# RUDOLF CARNAP
# ON SEMANTICAL SYSTEMS
# AND
# W.V.O. QUINE'S
# PRAGMATIST CRITIQUE

Rudolf Carnap (1891-1970) was a leading member of a group of philosophers and scientists in Vienna, Austria, during the interwar years, which called itself the "Vienna Circle." A statement of the group's manifesto, "The Scientific Conception of the World", written by Otto Neurath with Carnap's collaboration can be found in Neurath's *Empiricism and Sociology*. The group was scattered when the National Socialists came to power in Germany, and although Carnap was a native German citizen, he and several other members of the group migrated to the U.S. With the aid of Willard Van Quine of Harvard University, Carnap received an appointment to the faculty of philosophy at the University of Chicago in 1935, which he retained until 1952 when he spent two years at the Institute for Advanced Study at Princeton. In 1954 he filled the vacancy created by the death of Hans Reichenbach at the University of California at Los Angeles, and held the position until his retirement from teaching in 1961. However, he continued to write for the ten years of his intellectually active retirement. He died in 1970 and is memorialized in *Boston Studies in the Philosophy of Science* (1971).

## Logical Constructionalism

In his "Intellectual Autobiography" published in *The Philosophy of Rudolf Carnap* (ed. Schilpp, 1963) Carnap reports that while he was studying at the University of Jena during the years just before the First World War, he was greatly influenced by one of his teachers, Gottlob Frege,

who maintained that logic should be the foundation for mathematics. Shortly after the war Carnap read Bertrand Russell's *Principia Mathematica*, and was greatly impressed by Russell's theory of relations. But Carnap was even more impressed by Russell's philosophical outlook expressed in *Our Knowledge of the External World.* This book states that the logical-analytical method can provide a method of research in philosophy, just as mathematics supplies the method of research in physics. Carnap reports that upon reading this text he felt that its words had been directed to him personally. As a result of these influences, the construction of logical systems would characterize all of Carnap's philosophical work during his long career. There would be many other influences, but they would only produce variations on his basic agenda of logical constructionalism.

Carnap's philosophy of science was Positivist, and he and the other members of the Vienna Circle were favorably disposed to the philosophies of Mach, Poincare, and Duhem. The antimetaphysical and scientistic character of Mach's philosophy was reinforced by the early writings of Ludwig Wittgenstein. Wittgenstein maintained that all philosophical sentences including most notably all of metaphysics are pseudo sentences, and that in spite of their grammaticalness and common usage, these pseudo sentences are really devoid of any cognitive content. Later Wittgenstein departed from this view and moved away from the constructionalist approach in philosophy. But the earlier views of Wittgenstein expressed in his *Tractatus Logico-Philosophicus* had a lasting influence on the Vienna Circle Positivists. One of the central philosophical tasks that they set for themselves was the use of logical constructionalist methods to implement the Positivist philosophy, and especially the symbolic logic in the *Principia Mathematica* of Russell and Whitehead, and for this reason they are known as the “Logical” Positivists.

## Einstein and Mathematical vs. Physical Geometry

Like many philosophers of his generation, Carnap was impressed by Einstein's revolutionary theory of relativity. Philosophers such as Popper found the significance of this successful overthrow of the three-hundred-year reign of Newtonian physics in its implications for scientific criticism. But Carnap found its significance in the distinction between mathematical and physical geometry, or more generally in the role of mathematics as the logic for the physical theory. The central role in the relationship between the formal and the empirical in the development of modern physics became

 

the axis for Carnap's whole philosophical career. He made it the subject of a distinctive type of metatheory for science, which evolved into his metatheory of semantical systems.

Carnap had started his studies in experimental physics at the University of Jena before the First World War, and then later turned to philosophy after the war. In 1921 he wrote a Ph.D. dissertation titled *Der Raum*, in which he attempted to demonstrate that contradictory theories about the nature of space maintained by the mathematicians, philosophers and physicists, are entirely different subjects. He distinguished three meanings of the term "space" corresponding to the three disciplines that treat it. These are the formal meaning used by mathematicians, the intuitive meaning used by philosophers, and the physical meaning used by physicists. The intuitive meaning used by philosophers is based on the Kantian idea of "pure intuition"; Carnap later rejected this idea and retained only the formal and empirical meanings. A later development in Carnap's thinking on these matters occurred when he read Wittgenstein's *Tractatus*. Wittgenstein had defined formal meaning in terms of tautologies or logical truth. This was the origin of Carnap's thesis of analyticity, and he believed that the concept of logical truth supplied the key to the problem of formal systems such as mathematical geometry, which had enabled Einstein to make his revolutionary relativity physics. In his autobiography Carnap says that due to the doctrine of logical truth, Wittgenstein had the greatest influence on his thinking besides Russell and Frege.

After many years of silence on the subject of geometry, Carnap returned to it in his *Philosophical Foundations of Physics* (1966). There he says that he views the Euclidian, the Lobachevskian, and the Riemannian geometries as different languages in the sense of theories of logical structure, which as such are concerned only with the logical implications of axioms. In this work he references Einstein's *Sidelights on Relativity* (1921; English, 1923) where Einstein says that the theorems of mathematics are certain in so far as they are not about reality, and that in so far as they are about reality they are uncertain. Carnap states that the philosophical significance of Einstein's theory of relativity is that it made clear that if geometry is taken in an *a priori* or analytic sense, then like all logical truths it tells us nothing about reality, while physical geometry is *a posteriori* and empirical, and describes physical space and time.

Carnap notes that in relativity theory Einstein used the Riemannian mathematical geometry as the axiomatic system for his physical geometry, but the reason for the choice of which mathematical geometry to use for a

 

physical theory is not obvious. Several years before Einstein developed his relativity theory the mathematician Poincare postulated a non-Euclidian physical space, and said that physicists have two choices. They can either accept non-Euclidian geometry as a description of physical space, or they can preserve Euclidian geometry for the description of physical space by adopting new physical laws stating that all solid bodies undergo certain contractions and expansions, and that light does not travel in straight lines. Poincare maintained that physicists would always choose to preserve the Euclidian description of physical space, and would claim that any observed non-Euclidian deviations are due to the expansion or contraction of measurement rods and to the deflection of light rays used for measurement. Einstein's choice of the Riemannian geometry and physical laws for measurement was based on the resulting simplicity of the total system of physics. Relativity theory using Riemannian geometry greatly simplifies physical laws by means of geodesics, such that gravitation as a force is replaced by gravitation as a geometrical structure.

## The *Aufbau* and "Rational Reconstruction"

In 1928 Carnap published his *Der Logische Aufbau der Welt*. The book was translated in 1967 with the title *The Logical Construction of the World*, but in the literature the book is always referred to as the *Aufbau*. This work exhibits a detailed design for an ambitious investigation. In the first three of the book's five parts Carnap sets forth the objective, plan, and essentials of this investigation. His objective is the "rational reconstruction" of the concepts of all fields of knowledge on the basis of certain elementary concepts, that describe the immediately given in experience. His phrase "rational reconstruction" means the development of explicit definitions for concepts that originate in the more or less unreflected and spontaneous psychological processes of cognition. The task is not a work in psychology; it is a work in logic. It yields a constructional system, which Carnap states is more than merely a division of concepts into various kinds and an integration of the relations among them. It is furthermore a step-by-step logical derivation or "construction" of all concepts from certain fundamental concepts. The result is a genealogy of concepts, in which each concept has a definite place, because at each level concepts are constructed from others at a lower level, until one reaches the basis of the system consisting of basic concepts. And the logical construction is implemented by means of the theory of relations in Whitehead and Russell's symbolic logic, or "logistic."

 

The selected basic elements are "elementary experiences", which are unanalyzable, and the basis contains one basic relation, which takes the elementary experiences as arguments. The basic relation is "recollection of similarity", which in the logic is symbolized as *x Rs y*. This symbolism means: *x* and *y* are elementary experiences, which are recognized as partly similar through the comparison of a memory image of *x* with *y*. Carnap illustrates his system in the fourth part of the *Aufbau*, and develops various constructions for concepts such as quality classes, sensations, the visual field, colors, color solids, the space-time world, tactile-visual things, and "my body."

The fifth and concluding section of the book Carnap sets forth his explicit statement of the aim of science. He views the aim of science in terms of his rational-reconstruction and unity-of-science agendas. He says that the formulation of the constructional system is logically the *first* aim of science. From a purely logical point of view statements made about an object become statements in the strictest scientific sense only after the object has been constructed from the basic concepts. Only the constructional formula in the Russellian logistic - as a rule of translation of statements about an object into statements about the basic objects consisting of the relations between elementary experiences - gives a verifiable meaning to such statements, because verification means testing on the basis of experience. The *second* aim in turn is the investigation of the nonconstructional properties and relations of the objects. The first aim is reached by convention; the second aim is reached through experience. Carnap adds that in the actual process of science these two aims are almost always connected, and that it is seldom possible to make a selection of those properties that are most useful for the constructional definition of an object, until a large number of properties of the object are known. Carnap illustrates the relation between the two aims of science with an analogy: the construction of an object is analogous to the indication of the geographical coordinates for a place on the surface of the earth. The place is uniquely determined through the coordinates, so that any other questions about the nature of the place have definite meaning. The first aim of science locates experience, as does the coordinate system; the second aim addresses all other questions through experience, and is a process that can never be completed. Carnap says that there is no limit to science, because there is no question that is unanswerable in principle. Every question consists of putting forth a statement whose truth or falsity is to be ascertained. However, each statement can in principle be translated into a statement about the basic

 

relation and the elementary experiences, and such a statement can in principle be verified by confrontation with the given. Fifty years later Quine also uses the coordinate system analogy to express his thesis of ontological relativity. But instead of developing an absolute ontology consisting ultimately of the immediately given in terms of elementary experiences and a basic relation, Quine relativizes ontology to one's "web of beliefs" including science, and ultimately by nonreductionist connection to one's own "home" or native language. The Vienna Circle's unity-of-science agenda is integral to Carnap's view of the aim of science. He sees the task of unified science as the formulation of the constructional system as a whole. By placing the objects of science in one united constructional system, the different "sciences" are thereby recognized as branches of one science.

Carnap's idea of rational reconstruction is different from the views of some contemporary information scientists, who propose that their procedural reconstructions of historic scientific discoveries with computerized artificial-intelligence discovery systems are hypotheses in "cognitive psychology", also known as "cognitive science." However, such efforts can be recast into a linguistic analysis that is more familiar to philosophers and also more like Carnap's procedural approach than a psychological investigation.

## Logical Syntax of Language

When Carnap discovered *Gestalt* psychology, he reconsidered the phenomenalist constructionalism that he had undertaken in his *Aufbau*, and concluded that a physicalist language, a "thing language" describing things in ordinary experience, is more suitable as a basis of all scientific concepts. At about the same time he also learned of Hilbert's metamathematics program. The influence of Russell had led the Vienna Circle to prefer the logistic program of the foundations of mathematics to Hilbert's formalist approach. But Carnap was attracted to the idea of a metalanguage, not just for mathematics but for a logic of all science. This was his idea of a "metalogic", which he developed in his *Logical Syntax of Language* (1934). The metalogic is the logical syntax of language viewed as a purely analytic theory of the structure of its expressions. In his autobiography he reports that the whole theory of language structure and its possible applications in philosophy came to him like a vision during a sleepless night when he was ill in January 1931, and that on the following day he wrote down the idea in a manuscript of forty pages titled *Attempt at a Metalogic*, which was the first draft of his *Logical Syntax*.

 

One of the central ideas in this book is his distinction between metalanguage and object language. The former contains no reference to the meanings of linguistic signs occurring in the object language; it refers only to the logical structure of the expressions in the object language. Carnap says that his chief motivation for developing this syntactical method was to formulate more precisely philosophical problems that have evaded resolution when expressed in traditional manner. In 1934 he published "On the Character of Philosophical Problems" in the American journal *Philosophy of Science*, which expounded his treatment of metaphysical issues in the German edition of *Logical Syntax* published in the same year. In this work he distinguishes the formal or syntactical perspective from the connotative or material perspective. He identifies logic as a set of metalinguistic transformation rules, and the logic of the language of science, which is the object language, as one in which logical entailment is a formal transformation rule. Thus Carnap defines the "content" of a proposition in science as a class of entailments from a synthetic proposition in the science. Content is thus a purely formal concept, and the difference between the formal and material perspectives is merely a difference between modes of expression. Accordingly philosophical analysis consists of translating statements into the formal mode. Meaningful statements in science can be translated into the formal mode of speech, but the meaningless metaphysical statements cannot be translated into the formal mode. For this reason he maintained that differences between Positivists and realists disappear, when their respective positions are translated into the formal mode. Similarly problems in the foundation of physics are also problems in syntax. For example verification of physical laws is a matter concerning the syntactic deductive coherence between the general law-like propositions and singular propositions called protocol sentences, and the problem of induction is a question of how transformation rules lead from protocol sentences to laws.

In 1937 Carnap published his English edition of *Logical Syntax*. This latter edition contains additional material not in the earlier German edition, and its bibliography includes reference to Quine's "Truth by Convention" published in 1936, in which Quine rejected the idea of analytic truth. Quine viewed the thesis of analytical truth as the Achilles heel of Carnap’s philosophy of science, its parallel postulate to be replaced with the new Pragmatist philosophy of language. *Logical Syntax* is divided into five parts. The first three set forth two artificial object languages. Language I is designed to be acceptable to philosophers persuaded of the intuitionist philosophy of mathematics, because it includes no infinities. Language II is

 

adequate to all classical mathematics including what the intuitionists would not accept, and it includes Language I as a sublanguage. The fourth part sets forth the general procedures for constructing any artificial language, and is titled "General Syntax." Carnap defines general syntax as a system of definitions of syntactical terms. In general a language is any sort of calculus in the sense of a system of formation and transformation rules concerning expressions, which in turn are defined as finite, ordered series of elements called symbols. Formation rules determine concatenations of symbolic elements to form expressions, and transformation rules determine what transformations produce valid deductions and proofs. The interpretation of a language is the method of learning by explicit statements that are translations from an already interpreted language, and therefore can be formally represented and belongs to syntax. A system of axioms in a calculus may firstly be given, and then interpreted in various ways by translations that establish correlations between the expressions of the language being interpreted and those already interpreted.

The fifth and concluding part of the book pertains to philosophy and syntax, where philosophy is identified with the logic of science. The material for the 1934 article in *Philosophy of Science* was taken from section A of this part. In section B Carnap considers the logic of science as syntax, stating that the logical analysis of physics is the syntax of the physical language. The language must have formation rules both for the protocol sentences, which express observations, and for the postulated or "P-primitive" laws, which have the form of universal sentences of implication and equivalence. The transformation rules of the physical language consist either of only “L-rules”, which are logical rules, or of the L-rules together with “P-rules”, which are empirical rules. A sentence in physics is tested by deducing consequences using the transformation rules, until finally sentences in the form of protocol sentences are generated. These deduced protocol sentences are then compared with the protocol sentences that are observation reports, and the former are either confirmed or refuted by the latter. If a sentence which is an L-consequence of certain P-primitive sentences, contradicts a sentence which has been stated as a protocol sentence, then some change must be made in the system. But there are no established rules for the kind of change that must or must not be made, nor is it possible to set down any sort of rules as to how new primitive laws are to be established on the basis of actually stated protocol sentences. There are no rules for induction due to the universality of laws; the laws are hypotheses in relation to protocol sentences. Furthermore not only general

 

laws, but also singular sentences are formulated as hypotheses, i.e. as P-primitive sentences, which are sentences about unobserved processes from which certain observed processes can be obtained.

Carnap also treats the topic of scientific criticism, and maintains that there is no complete falsification or confirmation of any hypothesis. When an increasing number of L-consequences of the hypothesis agree with previously acknowledged protocol sentences, then the hypothesis is increasingly confirmed, but it is never finally confirmed. He states that it is impossible to test even a single hypothetical sentence, because the test applies not to a single hypothesis but also to a whole system of physics as a system of hypotheses. In this context Carnap references Duhem and Poincare. He also says that both P-rules and L-rules including those of mathematics are laid down with the reservation that they may be altered as soon as it seems expedient to do so, and that in this respect P-rules and L-rules differ only in degree with some more difficult to renounce than others.

Carnap's thesis that logical and descriptive language differs only in degree was proposed by Alfred Tarski. Carnap explains that if every new protocol sentence introduced into a language is synthetic, then L-valid (i.e. analytic) sentences differ from synthetic sentences, because such a new protocol sentence can be incompatible only with the P-valid synthetic sentence; it cannot be incompatible with the logical L-valid or analytic sentence. But then he further goes on to say that in spite of the above fact, it may come about that under the inducement of new protocol sentences the language may be altered to such an extent that the L-valid or analytic sentence is no longer analytic. He emphasizes in italics that the construction of the physical system is not effected in accordance with fixed rules, but is a product of convention. These conventions are not arbitrary; they must be tested. The choice of convention is influenced firstly by practical considerations such as simplicity, expediency, and fruitfulness, and secondly by their compatibility with the total system of hypotheses to which the already recognized protocol sentences belong. Thus in spite of the subordination of hypotheses to empirical control by means of protocol sentences, hypotheses contain a conventional element, because the system of hypotheses is never "univocally" determined by empirical material however rich it may be. Carnap never developed this thesis of the empirical underdetermination of a system of hypotheses, and the artifactual theory of language it implies, which was extensively developed by Quine in the 1950's and afterward. Later Carnap rejected Tarski's thesis that logic and

 

descriptive language differ only in degree, but he always maintained that definitions of L-true sentences are relative to the specific language system under construction.

## Semantical Systems: Definitions and Characteristics

Carnap's mature work in semantics is his *Introduction to Semantics* (1943). When he had written his *Logical Syntax* he had believed that metalogic should deal only with the form of expressions of the object language, and that no reference should be made to the meanings of the signs and expressions. In the preface to his *Introduction to Semantics* Carnap states that Tarski was the first to call his attention to the fact that the formal methods of syntax must be supplemented by semantical concepts, and also that these semantical concepts can be defined by means no less exact than those of syntax. He says that his *Introduction to Semantics* owes more to Tarski than to any other single influence, although he also notes that he and Tarski are not in complete agreement on the distinction between syntax and semantics, and on the distinction between logical and descriptive signs. In this new semantical perspective semantical systems were central to his philosophy for the remainder of his life. It is a concept that is fundamental to his views in philosophy of science, his philosophy of probability, and his philosophy of information theory.

Following the Pragmatist tradition, to which he had been introduced by Charles W. Morris in the United States, Carnap describes semiotics as the general theory of signs, which is divided into three parts based on the three factors involved in language. These factors are (1) the expression, (2) the *designatum*, and (3) the speaker. The part of semiotics that deals with all three of these factors is called pragmatics. The second part of semiotics, called semantics, abstracts from the speaker, and contains a theory of the meaning of expressions, which leads to the construction of a dictionary for translating the object language into the metalanguage. Finally the third part of semiotics is called syntax, which abstracts from both the speaker and the *designata* of the signs, in order to consider only the expressions. Carnap further distinguishes between descriptive semantics and syntactics on the one hand, and pure semantics and syntactics on the other. The former are included in pragmatics because they are empirical, while the latter are not because they are analytic. In pure semantics and syntactics the philosopher lays down definitions for certain concepts in the form of rules, and he

 

studies the analytic consequences of these definitions. Nearly all of Carnap's work is in pure semantics and pure syntactics, and the terms "semantics" and "syntactics" mean pure semantics and pure syntactics in his texts, unless otherwise noted; Carnap's interest is typically more in constructional systems than in empirical linguistics.

