

III

Scientific Explanation, Space, and Time

MINNESOTA STUDIES IN THE PHILOSOPHY OF SCIENCE

Minnesota Studies in the
PHILOSOPHY OF SCIENCE

VOLUME III

Scientific Explanation, Space, and Time

EDITED BY

HERBERT FEIGL AND GROVER MAXWELL

FOR THE MINNESOTA CENTER FOR THE PHILOSOPHY OF SCIENCE

UNIVERSITY OF MINNESOTA PRESS, MINNEAPOLIS

© Copyright 1962 by the
UNIVERSITY OF MINNESOTA

All rights reserved

PRINTED IN THE UNITED STATES OF AMERICA

Library of Congress Catalog Card Number: 57-12861

PUBLISHED IN GREAT BRITAIN, INDIA, AND PAKISTAN BY THE
OXFORD UNIVERSITY PRESS, LONDON, BOMBAY, AND KARACHI
AND IN CANADA BY THOMAS ALLEN, LTD., TORONTO

Preface

The contents of this third volume of *Minnesota Studies in the Philosophy of Science* include much that is relevant for a general logic and methodology of the empirical sciences. There is considerable emphasis, however, on the philosophy of the *physical* sciences. The Minnesota Center for Philosophy of Science, after devoting several years to the foundations of psychology, has shifted its attention to the philosophy of physics. This does not mean that we have abandoned our interest in psychology, or that work in that area has been terminated. Very likely, we shall return to it full force at a later date. In the meantime a large number of articles* published elsewhere represent our continuing endeavors in the philosophy of psychology and other areas. Even in the present volume there are contributions, such as those by C. G. Hempel, M. Scriven, M. Brodbeck, W. W. Rozeboom, and W. Sellars, which, in varying degrees, are relevant also for the philosophy of psychology and the philosophy of history.

As in the preceding volumes of our series, almost all contributions have either resulted from, or been modified by, intensive discussions held at Center conferences of varying duration at various times. Also, as before,

* H. Feigl, "Philosophical Embarrassments of Psychology," *American Psychologist*, 14:115-128 (1959); "Other Minds and the Egocentric Predicament," *Journal of Philosophy*, 55:978-987 (1958); "Mind-Body—Not a Pseudoproblem," in S. Hook, ed., *Dimensions of Mind* (New York: New York University Press, 1959), pp. 24-36; "Critique of Intuition," *Philosophy East and West*, 8:1-16 (1958); "On the Vindication of Induction," *Philosophy of Science*, 28:211-216 (1961); G. Maxwell and H. Feigl, "Why Ordinary Language Needs Reforming," *Journal of Philosophy*, 55:488-498 (1961); H. Feigl, "Matter Still Largely Material," *Philosophy of Science* (forthcoming, 1962); "Reduction of Psychology to Neurophysiology," *Daedalus* (forthcoming, 1962); G. Maxwell, "An Analytic Vindication of Induction," *Philosophical Studies*, 12:43-45 (1961); "Theories, Frameworks, and Ontology," *Philosophy of Science* (forthcoming); as well as a number of essays in H. Feigl and G. Maxwell, eds., *Current Issues in the Philosophy of Science* (New York: Holt, Rinehart, and Winston, 1961). See also the essays by P. K. Feyerabend in the forthcoming *University of Pittsburgh Studies in the Philosophy of Science*.

Preface

some basic divergencies in philosophical outlook could not be removed even by prolonged interaction. We invite the readers to form their own independent judgment.

We wish to express our deep appreciation to the many scholars who have collaborated with the Center either by way of longer visits, or shorter conferences, or by way of correspondence. Among them are Professors R. Carnap, Ernest Nagel, N. R. Hanson, R. C. Buck, Henry Mehlberg, P. E. Meehl, and Kurt Baier.

It is with pleasure and sincere gratitude that we acknowledge the financial support received from the Louis W. and Maud Hill Family Foundation in St. Paul, the National Science Foundation, and the University of Minnesota.

Thanks are also due to Dr. Bruce Aune of Oberlin College, who assisted us in the editing of manuscripts, and to Mr. John A. Visvader and Mr. Michael Radner for preparing the indexes of the present volume.

