Logical Positivism

'Logical Positivism' is the label given to a philosophical movement that originated in the 1920's in Vienna and Berlin, and to ideas associated with that movement. Although it is likely that no philosophers today would consider themselves logical positivists, the movement has had a great influence on the history of contemporary philosophy.

The movement arose in a series of regular discussion meetings among philosophers, physicists, mathematicians, and others who shared a common disdain for metaphysics and theology then prevalent in Europe and a common interest in foundational problems in the sciences. The meetings were led by Moritz Schlick who, from 1922 until his death in 1936, was chair of History and Philosophy of the Inductive Sciences at the University of Vienna. They included philosophers Rudolph Carnap and Herbert Feigl. political economist Otto Neurath, mathematicians Hans Hahn, Gustav Bergmann, and (while still a student) Kurt Gödel. The group cooperated extensively with a similar group in Berlin whose members included Hans Reichenbach and Carl Hempel. Subsequently influential visitors who joined the group for temporary periods included A.J. Ayer, W.V. Quine, Charles Morris and Ernest Nagel. Members admired and discussed the work of Ludwig Wittgenstein and Bertrand Russell, though neither were members and Wittgenstein was notoriously critical of it.

The group called itself the Verein Ernst Mach after the famous physicist. Mach was a previous holder of Schlick's chair whose broadly empiricist and anti-metaphysical stance was congenial to their own way of thinking. Today it is known by the label attached to its 1929 manifesto: the Vienna Circle. In addition to their regular discussion meetings the Vienna Circle joined with the Berlin group and others to organize conferences (including the 1930 Königsberg congress where Gödel announced his first incompleteness theorem), inaugurate a (now restarted and still surviving) journal *Erkenntnis*, and publish an ambitious series of monographs on "unified science" (a successor to which included Thomas Kuhn's *Structure of Scientific Revolutions*).

The views of members of the Vienna Circle changed over time and recent scholarship (well reported in Thomas Uebel's encyclopedia entry) uncovers the degree to which they disagreed among each other even in early years. Nevertheless we can identify a number of attitudes and doctrines as central. One was the view that whether a statement was "cognitively meaningful" depended on the possibility of its being verified or refuted by empirical evidence. The exact nature of this "criterion of meaning" was a subject of debate and discussion, but it was generally agreed that it would exclude statements of logic and mathematics (which were analytic expressions that concerned relations among representations of the world rather than features of the world itself), ethics (which were perhaps requests or expressions of emotion) and metaphysics (which were meaningless answers to pseudo-problems that appear puzzling because of linguistic confusions).

The verification theory of meaning went hand in hand with a rejection of Immanuel Kant's idea of judgements that were both synthetic (not merely conceptual) and apriori (knowable independently of experience). Kant had placed central judgements of philosophy and mathematics into this category and devoted his *Critique of Pure Reason* to investigating how such judgements were possible. The logical positivists, borrowing from recently developed logical machinery, replaced Kant's quasi-psychological notion of judgement with that of a proposition, and denied that any synthetic propositions could be known apriori. They themselves viewed this outlook as radically empiricist. (Indeed they generally preferred the label *logical empiricism* to *logical positivism*.) Recent scholarship, however, suggests that their views on this subject were more nuanced than commonly believed. At the core of scientific knowledge, on their views, were certain "conventions" or "axioms of coordination" (Reichenbach) not subject to direct empirical verification, and revisable only during periods of great scientific upheaval. (See Friedman.)

Equally central to the outlook was the idea that the sciences, especially the "exact" sciences of physics and mathematics, provided a paradigm of knowledge and that underlying all of the sciences, despite their apparently different methods and subjects matters, there should be a common scientific method. Much of their work was directed at exposing or carrying out this "unification" of the sciences.

The rise of the Nazi party in Germany and then Austria caused both the Vienna Circle and the Berlin group to disperse and thereby widened the influence of the movement. Many of their members ended up in English speaking, especially American, universities. It is likely that the diminishing, but still-perceived, gulf between "analytic" and "continental" styles of philosophy and the predominance of the former in English-speaking philosophy departments owes something to this phenomenon. Although few today would dismiss metaphysical questions as pseudo-problems, there is still a common belief that examination of language can shed light on them. There is also still, to some extent, admiration of mathematics and the "hard" sciences among philosophers and a view that they exhibit a clarity to which both philosophy and the social sciences should aspire. Various forms of non-cognitivism in meta-ethics are clearly descendants of the ethical views of some members of the Vienna circle.