A semantical system presupposes a syntactical system. A syntactical system or calculus, denoted *K*, consists of rules that define syntactical concepts, such as "sentence in *K*" and "provable in *K*." The smallest unit of syntax in the system is called a "sign." Signs are combined into "expressions" according to the formation rules for the calculus. The most important type of expression is the "sentence." Sentences are derivable from other sentences, i.e. are "proved", in accordance with the transformation rules of the calculus. Transformation rules are also called the system's "logic", and for purposes of illustration Carnap typically utilizes Russell's first-order predicate calculus. All the rules of the syntactical system are analytical rules, and are expressed in a metalanguage; the defined language system is the object language.

Carnap defines a semantical system as a system of rules formulated in a metalanguage and referring to an object language, which rules determine a truth condition for every sentence of the language, i.e. a sufficient and necessary condition for each sentence's truth. The semantical system supplies an interpretation of the sentences of the syntactical system or calculus, because to understand a sentence is the same as to know under what conditions it would be true. It may be noted that truth conditions are not truth values. The semantical rules do not determine whether or not a sentence is true; the truth value of the sentence must be determined empirically. The truth condition need not be satisfied for the semantical rule to state it. As a set of definitions, a semantical system denoted *S* must set forth certain things. It must define:

1. the classifications of the signs in *S*,
2. the classifications of the expressions in *S*, such as "term in *S*" and "sentence in *S*",
3. the meaning of "designation in *S*", and
4. the meaning of "true in *S*."

These definitions may be enumerations or they may be recursive definitions. The meanings of expressions that are smaller than sentences are given by statements of designation. For example the rule for designation for

 

predicates may include " '*H*' denotes the property human." The meanings of sentences are given by statements of truth conditions called Tarski sentences, such as " 'The moon is round', if and only if the moon is round." The sentence in double quotes is in the metalanguage consisting of English, and the symbol or clause in the single quotes is an expression in the object language. The truth condition statement could also be " 'The moon is round' is true, if and only if the moon is round", since to assert that a sentence is true with the predicate "is true" is to assert the sentence. These statements in the metalanguage are called "radical" concepts for the semantical system.

In the *Introduction to Semantics Carnap* describes L-semantics, which consists of L-concepts. In L-semantics an L-term applies whenever the term "true" applies on the basis of merely logical reasons in contrast to factual reasons. This truth is called L-truth or logical truth. The L-concepts are the same as those occurring in syntax, and Carnap states that logic is part of semantics even though it may also be dealt with in syntax. Corresponding to the L-concepts in semantics, there are identical C-concepts in syntax. The relation between syntax and semantics is such that the sentences of a calculus denoted *K* are interpreted by the truth conditions stated in the analytic semantical rules of the semantical system, denoted *S,* provided that *S* contains all the sentences of *K*. However, not all possible interpretations of the calculus *K* are true interpretations. A semantical system *S* is a true interpretation of *K*, if the C-concepts of *K* are in agreement with the corresponding radical concepts in *S*. Furthermore not all true interpretations of the calculus *K* are L-true. The semantical system *S* is called an L-true interpretation for the calculus *K*, if the C-concepts in *K* are in agreement with the L-concepts in *S*.

Later in his *Meaning and Necessity* (1947) Carnap develops a definition of L-truth in terms of his concept of state description. A state description in a semantical system denoted *S,* is a class of sentences in *S* which contains for every atomic sentence either the sentence or its negation but not both. Such a sentence is called a state description, because it gives a complete description of a possible state of the universe of individuals with respect to all the properties and relations expressed by the predicates of the system. It thus represents one of Leibniz's possible worlds or Wittgenstein's possible states of affairs. To say that a sentence holds in a state description means that it would be true if the state description were true, i.e. if all the atomic sentences belong to it were true. Thus the L-concepts are precisely those that are true in all state descriptions, because they are true in all

 

possible worlds, even though there is only one factually true state description.

Carnap further elaborates on L-truth in his "Meaning Postulates" (1952) reprinted in the appendix of the 1956 edition of *Meaning and Necessity*. His theory of L-truth and state descriptions initially applied to cases where the logically true statement is true only by virtue of the meanings of the logical terms in the statements, as in "Every *x* is either *P* or not *P*." But there are also cases such as "If *x* is a bachelor, then *x* is not married", which are true by virtue of the meanings of the descriptive terms. Meaning postulates are object-langauge sentences introduced into a semantical system, that define the relations among descriptive terms in the sentence in addition to the meanings assigned by rules of designation expressed in the metalanguage. These meaning postulates are not said to be factually true by virtue of empirical investigation, but are true by a decision of the architect of the semantical system, who uses them as semantical rules. Carnap then introduces a modification of his concept of state description to include another kind of statement, that is the conjunction of all meaning postulates in the semantical system. Then he says that a sentence in a given semantical system is L-true, if it is L-implied by this conjunction of meaning postulates. This expanded notion of L-truth with meaning postulates is Carnap's explication of analyticity, by which is meant statements whose truth is known by reference to either the logical form or to the descriptive terms in the statement. Later he refers to this expanded idea of L-truth as A-truth.

Using his concept of state description Carnap defines the concept of ranges: the range of a sentence is the class of all state descriptions in which a sentence holds. Rules of ranges in turn determine the range of any sentence in the semantical system *S*. These rules are semantical rules that determine for every sentence in *S*, whether or not the sentence holds in a given state description. By determining the ranges, these rules together with the rules of designation for the component predicates and individual variables give an interpretation for all the sentences in *S*. This amounts to saying that to know the meaning of a sentence is to know in which of the possible cases it would be true. Carnap thus describes a semantical system in terms of four types of semantical rules: (1) rules of formation for sentences, (2) rules of designation for descriptive constants, (3) rules of truth, (4) rules of ranges.

 

## Semantical Systems: Ontological vs. Linguistic Issues

*Meaning and Necessity* has a more specific purpose than the earlier *Introduction to Semantics.* The former is the development of a new method of semantical analysis, which Carnap calls the method of extensions and intensions, and which is based on the customary concepts of class and property respectively. Carnap maintains that these concepts of extension and intension should be substituted for the idea of naming of an abstract entity. In his autobiography he notes that some philosophers [who happen to include Quine and Goodman] reject this way of speaking as the "hypostatization of entities." In their view it is either meaningless or at least in need of proof, to say that such entities as classes and properties actually exist. But Carnap argues that such terms have long been used in the language of empirical science and mathematics, and that therefore very strong reasons must be offered, if such terms as "class" and "property" are to be condemned as incompatible with empiricism or as unscientific. He says furthermore that to label the use of such terms as "Platonistic" or as "Platonistic realism", as is done by these philosophers, is misleading, because these labels neglect the fundamental distinction between, say, physical laws containing real number variables, and ontological theses affirming or denying the reality of universals. Carnap dislikes the term "ontology", and he maintains that the issue between nominalists and realists regarding universals is a pseudo problem, which is devoid of cognitive content.

Carnap says his method of extension and intension is a superior basis for semantical analysis than an alternative method based on the naming relation, because the latter leads to contradictions, when the names are interchanged with one another in true sentences. He thus refers to the "antinomy of the name relation", which is due to the fact that a predicate viewed as a name is ambiguous, since it can refer either to a class or to a property. Some systems avoid this ambiguity by rejecting properties, and Carnap rejects this loss. Others avoid the antinomy by having different names for properties and their corresponding classes, thus resulting in a higher degree of duplication of expressions. In Carnap's method of extension and intension the expressions for properties and for their corresponding classes have the same intension and extension. Thus both classes and properties are admitted without the inelegant duplication and without the antinomy; only one predicate is needed to speak about both a certain property and about its corresponding class.

 

The antinomy can be avoided by Carnap's method of prescribing the principle of interchangeability for expressions with the same extension, which is distinctive of extensional contexts. This prescription is achieved by means of the L-equivalence relation, such that extensions are defined in terms of intensions. The extension of a given intension is defined as the one L-determinate extension that is equivalent to the given intension. Extensions are thus reduced to intensions. The result is what Carnap calls a "neutral metalanguage." While the metalanguage for an object language based on the name relation will contain such terms as "the class human" and "the property human", the neutral metalanguage for an object language based on the method of extension and intension contains only the neutral expression "human."

In "Meaning and Synonymy in Natural Language" (1955) also reprinted in the appendix to the 1956 edition of *Meaning and Necessity* Carnap describes how his method of extension and intension is applicable in pragmatics as well as in pure semantics. "Pragmatic" in Carnap's lexicon means empirical linguistics. The purpose of this paper is to give a procedure for determining intension in natural language. This procedure is problematic, because unlike the construction of an artificial language, in which extension can be defined on the basis of intensions, the empirical investigation of an unknown natural language by the field linguist must begin with the identification of extensions that is not problematic. On the basis of either spontaneous or elicited utterances of a native speaker of the unknown natural language, the field linguist can ascertain whether or not the native is willing to apply a given predicate to a thing. By such investigation the linguist determines firstly the extension of the predicate, the class of things to which the native is willing to apply the predicate, secondly the extension of the contradictory class of things to which the native will not apply the predicate, and thirdly the class of things for which the native will neither affirm nor deny the applicability of the predicate. The size of the third class indicates what Carnap calls the degree of extensional vagueness of the predicate. Carnap admits that this determination of extension involves uncertainty and possible error, either due to a failure to recognize an individual case or due to a failure to make the correct inductive inference to the intended thing. But he says that these hazards apply to all concepts in science, and they offer no reason to reject the concepts of the theory of extension.

Carnap's thesis is that the analysis of intension for natural language is a scientific procedure, which is methodologically just as sound as the field

 

linguist's method of determining extension. And he notes his disagreement with Quine about this thesis. Carnap postulates the case in which two linguists agree on the extension of a native's use of a predicate, but not on the intension. Carnap maintains that in pragmatics the assignment of an intension is an empirical hypothesis, which like any other hypothesis can be tested by observation of linguistic behavior. In the empirical investigation of the native speaker's linguistic behavior, the linguist looks for what Carnap calls intensional vagueness. Extensional and intensional vagueness are related such that a decrease in one produces a decrease in the latter. This search is directed to finding out what variations of a given specimen are admitted within the range of the predicate, where "range" in the context of a discussion of natural languages means those possible kinds of objects for which the predicate holds. These are cases for which the native has never made a decision about the applicability of the predicate under investigation. The description of these possible cases is the intensional vagueness of the predicate. The linguist can therefore describe to the native speaker various imaginary cases, until he hits upon one that differentiates the otherwise co-extensive predicates. Carnap adds that rules of intension are necessary for the language of empirical science, because without them intensional vagueness would remain, and therefore prevent mutual understanding and communication. Carnap apparently believes that all vagueness can be removed from a predicate, when the predicate is taken from everyday discourse into scientific language. Carnap also elaborates his discussion to include intension for a robot. He maintains that from a logical point of view the pragmatical concept for a robot is the same as that for a human. If the internal structure of the robot is not known, however, the same empirical method that is used to determine intension for a human speaker can be used for a robot. In both cases the intension for a predicate for a speaker is the general condition that an object must satisfy for the speaker to apply the predicate to it. And if the intensional structure of the robot is known, the intension of a predicate can be known even more completely.

In his "Empiricism, Semantics and Ontology" (1950) also in *Meaning And Necessity* (1956) Carnap deals further with the problem of classes and properties, which some philosophers such as Quine refer to as abstract "entities." Again he notes that in the language of physics it is hardly possible to avoid abstract entities, and that using a language referring to them does not imply embracing a Platonistic ontology. He views such language as perfectly compatible both with empiricism and with strictly scientific thinking. In this paper he explains further why this compatibility

 

is possible. Firstly he notes that there are two kinds of questions concerning the existence or reality of entities. One kind is addressed by creating a system of new ways of speaking, which system is subject to new rules in the construction of a linguistic "framework", i.e. a whole semantical system, for the new entities in question. This first kind of question pertains to the existence of the entities referenced by the system as a whole, and Carnap calls these "external" questions. The other kind of question is appropriately called an "internal" question, since it pertains to the existence of a new kind of entity within the framework. Internal questions can be resolved by either logical or empirical scientific procedures. The question of the reality of a kind of entity described by a theoretical term might serve as an example of an internal question. The problem of abstract entities, however, is an external question, and it is this latter type of question that concerns Carnap in this paper. Carnap maintains that the introduction of a new language framework with its new linguistic forms does not imply any assertion of reality, but rather is merely a new way of speaking. Therefore, the acceptance of a linguistic framework containing terms referring to abstract entities does not amount to the acceptance of Platonism, because the new language framework is not a new metaphysical doctrine. Carnap then invokes his "principle of tolerance", which he had firstly expressed in his *Logical Syntax* many years earlier. The criterion he invokes as a semanticist is not an ontological one, but rather is a pragmatical one. The relevant criterion is whether abstract linguistic forms of variables are expedient or fruitful for the purposes for which the semantical analysis is designed, such as the clarification or construction of languages for the purpose of communication, and especially for communication in science.

**Semantical Systems: Physics and the Reduction of Theories**

Even before Carnap had published his *Introduction to Semantics*, he had formulated his concept of science as a semantical system, and this concept did not change fundamentally for the duration of his contributing career. The early statements of this concept are set forth in his "Logical Foundations of the Unity of Science" and "Foundations of Logic and Mathematics" in the *International Encyclopedia of Unified Science* (1938). In these works he asserts that philosophy of science is not the study of the activities of scientists, i.e. the pragmatics of science, but rather is the study of the results of the activity, namely the resulting linguistic expressions,

 

which constitute semantical systems. More specifically the philosopher treats the language of science as an object language, and develops a metatheory about the semantics and syntax of this object language. The metatheory is expressed in a metalanguage.

A physical theory is an interpreted semantical system. Procedurally a calculus is firstly constructed, and then semantical rules are laid down to give the calculus factual content. The resulting physical calculus will usually presuppose a logical mathematical calculus as its basis, to which there are added the primitive signs which are descriptive terms, and the axioms which are the specific primitive sentences of the physical calculus in question. For example a calculus of mechanics of mass points can be constructed with the fundamental laws of mechanics taken as axioms. Semantical rules are laid down stating that the primitive signs designate the class of material particles, the three spatial coordinates of a particle *x* at time *t*, the mass of a particle *x*, and the class of forces acting on a particle *x* or on a space *s* at time *t*. Thus by semantical interpretation the theorems of the calculus of mechanics become physical laws, that constitute physical mechanics as a theory with factual content that can be tested by observations. Carnap views the customary division of physics into theoretical and experimental physics as corresponding to the distinction between calculus and interpreted system. The work in theoretical physics consists mainly in the essentially mathematical work of constructing calculi and carrying out deductions with the calculi. In experimental physics interpretations are made and theories are tested by experiments.

Carnap maintains that any physical theory and even the whole of physics can be presented in the form of an interpreted system consisting of a specific calculus, an axiom system, and a system of semantical rules for interpretation. The axiom system is based on a logicomathematical calculus with customary interpretation for the nondescriptive terms. The construction of a calculus supplemented by an interpretation is called “formalization”. Formalization has made it possible to forgo a so-called intuitive understanding of the theory. Carnap says that when abstract, nonintuitive formulas such as Maxwell's equations of electromagnetism were first proposed as new axioms, some physicists endeavored to make them intuitive by constructing a "model", which is an analogy to observable macroprocesses. But he maintains that the creation of a model has no more than aesthetic, didactic, or heuristic value, because the model offers nothing to the application of the physical theory. With the advent of relativity theory and quantum theory this demand for intuitive understanding has waned.

 

A more adequate and mature treatment of physics as a semantical system, and especially of the problem of abstract or theoretical terms in the semantical system, can be found in Carnap's "The Methodological Character of Theoretical Concepts" (1956) and in his *Philosophical Foundations of Physics: An Introduction to the Philosophy of Science* (1966). Firstly some preliminary comments about terms and laws: All the descriptive terms in the object languages used in science may be classified as either prescientific or scientific terms. The prescientific terms are those that occur in what Carnap calls the physicalist or thing-language. This language is not the same as the phenomenalist language advocated by Mach. Carnap had earlier in his career attempted to apply constructionalist procedures to the construction of a phenomenalist language in his *Logical Structure of the World* (1928). But later he decided to accept a language in which the idea of a physical thing is not linguistically constructed out of elementary phenomena, because he came to believe that all science could be reduced to the thing-language. This thing-language refers to things and to the properties of things; in Russell's predicate calculus things and properties are symbolized as two distinct types of signs: instantiation signs and predicate signs. But the thing language is also expressible in a natural language such as English. The predicates or other descriptive signs referring to properties are of two types: observation terms and disposition terms. Observation terms are simply names for observable properties such as "hot" and "red." These words are called "observable thing-predicates." Disposition terms express the disposition of a thing to a certain behavior under certain conditions. They are called "disposition predicates" and are exemplified by such words as "elastic", "soluble", and "flexible." These terms are not observable thing-language properties, but by use of conditional reduction sentences they are reducible to observation predicates. Opposed to prescientific terms are scientific terms. Carnap classified all scientific terms as "theoretical terms" in a broad sense, even though physicists, as he notes, customarily refer to such terms as "length" and "temperature" as observation terms, because their measurement procedures are relatively simple. More abstract theoretical terms are exemplified by "electron" or "electrical field." A discussion of theoretical terms requires some further discussion of semantical rules in physical theory. There are two types of semantical rules: definitions and conditional reduction sentences. A reduction sentence for a descriptive sign is a conditional statement that gives for the sign the conditions for its application by reference to other signs. The reduction sentence does not give the complete meaning for the descriptive sign, but it gives part of its

 

meaning. It is a "method of determination" enabling the user to apply the term in concrete cases. A definition is a special case of a reduction sentence that gives all of the meaning of a descriptive term, because it is an equivalence or biconditional sentence. There is never more than one definition for a univocal term, but there may be many reduction sentences for a univocal term, each of which contributes to the term a part of its meaning. Unfortunately Carnap seems never to have elaborated on how the meanings of terms can have parts. Both types of semantical rules - definitions and reduction sentences - introduce new terms into an object language. If one language is such that every descriptive term in it is expressible by reduction sentences in terms of another language, then the second language is called a "sufficient reduction basis" for the first language. For all scientific terms the scientist always knows at least one method of determination, and all such methods always either are reduction sentences or are introduced into an axiomatic system of physics by explicit definition in the axiomatic system.