Herbert Feigl, *Director*

Grover Maxwell, *Research Associate*

MINNESOTA CENTER FOR PHILOSOPHY OF SCIENCE

November 1961

Synopsis

The brief summaries that follow will point up some of the main issues discussed in the papers in this volume.

1. *The Ontological Status of Theoretical Entities*: GROVER MAXWELL. The thesis of this paper, bluntly put, is that electrons, photons, and even electromagnetic fields are just as real, and exist in the same full-blooded sense, as chairs, tables, or sense impressions. Influential views to the contrary often assert (1) that theoretical terms such as 'electron' are useful in science only as calculating devices, having, like carpenter's tools, a legitimate use but no significant reference, and (2) that it is ontologically illuminating to remove such terms from the language of science by explicit definition, by the introduction of Ramsey sentences, or by the use of Craig's theorem. Assertions of this sort are criticized in detail, and an attempt is made to clarify the notions of reality, existence, and observability, which, misunderstood, supply a major stimulus to instrumentalist interpretations of scientific theories.

2. *Explanation, Reduction, and Empiricism*: P. K. FEYERABEND. This article contains an exposition and a criticism of two principles which contemporary empiricism shares with some very influential traditional philosophies, such as Platonism and Cartesianism. The first principle, the *principle of derivability*, asserts that explanation is by derivation, that when an explanation is given, the explanandum is derivable from its explanans without any change in its original formulation. The second principle, the *principle of meaning invariance*, asserts that the process of explanation leaves, or should leave, meanings unchanged. It is shown (1) that these principles are inconsistent both with actual scientific practice and with a reasonable, nondogmatic empiricism, (2) that contemporary empiricism which has adopted these principles thereby decreases the empirical content of scientific theories, making them less empirical and more

dogmatic, (3) that the difficulties which emerge when one attempts to solve such major philosophical problems as the mind-body problem, or the problem of the existence of the external world, are due to the fact that the two principles are made the *conditio sine qua non* of their solution, and (4) that a formal account of explanation is impossible. Finally, an attempt is made to present the outlines of a disinfected empiricism, one no longer bound by these two principles.

3. *Deductive-Nomological vs. Statistical Explanation*: CARL G. HEMPEL. The essay sets forth a comparative analysis of two basic types of explanation found in empirical science: explanation by deductive subsumption under laws of strictly universal form, and statistical, or probabilistic, explanation by means of laws of statistical form. Part I presents the concept of deductive-nomological explanation and examines some questions that have been raised about it in the recent literature. Part II is a first attempt to determine the distinctive logical features of probabilistic explanation. Foremost among these is its inductive character: the explanandum does not follow logically from the explanans, but receives more or less strong inductive support from it. As a consequence, probabilistic explanation is seen to differ in several important respects from its deductive counterpart. The search for criteria of acceptability for a probabilistic explanation finally leads to some problems concerning the notion of rational belief; these are tentatively dealt with in the light of current probabilistic theories of decision-making.

4. *Explanations, Predictions, and Laws*: MICHAEL SCRIVEN. This paper attempts to provide the most comprehensive treatment of the logic of explanation in the literature. An attempt is made to comment on every plausible analytical comment on the subject made in recent years; but the main aim of the paper is not to criticize, it is to synthesize a new account. The criticism of highly plausible views is a way of clearing the underbrush so that a fresh crop may grow, and a number of seedlings are planted in this essay. The argument is extended to cover "statistical" explanations and the paper by Hempel in the present volume in which some interesting propositions on this topic are put forward. An important new theme in the present essay is the attempt to give an analysis of scientific rigor which avoids the requirement of strict deduction. A point of special interest is the production of a putative proof that an analogue of the "requirement of total evidence" is necessary for all explanations, whether deductions from universal laws or merely probabilistic inferences.

5. *Explanation, Prediction, and "Imperfect Knowledge"*: MAY BRODBECK. This paper examines certain recent criticisms of the deductive model of scientific explanation and prediction and the associated rejection of the hypothetico-deductive account of scientific theories, of valid deduction, and of formal logic. These criticisms and rejections are shown to arise, first, from a failure to distinguish between the elliptical, context-bound use of language for communication and the context-free use of language for description of the world. More fundamentally, the view that there are nondeductive explanatory connections among individual facts, as well as the rejection of the account of scientific theories as deductive connections among contingent empirical laws, rests on a philosophically untenable notion of "conceptual analysis." This notion is shown to result in a theory of meaning that causes language to lose all contact with the world that it is supposed to be about. Positively, the paper discusses the philosophical reasons why scientific explanation must be deductive and, using the notion of "imperfect knowledge," tries to show how the deductive model can account for the common-sense fact that in everyday life, in history, and in the social sciences generally we frequently do explain facts after they occur that we were not able to predict beforehand.