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Paradoxes

A paradox is either an argument proceeding from intuitively plausible premises by apparently valid steps to a conclusion that seems plainly false or a pair of arguments proceeding from plausible premises by apparently valid steps to contradictory conclusions. Paradoxes of the second form are sometimes called *antinomies*. Because paradoxes reveal unresolved tensions among commonly held beliefs, reflection on them is and has always been an important source of insight in philosophy and other fields. We may distinguish three possible ways to deal with a paradox. A *skeptical* resolution (to a paradox of the first form) would accept the argument as sound and the conclusion, however contrary to common sense, as true. A *logical* resolution would deny the conclusion and isolate a false premise or fallacious step in the argument. The third reaction would be to declare the paradox irresolvable, but provide some reason why that fact should not bother us. One might think that the third option would not appeal to intellectually serious people. There are, however, a few noteworthy exceptions. The ninetheenth century religious philosopher, Soren Kierkegaard, held that Christian doctrine contained a number of paradoxes (notably one concluding that an infinite God was incarnated as a finite man) and that accepting such paradoxes, was virtuous, in part, *because* of the difficulty of doing so. More recently some advocartes of *paraconsistent* logics have suggested that, for example, both conclusions of some antinomies of set theory (see below) should be accepted. The challenges for such people is to explain why these contradictions should be accepted and not others, and why such "local" inconsistencies to do not undermine the rest of their belief structure.

Many of the paradoxes that exercise philosophers today can be traced to the *pre-Socratics*, whose speculations about the nature of the cosmos in 6th-4th century BCE are generally regarded as marking the origin of Western Philosophy. The first two mentioned below are attributed to Eubulides of Miletus. The second two are from Zeno of Elea, who used them (along with at least seven others) to argue for the doctrine of Parmenides, that motion and change are mere illusions.

The Liar

A man says that he is lying. Suppose first that he is telling the truth. Then what he says is true, i.e., he is lying. So the supposition that he was telling the truth must be false. On the other hand, suppose he is not telling the truth. Then what he says is not true, i.e., he is not lying. So he is telling the truth after all, and the supposition that he was not telling the truth must also be false.

The liar was the subject of extended discussion in both Medieval Latin and Medieval Arabic philosophy. (There is no evidence of historical connections between these discussions or between them and those by the ancient Greeks.) The kind of reasoning exhibited above inspired the proof of *Tarski's theorem* that it is impossible to formulate, in any language *L* with sufficient resources to describe its own syntax, a correct and adequate definition of truth for the sentences of *L*. Very similar reasoning (using provability in place of truth) informs the proof of Gödel's famous incompleteness theorems. Tarski's reflections on the liar led him to the conclusion that a predicate expressing truth in a language should be thought of as extending that language rather than a part of it. More recently, Saul Kripke has offered a theory in which truth and falsity can consistently apply to many sentences of their own language including, for example, sentences that assert their own truth.

Sorites (aka the heap). Suppose there is a heap of sand. It must be consitituted by some number n of grains of sand. But one grain of sand is not a heap. Furthermore adding a single grain to something that is not a heap will never transform it into a heap. So two grains is not a heap and therefore three grains is not a heap, and so on. By, applying this principle sufficiently many times, we see that n grains is not a heap. So there are no heaps of sand.

The sorites paradox was an important topic in Stoic logic and it is central to contemporary philosophical discussions of vagueness, a phenomenon that pervades language and, according some philosophical views, the world itself.

Achilles and the tortoise A race is conducted between Achilles and a tortoise with one tenth the speed. The tortoise is given a one hundred meter head start. When Achilles covers the first hundred meters to reach the tortoise's starting point, the tortoise will be at the 110 meter mark. When Achilles reaches this spot, the tortoise will be at meter 111; when Achilles gets there, the tortoise will be at 111.1. In general, every time Achilles gets to where the tortoise was, the tortoise will be at slightly more distant point. So Achilles will never catch the tortoise.

The arrow. Consider the arrow in flight. At every instant, it has a particular position in space. So at no instant does it move.

Zeno's paradoxes raise questions about the proper application to mathematical notions of infinity to space and time, many of which are discussed in the book edited by Salmon cited below.