Carnap states that he disagrees with the philosophy of the physicist Paul W. Bridgman, who stated in his *Logic of Modern Physics* (1927) that, every quantitative concept must be defined uniquely by the procedures for measuring it. This principle is called "operationalism", and it implies that there are as many different concepts of temperature or length as there are different ways of measuring temperature or length. Carnap maintains that these different operational rules for measurement should not be considered definitions giving the complete meaning of the quantitative concept. He prefers his idea of reduction sentences in which statements of operational procedures are semantical rules giving only part of the meaning of the theoretical term. In Carnap's philosophy what distinguishes theoretical terms from observation terms is precisely the fact that the meanings of theoretical terms are always partial and incomplete. This view distinguishes Carnap from Heisenberg and from other Positivists such as Nagel, who prefer equivocation to partial meanings. In Carnap's view statements of operational rules understood as reduction sentences together with all the postulates of theoretical physics function to give partial interpretations to quantitative concepts. These partial interpretations are never final, but rather are continually increased or "strengthened" by new laws and new operational or measurement rules that develop with the advance of physics. Such in brief is Carnap's taxonomy of terms.

Consider next Carnap’s views on scientific laws: Carnap classifies scientific laws as empirical laws and theoretical laws. This division does not

 

correlate exactly to the division between observation terms and theoretical terms in the broader and less abstract sense of his meaning of "theoretical term." The distinction is based on how the laws are developed. Empirical laws are also called empirical generalizations, because they are developed by inductive generalization, which to Carnap means recognition of regularities by observation of repeating instances. The empirical laws contain observation predicates or magnitudes that are measured by relatively simple procedures that can be expressed in reduction sentences or definitions. Empirical laws therefore may contain theoretical terms, such as "temperature", "volume", and "pressure", as occur in Boyle's gas laws, as well as observation terms as may occur in such universal generalizations as "all ravens are black." The scientist makes direct observations or repeated measurements, finds certain regularities, and then expresses the regularities in an empirical law. Theoretical laws on the other hand cannot be made by inductive generalization, because they contain theoretical terms in the narrower or more abstract sense; these theoretical terms are too abstract for making laws by generalization. Examples of these terms are "electron", "atom", "molecule", and "electromagnetic field." These are the descriptive terms that the physicists also call theoretical and unobservable, and measurements associated with these theoretical terms cannot be acquired in simple or direct ways. The development of theoretical laws proceeds by the physicists' imaginative construction of theories in the object language of their science.

Having examined Carnap's classification of the types of terms and of scientific laws, it is now possible to discuss the construction of physical theories. Logically there is firstly a calculus. Conceivably the calculus might be completely uninterpreted, but most often the calculus is supplied by what Carnap calls the logicomathematical calculus with its semantical rules for its logical terms supplying the "customary" interpretations. In other words the physicist seldom develops his own logic or mathematics, although he may use a pre-existing mathematics that had never previously been used in physics, e.g. a non-Euclidian geometry. The physicist then postulates certain axioms, and the descriptive terms in the axiomatic system will either be primitive terms or will be completely defined by reference to primitive terms given in the axioms. In the axiom system the primitive terms may be classified either as elementary terms or as theoretical terms in the narrow or more abstract sense. Elementary terms are either observation terms, or are simple magnitudes which are theoretical terms in the less abstract sense. The elementary terms are given their semantical interpretation by semantical

 

rules that either define them or give methods of determination by conditional reduction sentences.

The aim of the early Positivists was to make all the primitive terms elementary terms. In this way the semantics of the primitive terms would be given by semantical rules that would either designate them as observation predicates, or designate them by reference to experimental measurement procedures. And since none of the abstract theoretical terms are primitive in the axiomatic system, any such terms would have to be defined by reference to the primitive terms. This method would completely satisfy the early Positivist requirement that all the semantics in the physical theory be supplied by semantical rules that constitute an effective reduction of the theory to observations or to experimentally based measurements. This would surely insure that there would be no contamination of science by metaphysical "nonsense."

However, there is a problem with this approach, even though it would satisfy the requirements of the early Positivists. The theories actually constructed by physicists contain abstract theoretical terms that cannot be defined by reference to elementary descriptive terms having semantical rules directly giving them their empirical meanings. As Carnap states, what physicists actually do is not to make all the primitive terms elementary terms, but rather to make the abstract theoretical terms primitive in the axiomatic system and to make the axioms of the systems very general theoretical laws. In this constructional procedure the semantical rules initially have no direct relation to the primitive theoretical terms. Carnap borrows Carl G. Hempel's metaphorical language describing the axioms with their primitive terms as "floating in the air", meaning that the theoretical hypotheses are firstly developed by the imagination of the physicist, while the elementary terms occurring in the empirical laws are "anchored to the ground." There remains to connect the theoretical laws with the empirical laws. This is achieved by a kind of reduction sentence that relates the abstract theoretical terms in the theoretical laws with the elementary terms in the empirical laws. This reduction sentence is called the "correspondence rule." It is a semantical rule that gives a partial and only a partial interpretation to the abstract theoretical terms. Thus the axiomatic system is left open, to make it possible to add new correspondence rules when theories are modified and as physics develops, until one day the theory is completely replaced in a scientific revolution by a newer one with different axioms. The new correspondence rules add more empirical meaning to the theoretical terms as theory is developed, and they also enable the physicist to derive

 

empirical laws from the theoretical laws. The logical connection between the two types of laws enables the theoretical laws to explain known empirical laws, but Carnap maintains that the supreme value of a theory is its power to predict new empirical laws; explaining known laws is of minor importance in his view. He observes that every successful revolutionary theory has predicted new empirical laws that are confirmed by experiment.

But there still remains a problem for the Logical Positivist. In this more complicated relationship between theory and experiment, there is a question of how abstract theoretical terms can be distinguished from metaphysical "nonsense." Many philosophers of science, such as Popper, maintain that this is a pseudo problem that cannot be solved. But it was resolved to Carnap's satisfaction by the Ramsey sentence. The Cambridge logician, Frank P. Ramsey, proposed that the combined system of theoretical postulates and correspondence rules constituting the theory be replaced by an equivalent sentence, which does not contain the theoretical terms; in the Ramsey sentence the theoretical terms are eliminated and are replaced by existentially quantified dummy variables. The Ramsey sentence has the same explanatory and predictive power as the original statement of the theory, but without the metaphysical questions that are occasioned by the original formulation with its theoretical terms. Carnap reports that Ramsey did not intend that physicists should abandon their use of theoretical terms; theory is a convenient "short hand" that is useful to the physicist.

Finally mention must be made of another application of the reductionist logic, the unity of science. Both Mach and Duhem expressed the belief that there is a basic unity to all science. In the Vienna Circle the principal advocate of using constructional methods for advancing the unity of science was Otto Neurath, a sociologist who was interested in the sociology of science as well as its linguistic analysis. In his autobiography Carnap stated that Neurath's interest in this effort was motivated by the belief that the division between natural sciences and sociocultural sciences, a division that is characteristic of the Romantic tradition, would be a serious obstacle to the extension of the empiricological method to the social sciences. Neurath expressed a preference for the physicalist or thing language rather than the phenomenalist language, since the former is easier to apply in social sciences. His own views are given in his "Foundations of the Social Sciences" in the second volume of the *International Encyclopedia of Unified Science* (1944). But before Neurath had published his views, Carnap had published his "Logical Foundations of the Unity of Science" in the first volume of the *Encyclopedia* (1938), where he set forth the

 

constructionalist procedures for the logical reduction of the descriptive vocabulary of the empirical sciences to the observational thing language. The use of the thing language presumes in Carnap's view a philosophical thesis called physicalism, the view that the whole of science can be reduced to the physical language, the language of physical things. Carnap says that the physiological and behavioristic approaches in psychology and social science are reducible to the observational thing language, but that the introspective method may not be reducible. The aim of Carnap's constructionalist program is the logical reduction only of the descriptive terms in science to the observational thing language; this effort is not a reduction of the empirical laws of the sciences to one another. The reduction of laws occurs as a part of the development of the sciences themselves and is the task of the empirical scientist, not of the philosopher of science. The constructionalist procedures for the reduction of descriptive terms for the unity of science are the same as those that Carnap had developed for the reduction of theoretical terms.

**Semantical Systems: Probability and Induction**

In his article "Testability and Meaning" in *Philosophy of Science* (1936) Carnap abandoned the idea of verification, because he concluded that hypotheses about unobserved events in the physical world can never be completely verified by observational evidence. Thus he proposed instead the probabilistic idea of confirmation. He became interested in the philosophy of probability in 1941, when he considered that the concept of logical probability might supply an exact quantitative explication of the concept of confirmation of a hypothesis with respect to a given body of evidence, such that it would become possible to speak of a degree of confirmation in a measurable sense. Up to that time there were fundamentally two kinds of concepts of probability, which were proposed by their advocates as alternatives. The earlier view is the frequency concept advanced by Richard von Mises and Hans Reichenbach. The other view is the logical concept advanced by John Maynard Keynes in 1921 and by Harold Jeffreys in 1939, and also considered by Ludwig Wittgenstein in his *Tractatus*, where he defined probability on the basis of the logical ranges of propositions. Wittgenstein's interpretation construes a probability statement to be analytic unlike the frequency concept, which construes it to be synthetic or factual. Carnap believed that the logical concept of probability

 

is the basis for all inductive inference, and therefore he identifies the concept of logical probability with the concept of inductive probability.

In 1950 Carnap published *Logical Foundations of Probability*. This work on probability is not a development in the calculus of probability or in the techniques of statistical inference. It is Carnap's contribution to the interpretation of probability theory with the constructionalist approach, a further development of his metatheory of semantical systems. Here his distinction between object language and metalanguage serves as the basis for his relating the concepts of logical and statistical probability. Statements of statistical probability occur in an object language and are empirical statements about the world. Statements of logical probability occur in the metalanguage and are about the degree of confirmation of statements in the object language. Carnap also refers to the statements in the metalanguage for scientific theory as "metascientific" statements. However, for Carnap metascientific statements are not empirical, but rather are analytic or L-true; he does not recognize an empirical metascience. He accepts the frequency interpretation for the statistical probability asserted by statements in the object language; statistical probability therefore is the relative frequency of an occurrence of an event in the long run. Logical probability is the estimate of statistical probability, and it is the measure of the degree of confirmation. Symbolically he expresses this logical probability as:

$$c(h,e) = r$$

which means that hypothesis ***h*** is confirmed by evidence ***e*** to the degree ***r***. The variable ***r*** is the measure of the degree of confirmation, such that ***r*** can take values from 0.0 to 1.0; it is the estimate of the relative frequency and is expressed as:

$$r = m(e*h)/m(e)$$

where ***m(e*h)*** is the number of observation sentences describing observed confirming instances ***e*** of hypothesis ***h***, and ***m(e)*** is the number of observation sentences ***e*** describing the total number of observed instances, both confirming and disconfirming. He calls ***m*** a measurement function.

In Carnap's view the logical foundation of probability is logic in the sense of L-truth, and he therefore draws upon his metatheory of semantical systems, in which his ideas of state description and range have a central role. A state description is a conjunction containing for every atomic sentence that can be formed in a language, either its affirmation or its negation but not

 

both. Thus every L-true sentence is true in all the state descriptions, and every L-false or self-contradictory sentence is false in every state description. The F-true or factually true sentences are true in only some state descriptions but are not true in others. When the idea of state description is related to the concept of logical probability, the L-true sentences have a degree of confirmation of 1.0, and the L-false sentences have a degree of confirmation of 0.0. The F-true sentences on the other hand have a degree of confirmation between 1.0 and 0.0. A closely related concept is that of the range of a statement. The range is defined as the class of all state descriptions in which an empirical statement is true, and it may also be defined as those state descriptions that L-imply the statement. Using the concept of range the equation ***r = m(e*h)/m(e)*** may be said to be the partial inclusion of the range of ***e*** in ***h*** as measured by ***r***. Therefore the equation ***c(h,e) = r*** is analogous to the statement that ***e*** L-implies ***h*** except that the range of ***e*** is not completely contained in ***h***. Both types of statements are analytical or L-true statements in the metalanguage, because both are statements in logic, one in inductive logic and the other in deductive logic. In Carnap's philosophy the logical foundations of probability is logic in the sense of L-truth.

In 1952 Carnap published *The Continuum of Inductive Methods*, which was to be the volume on the theory of induction that followed *Logical Foundations of Probability*, but he became dissatisfied with this treatment. For many years he continued to work on induction. At the time of his death in 1970 he had completed "Inductive Logic and Rational Decisions" and "A Basic System of Inductive Logic, Part I", which were published in S*tudies in Inductive Logic and Probability,* Volume I (ed. Carnap and Jeffrey, 1971). Carnap did not complete Part II of "A Basic System", and it was edited for publication in 1980 by Jeffrey in *Studies in Inductive Logic and Probability*, Volume II. In "Inductive Logic and Rational Decisions" Carnap is concerned with Bayesian decision theory. In this context the term "probability" does not mean relative frequency, but rather means degree of belief. He distinguishes the psychological concept of actual degree of belief from the logical concept of rational degree of belief. The former is empirical and descriptive, while the latter is normative for rational decision making. Carnap considers the former to be subjective, since it differs from one individual person to another, while the latter is objective. Carnap maintains that contrary to prevailing opinion relative frequency is not the only kind of objective probability. He also calls the former "actual credence" and the latter "rational credence." Rational credence is the link between descriptive

 

theory and inductive logic, and like inductive logic it is formal, deductive and axiomatic. The concepts of inductive logic and of normative decision theory are similar but not identical. The latter are quasi psychological, while the former have nothing to do with observers and agents, even as these are generalized so that the decision theory is not subjective. Hence there are separate measure functions and confirmation functions for rational decision theory and for inductive logic. In his "A Basic System of Inductive Logic" Carnap develops a set-theoretic axiomatic system, which uses set connectives instead of sentence connectives, and which is equivalent to the customary axiom systems for conditional probability.

## Semantical Systems: Information Theory

In 1953 Carnap and Yehousha Bar-Hillel, professor of logic and philosophy of science at the Hebrew University of Jerusalem, Israel, jointly published "Semantic Information" in the *British Journal for the Philosophy of Science*. A more elaborate statement of the theory may be found in chapters fifteen through seventeen of Bar-Hillel's *Language and Information* (1964). This semantical theory of information is based on Carnap's *Logical Foundations of Probability* and on Shannon's theory of communication. In the introductory chapter of his *Language and Information* Bar-Hillel states that Carnap's *Logical Syntax of Language* was the most influential book he had ever read in his life, and that he regards Carnap to be one of the greatest philosophers of all time. In 1951 Bar-Hillel received a research associateship in the Research Laboratory of Electronics at the Massachusetts Institute of Technology. At the time he took occasion to visit Carnap at the Princeton Institute for Advanced Study. In his "Introduction" to *Studies in Inductive Logic and Probability*, Volume I, Carnap states that during this time he told Bar-Hillel about his ideas on a semantical concept of content measure or amount of information based on the logical concept of probability. This is an alternative concept to Shannon's statistical concept of the amount of information. Carnap notes that frequently there is confusion between these two concepts, and that while both the logical and statistical concepts are objective concepts of probability, only the second is related to the physical concept of entropy. He also reports that he and Bar-Hillel had some discussions with John von Neumann, who asserted that the basic concepts of quantum theory are subjective and that this holds especially for entropy, since this concept is based on probability and amount of

 

information. Carnap states that he and Bar-Hillel tried in vain to convince von Neumann of the existence of the differences in each of these two pairs of concepts: objective and subjective, logical and physical. As a result of the discussions at Princeton between Carnap and Bar-Hillel, they undertook the joint paper on semantical information. Bar-Hillel reports that most of the paper was dictated by Carnap. The paper was originally published as a *Technical Report* of the MIT Research Laboratory in 1952.

In the opening statements of "Semantic Information" the authors observe that the measures of information developed by Claude Shannon have nothing to do with what the semantics of the symbols, but only with the frequency of their occurrence in a transmission. This deliberate restriction of the scope of mathematical communication theory was of great heuristic value and enabled this theory to achieve important results in a short time. But it often turned out that impatient scientists in various fields applied the terminology and the theorems of the theory to fields in which the term "information" was used presystematically in a semantic sense. The clarification of the semantic sense of information is very important, therefore, and in this paper Carnap and Bar-Hillel set out to exhibit a semantical theory of information that cannot be developed with the concepts of information and amount of information used by Shannon's theory. Notably Carnap and Bar-Hillel's equation for the amount of information has a mathematical form that is very similar to that of Shannon's equation, even though the interpretations of the two similar equations are not the same. Therefore a brief summary of Shannon's theory of information is in order at this point before further discussion of Carnap and Bar-Hillel's theory.

Claude E. Shannon published his "Mathematical Theory of Communication" in the *Bell System Technical Journal* (July and October, 1948). The papers are reprinted together with an introduction to the subject in *The Mathematical Theory of Communication* (Shannon and Weaver, 1964). Shannon states that his purpose is to address what he calls the fundamental problem of communication, namely, that of reproducing at one point either exactly or approximately a message selected at another point. He states that the semantical aspects of communication are irrelevant to this engineering problem; the relevant aspect is the selection of the correct message by the receiver from a set of possible messages in a system that is designed to operate for all possible selections. If the number of messages in the set of all possible messages is finite, then this number or any monotonic function of this number can be regarded as a measure of the information produced, when one message is selected from the set and with all selections

 

being equally likely. Shannon uses a logarithmic measure with the base of the log serving as the unit of measure. His paper considers the capacity of the channel through which the message is transmitted, but the discussion is focused on the properties of the source. Of particular interest is a discrete source, which generates the message symbol by symbol, and chooses successive symbols according to probabilities. The generation of the message is therefore a stochastic process, but even if the originator of the message is not behaving as a stochastic process, the recipient must treat the transmitted signals in such a fashion. A discrete Markov process can be used to simulate this effect, and linguists have used it to approximate an English-language message. The approximation to English language is more successful, if the units of the transmission are words instead of letters of the alphabet. During the years immediately following the publication of Shannon's theory linguists attempted to create constructional grammars using Markov processes. These grammars are known as finite-state Markov process grammars. However, after Noam Chomsky published his *Syntactical Structures* in 1956, linguists were persuaded that natural language grammars are not finite-state grammars, but are potentially infinite-state grammars.

In the Markov process there exists a finite number of possible states of the system together with a set of transition probabilities, such that for any one state there is an associated probability for every successive state to which a transition may be made. To make a Markov process into an information source, it is necessary only to assume that a symbol is produced in the transition from one state to another. There exists a special case called an ergodic process, in which every sequence produced by the process has the same statistical properties. Shannon proposes a quantity that will measure how much information is produced by an information source that operates as a Markov process: given ***n*** events with each having probability ***p(i)***, then the quantity of information ***H*** is:

$$H = \sum_{i=1}^{n} p(i) \log p(i).$$

In their “Semantic Information" Carnap and Bar-Hillel introduce the concepts of information content of a statement and of content element. Bar-Hillel notes that the content of a statement is what is also meant by the

 

Scholastic adage, *omnis determinatio est negatio*. It is the class of those possible states of the universe, which are excluded by the statement. When expressed in terms of state descriptions, the content of a statement is the class of all state descriptions excluded by the statement. The concept of state description had been defined previously by Carnap as a conjunction containing as components for every atomic statement in a language either the statement or its negation but not both, and no other statements. The content element is the opposite in the sense that it is a disjunction instead of a conjunction. The truth condition for the content element is therefore much less than that for the state description; in the state description all the constituent atomic statements must be true for the conjunction to be true, while for the content element only one of the constituent elements must be true for the conjunction to be true. Therefore the content elements are the weakest possible factual statements that can be made in the object language. The only factual statement that is L-implied by a content element is the content element itself. The authors then propose an *explicatum* for the ordinary concept of the "information conveyed by the statement ***i***" taken in its semantical sense: the content of a statement ***i***, denoted ***cont(i),*** is the class of all content elements that are L-implied by the statement ***i***.

