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Foundations of the Formal Sciences

The History of the Concept of
the Formal Sciences

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The History of the Concept of the Formal Sciences

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Foundations of the Formal Sciences IV
 The History of the Concept of the Formal Sciences

Medieval logic as a formal science

A survey

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ABSTRACT. The paper discusses in how far medieval logic can appropriately be characterized as a formal science. In this respect, the special medieval approach to logic as a *scientia sermocinalis* is examined as well as its main doctrines, namely the theories of supposition and of consequences, and the famous characterization of logic as an *ars artium* or *scientia scientiarum*. It is pointed out that medieval logic is not devoted to the setting up of formal systems or any metalogical analysis of formal structures. Logic in the medieval sense of the discipline is necessarily connected with semantical aspects of natural language. Accordingly, we are confronted with a discipline going far beyond the formal structures of discourse. The classification of medieval logic as a formal science is appropriate only under selected perspectives.

Very few topics in the philosophical tradition are as common and well-known as the distinction between form and matter. Form and matter are distinguished not only in contexts of metaphysics and the philosophy of nature, but also in the philosophy of science, especially in matters of scientific classification. The notion of a formal science is widely used for those disciplines whose sentences consist of formally true statements.

Sometimes we speak of formal sciences in contrast either to non-formal sciences, which can be identified with Carnap's "Realwissenschaften"¹ or to natural sciences. One of the most familiar and paradigmatic instances of a

*I thank Angelika Koelzer and Martin Schäfer for helpful comments on this paper.

¹[Car61, p.81], cf. also the notion of "materiale Wissenschaften" in [Lay73, p.461].

formal science besides mathematics is logic. The notion of formal logic is based on the premise that the validity of an argument is a function of its structure or logical form. It is worth asking whether logic during all epochs, in all stages of its doctrinal development, can equally be classified as a formal science. Since medieval logic is still less known than the ancient and modern versions of the discipline – though it makes up the longest continuous epoch within the history of logic – the present paper is devoted to the question of in how far medieval logic can appropriately be characterized as a formal science.

First I will examine how logic was classified and characterized within the range of disciplines by the medieval authors themselves. Then I will go on to examine to what extent medieval logicians in their main conceptions give us explicit or implicit indications of the view that their discipline was concerned with formal topics and aspects. Separate paragraphs will be devoted to formal and material or descriptive constituents of language, to formal and semantical aspects of supposition theory, and to the distinction of formal and material consequences. In a final step I will discuss in which way the most famous characterization of logic in the Middle Ages, namely that of an *ars artium* or *scientia scientiarum*, suggests an understanding of logic as a formal science.

1 The rôle of logic in the Middle Ages

Regarding the rôle of logic within the framework of arts and sciences during the Middle Ages, we have to distinguish two related aspects, one institutional and the other scientific. As to the first aspect, we have to remember that the medieval educational system was based on the seven liberal arts, which were divided into the *trivium*, i.e., three arts of language, and the *quadrivium*, i.e., four mathematical arts. The so-called trivial arts were grammar, rhetoric, and logic, and during a period of several centuries virtually every educated person, at least every university graduate, received a training in these matters, especially in logic. Students in the medieval faculty of arts probably spent more time studying logic than any other discipline. This first – institutional – aspect concerning the rôle of logic is explained by the second – scientific – aspect. The trivial disciplines provided techniques of analysis and a technical vocabulary that permeate philosophical, scientific and theological writings. Logic, as mentioned before, was referred to and was generally regarded as the art of arts and the science of sciences. The increasing cultural dominance of the universities with their obligatory *disputationes* and their hierarchy of examinations on the one hand and the outstanding status of logic on the other were corresponding features of the educational world of the 13th century.

The core of the logic curriculum from the 12th century onwards was provided by the logical works of Aristotle. These represented the material for the study of types of predication, the analysis of simple propositions or statements² and their relations of inference and equivalence, the analysis of modal propositions, of the structure and the types of the syllogism, dialectical topics, fallacies and scientific reasoning as based on the demonstrative syllogism. Medieval logicians, however, realized that there were other, non-Aristotelian, approaches to logical subjects, questions and methods that could be investigated. The new approaches primarily included works on the signification and the supposition of terms – a distinction showing some similarity to the modern distinction between meaning and reference. The theory of signification deals with the capability of descriptive terms to function as signs, i.e., their property of being meaningful. The theory of supposition was concerned with the types of reference that terms in their function as subject and predicate obtain in the context of different propositions. Another emphasis was put on consequences or valid inference forms. These innovations were by no means regarded as an alternative to tradition, but supplemented the Aristotelian *logica antiqua* under the heading of *logica moderna* or *logica modernorum*.