Kant's antinomies The currency of the term *antinomy* in contemporary philosophy may be a result of the prominent place of four "Antinomies of Pure Reason" in Immanuel Kant's *Critique of Pure Reason*. The first two of these, (the "mathematical antinomies") conclude roughly that time and space are both limited and limitless in extent and that physical objects are both infinitely divisible and constituted by indivisible simples. The second two (the "dynamical antinomies") conclude roughly that there are no causes that are not determined by laws of nature and human free will is such a cause and that a necessary being does exist and cannot exist. Although Kant's treatment of the two classes of antinomies is significantly different, in both cases he blames the difficulty on our propensity to engage in *transcendent* metaphysics, in which we apply concepts appropriate to the sensible world to matters beyond which they coherently apply.

Russell's paradox The set of all chairs, not being a chair, is not a member of itself. The set of all sets of sets, on the other hand, is a member of itself. Let R be the set all sets that are not members of themselves. If R is a member of itself, it must satisfy the condition for being a member of R. So it is not a member of itself. On the other hand, if it is not a member of itself then it does satisfy exactly the condition required for membership in R. So it is a member of itself.

Russell's is the most famous of a series of paradoxes discovered around the turn of the twentieth century that undermined early efforts to provide a rigorous foundation for mathematics in logic and set theory. The lesson usually drawn today from Russell's paradox and some others in this series is that they make illegitimate appeal to a naive principle of *comprehension*–to every property (such as not being a member of itself) there corresponds a set of objects that satisfy it. Modern set theories employ a variety of means of circumscribing the naive principle of comprehension so as to maintain consistency.

Surprise Examination (aka *Hangman*). On Monday, Teacher (truthfully) tells students that there will be a surprise examination between Tuesday and Friday. If Teacher waits until Thursday, students will know Wednesday night that it won't be a surprise. So she can give the exam no later than Wednesday. But in that case, if Teacher waits until Wednesday, students will know Tuesday night. So the exam must be given on Tuesday and, being bright enough to deduce this, students do not face a surprise examination after all.

This paradox, according to W.V. Quine, has been discussed since 1943. Today it frequently appears in discussions of conditions under which *backwards induction* arguments are legitimate.

Newcomb. Before you are two boxes, one transparent and one opaque. The transparent box contains ten dollars. You are offered a choice between taking both boxes or just opaque one. A highly reliable predictor has already considered your choice. If he predicted you would choose both boxes, he left the opaque one empty; if he predicted you would choose the opaque box, he put a hundred dollars in it. Whatever he has predicted, two boxes are better than one, so you should choose both. On the other hand, given the reliability of the predictor, those who choose the opaque box can expect more money than those who choose both.

Robert Nozick, who popularized this puzzle among philosophers in a 1969 paper, reports that, unlike other antinomies where people tend to feel the full force of both arguments, people generally find one of the two options in Newcomb silly. They disagree, however, about which one. Reflection on Newcomb's problem has led to a division between *causal* and *evidential* decision theory.

Several other puzzles, while perhaps not quite conforming to the definition of paradox given above, continue to play an important role in philosophy and related disciplines. Two in particular are worth noting.

Moore's paradox is the observation by the British philosopher G.E. Moore that there is something absurd in saying "I went to the pictures last Thursday, but I don't believe that I did." It motivates recent thought on the logic and semantics of belief.

Prisoner's dilemma is named for a story devised in 1950 to illustrate a mathematical game of cooperation. Two prisoners are charged with a crime that they jointly committed. Without the testimony of the other, each can be given only a token penalty, with such testimony each can be given either a moderate or severe penalty. The prosecutor offers to let each go free if he confesses and testifies against the other. She promises each the severe penalty if his partner confesses while he refuses and the moderate penalty if both confess. In this situation, each prisoner does better by confessing whether his partner confesses or not. Yet, if both confess, both receive the moderate penalty, which is worse than they would get had both refused.

Prisoner’s dilemma has spawned an enormous literature on cooperation and rationality.

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Modal Logic

Traditionally, modal logic studies reasoning that turns on "modes" of truth, i.e., necessity, possibility and contingency. Today the term is used much more broadly to include a large portion of logic, especially that part the field of interest to philosophers.