The concept of the measure of information content of a statement is related to Carnap's concept of measure over the range of a statement. Carnap's measure functions are meant to explicate the presystematic concept of logical or inductive probability. For every measure function a corresponding function can be defined in some way, that will measure the content of any given statement, such that the greater the logical probability of a statement, the smaller its content measure. Let ***m(i)*** be the logical probability of the statement ***i***. Then the quantity ***1-m(i)*** is the measure of the content of ***i***, which may be called the "content measure of ***i***", denoted ***cont(i).*** Thus:

$$cont(i) = 1 - m(i).$$

However, this measure does not have additivity properties, because ***cont*** is not additive under inductive independence. The ***cont*** value of a conjunction is smaller than the ***cont*** value of its components, when the two statements conjoined are not content exclusive. Thus insisting on additivity on condition of inductive independence, the authors propose another set of measures for the amount of information, which they call "information measures" for the idea of the amount of information in the statement ***i***, denoted ***inf(i),*** and which they define as:

 

$$inf(i) = log \{1/[1-cont(i)]\}$$

which by substitution transforms into:

$$inf(i) = - log\ m(i).$$

This is analogous to the amount of information in Shannon's mathematical theory of communication but with inductive probability instead of statistical probability. They make their use of the logical concept of probability explicit when they express it as:

$$inf(h/e) = - log\ c(h,e)$$

where ***c(h,e)*** is defined as the degree of confirmation and ***inf(h/e)*** means the amount of information in hypothesis ***h*** given evidence ***e***. Bar-Hillel says that ***cont*** may be regarded as a measure of the "substantial" aspect of a piece of information, while ***inf*** may be regarded as a measure of its "surprise" value or in less psychological terms of its "objective unexpectedness." Bar-Hillel believed that their theory of semantic information might be fruitfully applied in various fields. However, neither Carnap nor Bar-Hillel followed up with any investigations of the applicability of their semantical concept of information to scientific research. Later when Bar-Hillel's interests turned to the analysis of natural language, he noted that linguists did not accept Carnap's semantical views.

## Shreider's Semantic Theory of Information

Carnap's semantic theory of information may be contrasted with a more recent semantic information theory proposed by the Russian information scientist, Yu A. Shreider (also rendered from the Russian as Ju A. Srejder). In his "Basic Trends in the Field of Semantics" in *Statistical Methods in Linguistics* (1971) Shreider distinguishes three classifications or trends in works on semantics, and he relates his views to Carnap's in this context. The three classifications are ontological semantics, logical semantics, and linguistic semantics. He says that all three of these try to solve the same problem: to ascertain what meaning is and how it can be described. The first classification, ontological semantics, is the study of the various philosophical aspects of the relation between sign and signified. He

 

says that it inquires into the very nature of existence, into the degrees of reality possessed by signified objects, classes and situations, and that it is closely related to the logic and methodology of science and to the theoretical foundations of library classification.

The second classification, logical semantics, studies formal sign systems as opposed to natural languages. This is the trend in which he locates Carnap, as well as Quine, Tarski, and Bar-Hillel. The semantical systems considered in logical semantics are basic to the metatheory of the sciences. The meaning postulates determine the class of permissible models for a given system of formal relations. A formal theory fixes a class of syntactical relations, whence there arises a fixed system of semantic relations between a text describing a possible world.

The third classification, linguistic semantics, seeks to elucidate the inherent organization in a natural language, to formulate the inherent regularities in texts and to construct a system of basic semantic relations. The examination of properties of extralinguistic reality, which determines permissible semantic relations and the ways of combining them, is carried considerably farther in linguistic semantics than in logical semantics, where the question is touched upon only in the selection of meaning postulates. However, linguistic semantics is still rather vague and inexact, being an auxiliary investigation in linguistics used only as necessity dictates. Shreider locates his work midway between logical and linguistic semantics, because it involves the examination of natural language texts with logical calculi.

Shreider's theory is a theory of communication that explains phenomena not explained by Shannon's statistical theory. Bibliographies in Shreider's English-language articles contain references to Carnap's and Bar-Hillel's 1953 paper, and Shreider explicitly advocates Carnap's explication of intensional synonymy in terms of L-equivalence. But Shreider's theory is more accurately described as a development of Shannon's theory, even though Shreider's theory is not statistical. English language works by Shreider include "On the Semantic Characteristics of Information" in *Information Storage and Retrieval* (1965), which is also reprinted in *Introduction to Information Science* (ed. Tefko Saracevic, 1970), and "Semantic Aspects of Information Theory" in *On Theoretical Problems On Information* (Moscow, 1969). Furthermore comments on Shreider and other contributors to Russian information science (or "informatics" as it is called in Russia) can be found in "Some Soviet Concepts of Information for

 

Information Science" in the *American Society for Information Science Journal* (1975) by Nicholas J. Belkin.

Like many information scientists who take up semantical considerations, Shreider notes that there are many situations involving information, in which one may wish to consider the content of the message signals instead of the statistical frequency of signal transmission considered by Shannon's theory. But Shreider furthermore maintains that a semantical concept of information implies an alternative theory of communication in contrast to Shannon's "classical" theory. Shannon's concept pertains only to the potential ability of the receiver to determine from a given message text a quantity of information; it does not account for the information that the receiver can effectively derive from the message, that is, the receiver's ability to "understand" the message. In Shreider's theory the knowledge had by the receiver prior to receiving the message is considered, in order to determine the amount of information effectively communicated.

More specifically, in Shannon's probability-theoretic approach, before even considering the information contained in a message about some event, it is necessary to consider the *a priori* probability of the event. Furthermore according to Shannon's first theorem, in the optimum method of coding a statement containing more information requires more binary symbols or bits. In Shreider's view, however, a theory of information should be able to account for cases that do not conform to this theorem. For example much information is contained in a statement describing a newly discovered chemical element, which could be coded in a small number of binary symbols, and for which it would be meaningless to speak of an *a priori* probability. On the other hand a statement describing the measurements of the well known physicochemical properties of some substance may be considerably less informative, while it may need a much more extensive description for its coding. The newly discovered element will change our knowledge about the world much more than measurement of known substances. Shreider maintains that a theory of information that can take into account the receiver's ability to "understand" a message must include a description of the receiver's background knowledge. For this reason his information theory includes a thesaurus, by which is meant a unilingual dictionary showing the semantic connections among its constituent words.

Let **T** denote such a thesaurus to represent a guide in which there is recorded our knowledge about the real world. The thesaurus **T** can be in any one of various states, and it can change or be transformed from one state to another. Let **M** represent a received message, which can transform the

 

thesaurus **T.** Then the concept of amount of information, denoted ***L***(**T**,**M**), may be defined as the degree of change in the thesaurus **T** under the action of a given statement **M.** And for each admissible text **M** expressed in a certain code or language, there corresponds a certain transformation operator θ, which acts on thesaurus **T.** The salient point is that the amount of information contained in the statement **M** relative to the thesaurus **T** is characterized by the degree of change in the thesaurus under the action of the communicated statement. And the understanding of the communicated statement depends on the state of the receiver's thesaurus. Accordingly the thesaurus **T** can understand some statements and not others. There are some statements that cannot be understood by a given thesaurus, and the information for such a thesaurus is zero, which is to say ***L***(**T**, **M)=0**, because the thesaurus **T** is not transformed at all. One such case is that of a student or a layman who does not have the background to understand a transmitted message about a specialized subject. Another case is that of someone who already knows the transmitted information, so that it is redundant to what the receiver already knows. In this case too there is no information communicated, and again ***L***(**T**,**M)=0**, but in this case it is because the thesaurus **T** has been transformed into its initial state. The interesting situation is that in which the receiver's thesaurus is sufficiently developed that he understands the transmitted message, but still finds his thesaurus transformed into a new and different state as a result of receipt of the new information. If the rules of construction of the transformation operator θ are viewed as external to the thesaurus **T**, then the quantity ***L***(**T**,**M**) depends on these rules. And when the transformation operator θ is also revised, a preliminary increase of the knowledge stored in the thesaurus **T** may not only decrease the quantity of information ***L***(**T**,**M**), but can also increase it. Thus someone who has learned a branch of a science will derive more information from a special text in the branch than he would before he had learned it. This peculiar property of the semantic theory of information basically distinguishes it from the Shannon's classical theory, in which the increase in *a priori* information always decreases the amount of information from a message statement **M**. In the classical theory there is no question of a receiver's degree of "understanding" of a statement; it is always assumed that he is "tuned." But in the semantic theory the essential role is played by the very possibility of correct "tuning" of the receiver.

In his 1975 article Belkin reports that Shreider further developed his theory of information to include the idea of "meta-information." Meta-information is information about the mode of the coding of information, i.e.

 

the knowledge about the relation between information and the text in which it is coded. In this sense of meta-information the receiver's thesaurus must contain meta-information in order to understand the information in the received message text, because it enables the receiver to analyze the organization of the semantic information, such as that which reports scientific research findings. Shreider maintains that informatics, the Russian equivalent to information science, is concerned not with information as such, but rather with meta-information, and specifically with information as to how scientific information is distributed and organized. Therefore, with his concept of meta-information Shreider has reportedly modified his original theory of communication by analyzing the thesaurus **T** into two components, such that **T=(Tm,To).** The first component **Tm** consists of the set of rules needed for extracting elementary messages from the text **M**, while the second component **To** consists of the factual information that relates those elementary messages systematically and enables the elements to be integrated in **T.** The relationship between **Tm** and **To** is such that a decrease in the redundancy of coding of **To** requires an increase of the meta-information in **Tm** for the decoding of the coding system used for **To**. Hence the idea of meta-information may be a means of realizing some limiting efficiency laws for information by analyzing the dependency relation between information and the amount of meta-information necessary to comprehend that information.

It would appear that if the coding system is taken as a language, then Shreider's concept of meta-information might include to the idea of metalanguage as used by Carnap and other analytical philosophers, or it might be incorporated into the metalanguage. Then the elements **Tm** and **To** are distinguished as metalanguage and object language respectively, although the philosophers have had little interest in examining the inverse dependency between them.

## The Philosophy of Science

*Aim of Science*

Carnap's explicit statement of the aim of science is set forth in his *Aufbau*. The aim of science consists in finding and ordering true propositions firstly through the formulation of the constructional system - the introduction of concepts - and secondly through the ascertainment of the empirical connections between the concepts. This is completely

 

programmatic, and says nothing about what scientists actually do in their research practices. For most contemporary philosophers a discussion of the aim of science is a discussion in the pragmatics of science, that is, what the scientist does as a user of scientific language when he does research. But Carnap identifies the pragmatics of language with the empirical investigation of historically given natural languages. He always constructs his own languages usually using Russell's symbolic logic, and then uses these artificial languages to address the philosophical problems of interest to the Positivist program for philosophy, namely, the reduction of theoretical terms to demonstrate their meaningfulness and the reduction of the vocabulary of science to the common basis set forth in the *Aufbau*, to advance its unification.

*Scientific Explanation*

Carnap also has explicit views on scientific explanation: He says it always involves laws, and he classifies scientific laws as either empirical laws or theoretical laws. Empirical laws explain facts, which are statements that describe individual instances. The explanation has the logical structure of a deduction. The premises of the deduction consist of at least one law that has the form of a conditional statement, and statements of fact that describe individual instances in the same terms as those occurring in the antecedent sentences of the conditional law. The conclusion is also a factual sentence that describes the individual instances in the same terms as those in the consequent sentence of the conditional law. In this manner empirical laws explain observed instances described by factual statements. Theoretical laws are related to empirical laws in a way that is analogous to the way that empirical laws are related to facts. The theoretical law is more general. It helps to explain deductively empirical laws that are already known and to permit the derivation of new empirical laws, just as the empirical laws help to explain facts that have been observed and to predict new facts. Furthermore the theoretical law puts several empirical laws into an orderly pattern, just as the empirical generalization puts many facts into an orderly pattern. The supreme value of theory is its power to predict new empirical laws; explaining known laws is of minor value. Every revolutionary theory in the history of science has predicted new empirical laws that are confirmed by empirical tests.

Unlike Duhem, Carnap does not stratify the semantics of physics. To say that theoretical laws explain empirical laws is not for Carnap to say as Duhem did, that the theory is an axiomatic system with conclusions that are

 

statements which parallel the empirical laws, and that have their own semantics that in turn refers to the empirical laws. In Carnap's view the theoretical terms receive all their semantics from the observation terms by means of reduction sentences which he calls “correspondence rules.” When Carnap says that theoretical laws explain empirical laws, he means that a deductive relationship is established between the axioms of the theory and the empirical laws, and that the relationship is mediated by the correspondence rules. The postulated axioms, which are the theoretical laws, together with the correspondence rules enable the physicist to explain empirical laws by logical deduction. In Carnap's philosophy the numerical approximation that Duhem saw existing between the solution sets for the equation deduced from the axioms on the one hand and the solution sets for the equation the empirical laws on the other hand, has no semantical implications and is not problematic. The post-Positivist philosophers agree with Duhem, and maintain that while the numerical difference between theoretical and empirical laws are experimentally indistinguishable due to measurement error, nonetheless the solution sets from the two types of laws are logically distinguishable, such that it is incorrect to say that experimental laws are logically derived from theoretical postulates. In Popper’s phraseology the derived theoretical laws (such as Newton’s) “correct” the experimental laws (such as Kepler’s) purporting to describe the same phenomena.

*Scientific Criticism*

Carnap's philosophy of scientific criticism is his thesis of confirmation. Both theoretical and empirical laws may be more or less confirmed, but empirical laws are confirmed directly by observation or measurement, while theoretical laws are confirmed indirectly through the confirmation of the empirical laws deductively derived from them. Both empirical and theoretical laws may be classified as either universal or statistical laws. Most of Carnap's discussion of this distinction is in the context of empirical laws. All empirical laws are statements expressing observed regularities as precisely as possible. If a certain regularity is observed at all times and in all places, then that regularity is expressed in the form of a universal law. But if the law asserts that an event or the relation of one event to another occurs in only a certain percentage of cases, then the statement is called a statistical law. Both types of laws occur in the object language of science, and both are empirical statements. Statements about either universal and statistical laws occur in the meta-language, that refers to

 

the object language of science in which the law and theory statements are expressed, and for either types the statements in the metalanguage may refer to the degree of confirmation of the laws. Statements of the degree of confirmation are statements of logical probability associated with both universal and statistical laws. Logical probability is an estimate of the long-term relative frequency stated by the statistical laws, and takes values between zero and one inclusively. The statements associating the degree of confirmation to a statement in the object language are statements in the metalanguage. The metalanguage is a language of the philosopher of science, and philosophy is not in Carnap's view an empirical or factual science. Philosophy of science is the logic of science, and the statements in the metalanguage are L-true or analytic. Logical probability is the logical relation similar to logical implication. By a logical analysis of a stated hypothesis *h* and the stated evidence *e*, one may conclude that *h* is not deductively implied but is partially implied by *e* to the degree *r*. For any pair of sentences *e* and *h* inductive logic assigns a number giving the logical probability of *h* with respect to *e*. In this way Carnap views the metalanguage to consist of analytic statements as opposed to the synthetic statements in the object language consisting of laws of nature.

*Scientific Discovery*

Carnap's philosophy of scientific discovery gives different accounts for the discovery of empirical laws and the discovery of theoretical laws. His philosophy of discovery of empirical laws is inductivist; induction is the measurement of the degree of regularity in observed instances known either passively by casual observation or actively by experimentation. His philosophy of discovery of theoretical laws recognizes the role of the creative imagination. He gives consideration to the use of computers. He expresses doubts that rules can be established to enable a scientist to survey millions of sentences giving various observational reports, and then by a mechanized procedure applying these rules to generate a general theory consisting of a system of theoretical laws that would explain the observed phenomena. This is because theories deal with unobservables and use a conceptual framework that goes far beyond the framework used for the description of observations. Creative ingenuity is needed to create theories. Therefore Carnap concludes that there cannot be an inductive machine, a computer system into which the scientist can input all the relevant observation sentences, and then get an output consisting of a system of laws that explain the observed phenomena. He only believed that given

 

observation *e* and hypothesis *h*, there could be an inductive machine which will mechanically determine the logical probability or degree of confirmation of *h* on the basis of *e.* It may be noted in this connection that the post-Positivist philosophers of science rejected the Positivist's strong distinction between theory and observation. Like Einstein and Heisenberg, they maintained that theory determines what is observed. Therefore, they maintain that there exists no theory-independent framework for observation.

**Hempel's Critique of Analyticity**

Carl G. Hempel (1905-1997) was one of Carnap's more sympathetic colleagues, and had been Carnap's assistant just after immigrating to the U.S. from Nazi Germany. In the *New York Times* (23 November 1997) obituary for Hempel, Quine was quoted as describing Hempel as a “moderate Logical Positivist”, and as saying that Hempel’s views had been succeeded by relativist doctrines, which would make science a matter of fads, and which Quine are “anti-scientific.” In his later years Quine concluded that his wholistic view of observation statements implies a relativistic theory of truth, and he retreated from the implications of his “Two Dogmas of Empiricism” (1952). After reading Quine's "Two Dogma's of Empiricism" in which Quine criticized Carnap's concept of analyticity, Hempel gave serious reconsideration to Carnap's analyticity thesis. Hempel does not reject Carnap's concept of L-truth. His disagreement is only with the concept of A-truth, the truth that Carnap calls meaning postulates, which are known to be true by virtue of the meaning relations among the descriptive terms in the sentence.

Hempel's critique of A-truth is set forth in "Implications of Carnap's Work for the Philosophy of Science" in Schilpp's *The Philosophy of Rudolf Carnap* (1963) and relevant comments are to be found in his earlier work, "Theoretician's Dilemma" in *Minnesota Studies* (1958). Firstly Hempel considers problems of empirical significance presented by analyticity. After contrasting Carnap's concept of reduction sentences with the idea of definition, taking note that the reduction sentence offers convenient schema for a partial operational meaning, Hempel states that contrary to Carnap the reduction type of sentence does not eliminate all dependency on general empirical laws in these sentences. He says that Paul W. Bridgman had advocated operational definitions with one definition for every method of measurement, because defining any measurement concept by more than one method of measure incurs the risk of an invalid empirical generalization,

 

even if the different methods yield the same measurement value. The reduction type of sentence eliminates this risk, because in it only one generalization is used. However, Hempel says that an inductive risk is still incurred even for reduction sentences, since even if only one operational criterion is used any application of a term requires a generalization. Therefore reduction sentences "fuse" together two functions of language, which had traditionally been thought to be totally different. These are firstly the specification of meanings and secondly the description of contingent fact. He maintains that the fruitful introduction of new concepts in science is always intimately bound up with the establishment of new laws.