The medieval logicians themselves did not classify their discipline as a *scientia formalis* – to my knowledge the expression was not used in the Middle Ages – but as a *scientia sermocinalis*, i.e., a science of argumentative speech, which was the overarching framework of the trivial arts. The *scientia sermocinalis* itself is one of three types into which science was divided, e.g., by Peter of Spain in his well-known [*Tractatus*, p.29, 14–16]. The differences (*differentiae*) of science, as Peter states, are *naturale*, *morale*, and *sermocinale*, a division which resembles the Stoic division into natural philosophy, ethics, and logic.³ William of Sherwood, another important logician of the 13th century, offers the same scientific differences, but – in contrast to Peter of Spain – as the result of a twofold division:⁴ Since there are two sources (*principia*) of things, nature and the soul, there will accordingly also be two kinds (*genera*) of things. The things whose source or principle is nature are the concern of natural science. The others, whose source or principle is the soul, are again divided into two types. Since according to Sherwood the

²In medieval logic “*propositio*” and “*enuntiatio*” both stand for a sentence signifying something true or false and are mostly used as interchangeable terms. However, using the term “*propositio*” we have to avoid the modern understanding of proposition, or propositional content, as what is asserted or what is expressed by a sentence.

³The *scientiae morales* and *naturales* as the counterpart to the *scientiae sermocinales* were sometimes brought together under the integrating concept of *scientiae reales*; cf. [Scho92, col.1508].

⁴Cf. [Introductiones, p.2, 1–12].

soul is created without virtues or knowledge, it performs certain operations by means of which it attains to the virtues, and these are the concern of ethics or *scientia moralis*. The soul performs different operations by means of which it attains to knowledge, and these are the concern of the science of argumentative speech or *scientia sermocinalis*. At this point we meet the same threefold division of science that occurs in Peter of Spain. It is worth mentioning that the first division regarding the nature of things is metaphysical while the second division regarding the different sorts of things whose source is the soul is epistemological. The sciences whose principle is the human soul are understood as concerning basic human activities or operations, and the specific differences among them are obtained from the goals of these activities, namely virtues on the one hand and science on the other.

The term "*scientia sermocinalis*" which stands for the subtle analysis of ordinary language came into use in the late 12th or early 13th century. The designation of logic as a *scientia sermocinalis* was commonly accepted during the 13th century, but it was not the only one. The term "*logica*" as derived from the Greek "*λόγος*" can mean both "*sermo*" and "*ratio*". Accordingly, logic was regarded either as a *scientia sermocinalis* or as a *scientia rationalis*. The medieval authors offer considerations supporting both titles. While logicians like William of Sherwood and Peter of Spain stressed the feature of logic as a linguistic science as mentioned above, other authors in the 13th century like Robert Kilwardy and St. Bonaventure called it linguistic and rational alike. In the 14th century the notion of logic as a rational science became predominant. An important reason lies in the fact that logic was about second intentions, which were higher-level concepts like "genus", "species", "predicate", etc. We make use of second intentions to classify our concepts or first intentions of things in the world. Second intentions reveal both universals and logical structures and were regarded as mental constructs or rational objects reached through abstraction, which means reflection on general features and relations of things and on actual pieces of discourse.

2 The analysis of the proposition

Since logic in the 13th century is focussed on the syllogism as the predominant mode of argumentation, most manuals like Peter of Spain's *Tractatus* and William of Sherwood's *Introductiones in logicam* provide us with a large and detailed treatment of the proposition as the immediate and constitutive basis of the syllogism. What is Sherwood's way of treating the proposition? There are two different approaches. The first can be identified with the well-known scholastic methodology of *definitio* and *divisio* accord-

ing to which Sherwood's initial explanation of the proposition is followed by a detailed division including different types of non-assertive statements. The second approach is based on an equally well-known epistemological principle presented by Sherwood at the very beginning of his treatise on syncategorematic words: In order to obtain an understanding of something, we are dependent on analysis, i.e., a subdivision into parts or constituents.⁵

In the initial paragraph of his *Syncategoremata*, Sherwood analyzes the proposition by distinguishing between two kinds of parts, namely principal and secondary ones. The principal parts, as Sherwood states, are the substantive (*nomen substantivum*) and the verb, for it is these parts which are necessary for an understanding of the proposition. Secondary parts of the proposition are the adjective, the adverb, conjunctions, and prepositions, because they are not necessary for the existence of a statement.

2.1 Formal or syncategorematic constituents of the proposition

Some secondary parts of the proposition, as Sherwood continues, are determinations of principal parts in respect of the things belonging to them. For example, when I say "*homo albus*" the word "*albus*" signifies that some thing which is a man is white. Other secondary parts are determinations of the principal parts (i.e., noun and verb), insofar as these are subjects or predicates. For example, when I say "*omnis homo currit*" the word "*omnis*", which is a universal sign, does not signify that some thing which is man is universal, but rather that "*homo*" is a universal subject. Secondary parts of this kind are called syncategorematic words. Sherwood inserts an etymological reduction — a mode of explication of a word that is often used by the medieval authors: The name "*syncategorema*", as Sherwood explains, depends on "*sin*" which means "*con*" and "*significative*" or "*predicative*" — as if to say "*conpredicative*", for a syncategorematic word is always joined with something else in discourse.⁶

What we learn from Sherwood is the fact that *syncategoremata* are not any determinations of nouns and verbs or their significates, but determinations concerning nouns and verbs in their function as basic parts of the proposition, i.e., in their logical-syntactical function as subject or predicate. In other words: Quantifying prefixes like "*omnis*" are not regarded as a kind of adjectival determinants of only the term following them, but conceived as operating on the proposition as a whole and thereby exercising some logical function. Subject and predicate of the proposition are usually named integral parts, which comes close to essential parts, and this notion

⁵[*Syncategoremata*, p.48]; revised critical edition with German translation and commentary by Christoph Kann and Raina Kirchhoff is in preparation.