6. *The Factual Content of Theoretical Concepts*: WILLIAM W. ROZEBOOM. This article attempts (1) to set forth in formal precision the belief-commitments which are entailed by acceptance of a scientific theory; (2) to clarify the currently problematic cognitive status of observationally irreducible theories; (3) to disclose a serious, heretofore unrecognized, semantic obstacle to uniting an empiricist epistemology with a realistic interpretation of theoretical terms; and (4) to suggest the framework of a solution to this difficulty. By formalizing certain plausible assumptions about the manner in which theories are actually used, together with carefully weakened forms of conventional semantic postulates, it becomes possible to deduce the factual commitments of an accepted theory without prejudging whether the theory is itself cognitively meaningful. A subsequent attempt to construe such theories as genuine, semantically proper assertions, however, is seen to require liberalization of the concept of "designation," resulting in a generalized semantics of which classical semantic theory is merely a limiting case.

7. *The Analytic and the Synthetic*: HILARY PUTNAM. If "analytic" statements are those which could not turn out to be false unless some change in the meaning of a term (affecting even the extension) first occurred, and

“synthetic” statements are those which could be subjected to experimental test (and this, it is contended, is how philosophers, in large part, are actually using these terms today, regardless of how they may formally define them), then many statements (e.g., some of the fundamental laws of physics) do not fall happily into either category. Rather than try to “stretch” the terms to cover the recalcitrant cases, this paper tries to analyze this situation in terms of a distinction between *single-criterion* concepts (e.g., “bachelor”), and *multiple-criterion* concepts (e.g., “man,” “acid,” “energy”), with the latter being subdivided into ordinary *cluster concepts* (“man,” “swan”) and *law cluster concepts* (“acid,” “energy”).

8. *The Necessary and the Contingent*: GROVER MAXWELL. The traditional segregation of sentences which are necessary (analytic) from those which are contingent (synthetic) is defended. Analyticity in the broad sense arises from linguistic rules expressed by sets of *meaning postulates* which *implicitly define* some of the terms which they contain. Necessity in both natural and constructed languages is discussed, including considerations of *context dependence*. Selection of particular meaning postulates is justified by actual linguistic usage and by other nonlogical factors such as simplicity, general usefulness, and personal preferences. The analytic-synthetic distinction among theoretical postulates is given special attention.

9. *Geometry, Chronometry, and Empiricism*: ADOLF GRÜNBAUM. In what precise sense do the metric geometry of physical space and the chronometry ingredient in the laws of physics have a *factual warrant*? The epistemological status of geochronometry is clarified via scrutiny of the concepts of rigid body and isochronous clock in the light of Riemann’s conception that the metric is *not* intrinsic to the continua of space and time. The resulting statement of the conventionality of congruence, which is espoused by both Carnap and Reichenbach, is coupled with a critique of some parts of their philosophy of geometry.

To elaborate the import of the thesis of the conventionality of congruence, the following rival objections to it are refuted: (i) the system of physical laws countenanced by it fails to provide *causal* understanding of dynamical phenomena, (ii) it is false as shown by an analysis of the logic of measurement (Russell-Whitehead objection) and by the deliverances of sense perception (Whitehead’s objection), and (iii) it is a mere truism of the elementary theory of signs and of the theory of models of formal

calculi, but its exponents misconstrue this triviality in a highly misleading way (objection of Eddington and Putnam).

The alternative metrizable of space and of time vouchsafed by the conventionality of congruence is shown to issue in a *linguistic* interdependence of geochronometry and physics which must be carefully distinguished from an *inductive* (epistemological) interdependence between them in the sense of P. Duhem. The latter’s claim that no explanans constituting a part of a wider scientific theory can ever be conclusively falsified is criticized as not only a *non sequitur* but also false. And Einstein’s espousal of this Duhemian conception in regard to the epistemological status of physical geometry is then rejected. For it is demonstrated that the initial epistemological inseparability of geometry and physics need not preclude the accessibility of the geometry itself to experimental determination.