In modal logic, narrowly construed, one considers the logical properties of *necessarily* and *possibly,* symbolized by $\Box$ and $\Diamond$, respectively. So, for example, if A is any sentence, $\Box$A is to be read as 'Necessarily A'. In terms of these, one formulates truths of modal logic:

K $\Box(A\supset B)\supset(\Box A\supset\Box B)$

T $\Box A\supset A$

Df $\Diamond A \equiv {\sim}\Box{\sim}A$

where ~, ⊃ and ≡ are familar connectives of negation, the conditional and the biconditional. **K** asserts that, if that A⊃B is necessarily true, then if necessarily A then necessarily B. **T** asserts that if necessarily A then A and Df $\Diamond$ asserts that A is possible if and only if its negation is not necessary. The last of these can be taken as a definition of $\Diamond$ in terms of $\Box$, thus reducing the stock of primitive connectives. Alternatively we could take $\Diamond$ as primitive and define $\Box$ Aas ${\sim}\Diamond{\sim}A$. In a similar way, a connective $\triangle$ of contingency can be taken as defined by ${\sim}\Box A\ \&\ \Diamond A$ or as a primitive connective that allows $\Box$A to be defined as $A\&\ {\sim}\triangle A$.

Necessity is a topic of great philosophical importance: indeed its concern with necessary, rather than contingent, truths is often thought to be a distinguishing characteristic of the discipline. Moreover, a number of important philosophical arguments, like the ontological arguments for the existence of God, make explicit reference to possibility and necessity. It is thus unsurprising that modal logic in the narrow sense is an important part of logic among philosophers. What is perhaps more surprising are similarities and connections that have emerged between this topics and others. All the principles above, for example, remain plausible logical truths, when $\Box$ and $\Diamond$ are read *It will always be the case that* and *It will sometime be the case that* or *It is known by ideally rational agent R that* and *It is consistent with R's knowledge that*. To do so is to begin investigation into *tense logic* and *epistemic logic*, which may be viewed as branches of modal logic, more broadly construed. Considering only the first and third formulas on the list, one might plausibly interpret $\Box$ and $\Diamond$ as *It obligatory that* and *It is permissible that* or as It is *believed by A that* and it is *consistent with A's beliefs that*. One thereby entertains *deontic logic* or *doxastic logic*. To distinguish it from these fields, the part of modal logic that specifically concerns necessity and possibility is sometimes called *alethic* modal logic. As the other branches of logic have matured, they have moved farther from their alethic roots. Nevertheless the term *modal logic* often includes them and topics even further removed to which mathematical tools developed in the investigation of alethic modality have been profitably applied. Indeed Much of the energy of the field now comes from computer science.

History

Alethic modality was a standard topic of logic in the Classical, Hellenistic and Medieval periods. Aristotle discusses logical relations among necessity, possibility, *not* and *if..then* that resemble those described above. He also shows concern about issues that might today be thought of as combining modal and tense logic–whether from the fact that something might happen one can infer that it will happen (plenitude), and whether it follows from the fact that something will happen that it must happen (determinism). Stoic and medieval logic reiterated and extended Aristotle's treatment, but modality was conspicuously and sometimes consciously dropped from the subject in the modern era.

The revival of interest in the subject owes much to writings of C.I. Lewis between 1912 and 1932 in reaction to Russell and Whitehead's *Principia Mathematica*. The logical system of the *Principia* contained as theorems formulas ~A⊃(A⊃B) and B⊃(A⊃B), which were read as saying that a false sentence implied any sentence and that any sentence implied a true one. Lewis proposed supplementing the connective ⊃ that Russell and Whitehead read as "implies," with a logically stronger connective ⇒ that he called *strict implication*. A 1932 book, written together with C.H Langford, set out five different axiomatic systems for strict implication. The second of these was extended to predicate logic by Ruth Barcan Marcus in 1946. In the presence of the other connectives, ⇒ and □ are interdefinable. A⇒B can be defined as □(A⊃B), or □A as (~A⇒A). Systems like those of Lewis and Langford and Marcus are now standardly taken as systems of alethic modal logic.