⁶Cf. [*Syncategoremata*]; the term "*syncategorema*" dates back to antique grammar, namely to Priscianus' [*Institutiones*, II 15 (p.54, 5-7)].

is intended to mean that a proposition is made up of them and not of others. In the example "*omnis homo currit*" the syncategorematic term "*omnis*", which itself is a secondary part of the proposition, determines the principal parts of the proposition in their function as subject or predicate. And this is an essential feature of syncategorematic words or of words in their syncategorematic use.

The most suitable way to develop an appropriate understanding of *syncategoremata* is to start with the complementary notion of *categoremata*. Categorematic terms are those which can function in their usual signification as subject or predicate term in a proposition. One of the usual examples given by medieval authors is the proposition "*homo currit*" which is composed of two categorematic terms. The *syncategoremata*, which do not meet the criterion of independent signification, must be connected with (at least) one suitable pair of *categoremata* in order to become an element within a proposition. This can be demonstrated by means of examples like "*omnis homo currit*", "*homo non currit*", or "*homo currit contingenter*". *Syncategoremata* affect the function of signifying of categorematic terms appearing after them in the same proposition. Apart from simple combinations of a single subject with a single predicate, complex or hypothetical propositions (these are synonyms in medieval logic) can be determined by *syncategoremata*, e.g., "*si homo currit, animal currit*" or "*Plato currit, et Socrates currit*". We can roughly distinguish two perspectives which were relevant for medieval approaches to the *syncategoremata*: The first, earlier perspective –predominant during the 12th and 13th centuries– was dedicated to the consignificative function of the *syncategoremata* themselves, while later inquiries, chiefly in the 14th century, were rather focussed on questions concerning the influence of *syncategoremata* on *categoremata* and their contextual reference, especially within *sophismata*.

Medieval logicians tended to extract from the vast number of *syncategoremata* those which are most relevant for logical purposes, disregarding most prepositions, conjunctions and other non-signifying words. Their main subject of interest was the quantitative or distributive signs ("*omnis*", "*uterque*", "*nullus*", "*aliquis*"), exceptive or exclusive signs ("*praeter*", "*solum*", "*tantum*", "*nisi*"), which include negations, affirmative or negative signs like "*est*" and "*non*", modal signs like "*necessario*" and "*contingenter*", the junctors "*si*", "*et*", and "*vel*", and the auxiliary verbs "*incipit*" and "*desinit*". Though medieval logicians mainly deal with syncategorematic words of logical relevance, we should refrain from assuming that *syncategoremata* can simply be identified with logical form or with logical operators, as Bocheński [Boc61, p.156f], Moody [Moo53, p.16-18], and Pinborg [Pin72, p.60f] do. On the other hand, the fact that not all *syncate-*

goremata are logical operators should not be criticized as an insurmountable deficiency of the theory, as Patzig [Pat81, p.13] does. Such criticism ignores the original intentions of the doctrine which has its roots in grammar and its genuine application in semantics. Or, to put it another way, the distinction of *categoremata* and *syncategoremata* was not intended to isolate formal elements of discourse in order to establish a formal science, but to provide us in a first stage with grammatical and in a second stage with semantical distinctions in an overarching science of discourse or of normal language.

2.2 Material or descriptive constituents of the proposition

The distinction of significant and non-significant parts of the proposition is closely connected to the medieval doctrine of the matter of statements (*materia enuntiationis*). This doctrine dates back at least to the 11th century⁷ and it can frequently be found in logic textbooks of the 12th, 13th and 14th centuries, e.g., in Abaelard, Peter of Spain, William of Sherwood and Albert of Saxony. What does it actually mean when we speak of the matter of a statement or a proposition, and how can this matter be relevant for logic under the aspect of a formal science? The matter of propositions is constituted by the subject and the predicate, that is by the semantic relationship of the terms that function as subject and predicate in a proposition. Three kinds of matter of the proposition are distinguished, natural, contingent, and separate.⁸ We speak of natural matter when the subject receives the predicate by its very nature, as in "*homo est animal*", since it belongs to man's nature to be an animal. The matter is contingent if the subject receives the predicate contingently, as in "*homo currit*", since it is contingent whether a man is running or not. Finally, the matter is separate if the predicate is naturally separated from the subject, as in "*homo est asinus*", since man as an *animal rationale mortale* is essentially excepted from being a donkey.

The main divisions of the proposition in medieval logic –namely the qualitative and quantitative divisions, the divisions into assertoric and modal statements, into *enuntiatio categorica* and *hypothetica*, and into *enuntiatio una* and *plures*– reflect the proposition's syntactical or formal structure. The reason is that medieval logic manuals –at least in the 13th and 14th centuries– follow the Aristotelian framework, according to which the main subject of logic is the syllogism. In order to analyze the syllogism, we have to go back to its immediate constituent, the proposition, and then to the proposition's immediate constituents, which at the same time are the ultimate meaningful constituents, namely the single words. Since therefore

⁷ Cf. [Dialectica, p.54, 20-55, 32].

