrad Lorenz's biological Kantianism (an evolutionarily determined *a priori*).

Any version of a naturalized epistemology, in other words, where an *a posteriori* element would be allowed a role in the construction of a formal ontology, might serve as such an alternative; and in fact such a naturalized epistemology is presupposed by conceptual realism, which we will describe in more detail later. The comparison of these alternatives, and a study of their adequacy (as well as of the adequacy of a more complete and perhaps modified account of transcendental apriority) as epistemological grounds for a categorial analysis that is directed upon the structure of thought, are issues that properly belong to comparative formal ontology. The transcendental approach claims to be independent of our status as biologically, culturally, and historically determined beings, and therefore independent of the laws of nature and our evolutionary history.

9 Set-Theoretic Semantics and Formal Ontology

The problem of the completeness of a formal ontology brings up a methodological issue that is important to note here. This is the issue of how different research programs can be carried out in restricted branches or subdomains of a formal ontology without first deciding whether or not the categorial analysis of that formal ontology is to be directed upon the structure of thought or the structure of reality. We do not always have to decide in advance whether or not there must (or even ever can) be a final completeness to the categories or of the laws of logic before undertaking such a research program. In particular, we can try to establish restricted or relative notions of completeness for special areas of a formal ontology, and we can then compare and evaluate those results in the context of comparative formal ontology. The construction of abstract formal systems and model-theoretic semantics within set theory will be especially useful in carrying out and comparing such research programs. In other words, set theory is an ideal framework within which to carry out comparative analyses of different formal systems proposed either as a formal ontology or a subsystem of such.

We must be cautious in our use of set theory, however, and especially in how we apply such well-known mathematical results as Kurt Gödel's incompleteness

¹⁸Cf. Piaget 1972 and Lorenz 1962.

theorems. Gödel’s first incompleteness theorem, for example, does not show, as is commonly claimed, that every second-order predicate logic must be incomplete, where by second-order predicate logic we mean an extension of first-order predicate logic in which quantifiers are allowed to reach into the positions that predicates occupy as well as of the subject or argument positions of those predicates. Rather, what Gödel’s theorem shows is that second-order predicate logic is incomplete with respect to its so-called *standard* set-theoretic semantics. In particular, we must not confuse membership in a set with predication of a concept, property, or relation. Nor should we wrongly identify the logical concept of a class, i.e., the concept of a class as the extension of a concept, property or relation, with the mathematical concept of a set, i.e., a set in the sense of the iterative concept, which is based on Georg Cantor’s power-set theorem that the set of all subsets of any given set always has a greater cardinality than that set. Cantor’s theorem, for example, while essential to the iterative concept of set, will in fact fail in certain special cases of the logical concept of a class—such as, e.g., the universal class, which is the extension of the concept of self-identity. For this reason we should note that

- a representation of concepts by sets in a set-theoretical semantics will not always result in the same logical structure as a representation of those concepts by the classes that are their extensions, and
- an incompleteness theorem based on the one kind of structure need not imply an incompleteness theorem based on the other.¹⁹

We should distinguish accordingly:

- (a) The logical notion of a class (as one or as many) as the extension of (and therefore having its being in) a concept.
- (b) The mathematical iterative notion of a set (which has its being in its members).

A set-theoretical semantics for a formal theory of predication must not be confused, in other words, with a semantics for that theory based on its own forms of predication taken primitively. For the latter is based on the very forms of predication that it is designed to interpret, and it is in that sense *an internal semantics* for that theory, while the set-theoretical semantics, being based on the membership relation of a framework not internal to the theory itself, is *an external semantics* for that theory. This means that in constructing a set-theoretical semantics for a formal theory of predication we must be cautious not to confuse and literally identify the internal content or mode of significance of the forms of predication of that theory with the external model-theoretic content of the membership relation, or (as in the case of a set-theoretic possible-worlds

¹⁹See Cocchiarella 1988 and 1992 for a discussion and example of a framework in which Cantor’s theorem fails.

semantics) with the external content of any function (e.g., on models as set-theoretic representatives of possible worlds) defined in terms of the semantically external membership relation. If we do not confuse predication with membership in this way, then we will be able to see why the incompleteness of second-order predicate logic with respect to its standard set-theoretical semantics need not automatically apply to any formal ontology designed to include second-order logic as part of its formal theory of predication. The careful separation and clarification of these issues is a topic that belongs to the methodology of comparative formal ontology.

Distinguish:

- (a) Predication in a formal theory of predication corresponding to a given theory of universals.
- (b) Membership in a set based on the iterative concept of set.

Gödel's first incompleteness theorem does show that any formal ontology that includes arithmetic as part of its pure formal content must be deductively incomplete; that is, not every well-formed sentence of the pure logical grammar of such a formal ontology will be such that either it or its negation is provable in that formal ontology. This does impose a limitation on what can be deductively achieved in such a formal ontology, and it requires a modification, if not a complete revision, of any categorial analysis, such as Husserl's, where the ideal of deductive completeness even for an "infinite multiplicity" such as the system of natural numbers is taken as an essential part of that analysis.

