History of Logic from Aristotle to Gödel

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Selected Bibliography on The Rise of Contemporary Logic from Boole to Gödel

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6. ———. 1994. *Logic and Its History in the Work and Writings of Jean Van Heijenoort*. Ames: Modern Logic Publishing.
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   "By 'Modern Logic' (abridged as 'ML') the class of studies is meant which were originated by Leibniz, developed, among others, by Boole, Peirce, Frege, Peano, Lesniewski and their followers; in other term the class of studies listed in Alonzo Church's Bibliography and in *The Journal of Symbolic Logic.*
   The expression 'ML' is sometimes used, it is true, in other ways, e.g. to denote studies in Hegelian dialectics. Those uses are irrelevant for the sake of the present paper which will be exclusively concerned with ML as described above. It may be only said, that no other known sort of contemporary logic can compare with the latter as far as standards of procedures and quality of results are concerned.
   The aim of the paper is to describe - as the title selected by the organizers of the conference indicates - the general sense and character of ML thus understood. In other terms an attempt will be made to find the fundamental characteristics of ML-al studies.
   The method used will be comparative. We are going to ask: How does ML compare with three fields with which it is usually linked: logic, mathematics and philosophy? Is ML Logic and, if so, how does it differ from other types of logic? Is it a mathematical discipline and, if that is the case, what is the difference between it and other mathematical sciences? Is it philosophy and, this being admitted, what is its place among the other philosophical disciplines?
   The present paper will be mostly concerned with the first class of problems, the comparison between ML and the other types of logic; the other two classes of problems will be treated only marginally. As far as the main problems are concerned, the method will necessarily be historical: for, contrary to mathematics and philosophy, all other forms of logic with which ML may be compared belong to the past." p. 3
8. Brady, Geraldine. 2000. *From Peirce to Skolem. A Neglected Chapter in the History of Logic*. Amsterdam: Elsevier.
   Contents: Introduction 1; 1. The early work of Charles S. Peirce 9; 2. Peirce's calculus of relatives: 1870 23; 3, Peirce on the algebra of logic: 1880 51; 4. Mitchell on a new algebra of logic: 1883 75; 5. Peirce on the algebra of relatives: 1883 95; 6. Peirce's logic of quantifiers: 1885 111; 7. Schröder's calculus of relatives 143; 8. Löwenheim's contribution 169, 9. Skolem's recasting 197; Appendices. 1. Schröder's Lecture I 207; 2. Schröder's Lecture II 223; 3. Schröder's Lecture III 251; 4. Schröder's Lecture V 257; 5. Schröder's Lecture IX 295; 6. Schröder's Lecture XI 339; 7. Schröder's Lecture XII 379; 8. Norbert Wiener's Thesis 429; Bibliography 445; Index 461-468.
   "This book is an account of the important influence on the development of mathematical logic of Charles

S. Peirce and his student O. H. Mitchell, through the work of Ernst Schröder, Leopold Löwenheim, and Thoralf Skolem. As far as we know, this book is the first work delineating this line of influence on modern mathematical logic.
Modern model theory began with the seminal papers of Löwenheim (1915) "On possibilities in the calculus of relatives" and Skolem (1923) "Some remarks on axiomatized set theory". They showed that in first-order logic, if a statement has an infinite model, it also has a model with countable domain. They observed that second-order logic fails to have this property; witness the axioms for the real number field. Their papers focused the attention of a growing number of logicians, starting with Kurt Gödel and Jacques Herbrand, on models of first-order theories.(1) This became the main preoccupation of model theory and a large component of mathematical logic as it developed over the rest of the twentieth century. In addition, the work of Herbrand, based on the notion of Skolem function, became, through J. Alan Robinson, the main basis of systems of automated reasoning.
A careful examination of the contributions of Peirce, Mitchell, Schröder, and Löwenheim sheds light on several questions: How did first-order logic as we know it develop? What are the real contributions of Peirce, Mitchell and Schroder, over and above the better known contributions of Gottlob Frege, Bertrand Russell, and David Hilbert?
As a result of this investigation we conclude that, absent new historical evidence, Lowenheim's and Skolem's work on what is now known as the downward Lowenheim-Skolem theorem developed directly from Schroder's *Algebra der Logik*, which was itself an avowed elaboration of the work of the American logician Charles S. Peirce and his student O. H. Mitchell. We have been unable to detect any direct influence of Frege, Russell, or Hilbert on the development of Löwenheim and Skolem's seminal work, contrary to the commonly held perception. This, in spite of the fact that Frege has undisputed priority for the discovery and formulation of first-order logic.
This raises yet other intriguing questions. Why were the contributions of Peirce and Schröder neglected by later authors? Was it because Peirce published in American journals that were not easily available to Europeans? Was it because Schröder had a verbose and sometimes obscure style as a writer? Was it because the logical notations used by Peirce and Schröder were simply less readable than those of Frege? After reading this book, the reader should be able to form his or her own opinions." pp. 1-2
(1) We do not discuss here the Frege-Russell-Hilbert tradition leading to first-order logic and Gödel, since this development has many excellent treatments in the literature already, such as the beautiful book of the late Jean van Heijenoort, *From Frege to Gödel*. Van Hejenoort's book treats Frege, Löwenheim, and Skolem, but does not cover either Peirce's or Schröder's work, which led to Löwenheim's paper. This omission is also present in the historical papers of other otherwise very well-read logicians. There are masterful accounts of the seminal papers of Löwenheim and Skolem in the late Burton Dreben's introduction to Gödel's thesis in *Collected Works of Kurt Gödel* and in the late Hao Wang's introduction to Skolem's *Selected Works in Logic*. But Peirce and Schröder get no attention.