⁸ Cf. [Introductiones, p.20, 256-22, 270; 234, n. 31]; cf. also [Jac80, p.61-64].

the treatment of the proposition can be subsumed under the treatment of the syllogism, the proposition will mainly be distinguished and treated under formal aspects. The main reason for studying the syllogism is to learn to set up valid demonstrations, which are necessarily in syllogistic form. But, of course, the defining properties of a demonstration go beyond formal considerations. The further specifications of a syllogistic demonstration concern its matter, *i.e.*, the nature of the premises or the propositions respectively. The distinction of the matter of the proposition, however, is obviously concerned with semantic features. Nevertheless, the treatment of the propositional matter within the framework of syllogistics and its constituents makes good sense insofar as it is of a certain relevance to the proposition's quantity. Since propositions in natural and in separate matter are always valid universally, particular propositions in a proper sense can only occur in contingent matter. Thus the matter of statements – a semantic category – has influence on their mutual quantitative relations – a formal aspect –, as becomes evident in Sherwood's explanations. Sherwood stresses the fact that whenever a particular statement is true in natural matter – *e.g.*, “*aliquis homo est animal*” – its subcontrary cannot be true (against the rule that subcontraries can be true at the same time), because whatever is affirmed of one particular in a proposition in natural matter has to be affirmed of all particulars. Similarly, as Sherwood adds, whatever is separated from or negated of one particular in separate matter is separated from or negated of all. When, for instance, the proposition “*aliquis homo non est asinus*” is true, its subcontrary “*aliquis homo est asinus*” cannot be true, violating the rule of subcontraries by virtue of the essential separation of “*homo*” and “*asinus*”. To sum up, in natural matter and in separate matter, according to Sherwood, a particular proposition interchanges with (*convertitur cum*) a universal one. Therefore, subcontraries in these two matters cannot be true at the same time, and, furthermore, the truth of the particular subalternate entails (*infert*) the truth of the universal subalternant. These truths are not – as Sherwood concludes – dependent on the nature of the particular proposition, that is on its formal feature, but on the nature of its matter.

3 The theory of supposition

In contrast to the above-mentioned syncategorematic words, such as the copula, quantifiers and so on, the descriptive or categorematic signs, which function as subject or predicate in a proposition, were called terms (*termini*). The medieval treatises on the properties of terms (*proprietales terminorum*) rest upon an initial distinction: A term's property of being meaningful on its own or of having a prepropositional reference is called its

signification (*significatio*). This property belongs to categorematic words by virtue of their capability to serve as language signs. On the other hand, the property of supposition (*suppositio*) is acquired by an already meaningful term when it functions as subject or predicate of a proposition. Supposition theory was used to describe what a categorematic term in its function as subject or predicate of a proposition means in a particular context, and it could serve to test inferences or diagnose fallacies. When medieval logicians claimed a statement *de virtute sermonis* or literally to be false, they maintained that the theory of supposition enables us to analyze the statement's true meaning, which may be covered up by misleading grammatical features. The supposition of a term was defined by William of Ockham (and others) as a term's standing for something else in a proposition in such a way that the term is truly predicated of that thing (or of a pronoun pointing to the thing).⁹ On the basis of definitions like this, some authors constructed a theory of truth-conditions for categorical sentences. For instance, a universal affirmative proposition was considered to be true if and only if its predicate supposits for everything for which the subject supposits. Other cases were handled analogously. In general, the theory of supposition was used for two remarkably different purposes. On the one hand it served as a tool for semantic distinctions, on the other hand it constituted a kind of theory of quantification.

3.1 Supposition and semantic analysis

Roughly speaking, the semantical distinctions run as follows: If we take the proposition “*homo est animal*”, the term “*homo*” stands for (*supponit pro*) its normal referents, as when “*homo*” is taken for individual human beings like Socrates, Plato and so on. In this case, “*homo*” has personal supposition (*suppositio personalis*). In contrast, in the proposition “*homo est disyllabum*”, the term “*homo*” does not stand for what it usually signifies, namely men, but for the word “*homo*” itself and has material supposition (*suppositio materialis*). A third case is represented by the proposition “*homo est species*”, where the word “*homo*” stands neither for its significates nor for the word itself or for the design of the word, but for the universal or for the concept expressed by it and has simple supposition (*suppositio simplex*). Simple supposition was a highly controversial issue, as we can infer from the disputed status of the universals or concepts themselves.