Until the late 1940's investigations of modal logic were purely *axiomatic*. Systems identified particular formulas thought to be logical truths as axioms, and particular rules thought to generate logical truths from other logical truths. A logic was identified with its *theorems*, i.e., formulas derivable from the axioms via the rules. Without a corresponding semantics, understanding these logics required considerable effort and ingenuity. In 1947 Rudolph Carnap introduced an alternative approach. His innovation was to adapt the idea (usually attributed to Leibniz though anticipations are found in Descartes and even Duns Scotus) that necessity is truth in all possible worlds. More specifically, Carnap characterized logical necessity as truth in all *state descriptions*, which he defined in terms of primitive symbols of a formal language. The formulas logically true on this characterization coincide with the theorems of **S5**, the fifth of Lewis and Langford's systems. In the fifties and sixties a number of authors proposed refinements and generalizations of Carnap's idea, that made it possible to provide a semantics suitable for many other modal logics. The clearest and most elegant of these was by Saul Kripke. On Kripke's account, a *model structure* (or, as we would now say, a *frame*) for propositional logic is a structure (G,K,R) where K is a non-empty set of "possible worlds", G is a member of K (the actual world), and R is a binary "accessibility" relation on K. The idea is that what is possible for us is itself relative to the world we inhabit. World u is accessible from v, if u is possible when v is actual. A *model* simply adds to that frame a *valuation* that assigns truth values to sentence letters at each possible world. □A is true at world w in model M if A is true all worlds accessible from w. If R is *universal,* so that every world is accessible from every other, then this semantics is similar to Carnap's and again characterize **S5**. Kripke's frames made it much easier to answer many of the questions about the axiomatic modal systems and opened up many lines of enquiry that engage the field today. These include foundational questions about the nature of possible worlds, philosophical questions about other notions that can be usefully explicated using the possible worlds framework (including counterfactual conditionals, causality, propositions, and supervenience), and more mathematical questions about the terrain of possible logics characterizable within this framework or various alternate ones.

Important Modal Systems

S5, mentioned above, is probably the most important system of propositional modal logic. It can be characterized by adding to **K**, **T**, and **Df**◊ above, the scheme **5** (◊A⊃□◊A), and taking as rules Modus Ponens (from A and A⊃B infer B) and Necessitation (from A infer □A). (These rules must be understood as generating logical truths from logical truths. Necessitation would illegitimate were it interpreted as generating truths from truths.) **S5** has the noteworthy property that strings of two or more □'s and ◊'s can be eliminated. Any formula containing such strings is equivalent to one obtained by removing all but the last □ or ◊ in each such string. Given its characterization by universal Kripke frames, this is a natural candidate for a logic of necessity. If **5** is replaced by the formula scheme **4** (□A⊃□□A), one obtains **S4** of the Lewis and Langford hierarchy. **S4** is determined by the class of all transitive Kripke frames. It is a plausible ideal-knower epistemic logic. Replacing both **5** and **T** by **D** (□A⊃◊A) produces **KD**, which may be regarded as a rudimentary deontic logic. Dropping the **D** axiom produces the logic **K**, which is determined by the class of all Kripke frames and is therefore the weakest modal logic determined by any class of Kripke frames. These are just a few of the hundreds of modal logics that have been discussed by philosophers and the countless number of possible logics of this kind. It is worth noting that among these are logics weaker than **K** (and therefore not determined by any class of Kripke frames) and logics stronger than **K** but still not characterized by any class of Kripke frames. The latter are sometimes called incomplete logics, because there are formulas valid in all frames that make the theorems true, which are not themselves theorems.

Extending modal systems to predicate logic introduces a number of difficulties, both conceptual and technical. Should predication and quantifiers be *actualist*, so that predicates hold in a world only of objects existing in that world, and quantifiers are interpreted in each world as ranging over objects in that world? Or should we allow *possibilist* predication and *possibilist* quantification? Should individual constants be *rigid*, so that they denote the same object in every world or should we interpret them *conceptually* so that they may denote different objects in different words. Consider, for example, the formula ∃x□Hx representing *Someone is necessarily human*. If predicates and quantifiers are given an actualist interpretation, then the formula would be false (because no human exists in all worlds). But it is plausible to think that we actual humans are necessarily human. If quantification and predication are both possibilist, then the formula can be seen as true, but so equally can ∃x□Ux--*Something is necessarily a unicorn*. Requiring actualist quantification and possibilist predication would seem to accommodate the formulas about humans and unicorns reasonably. If constants are rigid, however, it would also allow classically valid formulas like Ht → ∃xHx to be false. Formal interpretations of modal predicate logics require a number of such choices. Seeing the tradeoffs involved can help clarify understanding of central issues in metaphysics and the philosophy of language.

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