9. Church, Alonzo. 1951. "A Formulation of the Logic of Sense and Denotation." In *Structure Method and Meaning. Essays in Honor of Henry M. Sheffer*, edited by Henle, Paul, Kallen, Horace M. and Langer, Susanne K., 3-34. New York: Liberal Arts Press.
"The intensional aspects of Frege's logical doctrine, and his distinction between the sense (*Sinn*) and the denotation (*Bedeutung*) of a name, were explained by him informally in his paper, *Uber Sinn und Bedeutung*, (1) and in incidental passages in a number of his other publications, including the first volume of his book, *Grundgesetze der Arithmetik* (Jena, 1893). In his more formal work, Frege's formalized language (*Begriffsschrift*, or *Formelsprache*) has an entirely extensional interpretation, and it may even be that his interest in intensional logic was primarily to clear up certain difficulties regarding its relationship to extensional logic, (2) so as to be able to proceed with development of the latter unhampered. Nevertheless, it seems that Frege would agree that intensional logic also must ultimately receive treatment by the logistic method. And it is the purpose of this paper to make a tentative beginning toward such a treatment, along the lines of Frege's doctrine.
While we preserve what we believe to be the important features of the theory of Frege, we do make certain changes to which he would probably not agree. One of these is the introduction of the simple theory of types as a means of avoiding the logical antinomies. Another is the abandonment of Frege's notion of a function (including propositional functions) as something *ungesattigt*, in favor of a notion according to which the name of a function may be treated in the same manner as any other name, provided that distinctions of type are observed. (But it is even possible that Frege might accept this latter change, on the basis of an understanding that what we call a function is the same thing which he calls *Werthverlauf einer Funktion.*)" pp. 3-4
(1) In *Zeitschrift fur Philosophie und philosophische Kritik*, (1892), 25-50. See English translations of this paper by Black, in *The Philosophical Review*, LVII (1948), 207-230, and by Feigl, in *Readings in Philosophical Analysis* (New York, 1949); and also a discussion of Frege's doctrines by Russell, in Appendix A of *The Principles of Mathematics*. In reading these, it is necessary to make allowance for differences in the translations that are adopted of some of Frege's terms. We shall here translate Frege's *ausdr?cken* as "express" and Frege's *bedeuten* or *bezeichne*n as "denote" or "be a name of," so that a

name is said to express its sense and to denote or to be a name of its denotation.
(2) We mention the doctrine of Frege's *Begriffsschrift* of 1879, according to which the relation of identity or equality is a relation between names rather than between the things named, apparently on the ground that identity construed in the latter sense would be too trivial a relation to serve its intended purpose. If use and mention are not to be confused, the idea of identity as a relation between names renders a formal treatment of the logic of identity all but impossible. Solution of this difficulty is made the central theme of *Uber Sinn und Bedeutung* and is actually a prerequisite to Frege's treatment of identity in *Grundgesetze der Arithmetik*.