Hempel then generalizes on his thesis that reduction sentences have the two functions of meaning specification and empirical law, to produce his own general conception of a semantical or "interpretative" system. Firstly he distinguishes an observational and a theoretical vocabulary. Then he states that a theory *T* characterized by a set of postulates with primitive theoretical terms constituting the theoretical vocabulary, is made an interpreted system by the set of sentences *J* satisfying three conditions: (1) *J* is logically compatible with *T*; (2) *J* contains no extralogical (descriptive) terms that are not an element of the observational or theoretical vocabulary; (3) *J* contains elements of the observational and theoretical vocabulary in an essential way, i.e. in a manner that does not make *J* logically equivalent to some set of sentences in which neither the observational or the theoretical terms occur. Interpretative systems so conceived share the same two characteristics that distinguish reduction sentences from definitions. Firstly they give only partial definitions of the theoretical terms they specify, and secondly they are not purely stipulative in character, but imply certain statements containing only observational terms. However unlike Carnap's concept of a semantical system with reduction sentences, Hempel's general concept of an interpretative system does not provide an interpretation, complete or incomplete, for each theoretical term individually in the whole system. Therefore in the interpretative system *J* the theoretical terms are not dispensable, and Hempel argues that in his definition of an interpretative system, the distinction between the theory and its interpretative sentences is arbitrary, because these two types of sentences have the same status and function. It is only in conjunction with the interpretative sentences that the theory can imply observational sentences, and the interpretative sentences no less than the theory may be theoretical laws. Furthermore, when discrepancies between predictions and experimental data call for modification of the predictive apparatus, suitable adjustments may be made

 

not just by changing the theory but alternatively by changing the interpretative sentences. Therefore interpretative sentences must have the same status as the sentences constituting the theory, thus making it difficult to identify either theory or interpretative sentences as analytic. Following a similar line of argument Hempel rejects Carnap's proposal of introducing predicates by means of meaning postulates, which purport to separate the meaning specification function from the empirically descriptive function. Hempel questions the rationale for separating these two functions. He asks what distinctive status is conferred on a meaning postulate, since any statement once accepted in empirical science may conceivably be abandoned for the sake of resolving a conflict between theory and the stated body of available evidence. He says that apart from logical and mathematical truths, there can be no scientific statements that satisfy conditions for analytic meaning postulates.

In addition to discussing problems for empirical significance of analytical sentences, Hempel also discusses problems of empirical testing. He references Carnap's *Logical Syntax of Language*, where Carnap references Poincare and Duhem, saying that no statement accepted in empirical science is taken to be immune from criticism and revision. Carnap furthermore stated that a statement in a scientific theory cannot be tested in isolation, but must be tested with other accepted statements, such that it is the entire theoretical system that is tested. And this is what Quine also maintains in his "Two Dogmas", which Hempel references in this context. Hempel relates that on Carnap's view of a semantical system, in which theoretical terms are viewed as being introduced by reduction sentences based on an observation vocabulary, it is possible to speak of individual sentences containing theoretical terms as being confirmable by reference to observation sentences. But Hempel notes that in his general concept of an interpreted theory, this idea has no useful counterpart, because one would have to say that the experimental import of a sentence relative to an interpreted theory is expressed by the class of nonanalytic observation sentences implied by the sentences and the theory. His view renders the notions of testability and experiential significance relative to a given theory, assigning all sentences of the theory the same experiential import represented by the class of all observation sentences implied by the theory. This is because testability and empirical significance are attributable not to scientific statements in isolation, but only to interpreted theoretical systems. Furthermore, as Kuhn notes in *The Road Since Structure* (1993), a few years after writing "Theoretician's Dilemma" Hempel began speaking of

 

"antecedently available terms" instead of "observation terms", thus implicitly adopting what Kuhn describes as a developmental or historical view of science.

Hempel concludes that these considerations make it doubtful that the basic tenants of Positivism and empiricism can be formulated in a clear and precise way. The circumstance that empirical significance and testability requirements are applicable to entire theoretical systems, make these requirements extremely weak. For the Positivist that weakness permits the disturbing possibility of adding to contemporary physical theory an axiomatized metaphysics of Being and Essence that would be an empirically significant system. One alternative is to exclude theoretical terms altogether, but Hempel invokes the criterion of simplicity. He concludes that the problem of giving a precise explication of this aspect of scientific theories presents a new and challenging task for the philosophy of science.

## Carnap's Reply to Hempel

Carnap replies to Hempel's attack on the analytic-synthetic distinction both in the Schilpp volume containing Hempel's critique and in the concluding two chapters of his *Philosophical Foundations of Physics* (1963). He maintains that the analytic-synthetic distinction is of supreme importance for philosophy of science. The theory of relativity could not have been developed had Einstein not recognized the sharp dividing line between pure mathematics, in which there are many logically consistent geometries, and physics, in which only experiment and observation can determine which of these mathematical geometries can be applied most usefully to the physical world. This reply made late in Carnap's career reveals how influential Einstein's development of relativity theory was on Carnap's philosophical thinking.

Firstly however Carnap takes up the identification of the analytic-synthetic distinction in natural language. He notes that natural language is sufficiently imprecise that not everyone understands every word in the same way, such that some sentences may be ambiguous as to whether they are analytic or factual. The division depends on what characteristics described by the predicate terms are taken to be essentially or definitively related to one another. For example does red colored head plumage define a redheaded woodpecker? If not, then a green headed bird may be classified as a redheaded woodpecker, if it has other characteristics deemed definitive

 

of the species. Carnap maintains that while certain statements may be ambiguous due to the vagueness of the predicates, the analytic-synthetic distinction as such is not therefore problematic for the same reason.

Carnap next turns to the analytic-synthetic distinction in an artificial observation language. In this case the distinction is determined by laying down precise rules, which are the meaning postulates or A-postulates. These rules determine what characteristics described by predicate constants are essential to their subjects. To the extent that these rules are vague, there will be sentences that are vague with respect to the analytic-synthetic status. But Carnap says that in such cases the distinction between analytic and synthetic is not as such vague.

Then he turns to the determination of the distinction in an artificial theoretical language, where the fact that theoretical terms cannot be given complete interpretations causes special difficulties. He takes as an example the track in the Wilson cloud chamber, which can be observed and can be explained in terms of an electron passing through the chamber. Such observations provide only a partial and indirect empirical interpretation of the entity referenced by the theoretical term "electron", to which the observed track is linked by correspondence rules. The problem is to find a way to distinguish in the linguistic network of correspondence postulates and theoretical postulates, those sentences that are analytic and those that are synthetic. It is easy to identify the L-true sentences, because descriptive terms are not involved in determining L-truth. But A-truth, the truth of analytic sentences, is problematic in this case. To recognize analytic statements in a theoretical language, it is necessary to have A-postulates that satisfy the meaning relations holding among the theoretical terms. But the theoretical postulates alone cannot serve as A-postulates, since without the correspondence rules the theoretical postulates have no interpretation at all. Yet the theoretical postulates together with the correspondence postulates cannot be analytic, because then the theory would have no empirical content.

Carnap notes Hempel's proposal that there is a double role for the theoretical and correspondence postulates, that defies the analytic-synthetic distinction, such that these postulates both stipulate meaning and also make empirical assertions. But Carnap proposes another way that preserves the empirical content of scientific theories while admitting the analytic-synthetic distinction. His proposal utilizes the Ramsey sentence, but without Ramsey's final step of eliminating the theoretical terms from the semantical system, since he believes that eliminating theoretical terms is too inconvenient for the scientists, who find that theoretical terms simplify their

 

work enormously. Instead of splitting an interpreted theory into theoretical postulates and correspondence rules, Carnap proposes splitting it into analytic and factual sentences with the factual part consisting of a Ramsey sentence equivalent to the empirical content of the interpreted theory. The Ramsey sentence therefore implies the whole interpreted theory, and this implication is itself analytic; it is the analytic part of the theory. Carnap maintains that this analytic implication provides a way to distinguish between analytic and synthetic statements in the theoretical language, because the analytic implication is that if there exist entities, that are referenced by the existential quantifiers of the Ramsey sentence, that are of a kind bound together by all the relations expressed in the theoretical postulates of the theory, and that are related to observed entities by all the relations specified by the correspondence postulates of the theory, then the theory itself is true.

In his "Theoretician's Dilemma" Hempel had criticized the Ramsey sentence as avoiding reference to theoretical entities only in Greek variables rather than in spirit. The Ramsey sentence still asserts the existence of certain entities of the kind postulated by a physical theory without guaranteeing any more than does the physical theory that those entities are observable or at least are fully characterizable in terms of observables. Therefore, the Ramsey sentence provides no satisfactory way of avoiding theoretical concepts.

In his replies to Hempel in Schilpp's book Carnap says that he agrees with Hempel that the Ramsey sentence does refer to theoretical entities by the use of abstract variables. But he argues that these entities are not unobservable physical objects like atoms or electrons, but rather are purely logicomathematical entities such as natural numbers, classes of such numbers, or classes of classes. The Ramsey sentence for a physical theory is a factual statement that says that the observable events in the world are such that there are natural numbers, classes of such numbers, or classes of classes, that are correlated with the events in a prescribed way, and which have among themselves certain relations.

## Quine's Pragmatist Critiques

Willard Van Orman Quine (1908-2000) was born in Akron, Ohio. In 1930 he graduated *summa cum laude* in mathematics from Oberlin College, and then entered Harvard University's graduate school of philosophy. He

 

wrote his doctoral dissertation under the direction of Alfred North Whitehead, the co-author with Bertrand Russell of the *Principia Mathematica*, and he published it as *A System of Logistic* in 1934. Quine became a faculty member of Harvard's department of philosophy in 1936, where he remained for the duration of his long career. He enjoyed traveling, and wrote an autobiographical travelogue as *The Time of My Life* in 1985. Quine described his long acquaintanceship with Carnap in "Homage to Rudolf Carnap" (1970), a memorial article published in the year of Carnap's death, and reprinted later in Quine's *Ways of Paradox* (1976). Quine met Carnap during his European travels in the 1930's, and their dialogues continued after Carnap relocated to the United States in 1935. While Quine might be regarded as Carnap's principal protagonist, their philosophies are much more similar than different. In the memorial article Quine refers to Carnap as a towering figure, who dominated philosophy in the 1930's as Russell had in previous decades, and he also refers to Carnap as his greatest teacher. Their private correspondence has been published under the title *Dear Carnap, Dear Van* (ed. Creath, 1990), which reveals nothing about their philosophical views that is not already known from their published works, but exhibits their enduring friendship notwithstanding their widening philosophical differences.

Quine's best known criticism of Carnap's philosophy is his rejection of the analytic type of statement. This criticism together with several others has their basis in Quine's Pragmatist view of empiricism. Quine published a brief statement of his own doctrine of empiricism as "The Pragmatist's Place in Empiricism" (1975), later appearing in his *Theories and Things* (1981) as "Five Milestones of Empiricism." This paper is ostensibly a history of empiricism in terms of five historical turning points, but the five historical milestones also happen to be the central theses of Quine's own Pragmatist philosophy. He summarizes these five historical turning points as follows:

1. The shift from ideas to words
2. The shift of semantic focus from terms to sentences
3. The shift of semantic focus from sentences to systems of sentences
4. The abandonment of the analytic-synthetic distinction
5. The abandonment of any first philosophy prior to natural science

Quine's several criticisms of Carnap's Positivist version of empiricism may be viewed as having a basis in these five distinctive aspects of his Pragmatist version of empiricism. The first two of the five points are the

 

basis for Quine's criticism of Carnap's doctrine of intensions, as well as a critique of the idea of propositions. The third point, sometimes known as the Duhem-Quine thesis, is the basis for Quine's critique of logical reductionism and for his wholistic thesis of semantical indeterminacy and his thesis of ontological relativity. The fourth is his rejection of analyticity, which follows from the third point. And the fifth and final point is Quine's critique of Carnap's doctrine of "frameworks" and of the distinction between "internal" and "external" questions. Each of these criticisms is considered in greater detail below.

## Quine's Critique of Intensions and Propositions

At the close of his "Foreword" to Quine's *A System of Logistic* Whitehead commented that logic prescribes the "shapes" of metaphysical thought. The logic under consideration of course was that in Whitehead and Russell's *Principia Mathematica*, and the metaphysics that is “shaped” by the Russellian syntactical categories - giving the existential claim to the quantifiers - is nominalism. There was probably no expositor of this logic that both illustrated and advocated Whitehead's comment more consistently than Quine. For more than a decade after *System of Logistic* Quine published a number of articles which describe how the Russellian symbolic logic and specifically how its theory of quantification enables the user of the logic to exhibit explicitly his ontological commitments, the shape of his metaphysics. The user's ontological commitment to the kinds of things he believes exists, is exhibited by the variable, the symbol that is bound by either the existential or the universal quantifier. The term "variable" in this context has a distinctive meaning that it does not have in mathematics. In his "A Logistical Approach to the Ontological Problem" (1939) reprinted in *Ways of Paradox* (1966) Quine expresses the role of logical quantifiers with the memorable refrain: To be is to be the value of a variable. This means that what entities there are from the viewpoint of a given discourse in the logic depends on what symbols are accessible to binding by quantifiers to become variables in the symbolic logic, and a shift from one discourse to another may involve a shift of ontology.

In 1947 Quine published "On Universals" in *Journal of Symbolic Logic* and "Logic and the Reification of Universals" in *From A Logical Point of View* (1953). In these papers he describes how the nominalist and realist views toward the historic problem of universals are expressed in the

 

Russellian notation. The nominalist view is that only individuals exist, and it is expressed in the Russellian notation by limiting the quantifiers to ranging only over symbols referencing individual entities. On the other hand the universalist view affirms that attributes or properties exist. In the Russellian notation the existence of attributes is expressed by placing predicates within the range of quantifiers. For this reason Quine calls the universalist view the "Platonist" view, and he calls the attributes "abstract entities." Or when the abstract entities are said to exist in the human mind as meanings or concepts, Quine calls them "mental entities." The Russellian logic thus imposes a dichotomy that reduces both realism and conceptualism to distorting caricatures that philosophers since Plato have dismissed. The notational role of the quantifier is referential, such that whatever type of symbol may assume the role of a variable bound by a quantifier, thereby assumes the role of referencing an entity. Ostensibly Quine's purpose is not to advocate one or the other ontological thesis, but to advocate the role of the quantifiers as making a philosopher's ontological commitment explicit.

Quine has his own view on the issue of universals. In 1947 he co-authored with Nelson Goodman "Steps Toward A Constructive Nominalism" in *The Journal of Symbolic Logic*. Unlike most papers appearing in academic journals, this article was not so much an analytical paper, as it was a kind of manifesto advocating a nominalist programme for applying the symbolic logic. Quine has denied that he is a nominalist, because he accepts the existence of classes, which he views as a kind of abstract entity. And he accepts the existence of classes, because he could not eliminate them in the logistic reductionist programme. But he denies that descriptive predicates have any signification with a foundation in reality, and offers no explanation as to why classes are anything but arbitrary collections. Typically nominalists do not reject classes. What they reject is that there are either mental concepts or real attributes that are the basis for classes, and they view classes as merely collections of entities that are referenced by terms. Thus notwithstanding Quine's attempt to separate his views from nominalism, he is a *de facto* nominalist, because he explicitly rejects the existence of such abstract entities or mental entities as properties, attributes and intensions, such as are propounded not only by Carnap but also by the majority of Pragmatist philosophers today. Today philosophers of science investigating scientific revolutions and also those developing computational systems have come to accept the existence of a three-level cognitive semantics of words, intensions and extensions, instead of a two-level referential semantics of only words and extensions. Nominalists are

 

always troubled by coreferential terms having the same extension but having different meanings or intensions. One reason that Quine rejects these latter types of abstract entities is that they can be eliminated from the logistic reductionist programme as he construes it. The second reason is that he denies that Carnap's intensions can be treated extensionally, as Carnap attempts to treat them by relating them to classes by analytical statements, a type of statement that Quine rejects.

In "Five Milestones" Quine notes that the first of the five turning points in the history of empiricism, the shift from ideas to words. In his *Word and Object* he calls this shift “semantic assent”, which he advocates because philosophical discourse is carried into a domain where participants are better agreed on the objects, i.e. the words. In “Five Milestones” he says that the shift originated with the medieval nominalists. He argues against the reification of universals, and says that affirming the existence of abstract or mental entities is due to a common confusion, in which descriptive predicates are given a referential function that is properly had by bound variables. In "Ontological Relativity" he describes this error as a case of the copy theory of knowledge, which he says is an uncritical semantics. He ridicules this error as the "myth of the museum" and the "fantasy of the gallery of ideas", by which he means that words are mistakenly understood to be labels for ideas or meanings, as though they were exhibits. He views the confusion between names and descriptions to be a particularly pernicious philosophical error, and he maintains that Russell's theory of descriptions offers the way to avoid it. This is the technique used by Russell in his "On Denoting" in *Mind* (1908). In his "On What There Is" (1948) reprinted in *Logical Point of View* Quine says that Russell's theory of descriptions enables the philosopher to transform names into predicates, such that names should not be taken as an ontological criterion for deciding what is real. The correct criterion for determining the ontology of a language is the use of the quantified symbol or variable, so that predicates are not confused with names, and no claims are made to the effect that predicates name entities, unless the predicates are explicitly quantified.

Closely related to the first milestone, the second is the shift of semantic focus from terms to sentences. In "Five Milestones" Quine explains that the meanings of words are abstractions from the truth conditions of the sentences that contain them, and that it was the recognition of this semantic primacy of sentences that gave us contextual definition. Quine traces the development of contextual definition, which he calls a revolution in semantics, to Jeremy Bentham's technique of "paraphrasis",

 

which is a kind of paraphrasing or circumlocution. If Bentham found some terms convenient but ontologically embarrassing, contextual definition enabled him in some cases to enjoy the services of the term, while disclaiming its denoting. In "Russell's Ontological Development" (1966) reprinted in *Theories and Things* (1981) Quine joins Ramsey's characterization of Russell's theory of descriptions as a paradigm of philosophical analysis, and he says that our reward for the paraphrasis technique is the recognition that the unit of communication is the sentence and not the word.

In his *Meaning and Necessity* Carnap explicitly affirms that intensions are not names either of concepts or of abstract entities. He maintains that like physical properties intensions may be said to be objective without invoking any hypostatization, and that they are indifferent to either concrete or abstract objects. Carnap's intensions are reminiscent of the Scholastic logicians' distinction between *suppositio* and *significatio* for terms, although Carnap never makes this comparison. According to the theory of *suppositio* a univocal term's *significatio* or meaning is the same whether the term occurs either as a subject or as a predicate in an affirmative categorical proposition. But its *suppositio* or supposition as a subject is called "personal", because it references the individual members of the class according to its associated quantifier, while its supposition as a predicate is called "simple", because no reference is made to the members of the class it signifies, and its meaning is used indifferently with respect to instantiation. It is the use of simple supposition that enables both the Aristotelian-Scholastic logician and the ordinary-language user to say, “Every raven is black” and affirm the reality of the attribute blackness without also affirming the existence of a Platonic entity called “blackness.” The Aristotelian logician can distinguish names and predicates while still affirming that the descriptive predicates describe something real. This capability is denied the user of the Russellian predicate logic, who can only affirm the reality of blackness by quantifying the predicate and therefore treat it as an entity; he can only distinguish names and predicates by being nominalist, by denying that descriptive predicates describe anything. As it happens, when Quine attacks Carnap's admission of attributes and intensions, as he does in "On the Individuation of Attributes" (1975) in *Theories and Things*, he attacks Carnap's use of analytic statements and does not claim that Carnap has confused names and predicates. But even apart from the issue of analyticity, Carnap's theory of intensions is inconsistent, because he also accepts the Russellian predicate logic. In the section of *Meaning and Necessity* in which he discusses

 

variables, Carnap explicitly agrees with Quine's view that the ontology to which one's use of language commits oneself comprises simply of the objects that one treats as falling within the range of values of one's variables, and he explicitly accepts Quine's refrain that to be is to be the value of a variable. Quine and Whitehead recognized, as Carnap had not, that one's logic shapes one's metaphysics, and Quine's papers on theory of reference had as their basis the thesis that the Russellian logic expresses existence exclusively by means of the instantiating quantifiers.