Medieval authors often started with a division of proper and improper supposition in order to distinguish the genuine uses of a term from, *e.g.*, its metaphorical use. The subsequent division of proper supposition into personal, material, and simple supposition represents the three basic types

⁹ Cf. [Summa Logicae, p.193, 11-14].

of contextual reference. Nevertheless, authors like Walter Burleigh do not start with the threefold distinction of personal, material, and simple supposition, but with the twofold distinction of a *suppositio materialis* and a *suppositio formalis* and divide the latter into *suppositio personalis* and *suppositio simplex* in a second step. The idea underlying this version is to distinguish the material supposition as a nonsignificative use of a term from two significative uses under the heading of formal supposition, namely one for concrete significates in the sense of, e.g., single human beings and the other for a general form or universal nature. Obviously, this position corresponds to a realistic assumption according to which a universal nature can be regarded as a significate of the general term "*homo*". The position mentioned first, however, which assumes personal supposition – the standing for individual objects in the physical world – as the only significative use of a term represents a nominalistic position.

Though material supposition shows affinities to 20th-century quotation devices, it cannot be identified entirely with the modern notion of the mention of a word in contrast to its use. The idea of mentioning a word usually indicated by quotation marks is closely connected to the assumption that by quotation marks a new term ("*homo*") with quotation marks is generated in order to refer to the original term (*homo*) without quotation marks. While the modern approach is based on the distinction of two different language signs, one of which is introduced to refer to the other, the medieval theory of supposition is based on the quite different idea of assuming different modes of use (*acceptio sive usus*) of one and the same term, and one of these modes is the material use (cf. [Kan95]).

To sum up, the distinction of personal, material, and simple supposition represents a semantic approach aiming to point out the different types of contextual reference of subject terms which depends on the predicate terms they are conjoined with. The theory of supposition, however, provides us with a different approach to questions of contextual reference, which is regarded as syntactical rather than semantical and which at first glance fits in much better with the features of logic as a formal science.

3.2 Supposition and syntactic analysis

Within the analysis of propositions whose general terms stand in personal supposition or are used significatively for a term's singular referents, the theory of supposition provided a tool for distinctions nowadays treated by quantification theory (cf. [Wei79]). Basically three modes of personal supposition were distinguished, (1) determinate, (2) confused and distributive, and (3) purely confused supposition. These modes were analyzed and explained by means of the descent (*descensus*) to singulars.

(1) A term stands in determinate supposition (*suppositio determinata*) when it is conjoined with the existential quantifier "some" or "*aliquis*" as in the proposition "*aliquis homo currit*". Here the term "*homo*" stands or supposits for all its single referents, so that one can infer a disjunctive set of singular propositions. The subject terms name all of the individuals for which the general term stands, and the respective predicate terms are identical with that of the particular proposition. Therefore, assuming that the only men are Socrates, Plato and Cicero, it follows that if some man is white, Socrates is white or Plato is white or Cicero is white.

(2) When a term in a general proposition is combined with a universal quantifier, e.g., in the proposition "*omnis homo currit*", "*homo*" has confused and distributive supposition (*suppositio confusa et distributiva*). This kind of supposition given by the universal quantifier to the term immediately following it means that the term stands for all its individual instances in such a way that the descent to singular propositions yields a conjunction of propositions. Thus from our example "*omnis homo currit*" we may infer the conjunction "*Sortes currit, et Plato currit, et Cicero currit*".

(3) A third type of personal supposition is the merely confused supposition (*suppositio confusa tantum*) which occurs when the predicate term of a universal affirmative proposition stands for all its individual referents. Here the reduction to singulars is effected not by a disjunction or conjunction of singular propositions but rather by a proposition with a disjoint predicate. So, if we take the supposition of "*animal*" in our example "*omnis homo est animal*", we may infer that every man is this animal or that animal or that other animal. In contrast, it does not follow that every man is this animal, or every man is that animal, and so on.

The second mode, i.e., confused and distributive supposition, is called mobile if one is entitled to carry out the descent to singulars as in the example "*omnis homo currit*". Otherwise, confused and distributive supposition is immobile, as for instance in the proposition "*omnis homo praeter Socratem currit*". Due to the phrase "*praeter Socratem*" the descent in this case is possible only in a deficient or restricted manner.

The main point about the merely confused supposition lies in the fact that it implies recognition of the problem of multiple quantification and of the extension of the scope of one quantifier to include another. Medieval logicians obviously refrained from using quantifying prefixes like "*omnis*", "*nullus*", and "*aliquis*" as a kind of adjectival determinants of exclusively the term following them, but – as already pointed out in the context of syncategorematic words – regarded them as also operating on the supposition of both terms combined in a proposition. For example, the case was considered in which every man is looking at himself, but at no other man. Here

from the true proposition "every man is looking at a man" (*omnis homo videt hominem*) we cannot infer the proposition "there is a man that every man is looking at", although the converse implication would be valid: From the proposition that "there is a man that every man is looking at" we can infer the proposition "every man is looking at a man". This gives rise to the theory of ascent (*ascensus*) as the procedure corresponding to descent, which leads medieval authors to subtle questions concerning the equivalence of the propositions underlying the descent and those resulting from it (cf. [Spa88]). Another subject of interest is the question whether there are just these three modes of descent presented here, or whether other modes should be assumed, especially that of a proposition with a conjunct predicate — a mode which was introduced and discussed by several logicians in the 14th century as a *descensus conditionatim* (cf. [Rea91]). I have to leave these particular difficulties aside here, since my present intention is of a more general kind.