10. *Time and the World Order*: WILFRID SELLARS. This paper is a dialectical exploration of temporal discourse in an attempt to throw new light on a number of classical philosophical puzzles about time. Part I is concerned with such topics as (a) the ‘timelessness’ of truths or facts about temporal episodes; (b) the clash between substance ontologies and ‘event’ ontologies; (c) the connection between tensed verbs and temporal predicates; (d) the meaning of ‘exists’ and the existence of past and future events; (e) the status of becoming. Part II is concerned with issues pertaining to the connection (if any) between truth-or-falsity and determinism. It includes some tentative remarks on the philosophical significance of quantum mechanics and on the interpretation of three-valued ‘logics.’

Contents

SYNOPSIS	vii
THE ONTOLOGICAL STATUS OF THEORETICAL ENTITIES, by <i>Grover Maxwell</i> , UNIVERSITY OF MINNESOTA	3
The Problem, 4. The Observational-Theoretical Dichotomy, 7. What If We could Eliminate Theoretical Terms? 15. "Criteria" of Reality and Instrumentalism, 20. The Ontological Status of Entities—Theoretical and Otherwise, 22.	
EXPLANATION, REDUCTION, AND EMPIRICISM, by <i>P. K. Feyerabend</i> , UNIVERSITY OF CALIFORNIA	28
1. Two Assumptions of Contemporary Empiricism, 32. 2. Criticism of Reduction or Explanation by Derivation, 43. 3. The First Example, 46. 4. Reasons for the Failure of (5) and (3), 48. 5. Second Example: The Problem of Motion, 52. 6. Methodological Considerations, 62. 7. Criticism of the Assumption of Meaning Invariance, 74. 8. Summary and Conclusion, 91. References, 95.	
DEDUCTIVE-NOMOLOGICAL VS. STATISTICAL EXPLANATION, by <i>Carl G. Hempel</i> , PRINCETON UNIVERSITY	98
1. Objectives of This Essay, 98. PART I. DEDUCTIVE-NOMOLOGICAL SYSTEMATIZATION, 99: 2. The Covering-Law Model of Explanation, 99. 3. Truth and Confirmation of Deductive Explanations, 101. 4. Causal Explanation and the Covering-Law Model, 103. 5. Covering Laws: Premises or Rules? 110. 6. Explanation, Prediction, Retrodiction, and Deductive Systematization—a Puzzle about 'About,' 113. PART II. STATISTICAL SYSTEMATIZATION, 121: 7. Laws of Strictly General and Statistical Form, 121. 8. The Ambiguity of Statistical Systematization, 125. 9. The Theoretical Concept of Statistical Probability and the Problem of Ambiguity, 128. 10. The Inductive Character of Statistical Systematization and the Requirement of Total Evidence, 133. 11. The Logical Form of Simple Statistical Systematizations: A Rough Criterion of Evidential Adequacy, 141. 12. On Criteria of Rational Credibility, 149. 13. The Nonconjunc-	

Contents

tiveness of Statistical Systematization, 163. 14. Concluding Remarks, 166. References, 167.	
EXPLANATIONS, PREDICTIONS, AND LAWS, by Michael Scriven, INDIANA UNIVERSITY	170
1. Preface, 170. 2. Outline, 172. 3. Preliminary Issues, 172. 4. Fundamental Issues, 196. 5. The Alternative Analysis, 224. 6. Comments on Hempel's Account of Statistical Explanation, 226.	
EXPLANATION, PREDICTION, AND "IMPERFECT" KNOWLEDGE, by May Brodbeck, UNIVERSITY OF MINNESOTA ...	231
The Attack on the Deductive Model, 231. Common-Sense Facts vs. Philosophical Claims, 233. The Appeal to Ordinary Usage and to "Understanding," 234. Language as Communication vs. Language as Description, 236. Why Explanation Must Be Deductive, 238. "Perfect" Knowledge and Deductive Explanation, 241. "Certainty" of Premises vs. Deductive Validity, 242. "Imperfect" Knowledge and Deductive Explanation, 245. Explanation by 'Causes' vs. Explanation by Laws, 249. Explanation and Imperfect Knowledge of History and Society, 252. Inference Tickets and Enthymemes, 254. "Conceptual Analysis" and Rejection of Hypothetico-Deductive Theories, 258. Criticism of the Premises of the Deductive Model, 262. "Lawlike" Hypotheticals vs. Causal Laws, 264. Motives, Meaning, and a Science of Man, 267. Concluding Remarks, 272.	
THE FACTUAL CONTENT OF THEORETICAL CONCEPTS, by William W. Rozeboom, WESLEYAN UNIVERSITY ..	273
THE ANALYTIC AND THE SYNTHETIC, by Hilary Putnam, MASSACHUSETTS INSTITUTE OF TECHNOLOGY	358
Analytic and Nonanalytic Statements, 368. The Rationale of the Analytic-Synthetic Distinction, 381. The Analytic-Synthetic Distinction in Natural Language, 389.	
THE NECESSARY AND THE CONTINGENT, by Grover Maxwell	398
GEOMETRY, CHRONOMETRY, AND EMPIRICISM, by Adolf Grünbaum, UNIVERSITY OF PITTSBURGH	405
1. Introduction, 405. 2. The Criteria of Rigidity and Isochronism: The Epistemological Status of Spatial and Temporal Congruence, 408: (i) The Clash between Newton's and Riemann's Conceptions of Con-	