The Russellian manner of expressing ontological commitment has its peculiar and controversial aspects, which are clear when contrasted with the earlier Aristotelian logic. In the Aristotelian logic the quantifier does not affirm existence. Instead existence is affirmed by the copula term "is", as in "Every raven is black." The noteworthy difference is that in the Russellian notational conventions the only existence that can be affirmed is the entities referenced by the quantified variable, such that any attempt to affirm the reality of attributes or properties must describe them as entities referred to by a quantified predicate. In the Aristotelian logic, however, the reality of what may be called an attribute signified by the predicate need not be hypostatized as some kind of Platonic entity. Quine is therefore consistent in his use of the Russellian logic, when he describes the reality status of red, the property, as an abstract “entity”, and when he describes the reality status of red, the meaning, as a mental “entity.” According to the syntactical categories admitted by the Russellian logic all philosophers are either nominalists or Platonists, since they must either deny attributes as real by not quantifying the predicate, or they must affirm them as Platonic entities by quantifying over the predicate. In the Russellian logic attributes, properties, aspects, and accidents have no reality status except as subsisting entities. Carnap's attempt to admit intensions or meanings and properties that are not hypostatized, is inconsistent with his use of the Russellian logic and with his agreement with Quine that ontology is described by means of bound variables. And his complaint about erroneously labeling philosophers "Platonists" is similarly inconsistent. Other and more consistent philosophers have recognized the Russellian logistic to be an Orwellian-like "newspeak" for advocating a nominalist agenda hidden in its notational conventions, which the pontificating Quine would enforce as a "canonical notation.”

In his *Medieval Logic and Metaphysics* (1972) the University of Manchester British philosopher, David P. Henry, asks how modern logic, caught as it is in the "entanglement" of the expression of existence in the

 

quantifiers, can recapture the untrammeled approach to existence enjoyed by its medieval predecessors. He proposes reconsideration of the modern formal logic of the Polish logician S. Lesniewski (1886-1939), which is unfamiliar to most modern logicians. In his autobiography Quine recounts his arguing with Lesniewski about "abstract entities" (Quine's characterization) while visiting Warsaw in the 1930's. Henry notes that Lesniewski's logic employs an interpretation of the quantifiers, which enables their dissociation from its currently conventional entanglement with the notion of existence. Henry gives examples of how Lesniewski's interpreted system with its ontology may be used in the analysis of medieval themes including *suppositio* with an artificial language designed by Henry. In the present context the significance of Henry's work is that it shows how Quine's ontological agenda does not imply a simplistic dichotomy between modern mathematically expressed logic and antiquated colloquially expressed Aristotelian logic, but rather depends on very specific notational conventions distinctive of the Russellian logistic, to which there can and do exist alternatives. Quine's *weltanschauung* seen through the lenses of Russellian logistic with its ontological agenda reducing attributes either to "abstract entities" or to unreality is terminal case of the mathematician’s disease, and it invites comparison with the obliviously contemplative noblemen of the airborne floating island of Laputa in Swift's satirical *Gulliver's Travels*. The Laputians viewed the world through the lenses of Cartesian geometry with Descartes' ontology of primary and secondary qualities. In Descartes' philosophy only geometrical or "primary" qualities have objective reality, while all others are "secondary" in the sense of subjective and unreal. The Laputian noblemen were so obliviously faithful to their distorted Cartesian view of the real world, that they viewed all reality as geometrical figures including even their wives, who were not similarly faithful to the Cartesian ontology, and who therefore felt so neglected that they were inclined to be unfaithful to their husbands. Comparison with Gulliver's travelogue is not merely rhetorical. Quine's rejection of properties, attributes and qualities denies such qualitative differentiation its foundation in reality, and renders Quineian reality as starkly nominalist as Descartes' was extensionalist. And it may be added that attempted paraphrasis by quantifying predicates does not evade nominalist ontology; it only incurs a fallacy that Whitehead called “misplaced concreteness, the Platonic hypostatization of properties which earlier logicians had avoided by their theory of *suppositio*. Also the nominalism built into the Russellian notational conventions by combining

 

existence and quantification is a prior ontological commitment, which is as inconsistent with Quine's ontological relativity as his Positivist behaviorism. Like the Laputian nobility, professors of Russellian predicate logic would greatly benefit, if their graduate-student assistants, who must humor the professor's pretenses, were what Gulliver called "flappers", *i.e.* assistants who swat their superiors in the face whenever the superiors lost touch with reality.

## Quine's Critique of Reductionism

Quine took Whitehead's comment, that logic shapes metaphysical thought, beyond logic, and made it a general theory of language. One of the implications is Quine's thesis of the system-determined nature of semantics. Thus the third milestone in "Five Milestones" is the semantical shift from sentences to whole systems of sentences. This shift to a wholistic (or holistic) view of the semantics of language is a central characteristic of Quine's philosophy, although it went through some retrogression. He came to think that his earlier and more radical Pragmatism implies an unwanted cultural relativistic view of truth. Consequently in the 1970's he attempted to restrict the extent of his semantical wholism, so that the semantics of theory is not viewed as contributing to the semantics of observation language.

His first statement of his wholistic thesis is what he later calls his metaphorical statement given in "Two Dogmas of Empiricism" (1951), one of his best known papers, reprinted in his *Logical Point of View* and often found in anthologies. The two dogmas he criticizes in this paper are the Logical Positivist theses of analyticity and reductionism. He defines the reductionist thesis as the belief that each meaningful sentence is equivalent to some logical construct based on terms referring to immediate experience. And he notes that Carnap was the first empiricist who was not content with merely asserting the reducibility of science to terms of immediate experience, but who actually took steps toward carrying out the reduction in the *Aufbau*. Then Quine says that while Carnap later abandoned this radical reductionist effort, the dogma of reductionism continues in the idea that to each synthetic (i.e. empirical or nonanalytic) statement there is associated a unique range of possible sensory events, such that the occurrence of any of them would add to the likelihood of truth of the statement. Similarly for each synthetic statement there is associated another unique range of possible

 

sensory events whose occurrence would detract from that likelihood. This dogma is implicit in the verificationist theory of meaning, and it survives in the thesis that each statement taken in isolation can admit of either confirmation or "infirmation", which is to say, either verification or falsification.

The view of empiricism that Quine advocates as his alternative to reductionism is the thesis that statements about the external world face the tribunal of sense experience not individually, but only as a corporate body. Quine references Duhem in this context and his alternative view of empiricism has since come to be known as the "Duhem-Quine Thesis." However, while Quine references Duhem in "Two Dogmas", his wholistic view is more radical than Duhem's, because Quine purges Duhem's philosophy of physical theory of its Positivism by ignoring Duhem's two-tier semantics, which led to Duhem's distinction between "practical facts" and "theoretical facts." Quine's treatment here of the difference between observation and theory is not a Positivist semantical metatheory. Furthermore, Quine's radical wholism does not admit a distinctive semantical status even for pure mathematics and formal logic. Speaking metaphorically Quine says that the totality of our beliefs including mathematics and logic is a man-made fabric, which impinges on experience only along the edges. Then mixing metaphors he describes total science as a field of force whose boundary conditions are experience in which the laws of logic and mathematics are simply statements in the field that are more remote from experience. Any conflict with experience at the periphery occasions adjustments in the interior of the field, such that truth values must be redistributed over some statements, and a re-evaluation of some statements entails re-evaluation of others due to the logical connections among them.

The enabling feature of Quine's wholistic doctrine of empiricism is his thesis that the total field is so empirically "underdetermined" by its boundary conditions, which are experience, that there is much latitude for choice as to what statements to re-evaluate in the light of any single contrary experience. And the criterion governing the choice of beliefs in the underdetermined system is entirely pragmatic, where the objective is a relatively simple conceptual scheme for predicting future experience in the light of past experience. The thesis of the empirical underdetermination of language can be traced to Duhem's view of scientific theory. Duhem said that there could be many theories, all equally empirically adequate, that explain the same phenomenon. But Quine furthermore extends Duhem's thesis to include not

 

just theory but all of language including observation language. He maintains that no statement is immune from revision, and he notes that revision even of the law of the excluded middle has been proposed as a means of simplifying quantum physics. Quine notes that there is a natural tendency when making revisions to disturb one's existing system of beliefs as little as possible, with the result that those statements that we are least likely to revise are those that have sharp empirical reference, while those that we are most likely to revise are those more theoretical statements that are relatively centrally located within the total network or web of beliefs. Later in his *Philosophy of Logic* (1970) this natural tendency becomes the "maxim of minimum mutilation", an idea similar to James' thesis of "minimum disturbance" in the latter's *Pragmatism* (1907).

Quine's most elaborate statement of his wholistic thesis is set forth in his first full-length book, *Word and Object* (1960). Instead of the metaphorical statement of his view in "Two Dogmas" a decade earlier, here he expresses his thesis in the literal vocabulary of behavioristic psychology. Much of the book is an exposition of his thesis of semantic indeterminacy as it is manifested in translation between languages, and thus appears as his indeterminacy of translation thesis. In the translation situation he portrays the field linguist in the same situation that Carnap postulates in "Meaning and Synonymy in Natural Language", where Carnap attempted to describe how the field linguist can ascertain a term's intension by identifying its extension from the observed behavior of native speakers of an unknown language. Carnap admitted that this determination of extension involves uncertainty and possible error due to vagueness, but he excused this uncertainty and risk of error because it occurs even in the concepts used in empirical science. While this admission of extensional vagueness in science made the fact unproblematic for Carnap, it had just the opposite significance for Quine. For Quine extensional vagueness is an inherent characteristic of language that he calls "referential inscrutability", and which he later calls "ontological relativity." And what Carnap called the intensional vagueness, Quine prefers to consider as a semantical indeterminacy in stimulus meaning but without admitting intensions.

Quine rejects Carnap's thesis of intensions, explicates his own theory of meaning in terms of behavioristic psychology, and proposes his doctrine of "stimulus meaning." Stimulus meaning is a disposition by the native speaker of a language to assent or dissent from a sentence in response to present stimuli, where the stimulus is not just a singular event but rather a "universal", a repeatable event form. Stimulus meaning is the semantics of

 

those sentences that Quine had earlier described metaphorically as positioned at the edge of the system of beliefs viewed as a force field, as opposed to the more theoretical sentences that are in the interior of the field. In Quine's philosophy the idea of stimulus meaning is not a special semantics, but rather is an attempt to isolate the net empirical content of each of various single observation sentences without regard to the theory that contains them yet without loss of what the sentence owes to that containing theory. This attempt to isolate the semantics of observation language is a move away from his earlier critique of reductionism, where reductionism is understood as statements having a unique range of possible sensory events, such that the statements can be criticized in isolation. But at this stage Quine still retains his original thesis of empirical underdetermination, in which empirical underdetermination is integral to his wholistic thesis of semantical indeterminacy or vagueness.

The underdetermination thesis admitting multiple and alternative observation sentences for the same stimulus situation presents a question: how can the same stimuli yield alternative stimulus meanings? One of Quine's answers is that the alternative theories or belief systems in which the stimulus situation is understood, supply different significant approximations. But there still remains the question of how stimulus meanings are to be construed as approximations. Quine has a theory of vagueness that he sets forth in the third and fourth chapters of *Word and Object*, which resembles the latter Wittgenstein's thesis of paradigms, except that Quine explicitly invokes the behavioristic stimulus-response analysis of learning. On this analysis Quine rejects the view that stimulations eliciting a verbal response "red" are a well defined or neatly bounded class. He maintains that the stimulations are distributed about a central norm, which when a language is initially being learned, may be a very wide distribution. The penumbral objects of a vague term are the objects whose similarity to those for which verbal response has been socially rewarded in the learning process, is relatively slight. The learning process is an implicit induction on the part of the subject regarding society's usage, and the penumbral cases are those words for which that induction is most inconclusive for want of evidence, because the evidence is not there to be gathered. And society's members have had to accept similarly fuzzy edges when they were learning. There is an inevitability of vagueness on the part of terms learned by ostension, and it carries over to other terms defined by context on the basis of these ostensively learned terms.

 

Since Russell Hanson's *Patterns of Discovery* (1958) the participation of theoretical concepts in the semantics of observation language is often expressed by saying that observation is "theory-laden." And this semantical participation of theory in observation has made problematic the objectivity of observation, and therefore the decidibility of scientific criticism. In 1968 in "Epistemology Naturalized" in *Ontological Relativity* Quine states that Kuhn and Hanson among others have tended to belittle the role of evidence in science and to accentuate cultural relativism, and that such philosophers represent a wave of epistemological nihilism. He notes Hanson maintains that observations vary from observer to observer according to the amount of knowledge that the observers bring with them. Thus one man's observation is another man's closed book or flight of fancy, with the result that observation as the impartial and objective source of evidence for science is bankrupt. At this stage of Quine's thinking the semantical contribution of theory to observation is still problematic for him, but he continued to characterize observation language in terms of behavioristic theory of learning. In the chapter titled "Observation" in his *The Web of Belief* (1970) Quine says that an observation sentence is a sentence that can be learned ostensively by the association of heard words with things simultaneously observed, an association which is conditioned and reinforced by social approval or successful communication, and which becomes habitual. And due to the social character of its learning, the observation sentence must be understandable by all competent speakers of the language who might be asked to assent to it. Thus according to Quine the sentence "That is a condenser" is not an observation sentence, even if experts agree to it. Quine maintains contrary to the Positivists, that what qualifies a sentence as observational is not the lack of theoretical terms that may occur in theory formulations, but just that the sentence taken as an individual whole commands assent consistently or dissent consistently when the same global sensory stimulation is repeated. This behavioristic characterization initially enabled Quine to evade reference to semantics in his identification of observation language, and thereby to separate his view from that of the Positivists, who defined observation language in semantical terms. But in attempting to avoid a cultural relativist view of truth he thought he found in the likes of Hanson, Quine found himself getting back into the semantics of observation with the very Positivist objective of keeping the semantics of observation uncontaminated by that of theory.

After *Word and Object* and *Web of Belief* Quine further developed the Duhem-Quine thesis in his "On Empirically Equivalent Systems of the

 

World" in *Erkenntnis* (1975), which as it happens had in 1930 been made the official journal of the Vienna Circle. This development of the Duhem-Quine thesis represents a further restriction on Quine's earlier version on his wholistic semantical thesis of observation. Previously he had viewed empirical underdetermination as integral to semantical indeterminacy or vagueness in his semantical wholism. But in this paper he revises the concept of empirical underdetermination of language, and separates it from the wholistic view of the Duhem-Quine thesis. The scientific hypotheses that purport to describe things beyond the reach of observation are related to observation sentences by a kind of one-way implication, such that many alternative hypotheses may imply the same set of observation sentences, but not vice versa. Observation sentences do not uniquely imply just one theory purporting to explain the observable events. It now is in this sense that natural science is "empirically underdetermined" by all possible events. Quine says that underdetermination lurks where there are two irreconcilable theory formulations each of which implies exactly the desired set of observation conditionals plus extraneous theoretical matter, and where no formulation affords a tighter fit. In Quine's vocabulary the phrase "observation conditional" is an empirical generalization expressed in conditional form and implying an observation sentence describing an individual event. And his phrase "theory formulation" is a conjunction of the axioms of a deductive theory, which implies observation conditionals. This is a different sense of "empirical underdetermination" than what Quine meant in "Two Dogmas", because it resurrects the idea of a semantically neutral observation language, which philosophers such as Hanson, Kuhn and Feyerabend reject. These philosophers find a phrase such as "same observation sentences" when speaking of sentences implied by alternative theories to be very problematic; they deny that different theories can have the same set of observations due to the contribution of the semantics of theory to the semantics of observation language.

Having revised "empirical underdetermination", Quine then distinguishes his revised concept from the wholistic doctrine of the Duhem-Quine thesis. He reiterates that the wholistic doctrine says that scientific statements are not separately vulnerable to adverse observations, since it is only jointly as a theory that they imply their observable consequences, with the result that any one of the statements can be adhered to in the face of adverse observations by revising others. Then he states that wholism lends credence to the underdetermination thesis, because in the face of adverse observations we are free always to choose among various adequate

 

modifications of our theory, and all possible observations are insufficient to determine theory uniquely.

Also in this work Quine considers several criticisms or "reservations" about the wholism of the Duhem-Quine thesis, and in his defenses he will pick and choose between underdetermination (revised) and wholism (unrevised). The first criticism is that some statements closely linked to observation are separately susceptible to tests of observation, while at the same time these statements do not stand free of theory because they share much of the vocabulary of the more remote theoretical statements. Quine answers that the Duhem thesis does not imply equal status for all statements. He says that the Duhem thesis applies even for observation statements, since scientists do occasionally revoke observation statements when these statements conflict with a well attested body of theory, and when the experiment yielding the observation cannot be replicated. This is such a weak concession to semantical wholism and the indeterminacy of observation, that it effectively limits wholistic theory participation in the semantics of observation language to the status of errors of observation.

A second reservation pertains to the breadth of the theory: If it is only jointly as a theory that scientific statements imply their observable consequences, then how inclusive does that theory have to be? Does the wholistic scope have to include the whole of science taken as a comprehensive theory of the whole world? Quine sees science as an integrated system of the world as science exists at any point in its historical development, but unlike the Positivists he does not view it as integrated by reductionism into a single unified science. He says that Duhem wholism admits that science is neither discontinuous nor monolithic, but as variously joined and loose in its joints in varying degrees. Later in "Five Milestones" Quine elaborates on this idea by saying that all sciences interlock to some extent not only due to a common logic and mathematics, but also because small "chunks" may be ascribed their independent empirical meaning nearly enough, since some vagueness in meaning must be allowed for. This defense based on vagueness calls upon the semantical indeterminacy that enables wholism.