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Logic and Axiomatic Set Theory." *History and Philosophy of Logic* no. 1:95-138.
"What has been the historical relationship between set theory and logic? on the one hand, Zermelo and other mathematicians developed set theory as a Hilbert-style axiomatic system. On the other hand, set theory influenced logic by suggesting to Schr?der, L?wenheim and others the use of infinitely long expressions. The question of which logic was appropriate for set theory -- first-order logic, second-order logic, or an infinitary logic -- culminated in a vigorous exchange between Zermelo and G?del around 1930."

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30. Peckhaus, Volker. 1997. "The Way of Logic into Mathematics." *Theoria* no. 12:39-64.
"Using a contextual method the specific development of logic between c. 1830 and 1930 is explained. A characteristic mark of this period is the decomposition of the complex traditional philosophical omnibus discipline logic into new philosophical sub-disciplines and separate disciplines such as psychology, epistemology, philosophy of science and formal (symbolic, mathematical) logic. In the 19th century a growing foundational need in mathematics provoked the emergence of a structural view on mathematics and the reformulation of logic for mathematical means. As a result formal logic was taken over by mathematics in the beginning of the 20th century as is shown by sketching the German example."

31. ———. 1999. "19th Century Logic between Philosophy and Mathematics." *Bulletin of Symbolic Logic* no. 5:433-450.
"The history of modern logic is usually written as the history of mathematical or, more general, symbolic logic. As such it was created by mathematicians. Not regarding its anticipations in Scholastic logic and in the rationalistic era, its continuous development began with George Boole's The Mathematical Analysis of Logic of 1847, and it became a mathematical subdiscipline in the early 20th century. This style of presentation cuts off one eminent line of development, the philosophical development of logic, although logic is evidently one of the basic disciplines of philosophy. One needs only to recall some of the standard 19th century definitions of logic as, e.g., the art and science of reasoning (Whateley) or as giving the normative rules of correct reasoning (Herbart). In the paper the relationship between the philosophical and the mathematical development of logic will be discussed. Answers to the following questions will be provided:
1. What were the reasons for the philosophers' lack of interest in formal logic?
2. What were the reasons for the mathematicians' interest in logic?
3. What did "logic reform" mean in the 19th century? Were the systems of mathematical logic initially regarded as contributions to a reform of logic?
4. Was mathematical logic regarded as art, as science or as both?"

32. Proust, Joëlle. 1989. *Questions of Form. Logic and the Analytic Proposition from Kant to Carnap*. Minneapolis: University of Minnesota Press.
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"This work attempts to throw some light on an interesting feature in the development of German logic which has not yet received the attention it deserves. Almost a whole generation of German philosophers did not accept the new mathematical logic at the turn of the 20th century. In this respect development in Germany differs greatly from that in Britain where George Boole's ideas received the attention of

philosophers through the work of W.S. Jevons. However, both Gottlob Frege and Ernst Schroder, the main representatives of mathematical logic in Germany, remained isolated figures whose works were either strongly criticized or completely neglected by philosophers. Schroder was able to get some attention to his ideas but the influence of Frege remained very limited for a long time. Frege's ideas started to have an impact in Germany only through the *Principia Mathematica* by Russell and Whitehead. The fate of mathematical logic in Germany cannot be explained away by saying that German philosophers were not interested in logic. They were. In fact, the landscape of German traditional logic is at that time so rich and varied that it is difficult to give a coherent account of it. What makes the period particularly interesting are the interrelationships between psychology, logic and linguistics. All these disciplines came of age in Germany almost simultaneously. Wilhelm Wundt founded modem experimental psychology during the 1870s. Frege did the same for modem mathematical logic at the end of the same decade. As linguistics underwent a deep change at the turn of the 20th century, the basic concepts of language and linguistics were studied not only by linguists but also by philosophers and psychologists.
In the late 19th century linguistics, philosophy and psychology were seen to be much closer to each other than nowadays. Linguists, philosophers and psychologists alike wrote on logical questions. Particularly interesting is the relationship between logic and psychology. In this period philosophers and psychologists were involved in an intense struggle over the chairs of philosophy. This struggle influenced deeply the logical discussion of the period (the debate over the so-called 'psychologism'). One group of logicians believed that their work could be made easier by the results of the new experimental psychology. In other words, they believed that the new scientific psychology could offer a solid foundation for the new scientific logic. Another group of logicians criticized these attempts and tried to present logic as an independent philosophical science. However, both groups had one thing in common: a negative attitude towards mathematical logic.
The present survey of the critique of mathematical logic at the turn of the 20th century attempts to answer several interesting questions: How did the contemporary German philosophers see the role and significance of logic? What kind of relationships did they claim to exist between logic, mathematics, linguistics and psychology? What exactly were the arguments of the (now) almost forgotten critics? I shall start by giving a historical survey of the development of German logic 1830-1920 as it appears against the background of German academic philosophy (chapter 1). Next I shall study the interrelationships between logic and psychology (chapter 2), logic and linguistics (chapter 3), and logic and mathematics (chapter 4). After this I shall present the general features of the reception of mathematical logic in Germany between 1880 and 1920 (chapter 5). This is followed by a more detailed account of the arguments of three individual critics: Fritz Mauthner (chapter 6), Heinrich Rickert (chapter 7), and Theodor Ziehen (chapter 8). I have chosen these three for several reasons. Firstly, each represents a different viewpoint: Mauthner was mainly interested in the problems of language, Rickert was one of the most prominent philosophers of the period, and Ziehen was originally a psychologist. Secondly, I have wanted to bring forward previously unknown figures (this is the reason why I did not choose Husserl, for instance, who wrote much on the subject). Thirdly, I have tried to choose critics who presented interesting ideas. And lastly, in order to have a large enough corpus for study I have had to choose writers who wrote much on the subject."