The fact that supposition theory on the first level of division is a tool to analyze significative and nonsignificative uses of terms and on the second level, namely that of descent to singulars, is a theory to analyze quantification resulted in the view that supposition theory is more adequately viewed as two separate theories (cf. [Sco66, p.30]). Under the overarching perspective of contextual reference, however, there are good reasons to regard supposition theory as a unified theory, integrating semantic and syntactic aspects and at the same time formal and non-formal aspects of language. With regard to logic as a formal science we have to emphasize that supposition of terms in general was investigated as occurring in natural discourse, and no artificial language adapted to the uses of logic was constructed. Altogether, there was no fixed system, but rather an open-ended set of rules governing the different types of supposition in order to handle all casual and special instances of contextual reference.

4 The theory of consequences

In medieval logic, complex propositions composed of two or more categorical propositions joined by any sentential connective were called hypothetical. According to a customary etymological explanation a hypothetical statement is a complex statement in which one proposition in the literal sense of "*hypo*" and "*thesis*" is "put under" another. Hypothetic statements in this broad sense were classified, depending on the connective involved, as copulative, i.e., conjunctive, disjunctive, conditional, causal, temporal, and local. In each case, the function of the connective was usually defined by stating truth rules. The truth-value of these hypothetical statements is a function of the truth-values of the categorical propositions of which the hypothetical

statement is composed. Accordingly, the conditional form, which is essential for the present context, could clearly be distinguished from other types of connections by only formally syntactic criteria, i.e., the content or matter of the propositions being joined were not taken into account. Thus, the conjunctive was said to be true if and only if both component propositions were true, and the disjunctive was said to be true, if one of its components was true. A valid conditional or inference, which is the medieval *enuntiatio hypothetica* in the strict sense, was called a *consequentia* and its components were distinguished as *antecedens* and *consequens*.¹⁰ As far as truth conditions are concerned, Sherwood said that for the truth of the conditional statement it was not required that its parts be true, but only that whenever (*cum*) the antecedent was true the consequent was true.¹¹ Peter of Spain claimed that the antecedent could not be true without the consequent, adding that every true conditional was necessary and every false conditional impossible.¹²

The notion of *consequentia* was already discussed in the context of conditional statements in the 11th century. However, it was not until the 14th century that consequences became the subject of separate treatises called *De consequentiis*, which provide a concise formulation of the rules governing the validity of a conditional argument. It has been presumed that the inquiry of consequences grew out of the study of dialectical or topical arguments, but the point is still controversial. Unlike modern logicians medieval authors seem to have paid only little attention to the distinction between consequences as rules of inference, as conditional statements, or as arguments which may be valid or invalid.

Throughout the 14th century consequences were divided into two main classes, formal and material. A consequence was usually called formal if it was valid on account of the logical form of the component sentences, or under all transformations of the categorematic terms, i.e., the matter or content of the propositions. In formal consequences, as authors like Ralph Strode or Robert Fland explain, the consequent is understood in the antecedent formally.¹³ In contrast, a materially valid consequence was defined as one which does not hold for all terms arranged in the same way, i.e., not on formal grounds alone, and here the validity is dependent on the subject and predicate terms involved, as in the proposition "*si homo currit, animal currit*". We have to point out, however, that there was another approach to the notion of a material consequence, since there were authors like

¹⁰For the theory of consequences cf. [Jac93, p.101-259]; cf. also [Sch188].

¹¹Cf. [Introductiones, p.22, 285-287].

¹²Cf. [Tractatus, p.9, 15-18].

¹³For a criticism of this psychological or epistemic account of consequences, cf. [Boh01], especially p.154-158.

William of Ockham who maintained that a material consequence involved the independence of antecedent and consequent. According to this position there finally remained just two instances of the material consequence, namely the two paradoxes of strict implication, *i.e.*, that anything follows from an impossible proposition (*ex impossibile quodlibet*) and that a necessary proposition follows from anything (*ex quolibet sequitur necessarium*). At the same time, these authors concentrated on the area of inferences in which *antecedens* and *consequens* are semantically related to each other, so that the antecedent actually indicates a sufficient condition for the truth of the consequent, while *vice versa* the consequent is dependent upon the antecedent. In Ockham's view and in contrast to the modern approach to the subject, the main interest is in formal inferences which—in this challenging use of the term—rest upon semantic reasons for validity.

In the 14th century the theory of consequences tended to replace syllogistics as the central and paradigmatic form of argumentation. Authors like John Buridan, Albert of Saxony, and Paul of Venice regarded the syllogism as just one among different types of consequences and incorporated syllogistics in their comprehensive treatises on *consequentiae*. These treatises contain a mixture of quite different types of rules. Some rules are of general kind, *e.g.*, "if *A* is the antecedent of *B*, and *B* is the antecedent of *C*, then *A* is the antecedent of *C*". Other rules are propositional and truth-functional, *e.g.*, "since a conjunction is true if and only if its conjuncts are true, from '*A* and *B*' we may infer *A*". Moreover, *modus ponens*, *modus tollens* and De Morgan's laws are given. Medieval philosophers did not present any kind of systematization of consequential rules, but mere collections with respect to paradigmatic difficulties in disputational practice. Just like supposition theory, the theory of consequences also reveals a certain interest in formal and material aspects of argumentation alike.