Contents

gruence and the Role of Conventions in Geochronometry, 408. (ii) Physical Congruence, Testability, and Operationism, 428. (iii) The Inadequacies of the Nongeometrical Portion of Riemann's Theory of Manifolds, 430. 3. An Appraisal of R. Carnap's and H. Reichenbach's Philosophy of Geometry, 432: (i) The Status of Reichenbach's 'Universal Forces,' and His 'Relativity of Geometry,' 432. (ii) Reichenbach's Theory of Equivalent Descriptions, 446. (iii) An Error in the Carnap-Reichenbach Account of the Definition of Congruence: The Non-Uniqueness of Any Definition of Congruence Furnished by Stipulating a Particular Metric Geometry, 447. 4. Some Chronometric Ramifications of the Conventionality of Congruence, 453: (i) Newtonian Mechanics, 453. (ii) The General Theory of Relativity, 463. (iii) The Cosmology of E. A. Milne, 465. 5. Critique of Some Major Objections to the Conventionality of Spatio-Temporal Congruence, 471: (i) The Russell-Poincaré Controversy, 471. (ii) A. N. Whitehead's Unsuccessful Attempt to Ground an Intrinsic Metric of Physical Space and Time on the Deliverances of Sense, 473. (iii) A. S. Eddington's Specious Trivialization of the Riemann-Poincaré Conception of Congruence and the Elaboration of Eddington's Thesis by H. Putnam and P. K. Feyerabend, 485. 6. The Bearing of Alternative Metrization on the Interdependence of Geochronometry and Physics, 493: (i) The Fundamental Difference between the Linguistic Interdependence of Geometry and Physics Affirmed by the Conventionalism of H. Poincaré and Their Epistemological (Inductive) Interdependence in the Sense of P. Duhem, 493. (ii) Exegetical Excursus: Poincaré's Philosophy of Geometry, 505. 7. The Empirical Status of Physical Geometry, 506: (i) Einstein's Duhemian Espousal of the Interdependence of Geometry and Physics, 506. (ii) Critique of Einstein's Duhemian Thesis, 510. 8. Summary, 521. Bibliography, 522.	
TIME AND THE WORLD ORDER, by Wilfrid Sellars, YALE UNIVERSITY	527
I. FACTS, EPISODES, AND THINGS, 528: 1. Truths about Other Times, 528. 2. Do Past and Future Episodes Exist? 541. 3. Time and Temporal Relations in a World of Things, 550. 4. Do Past and Future Things Exist? 556. 5. Relativity and the Objectivity of Becoming, 567. 6. The Problem Recast: an Ontology of 'Events'? 577. 7. More on 'To Exist,' 583. 8. Existence and Tense, 588. 9. Things or 'Events'? 593. II. DETERMINISM AND TRUTH, 595: 10. Decidability and Truth: Toward a Three-Valued Logic? 595. 11. Decidability and Truth: A Radical View, 604. 12. Decidability and Truth: Conclusion, 612.	
NAME INDEX	619
SUBJECT INDEX	622

MINNESOTA STUDIES IN THE PHILOSOPHY OF SCIENCE