34. ———. 2005. *Thought and Logic. The Debates between German-Speaking Philosophers and Symbolic Logicians at the Turn of the 20th Century*. New York: Peter Lang.
"The book deals with the reception and critique of symbolic logic among German-speaking philosophers at the turn of the 20th century. The first part discusses the period from the late 1870s up to the end of the 19th century. The main issue is the arrival of the Boolean algebra of logic in Germany and Austria. It examines also the reasons why Gottlob Frege was so unsuccessful in his attempts to draw the attention of philosophers to his logicist programme. The second part deals with the first two decades of the 20th century. Its main topic of inquiry is the reception of Bertrand Russell's and Louis Couturat's ideas in the German-speaking world. In particular, it concentrates on the relationship between Russell and neo-Kantians."

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Maria, 397-401. Berlin: Walter de Gruyter.

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"This paper is both a first step towards, and an invitation to go on with, the study of the reception of modern -- symbolic, mathematical -- logic in Spain. I examine the first and unsuccessful introduction of modern logic in mathematical and philosophical circles, between 1890 and 1930. Such reception failures are usually attributed to external and/or general circumstances, ranging from personal to institutional and cultural conditions of Spanish learning.
But here we should also take into account the very working of the so-called "sowers", i.e., introducing people, as well as some other internal factors and frames of this non-reception case."

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43. ———. 2003. "The Achievements of the Polish School of Logic." In *The Cambridge History of Philosophy 1870-1945*, edited by Baldwin, Thomas, 401-416. Cambridge: Cambridge University Press.
"In the most narrow sense, the Polish school of logic may be understood, as the Warsaw school of mathematical logic with Jan Lukasiewicz, Stanislaw Lesniewski, and Alfred Tarski as the leading figures. However, valuable contributions to mathematical logic were also made outside Warsaw, in particular by Leon Chwistek. Thus, the Polish school of logic *sensu largo* also comprises logicians not belonging to the Warsaw school of logic. The third interpretation is still broader. If logic is not restricted only to mathematical logic, several Polish philosophers who were strongly influenced by formal logical results, for example Kazimierz Ajdukiewicz and Tadeusz Kotarbinski, can be included in the Polish school of logic *sensu largissimo*. Polish work on logic can therefore encompass a variety of topics, from the 'hard' foundations of mathematics (e.g. inaccessible cardinals, the structure of the real line, or equivalents of the axiom of choice) through formal logic, semantics, and philosophy of science to ideas in ontology and epistemology motivated by logic or analysed by its tools. Since the development of logic in Poland is a remarkable historical phenomenon, I shall first discuss its social history, especially the rise of the Warsaw school. Then I shall describe the philosophical views in question, the most important and characteristic formal results of Polish logicians, their research in the history of logic, and applications of logic to philosophy. My discussion will be selective: in particular I will omit most results in the 'hard' foundations of mathematics." p. 401

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