5 *Dialectica est ars artium*: Logic and its special status

During the Middle Ages until early modern times logic was characterized as *ars artium* or, as was sometimes added, *scientia scientiarum*. This formula which ascribes a special status to logic with regard to other disciplines, seems to go back to Augustine [Ord., X.III, 38], who had characterized logic as *disciplina disciplinarum*. The formula was not only often repeated in the medieval logical tradition, especially in the initial paragraphs of logic treatises and compendia, but also caused numerous and valuable reflections or comments. A prominent instance in the 14th century is the Buridan-commentator John Dorp who—after reflecting on logic as *ars* and *scientia*, as *scientia speculativa* and *practica*, and as *logica utens* and *docens*—starts

his detailed interpretation of the *ars artium* formula by a reflection on the genitive case of the word "*artium*".¹⁴ According to Dorp, the construction "*ars artium*" ascribes to logic a certain exceeding (*excessus*) in comparison with all other disciplines, which should not be understood as an exceeding in the sense of highest perfection but in the sense of highest generality. Generality again can be understood in a twofold manner, namely as generality of perspectives on the one hand and as generality of application or use on the other. John Dorp sees the special status of logic in this generality of application, and he regards logic as a universal tool for other disciplines. This picture of logic as an instrument of scientific inquiry started to gain widespread popularity after the recovery of Aristotle's *Analytica posteriora* in the early 13th century. Dorp's further reflections concern two commonly used additions to the *ars artium*-formula, namely "*et scientia scientiarum*" and "*ad omnium methodorum principia viam habens*", which both also occur in Peter of Spain.

Dorp's question, whether the *ars artium*-formula was incomplete without the addition "*et scientia scientiarum*" or not, can be answered by means of a distinction in the notion of science itself: If "*scientia*" is understood in a broad and unspecific sense, it is almost synonymous with "*ars*", and consequently the addition in question is redundant. If, however, "*scientia*" is used in the narrow sense of a *habitus speculativus*, the addition would be mistaken since the notions of art and science in their strict meanings cannot tally with the notion of logic at the same time. Therefore, in the present context "science" is taken in its broad sense. Though the addition of "*et scientia scientiarum*" assuming "*scientia*" in the broad sense is scarcely needed, it does not seem redundant either, since according to Dorp it is suitable to stress the prominent position of logic.

The second additional clause to the formula, namely the phrase "*ad omnium methodorum principia viam habens*", emphasizes the Aristotelian characterization of logic as an *organon* or tool concerning all disciplines. I will disregard Dorp's manifold explanations of the assumption that every science bases the construction of argumentation on the genuine principles of that science and at the same time owes these principles to logic. Rather I will focus on one remark made by Dorp in discussing the question whether or not the further addition "*aliarum a se*" should be added to our formula. By means of this addition some authors want to exclude logic itself from those sciences that logic paves the way for. If the addition "*aliarum a se*" was apt, it would be necessary to name some discipline apart from logic for which could be claimed *vice versa* that logic owes its principles to it or that it paves the way for logic. Since, however, such a discipline does

¹⁴[Compendium, Tract. I, Diffinitio logicae]. Cf. [Kan94, p.338-340].

not exist, Dorp concludes that the phrase "*aliarum a se*" is not redundant but rather mistaken. As a result, logic must be subsumed under those disciplines to which it lends the way and the principles. Finally the special status ascribed to logic rests on its feature of universal application in the field of arts and sciences. The fact that logic obtains this function and is able to provide us with an interdisciplinary instrument of argumentation rests upon its abstractive character, *i.e.*, the fact that it is not restricted to any individual subject matter. It is worth asking whether logic could be regarded as a formal science just in this respect of extreme abstraction from content or in the respect that logic represents an indispensable tool in quite different doctrinal areas.

6 Concluding remarks

If we understand logic as a formal science, we focus on restricted aspects of language or discourse. In this case, as Strawson puts it, logic is the study of the "general forms of the proposition" and of "certain relations of dependence or independence [between propositions] as regards truth value" [Str92, p.36]. Moreover, for Read, logic is formal

when it uses schematic letters to identify the formal structure of arguments, leaving only the logical expressions ('logical constants' as they are often called) in place. [Rea95, p.61]

In the Middle Ages, however, we are confronted with a remarkably different understanding and use of logic, since medieval logic not only analyzes the complex syntax and semantics of the natural language usually without the help of symbolic techniques, but also includes general questions which are nowadays subsumed under the heading of philosophy of language.