The deductive incompleteness of an ontology that contains arithmetic is not the same as the incompleteness of the categorial structure of that ontology, in other words, and in particular it does not show that the formal theory of predication that is part of that structure is incomplete. What must be resolved in a formal ontology that is to contain arithmetic as part of its pure formal content is the problem of how the possible completeness of its internal content as a formal theory of predication is to be distinguished from its necessary deductive incompleteness, and how within that pure formal content we are to characterize the content of arithmetic (and perhaps, more generally, all of classical mathematics as well). Finally, in regard to Gödel's second incompleteness theorem what must also be resolved for such a formal ontology is the question of how, and with what sort of significance or content, we are to prove its consistency, since such a proof is not available within that formal ontology itself. Again, these are issues that are to be investigated not so much in a particular formal ontology as in comparative formal ontology.

10 Conceptual Realism

Comparative formal ontology, as our remarks have indicated throughout, is the proper domain of many issues and disputes in metaphysics, epistemology,

and the methodology of the deductive sciences. Just as the construction of a particular formal ontology lends clarity and precision to our informal categorial analyses and serves as a guide to our intuitions, so too comparative formal ontology can be developed so as to provide clear and precise criteria by which to judge the adequacy of a particular system of formal ontology and by which we might be guided in our comparison and evaluation of different proposals for such systems. It is only by constructing and comparing different formal ontologies that we can make a rational decision about which such system we should ourselves ultimately adopt.

I have myself constructed and compared a number of such systems and have come to the conclusion that the framework of conceptual realism is the formal ontology that we should adopt. Unlike the a priori approach of the transcendental method, which claims to be independent of the laws of nature and our evolutionary history, i.e., of our status as biological beings with a culture and history that shapes our language and much of our thought, conceptual realism is framed within the context of a naturalistic epistemology and a naturalistic approach to the relation between language and thought, thought and reality, and our scientific knowledge of the world. The following are some of the features of conceptual realism that we will cover in future lectures.

As a conceptualist theory about the mental acts that underlie reference and predication in language and thought, the categorial analyses of conceptual realism are primarily directed upon the structure of thought.

The categorial analyses of conceptual realism are directed upon the structure of thought.

But what guides us in these analyses is the structure of language as a representational system, and in particular as a representational system that is categorially structured and logically oriented. Our methodology, in other words, is based on a linguistic and logical analysis of our speech and mental acts, and not, e.g., on a phenomenological reduction of those acts.

The realism part of conceptual realism, as we will see, contains both a natural realism and an intensional realism, each of which can be developed as separate subsystems, one containing a modern form of Aristotelian essentialism, and the other containing a modern counterpart of Platonism based on the intensional contents of our speech and mental acts. We call these two subsystems conceptual natural realism and conceptual intensional realism.

The realism of conceptual realism contains two subsystems:

- (1) a conceptual natural realism (as a modern form of Aristotelian essentialism), and
- (2) a conceptual intensional realism (as a modern counterpart of Platonism).

In addition to the categorial analyses that are directed upon our speech and mental acts, conceptual natural realism also contains a categorial analysis that is directed upon the structure of reality, and in particular an analysis in which natural properties and relations are taken as corresponding to some, but not all, of our predicable concepts, and natural kinds are taken as corresponding to some, but not all, of our sortal common-name concepts. Natural kinds are not properties in this framework. The category of natural kinds is the realist analogue of a category of common-name concepts and not of predicable concepts. Common-name concepts are a fundamental part of conceptual realism's theory of reference, just as predicable concepts are a fundamental part of conceptual realism's theory of predication. Proper as well as common names are part of this theory of reference, and together both are described in a separate logic of names as another subsystem of conceptual realism. As we will explain later, S. Leśniewski's ontology, which has also been described as a logic of names, is reducible to our conceptualist logic of names.²⁰

Conceptual intensional realism, as we have developed it, is a logic of nominalized predicates and propositional forms as abstract singular terms, i.e., a logic of the abstract nouns and nominal phrases that we use in describing the intensional contents of our speech and mental acts. The intensional objects that are denoted by these abstract singular terms serve the same purposes in conceptual intensional realism that abstract objects serve in logical realism as a modern form of Platonism. The difference is that, unlike Platonic Forms, the intensional objects of conceptual realism do not exist independently of mind and the natural world, the way they do in logical realism, but are products of the evolution of culture and language, and especially of the institutionalized linguistic practice of nominalization.

The way both forms of realism are contained within the general framework of conceptual realism shows how a modern form of Aristotelian essentialism is compatible with an intensional logic that is a counterpart to a modern form of Platonism.

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²⁰See Cocchiarella 2001 for a proof of this reduction. For a description of Leśniewski's ontology, see Slupecki, 1955.

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