A third reservation is that the semantical and ontological wholism may imply a cultural relativistic view of truth. Quine denies that his wholism implies a cultural relativistic view of truth. His first argument is external to the wholistic thesis. He finds a paradox in the thesis of cultural relativism: if truth were culture bound, then the advocate of cultural relativism ought to see his own culture-bound truth as absolute. The cultural

 

relativist cannot proclaim cultural relativism without rising above it, and he cannot rise above it without giving it up. Quine then turns to the issue of irrationality of theory choice, the argument for cultural relativism that is internal to wholism. He argues that the choice between empirically equivalent alternative systems need not be irrational; he says he will settle for a "frank dualism." He says that oscillation between rival theories is standard scientific procedure, because it is thus that one explores and assesses alternative hypotheses. In this defense Quine switches between underdetermination and wholism. Rationality of theory choice is based on comparability of theories permitted by a neutral observation language, that is admitted by Quine's revised underdetermination thesis, since it is only theories and not observations that are incompatible. The dualism is therefore merely one due to empirical equivalence. But the idea of empirical underdetermination as newly revised in this article is not the context in which the issue of irrationality of theory choice emerges. It emerges in the context of wholism where theory participates in the semantics of observation language. Quine switches to the wholistic context, when he says that whatever we affirm, we affirm as a statement within our aggregate theory of nature as we now see it, and that there is no extratheoretic truth. Quine's frank dualism has not been very frank in this defense. Quine's revised concept of empirical underdetermination is not consistent with his semantical wholism. The revised concept of underdetermination permits a neutral observation language, while the Duhem-Quine wholism continues to permit theory to resolve the vagueness in the semantics of observation language.

Quine eventually recognized this inconsistency. Just as he imposed logical one-way restrictions for his revised concept of empirical underdetermination, he found that he must impose semantical one-way restrictions in the semantical wholism of the Duhem-Quine thesis. In his "Empirical Content" (1981) in *Theories and Things*, which he notes contains "echoes" from "Empirically Equivalent Systems of the World", Quine explicitly uses Hanson's terminology saying that observation sentences are "theory-laden." But Quine reconstrues the intended meaning of Hanson's phrase to mean that the terms embedded in observation sentences may recur in theory formulations. Thus while Quine here says that observation sentences are theory-laden, he denies to the semantics of theory any participating role in the semantics of observation. In fact in Quine's construing of "theory-laden" it is not observation language that is theory-laden, but rather theory that is observation-laden. At least he did not revert

 

to the old Carnapian reduction sentences, to make theory observation-laden. Still later in "Truth" in his *Quiddities* (1988) he is explicitly reconciled about refusing to admit theory any resolving function in the semantics of observation. There he says that we work out the neatest world system, and we tighten the squeeze by multiplying the observations. Tightening the squeeze in observation sentences is the progressive reduction of vagueness but only by the addition of information in additional observation sentences. Quine's limitation on which contexts may resolve vagueness and which ones may not is arbitrary and *ad hoc*. His wish to make observation sentences semantically uncontaminated by theory is a Positivist atavism, even though his motivation is not characteristically Positivist. His point of departure was not a preconceived semantics for observation; he attempted a behavioral (behavioristic) characterization of observation language instead. Still, he believed that an unrestricted wholistic, theory-dependent, context-determined semantics encompassing both theory and observation language implies a relativistic and subjectivist philosophy of truth. Fear of a relativistic view of truth led him to revise his original version of his Duhem-Quine thesis.

Quine the logician always saw theory language as an axiomatic system with observation language serving as its derived theorems. For Quine, Isaac Newton's mechanics is still "theory" today. On the Pragmatist concept of scientific theory, however, theory language is identified not by contrast to an observation semantics or by semantics at all, but by reference to its function or pragmatics in science: it is discourse that is proposed for testing in contrast to that which is presumed for testing. Thus, observation language need not be exclusively identified as either theory or nontheory language (unless the Pragmatist simply chooses to define "observation" correlatively to his functional definition of "theory"). And all contexts consisting of explicitly or implicitly universally quantified sentences believed to be true operate to resolve the vagueness in the meanings of their common univocal terms. Quine's view is not a Pragmatist view of theory based on the function of theory in empirical basic science, but is better characterized as an archival concept of theory, or what Hanson called an "almanac" view. Correspondingly his concept of observation language is an archival concept of observation language. Quine believed that this archival view would enable him to make observation language a repository of permanent truth. And his motive is his wish to evade the relativistic view of truth, which he believed is implied by the unrestricted context determination of semantics.

 

More recently a member of Quine's intellectual entourage, Donald Davidson, has attempted to evade semantical relativism with a turn to instrumentalism. Davidson's principal statement of his thesis is set forth in his "The Very Idea of a Conceptual Scheme" (1974) and "Belief and the Basis of Meaning" (1974) reprinted in his *Inquiries into Truth and Interpretation* (1984), a book he dedicates to Quine with an inscription "without whom not." He rejects the representationalist view of the semantics of language, which he considers a third dogma of empiricism after the first two referenced by Quine in the latter's 1952 "Two Dogmas" article. Like Dewey's rejection of the dualism of "experience" and "nature" Davidson rejects the dualism of "scheme" and "world", of "conceptual scheme" associated with language and "empirical content", of "organizing system and something waiting to be organized", that he finds in the views of Whorf, Kuhn, and Feyerabend. In this manner he remains more faithful to Quine's original behaviorism than Quine did. Given the mutual and reciprocal determination of between belief and semantics, the decision necessary for interpreting another's discourse is to maximize our shared beliefs, such that there can be no basis for concluding that others have concepts or beliefs radically different from one's own. Davidson concludes that in giving up the dualism of scheme and world, we do not give up the world, but rather re-establish "unmediated touch" with the familiar objects that make our sentences and opinions true or false. Thus Davidson argues that there is no conceptual relativism, because there are no conceptual schemes to be relativistic.

But Davidson's conclusion is a *non sequitur*. Firstly he confuses two distinct questions: one is the question of what is meaning, and the other is the question of what is the meaning of a term, sentence, or theory and how is this determination made. The existence of conceptual schemes is an answer to the former question, and his behavioristic procedure is his answer to the latter one. The answers are made interdependent only because Davidson is a behaviorist, which is to accuse him of being a Positivist. And his Positivism makes him inconsistent with Quine's and his acceptance of ontological relativity, because Positivism requires a prior ontological commitment. Davidson does not practice ontological relativity in his own philosophical discourse. Secondly the word "unmediated" in his phrase "unmediated touch", which purportedly justifies his denying language its representational semantics, is a weasel word. In fact the interpreter's charitable decision required for interpretation does not imply any rejection of the representational nature of the semantics of language. This interpretative

 

decision is operative when someone uses a dictionary with the charitable assumption that its lexical entries are true, so that he can assimilate the meanings of the terms he is researching. And also when a community of scientists in a profession considers an experiment and agrees on the validity of the test design statements, so that the scientists can describe the phenomenon under examination and the experiment's outcome. Neither the thesis of the charitable decision required for communication nor the thesis of the interdependence between truth nor meaning imply any rejection of the representational nature of the semantics of language; representationalism is perfectly consistent with both theses. "Representation" may be a weasel word, because there survives an atavistic belief residual from modern philosophy including Positivism, that the knower is a spectator to his ideas. Of course the knower can be a spectator of his ideas, but this inspection is a reflection *ex post facto* to his firstly already having the inspected knowledge of the real world. Apart from this secondary reflective knowledge, the spectator thesis about knowledge of the real world is readily rejected, when we realize that what we know firstly is not our ideas, but the real world, and most notably that our knowledge is thus constituted by our ideas rather than the ideas being an object of knowledge. Contrary to Davidson, therefore, these and their schemes are quite admissible, and they very much involve semantical relativism.

Both Quine and Davidson are motivated to evade semantical relativism, because both mistakenly believe that a relativistic, context-determined, semantics implies a relativistic thesis of truth. Regardless of how culture-bound and context-determined may be the semantics of a language, it is not possible capriciously either to affirm or to deny truthfully just anything expressed by sentences made with those concepts. The empirical underdetermination of language implies that many alternative sentences can be said which are consistent with the same observations. Still, the empirical constraint imposed exogenously on sentences by the recalcitrant real world - even when not yet interpreted - forbids just any arbitrary distribution of truth-values over a set of logically related, semantically interpreted grammatical sentences. When any subset of these sentences is given definitional force to specify its semantics, then only some of the remainder sentences containing the same descriptive terms can also be true. Truth is always relative to what is said, but the real world in which all language users live forbids ingenuously asserting just any old thing in the semantically interpreted language. Therefore, semantical relativity does not imply relativism of truth, but just the opposite: with a metatheory of

 

semantical description exhibiting the composite nature of meanings, semantical relativity explains the partial equivocation that makes it impossible for the same sentences occurring in two different belief systems, to be completely true in one belief system and completely false in another. It explains how the same sentence is not simply and completely the same statement in each system, but is partially the same in each, and to that extent true in both systems. And for the same reason it also explains why the semantics of observation language need not be quarantined from the semantics of theory, in order to assert the objectivity of truth. Observation statements, which pragmatically defined are merely singular test design statements, may be common to pragmatically defined contrary theories, such that belief in the test design statements makes the test outcome contingent and not willfully or necessarily verifying, and makes a falsifying test outcome of one of the theories an objective truth.

Each person acquires the semantics of what Quine calls observation sentences from his own personal experiences, and he acquires it publicly and ostensively in the circumstances of his learning situation in his personal history. There is a wide variation among people between what is learned ostensively and contextually, but even for those simple statements learned ostensively by most people, intersubjectivity is increased with successive approximation, as the web of belief grows and imposes increasingly more shared truth conditions on the ostensively acquired semantics. The entire web of beliefs may be viewed on analogy with an underdetermined system of conditional equations, in which the addition of a new equation further restricts the range of numeric values that the set of variables may accept as solution sets. One difference between the mathematical system and the language system is that with just a sufficient number of restrictions the equation system may admit to only one solution set, whereas language is never restricted to a unique interpretation. Another noteworthy departure from the mathematical analogy is that the mathematical variables can take only one numeric value at a time without becoming ambiguous, while each of the descriptive terms, including those used as mathematical variables in applied mathematics in empirical science, simultaneously take on the semantic values distinguishable in the explicitly related universal statements in the system of beliefs, subject only to the preservation of univocity. Thus all the terms explicitly related by the sentences in the web of beliefs may participate in one another's univocal semantics, and thereby resolve one another's vagueness in relation to each other. Furthermore as implicit

 

statements are made explicit by deduction, the vagueness in the meanings of the terms of the system is even further resolved.

But Quine viewed meanings as abstract or mental "entities", and then developed his behavioristic theory of stimulus meanings, which he called "behavioral dispositions" to evade the representative function of language. He could not be expected to have developed a metatheory of semantical description enabling him to describe how meanings participate in one another. The closest Quine came to the idea of semantical participation was the idea of the resolution of vagueness. His rejection of the dichotomous analytic-synthetic distinction is a worthy start toward such a metatheory, but his rejection of the distinction was actually a rejection of analyticity as such, except in the cases that he called "analytical hypotheses" used for translations. As it happens, rejection of the analytic-synthetic dichotomy does not imply the rejection of analyticity as such. Universally quantified statements believed to be true for empirical reasons may also be used analytically to exhibit the complexity in the meanings of their constituent terms by displaying their component semantic values that constitute the discriminating capability in the descriptive function of the language. In other words all universal empirical statements in the web of beliefs are analytical hypotheses. And theories are those that are viewed as relatively more hypothetical than other empirical statements.

## Quine's Critique of Analyticity

The fourth of the five milestones that Quine finds in the history of empiricism is the abandonment of analyticity in the traditional analytic-synthetic dichotomy. He calls his exclusive acceptance of synthetic statements "methodological monism." The rejection of analyticity is one of the earliest theses in Quine's philosophy of language. In his *Dear Carnap, Dear Van* Creath reports that when Quine had first met Carnap in March 1933, Quine was reading the manuscript for Carnap's Logical Syntax as Carnap's wife was typing it. Creath notes that a brief shorthand note later found among Carnap's archived papers reveals that Quine had asked whether or not the difference between the analytic axioms of arithmetic and the synthetic empirical claims about physical bodies is merely a difference of degree, which reflects our relative willingness to abandon the various beliefs under consideration. Quine's first published statement of the rejection of the traditional analytic-synthetic distinction is in his "Truth by

 

Convention" (1936) originally in *Philosophical Essays for A.N. Whitehead*, and later reprinted in his *Ways of Paradox*. Analytic statements are those that are true by linguistic convention, and they include the propositions of logic and mathematics. Essentially his argument in this paper is based on the rejection of an infinite regress; he argues that some logic is needed and is presupposed to develop logic. Thus he asks whether or not it makes any sense to say that the truths of logic and mathematics are destined to be maintained independently of our observation of the world, so that truth by convention may apply.

Fifteen years later Quine's critique of analyticity took a different tack in "Two Dogmas", where he formulated the Duhem-Quine thesis of semantical wholism, and attacked linguistic synonymy upon which analyticity is based. The statement "No bachelor is married" is made analytic by substitution of synonyms "bachelor" and "unmarried man" in the statement "No unmarried man is married", because the latter statement is true in all interpretations of its nonlogical or descriptive terms. Quine notes that Carnap explained analyticity by appeal to state descriptions; a statement is analytic if it is true in all state descriptions. Quine says that appeal to state descriptions works only if the atomic statements of the language are mutually independent, i.e. if the language has no extralogical synonym pairs such as "bachelor" and "unmarried man." Thus on Quine's thesis, Carnap's criterion for analyticity in terms of state descriptions is a reconstruction at best of logical truth, not of analyticity. Quine argues that all instances of synonymy except those occurring in purely stipulative definitions introducing notational abbreviations are based on observed synonymy occurring in natural language. These include synonymies occurring in reduction sentences, analytic sentences and Carnap's semantical rules; and they all depend on the thesis contrary to Duhem's thesis, that it is possible to determine the truth or falsehood of sentences in isolation from one another. Invoking Duhem's thesis Quine rejects the distinction between a factual component and a linguistic component in the truth of any individual statement, which is the basis for the analytic-synthetic distinction.

Shortly after writing "Two Dogmas" Quine wrote "Carnap and Logical Truth" (1954) in *Philosophy of Rudolf Carnap* (1963). This critical essay's most distinctive characteristic relative to Quine's prior essays is its treatment of the effects of linguistic and scientific change on analyticity and logical truth. Carnap's interest in philosophy was originally inspired by Einstein's use of non-Euclidian geometry and by Hilbert's formalistic approach to mathematics. Quine says that the initial tendencies to treat

 

geometries as true by convention together with the tendency toward formalization were extended to mathematical systems generally. But Quine maintains that formalist mathematics has been "corrupted" by supposing that postulates are true by convention, and he rejects the idea of semantically uninterpreted postulates. Quine treats the subject of postulates in a manner similar to his earlier treatment of definitions in "Two Dogmas." He distinguishes two types of postulates: "legislative" and "discursive." The former type is a stipulative definition that merely introduces previously unused notation, and it initiates truth by convention. Discursive postulation on the other hand is a selection from a pre-existing body of truths, of certain ones for use as a basis from which to derive others initially either known or unknown. Most notably what discursive postulation fixes is not truth, but only some particular ordering of the truth. All postulation may be said to be conventional, but only legislative postulation admits to truth by convention. The importance of the distinction, however, is that it refers to an act and not to any enduring consequences. The conventionality in postulation is a passing trait, which is significant at the moving frontier of science, but which is useless in classifying the sentences behind the lines. Conventionality is a trait of events and not of sentences. And if legislative postulates are subsequently singled out in some later exposition, they have the status of discursive postulates in the subsequent exposition. The artificiality of legislative truth does not linger as a localized quality, but suffuses with the corpus and becomes integral with it. Quine does not explicitly reference Duhem in this context, but Duhem's wholism is clearly operative. Quine says that legislative postulation occurs continually in the theoretical hypotheses of natural science. The justification of any theoretical hypothesis can at the time of hypothesizing consist in no more than the elegance or convenience which the hypothesis brings to the containing body of laws and data. There is indirect but eventual confrontation with empirical data, but this can be remote. Furthermore, some such remote confirmation with experience may be claimed even for pure mathematics and logic. A self-contained theory that can be checked with experience includes not only its various theoretical hypotheses of so-called natural science, but also such portions of logic and mathematics as it makes use of. There is no line to be drawn between hypotheses that confer truth by convention and hypotheses that do not; logic and mathematics are not qualitatively different from the rest of science.

Quine elaborates by illustration: Suppose a scientist introduces a new term for a certain substance or force by an act of legislative definition or

 

postulation. Progressing, he then evolves hypotheses regarding further traits of the named substance or force. And then further progressing he identifies this substance or force with one named by a complex term built up of other portions of his scientific vocabulary. This new identity will figure in the ensuing developments quite on a par with the identity which first came by the act of legislative definition, or on a par with the law which first came by the act of legislative postulation. And revision in the course of further progress can touch any of these affirmations equally. Quine says that scientists proceeding in this way are not slurring over any meaningful distinction. Legislative acts occur routinely. Carnap's dichotomy between analytic and synthetic, between truth by meaning postulate and truth by force of nature, has no clear meaning, even as a methodological ideal. The fabric of our sentences, our web of beliefs as Quine calls them later, develops and changes through more or less arbitrary and deliberate revisions and additions of our own, more or less directly occasioned by the continuing stimulation of our sense organs.

Carnap replies at the end of the volume in which Quine's critique was published. He emphasizes that his explication of "analytic" has always been for a formalized language, one for which explicit semantical rules are specified and that lead to the concept of truth. He rejects Quine's demand that semantical concepts such as analyticity and synonymy must also be explicated pragmatically by an empirical criterion in behavioristic terms applicable to natural language. He therefore maintains that Quine's objections are not directed against his semantical *explicata*, and that A-truth is not objectionable. Carnap then turns to Quine's critique of analyticity in situations where there is a change in artificial language, from *L(n)* to *L(n+1)*. Firstly Carnap agrees with much of what Quine says in "Two Dogmas", where Quine sets forth his neo-Duhemist wholistic thesis. Carnap agrees that a scientist who discovers a conflict between his observations and his theory and who must therefore make a readjustment somewhere in the total system of science, has much latitude with respect to the places where a change is to be made. Remarkably Carnap also agrees that in this procedure of readjustment, no statement is immune to revision, not even statements of logic or mathematics. But Carnap rejects Quine's characterization of an analytic statement as one held true come what may. And Carnap furthermore denies that a change in language invalidates the analytic-synthetic distinction. In defense of analyticity Carnap distinguishes two types of linguistic change. The first type is a change of language from *L(n)* to *L(n+1)*. He says that this type constitutes a radical alteration and perhaps

 

a revolution. It occurs only at certain historically decisive points in the development of science. The second type is a mere change in or an addition of a truth-value ascribed to an indeterminate statement. An indeterminate statement is one having a truth-value that is not fixed by the rules of the language, i.e. by postulation of logic, mathematics, or perhaps physics. This second type of change occurs "every minute" according to Carnap. He says that his concept of analyticity has nothing to do with the first type of transition; his concept of analyticity refers only to some given language, *L(n)*. The truth of a sentence, *S*, in *L(n)* is based on meanings in *L(n)* of the terms occurring in *S*. In *L(n)* analytic sentences cannot change their truth-value, and furthermore neither can the synthetic postulates of physics and their logical consequences.