Moreover, logic –like the *scientiae sermocinales* in general– in the Middle Ages is understood as a methodological discipline. A generally accepted view was that logic is about discriminating the true from the false by means of arguing. Its aim is not to analyze the nature of things, but to reflect upon operations by means of which the human soul attains to knowledge. The operation leading to science is language in its specific form of inferential or concluding discourse. Logic, grammar, and rhetorics are intended and understood as reflexive disciplines concerned with the analysis of discourse. This analysis is not merely descriptive. Since the aim of the *trivium* is teaching to speak correctly, elegantly and truly, the *scientiae sermocinales* are critical and normative as well. Furthermore, by reflecting on operations leading to knowledge, logic had a clear-cut cognitive orientation in terms of finding the truth and of proceeding from the already known to the yet unknown.

Though according to Boehner the theories of supposition and of consequences reveal a "perfect sense for the formality of logic" [Boe63, p.315], medieval logic is in no way devoted to the setting up of formal systems or any metalogical analysis of formal structures. And its concern is by no means restricted to the syntactical reconstruction of the formal elements of discourse. We cannot speak of any kind of priority either. Logic in the medieval sense of the discipline is necessarily connected with semantical aspects of basic relevance. It is assumed that one can work within natural language, or some purified version of it. The semantics of natural language is always the basis for establishing any logical principles, and a deductive system of a purely syntactic nature simply is never intended, perhaps chiefly because an artificially constructed logical language, in which the syntax can be specified independently of semantics, is never envisioned. The fact that medieval philosophers used to accept the concept of logic as an overarching discipline of discourse was a predominant reason for integrating syntactical with semantical approaches and for regarding this discipline as a key to all other sciences.

The initial question of in how far medieval logic can be regarded as a formal science after all cannot be answered in an unambiguous and definitive way, but requires weighing the pros and cons.¹⁵ Since logic during the Middle Ages is centred around Aristotelian syllogistics and the syllogism itself was traditionally characterized by means of its formal validity, medieval logic appears as a formal science. But when we take a look at the 14th century, syllogistics are integrated into an overarching doctrine of inferences, among which the syllogistic or formally valid inference was just one type of argumentation among others, since there were also topical inferences or material consequences holding in virtue of some extrinsic feature, such as the meanings of their terms. Furthermore, the medieval theory of fallacies concerns different types of deceptive arguments or illegitimate inferences, and thus its subject matter is not purely formal. Actually, we are confronted with a discipline going far beyond the formal structures of discourse. Therefore I do not agree with Boehner who maintains that to "speak of 'formal logic' is, in scholastic terminology, a *nugatio* or tautology" and that "medieval logic is interested only in the formality or structure of discourse" [Boe52, p.xvi]. And I do not agree with Moody who regards medieval logic as a science that is restricted to the aim of formalizing the usage of language and that intends to formulate the logical syntax for scientific discourse.¹⁶ As a discipline of disputational practice medieval logic was rather concerned with features that in our times Ryle treated under

¹⁵ Cf. [Nis52], especially p.108.

¹⁶ Cf. [Moo53, p.10-16 *et passim*].

the heading of "informal logic" — an area in which the standards of formal logic, "the ideals of systematization and rigorous proof", are not at work [Ryl56, p.111]. Accordingly the idea that logic in the Middle Ages was exclusively understood as a discipline concerned with formal validity was rejected by King [Kin01]¹⁷. Formal validity, as King emphasizes, was taken just as one specific kind of validity, while medieval logicians considered validity in general. Though medieval logic partially is formal (admittedly without being formalized), it nevertheless reveals informal or, as King [Kin01, p.135] prefers to say, "nonformal" features.

When we ask what the formal sciences are and how they have been perceived through history, we have to note that we make use of a scientific classification that did not prevail in the Middle Ages. During the Middle Ages logic neither employs its own esoteric language nor was it exclusively concerned with formal features of discourse. For the reasons given here, medieval logicians themselves would have refrained from regarding their discipline as a formal science as understood nowadays. In modern logic questions of syntax and semantics as well as constructions of formal systems and the inquiry of their interpretability are strictly distinguished, while in medieval logic syntactic and semantic questions are closely related to each other. When the study of logic is stimulated by the question of the foundation of arithmetic — a classic topic that gave rise to formal logic in its modern version — different intentions are in operation as compared with those that lead to a *scientia sermocinalis*. Medieval logicians are concerned with questions of the logical form of argumentation within natural language as it is used in philosophical and theological matters. Nevertheless, it makes good sense to treat medieval logic under the heading of formal sciences and their historical development, since it is part of the history of a discipline which in its predominant features and intentions is nowadays generally accepted as a formal science.¹⁸ To sum up, the classification of medieval logic as a formal science is appropriate only under selected perspectives. The distinction of formal and non-formal does not fit in too well with the medieval view of the sciences. The notion of a *scientia sermocinalis* (or *scientia rationalis*) which obtained the status of a most general tool transcending the individual subjects and questions of the particular disciplines fits in much better with the central features of medieval logic outlined here.

¹⁷Especially p.135sq.

¹⁸For the difference between formal logic and theory of logical form, cf. [Per84a], especially p.17: "A formal logic codifies the possible forms of rational discourse as such. A theory of logical form examines the structures inherent in a given language used by ordinary persons in a particular time and place. A formal logic is normally developed as a formal system with axioms, theorems and rules for the manipulation of uninterpreted signs. A theory of logical form need not be presented as a formal system."

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