Quine's critique of analyticity is principally directed against what Carnap called A-truth, which is truth based on the semantics of the descriptive vocabulary in the sentence, a lexical basis. As a symbolic logician Quine continues to rely on logical truth, on the kind of sentence that Carnap calls L-truth, but his reasons are different than Carnap's. In "The Ground of Logical Truth", the eighth chapter in his *Philosophy of Logic*, Quine admits to an acceptable sense of logical truth, the truth that is evident due to the grammatical structure of the logically true sentence. But Quine rejects Carnap's doctrine of linguistic truth, the thesis that language alone can make logical truth independently of the nature of the world. In view of Carnap's defense of analyticity, it is doubtful that Carnap continued to maintain such a view. In any event, Quine maintains that the validity of logical truth depends on the relation of grammatical structure to the structure of the real world. He argues that the distinction between the lexical and the grammatical is variable not only among different languages, but also within the same language.

## Quine's Rejection of First Philosophy

Quine’s taking Whitehead’s comment that logic shapes metaphysical thought beyond logic and making it his general theory of language, has another and even more important implication: Quine’s thesis of ontological relativity. Thus the last of the five milestones in Quine's history of empiricism is what he calls the abandonment of the goal of a first philosophy. By first philosophy he means any philosophy that is prior to natural science. Traditionally metaphysics and epistemology are considered

 

to be first philosophy. Quine calls his position "naturalism." The term "naturalism" has meant many different things in the history of philosophy. A term that Quine does not use is "scientism." In "Five Milestones" Quine defines his naturalism as the view that natural science is an inquiry into reality, a fallible and corrigible inquiry, but not answerable to any suprascientific tribunal, and not in need of any justification beyond observation and the hypothetico-deductive method. This statement by Quine is not merely an affirmation of the autonomy of empirical science from metaphysics, as may be found in Duhem's philosophy of science. Quine rejects the view that there is any philosophical tribunal for science, by which he means any knowledge separate from empirical "common sense" that he views to be continuous with science in his wholistic philosophy of language. Furthermore, Quine maintains that epistemology is an empirical discipline that he assimilates into empirical psychology, which for him is behavioristic psychology. He describes the scientific epistemologist as asking how animals, presumably human, can have managed to have arrived at science from the limited information from surface stimulations, and as pursuing this inquiry to yield an account that pertains to the learning of language and the neurology of perception.

Quine gives two reasons for his naturalism by which he rejects all first philosophy. One reason is what he calls an "unregenerate" realism, the robust state of mind of the natural scientist who has never felt any qualms beyond the negotiable uncertainties internal to his science. He expresses his realism even more emphatically in his "Scope and Language of Science" (1954) reprinted in *Ways of Paradox*. There he states that we cannot significantly question the reality of the external world or deny that there is evidence of external objects in the testimony of our senses. For to do so is to dissociate the terms "reality" and "evidence" from the very application which originally did most to invest these terms with whatever intelligibility they may have for us. He maintains that the notion of reality independent of language is derived from our earliest impressions, and then carried over into science as a matter of course. The second reason for Quine's realism is what he calls the despair of being able to define theoretical terms generally in terms of phenomena even by contextual definitions. This is a rejection of the Logical Positivist problem for which reductionism of theoretical terms was thought to provide an answer. On the Positivist philosophy there is no justification for affirming the reality of theoretical entities, unless these terms are firstly established as semantically meaningful. The purported solution is the reduction of theories to observation sentences, which are the

 

source for the semantics and ontology of theories. Quine rejects the Positivists' problem, because it involves a prior ontology or first philosophy consisting in the Positivists' observation language. In Quine's view Positivism is a kind of metaphysics, Positivists' antimetaphysical rhetoric notwithstanding.

Fundamental to Quine's second reason for rejecting first philosophy is his thesis of ontological relativity. This thesis can be found in Quine's literary corpus even before he came to call it "ontological relativity" in the mid-1960's. In "Two Dogmas" after rejecting the dogma of reductionism, he says that physical objects are conceptually imported into the linguistic system as convenient intermediaries, as irreducible posits comparable epistemologically to the gods of Homer. What he calls the "myth" of physical objects is epistemologically superior to others including the gods of Homer, in that it has proved to be more efficacious than other myths as a device for working a manageable structure into the flux of experience. Microphysical entities are posited to make the laws of macroscopic objects and ultimately to make the laws of experience more manageable. Science is a continuation of common sense, and it continues the commonsense expedient of swelling ontology to simplify theory. Shortly later in "Posits and Reality" (1955) Quine says that if we have evidence for the existence of bodies of common sense, we have it only in the way in which we may be said to have evidence for the existence of molecules. All science is empirically underdetermined, and the only difference between positing microphysical and macrophysical entities is that the theories describing the former are more underdetermined. In this context Quine is using the term "underdetermined" in same sense as he used it in "Two Dogmas" to express his neo-Duhemist wholistic view of language.

The thesis of ontological relativity is also prefigured in *Word and Object*. Just as Carnap recognized extensional vagueness, Quine recognized referential indeterminacy, which he calls referential "inscrutability." Inscrutability of reference is due to the semantic indeterminacy of direct ostension. This indeterminacy is encountered when the field linguist attempts to translate a previously unknown language, but it also occurs more generally in all language, and is not distinctive of the translation situation. The context-dependence of semantics makes reference and ontology completely system-determined in the linguistic context that determines the semantics of a discourse including notably the context constituted by a scientific theory. In chapter six of *Word and Object* Quine says that everything to which we concede existence is a posit from the standpoint of

 

the theory-building process, and is simultaneously real from the standpoint of the theory that is built. His phrase “ontological relativity” itself is set forth in "Ontological Relativity" (1968) in *Ontological Relativity*. Quine uses the phrase explicitly on analogy with Einstein's relativity theory in physics. He maintains that reference is nonsense except in relation to a coordinate system, where the coordinate system is some background language. Asking for ontological reference in any more absolute way than by reference to a background language is like asking for absolute position or absolute velocity, rather than for position or velocity relative to a frame of reference. The ultimate background language to which we take recourse in practice is our mother tongue, in which we take words at face value with their primitively adopted and ultimately inscrutable ontology. Any subordinate theory must be interpreted by reference to this home language. Quine opposes his thesis of ontological relativity to Carnap's thesis of the distinction between external ontological questions and internal factual questions set forth in "Empiricism, Semantics and Ontology.” In Quine's view there can be nothing like Carnapian external questions which are external to the home language. In "Carnap's Views on Ontology" (1951) reprinted in *Ways of Paradox* Quine maintains that ontological questions are on a par with questions in natural science. Within science there is a continuum of gradations from the statements that report observations to those that reflect basic features of quantum theory and relativity theory. Similarly statements of ontology and even of mathematics and logic form a continuation of this continuum, though these are more remote from observations than the central principles of quantum theory or relativity theory. Quine says that the differences along this continuum are only differences of degree and not differences in kind.

While the semantical wholism of the Duhem-Quine thesis has received much attention, it is seldom realized that Quine's rejection of all first philosophy is one of its most consequential implications for philosophy of science. When the Duhem thesis of physical theory is extended to the whole of language, not only is all semantics made context-determined, but also all ontologies described by the semantics are made vulnerable to empirical criticism; there are no longer any privileged or protected ontologies. Quine's thesis of ontological relativity has the historic and revolutionary effect of excluding all ontological considerations from the criteria for scientific criticism. In his philosophy it is empirical adequacy of scientific theories that decides ontological questions, rather than prior ontological commitments that decide the acceptability of scientific theories.

 

Quine subordinates all questions of ontology to the empirical adequacy of the theory affirming the ontological claims in question. He maintains that the human knower can never do better than to occupy the standpoint of one or another theory, whether the theory purports the existence of either macrophysical or microphysical entities. All entities are "posits" affirmed by one or another theory, and all are worthy of our patronage just to the extent that the theory positing them is empirically adequate. However detailed may be the relevant observation language, empirical underdetermination (in Quine's earlier sense) and its consequent semantical indeterminacy always admit alternative choices of theory. And the consequent referential inscrutability may admit to as many correspondingly alternative choices of entities.

Quine's rejection of prior ontological criteria in scientific criticism is also consistent with scientific realism, which gives the tested and nonfalsified explanation the role of defining ontology. Realism is not established by science; it is a prior prejudice. But science lets empirical justify the ontological claim that the explanation describes the real world. This thesis is not only characteristic of the contemporary Pragmatist philosophy, but was also the practice of Galileo, Einstein and Heisenberg. In developing his theory of relativity Einstein posited relativistic time as real instead of Newton's absolute time, and he rejected Lorentz's relegation of relativistic time to the status of apparent time and Lorentz's retention of Newton's absolute time as real. A central thesis of the Copenhagen interpretation, or at least Heisenberg's noninstrumentalist version, is its realistic claims about the wave-particle dualism and the indeterminacy principle, and Heisenberg referenced Einstein's realism in relativity theory as a precedent. However, the Copenhagen wave-or-particle dualism thesis cannot be affirmed on the basis of the mathematical equations of the quantum theory, since the mathematical expression has no syntactical categories for referencing entities. And Heisenberg's *potentia* ontology for the indeterminacy relations is also an added ontological claim about entities no less so than deBroglie-Bohm deterministic pilot-wave-and-particle ontology making the indeterminacy relations due to errors of measurement that are in principle correctable. The ontological claim justified by the empirical adequacy of the tested and nonfalsified mathematically expressed theory is limited to what the theory actually says, and the explanation is otherwise silent about ontology, and awaits further experimental findings. The practice of letting the empirical adequacy of a theory operate as the criterion for the acceptability of its ontology did not begin with Einstein or

 

Heisenberg. A historic and well known example is Galileo's realistic interpretation of the Copernican theory, which placed him in conflict with the Aristotelian ontology enforced by the Roman Catholic Papacy.

This is a distinctively and thoroughly Pragmatist view that separates Quine from both his Positivist and Romanticist predecessors. Ironically it also separates him from certain other aspects of his own philosophy. One such aspect is his behavioristic epistemology. The Romanticists insist upon and the Positivists insist against the introduction of "mentalism" in explanations in the social and behavioral sciences. But on the contemporary Pragmatist philosophy of science, this ontological issue is decided by the empirical adequacy of the behavioral and social science theories. Different theories in different sciences at different times or even at the same time will admit different ontologies. Quine's behavioristic "naturalized" epistemology is actually an exception to his thesis of ontological relativity.

Another such inconsistent aspect is Quine's ontological reductionism and his consequent *de facto* nominalism. In his "Introduction" to his *Dear Carnap, Dear Van* Richard Creath states that Quine's ontological reductionist agenda was due to Quine's interpreting Carnap's *Logical Syntax* in a manner that was nearly wholly unintended by Carnap. Carnap argued in *Logical Syntax* that talk which appears to be about possibilities, properties, relations, numbers, etc. can be reconstrued to be talk about sentences, predicates, etc. Creath says that in Quine's "Lectures on Carnap", a prepublication report on the theses of *Logical Syntax* given to the Society of Fellows at Harvard in 1934, Quine had interpreted Carnap to mean that there are no such metaphysical entities, and that philosophy therefore is syntax as a program of ontological reduction. Creath states that in fact Carnap actually rejected both the affirmation and the denial of the existence of such metaphysical entities as properties, because Carnap believed at the time that such discourse is metaphysical nonsense. Later Carnap took a more pragmatic view of such entities as intensions and properties. But for the duration of his career Quine continued in his ontological reductionist agenda, which apparently resulted from his early misinterpretation of Carnap, notwithstanding Quine's later formulation of his ontological relativity thesis. This persistence is inconsistent; ontological relativity renders logical elimination for the purpose of ontological reduction a philosophically pointless exercise, because its acceptance implies the rejection of any and all prior ontological commitments that would motivate the ontological reductionism. Ontological relativity makes all ontological commitments *a posteriori* to empirical criticism, and together with the

 

empirical underdetermination of all theories results in ontological pluralism, not reductionism. But Quine is neither the first nor the last philosopher-king to exercise a sovereign's right of eminent domain in his own philosophy, and exempt his preferred convictions from his own laws.

## Comment and Conclusion

Mach and Duhem were not only Positivist philosophers of science; they were also practicing research physicists, who furthermore wrote histories of physics. Carnap on the other hand was neither a practicing research physicist nor a historian of physics. His philosophical work was remote from the physicists' research practices, because the Vienna Circle had an epistemological (i.e. metaphysical) agenda for scientific criticism, which did not actually operate in research physics. Carnap aimed to construct a metalogic for science, but he did not apply his constructionalist techniques to the language used by scientists. Instead he used the symbolic logic of Russell and Whitehead to substitute for the object language that he claimed he was investigating. But the symbolic logic is not useful to the physicist. Carnap and others such as Russell and Braithwaite hailed the development of the Ramsey sentence as a great philosophical achievement. But it would be a rare physicist who would consider the Ramsey sentence at all consequential to either the practice or the history of physics. The situation is aptly stated by Radnitzky in the "Epilogue" in the first volume of his *Contemporary Schools of Metascience* (1968), where he says that the logical empiricists had not produced any metascience at all, because they did not study the producers of scientific knowledge or the production or even the results. The post-Positivist philosophers rejected Positivism because they correctly recognized its irrelevance to research science and its inadequacy as a philosophy of science.

When the post-Positivist philosophers rejected Positivism, many of them also rejected its constructionalism. Many Pragmatists in particular found their wholistic concept of the semantics of language incompatible with the mechanistic and procedural character of logical constructionalism. In the wholistic view the semantics of science makes the development of science a nonlogical process. But they rejected too much, because the Logical Positivists' linguistic-analysis approach is more valuable than either the Russellian symbolic logic or the Logical Positivist philosophy of science, which used the logic. In this age of the computerized discovery system

 

Carnap's constructionalism and his metatheory of semantical systems may with certain noteworthy modifications be carried forward into contemporary and future methodology of science. Some such modifications are as follows:

1. A first important modification is that the object language that is constructed by a discovery system is not the Russellian symbolic logic; it is the mathematical equations or other technical language actually used in the relevant science. Scientists never use the Russellian symbolic logic for the expression of their theories, and Carnap's use of the symbolic logic to express empirical science was never more than a caricature. In his distinctive *Primer of Quantum Mechanics* Marvin Chester explicitly renders Dirac's notational conventions as descriptive language. Given Carnap's interest in physics, his philosophical linguistic analyses would have been infinitely more interesting had he chosen Dirac's operator calculus to illustrate the syntax, semantics, and pragmatics of an object language in science, especially with respect to his thesis of intensions and extensions. Carnap's philosophy might have evolved considerably in the process of developing such a linguistic analysis.
2. A second modification of Carnap's work is the use of a computer language for the metalanguage. The computer language gives the metalanguage a disciplined and procedural character that a colloquial metalanguage does not have. The computer language in which the discovery system is written operates as a metalanguage in which the formation rules of the object language are expressed in computer instructions. The discovery system in other words is a metalanguage expressing a mechanized generative grammar.
3. A third modification pertains to Carnap's concept of semantical rules that interpret a semantical system. The semantical rules for interpreting a mechanically generated semantical system might be viewed as analogous to Carnap's meaning postulates, in that all of them are stated in the object language instead of the metalanguage, and are not like Carnap's rules of designation, which occur in the metalanguage. Two relevant types of semantical rules may be distinguished. One type consists of those semantical rules that are the mechanically generated statements and equations. These consist only of the statements constituting a mechanically generated and empirically acceptable theory, the outputted theory statements that are believed to be true. But not all the semantical rules occurring in the object language are mechanically generated. A second type consists of test design statements, which are accepted independently of any statements of theory generated by the

 

system, so that the generated theory is not tautological and can be tested independently.

But the semantical rules for mechanically generated semantical systems are unlike Carnap's meaning postulates, because they are not just analytical sentences. With Quine's rejection of any distinctively analytic truth it is possible to view sentences as both analytic and synthetic, and the semantical rules that describe the semantical interpretation of the object-language statements must be viewed as both analytic and synthetic sentences. They are more like Quine's analytical hypotheses or discursive postulates. These semantical rules might also be viewed as similar to Carnap's reduction sentences, which he says determine only "part" of the meaning of theoretical terms. But Carnap has never explained how it is possible for the meanings of terms to have parts. Viewing the sentences as both analytic and synthetic enables the empirical statements constituting the generated theory to exhibit the parts of the meanings of their constituent terms, just as analytic statements always have. Test design statements and generated theory statements, both of which are believed to be true for empirical reasons and not due to the meanings of their constituent terms, are object-language statements functioning as semantical rules, each of which contribute parts to the meaning of each of their common descriptive terms.

4. A fourth modification pertains to Carnap's idea of a state description. The Carnapian state description is not a useful concept for describing the semantical systems generated by mechanized discovery systems. In fact it is not useful for science at all. It consists of "atomic" statements expressed in Russellian logic, and was conceived with the intent of explicating precisely the ideas of L-truth and A-truth. The semantical systems generated by the discovery systems contain only universal statements constituting the theories generated with the formation rules in the computerized generative grammar. In contrast to the semantical systems in Carnap's philosophy, which were devised for static analyses, the semantical systems in metascience are intended to describe the semantical changes occurring in the development of new theories, which is a dynamic procedure. Accordingly the Carnapian idea of a state description must be revised for describing the computer system input and output object language, in order to reveal the semantical changes produced by the discovery system. The inputted information for the discovery system is drawn from the current cumulative state description consisting of the several theories that have been advanced to date by the

 

particular scientific profession. These theories supply the vocabulary inputted to the computerized discovery system. This vocabulary has its semantics specified by semantical rules consisting of test design statements, which are common to both input and output state descriptions. These test design statements are not changed by the discovery system, and they supply semantical continuity for identifying the subject of the theories independently of the theories. The computerized discovery system generates a set of outputted state descriptions consisting of alternative empirically adequate theories, which are semantical rules describing the semantics of the new theories.

5. A fifth modification consists of replacing Carnap's theory of information with Shreider's semantical metatheory, if the concept of state description as revised in the manner described above is identified with Shreider's concept of thesaurus. But unlike Shreider's theory there are actually two types of transformations involved. Firstly there is the mechanized syntactical transformation, the generation of new theories which are the output messages. And secondly there is also the semantical transformation on the part of the system users who communicate with the computer, when they attempt to interpret its output. The computer system is a transmitter and information source that generates message texts consisting of new theories. And the user receiving the message and having a thesaurus consisting of one of the input semantical systems, i.e. an old theory, must transform his thesaurus to conform to one of the output semantical systems, a new theory. Thus the amount of information transmitted to a user depends on the degree of transformation between his initial thesaurus and the outputted theory that must transform his thesaurus for him to understand the new theory.

   The psychological resistance might be large, if the amount of information communicated is large. And there may also a philosophical resistance depending on the using-scientist's philosophy of science. If the scientist is a Romantic, he will be philosophically ill disposed to accept the newly generated theories containing large amounts of information, because he will find they are not "intuitively plausible" and do not "make sense." Romanticism retards the development of science, because it forbids the unfamiliar. The Positivist like Mach will be less affected by such philosophical cognition constraints. Positivists believe in the special importance of the familiar, which they call the "observable." But some, like Carnap, opposed "models" in which technologically less accessible microphysical processes are explained on analogy with more

 

familiar macrophysical processes. The philosophy of science that offers the least impediment to the reception of new information is Pragmatism, according to which no ontology may even serve as a criterion for scientific criticism.

 