Principles of
Behavior:
An Introduction
to Behavior
Theory

Clark Hull

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行为的原理：行为理论导论

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[美] 克拉克・赫尔 著

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“新闻学与传播学经典丛书·英文原版系列”，选取了在新闻学与传播学历史上具有里程碑意义的大师经典名作，如传播学“四大奠基人”哈罗德·拉斯韦尔、保罗·拉扎斯菲尔德等，及加布里埃尔·塔尔德、罗伯特·帕克、哈罗德·伊尼斯、马歇尔·麦克卢汉、库尔特·卢因、卡尔·霍夫兰等这些学界耳熟能详的名家佳作。这些是传播学与新闻学的奠基之作，也是现代新闻学与传播学发展的基础。许多名作都多次再版，影响深远，历久不衰，成为新闻学与传播学的经典。此套丛书采用英文原版出版，希望读者能读到原汁原味的著作。

随着中国高等教育的教学改革，广大师生已不满足于仅仅阅读国外图书的翻译版，他们迫切希望能读到原版图书，希望能采用国外英文原版图书进行教学，从而保证所讲授的知识体系的完整性、系统性、科学性和文字描绘的准确性。此套丛书的出版便是满足了这种需求，同时可使学生在专业技术方面尽快掌握本学科相应的外语词汇，并了解先进国家的学术发展方向。

本系列在引进英文原版图书的同时，将目录译为中文，作为对原版的一种导读，供读者阅读时参考。

从事经典著作的出版，需要出版人付出不懈的努力，我们自知本套丛书也许会有很多缺陷，虚心接受读者提出的批评和建议。

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CHAPTER I

The Nature of Scientific Theory

This book is the beginning of an attempt to sketch a systematic objective theory of the behavior of higher organisms. It is accordingly important at the outset to secure a clear notion of the essential nature of systematic theory in science, the relation of theory to other scientific activities, and its general scientific status and importance.

THE TWO ASPECTS OF SCIENCE: EMPIRICAL AND EXPLANATORY

Men are ever engaged in the dual activity of making observations and then seeking explanations of the resulting revelations. All normal men in all times have observed the rising and setting of the sun and the several phases of the moon. The more thoughtful among them have then proceeded to ask the question, "Why? Why does the moon wax and wane? Why does the sun rise and set, and where does it go when it sets?" Here we have the two essential elements of modern science: the making of observations constitutes the empirical or factual component, and the systematic attempt to explain these facts constitutes the theoretical component. As science has developed, specialization, or division of labor, has occurred; some men have devoted their time mainly to the making of observations, while a smaller number have occupied themselves largely with the problems of explanation.

During the infancy of science, observations are for the most part casual and qualitative—the sun rises, beats down strongly at midday, and sets; the moon grows from the crescent to full and then diminishes. Later observations, usually motivated by practical considerations of one kind or another, tend to become quantitative and precise—the number of days in the moon's monthly cycle are counted accurately, and the duration of the sun's yearly course is determined with precision. As the need for more exact observations increases, special tools and instruments, such as graduated measuring sticks, protractors, clocks, telescopes, and microscopes, are devised to facilitate the labor. Kindred tools relating to a given field of science are frequently assembled under a single roof for convenience of use; such an assemblage becomes a laboratory.

As scientific investigations become more and more searching it is discovered that the spontaneous happenings of nature are not adequate to permit the necessary observations. This leads to the setting up of special conditions which will bring about the desired events under circumstances favorable for such observations; thus experiments originate. But even in deliberate experiment it is often extraordinarily difficult to determine with which among a complex of antecedent conditions a given consequence is primarily associated; in this way arise a complex maze of control experiments and other technical procedures, the general principles of which are common to all sciences but the details of which are peculiar to each. Thus in brief review we see the characteristic technical development of the empirical or factual aspect of science.

Complex and difficult as are some of the problems of empirical science, those of scientific theory are perhaps even more difficult of solution and are subject to a greater hazard of error. It is not a matter of chance that the waxing and waning of the moon was observed for countless millennia before the comparatively recent times when it was at last successfully explained on the basis of the Copernican hypothesis. Closely paralleling the development of the technical aids employed by empirical science, there have also grown up in the field of scientific theory a complex array of tools and special procedures, mostly mathematical and logical in nature, designed to aid in coping with these peculiar difficulties. Because of the elementary nature of the present treatise, very little explicit discussion of the use of such tools will be given.

THE DEDUCTIVE NATURE OF SCIENTIFIC THEORY AND EXPLANATION

The term *theory* in the behavioral or "social" sciences has a variety of current meanings. As understood in the present work, a theory is a systematic deductive derivation of the secondary principles of observable phenomena from a relatively small number of primary principles or postulates, much as the secondary principles or theorems of geometry are all ultimately derived as a logical hierarchy from a few original definitions and primary principles called axioms. In science an observed event is said to be explained when the proposition expressing it has been logically derived from a set of definitions and postulates coupled with certain observed conditions antecedent to the event. This, in brief, is the nature of scientific theory and explanation as generally understood and accepted in the physical sciences after centuries of successful development (*1*, pp. 495-496).

The preceding summary statement of the nature of scientific theory and explanation needs considerable elaboration and exemplification. Unfortunately the finding of generally intelligible examples presents serious difficulties; because of the extreme youth of systematic behavior theory (*1*, p. 501 ff.; *2*, p. 15 ff.) as here understood, it is impossible safely to assume that the reader possesses any considerable familiarity with it. For this reason it will be necessary to choose all the examples from such physical sciences as are now commonly taught in the schools.

We can best begin the detailed consideration of the nature of scientific explanation by distinguishing it from something often confused with it. Suppose a naïve person with a moderate-sized telescope has observed Venus, Mars, Jupiter, and Saturn, together with numerous moons (including our own), and found them all to be round in contour and presumably spherical in form. He might proceed to formulate his observations in a statement such as, "All heavenly bodies are spherical," even though this statement goes far beyond the observations, since he has examined only a small sample of these bodies. Suppose, next, he secures a better telescope; he is now able to observe Uranus and Neptune, and finds both round in contour also. He may, in a manner of speaking, be said to explain the sphericity of Neptune by subsuming it under the category of heavenly bodies and then applying his previous empirical generalization. Indeed, he could have predicted the spherical nature of Neptune by this procedure before it was observed at all:

> All heavenly bodies are spherical.
> Neptune is a heavenly body,
> Therefore Neptune is spherical.

Much of what is loosely called explanation in the field of behavior is of this nature. The fighting propensities of a chicken are explained by the fact that he is a game cock and game cocks are empirically known to be pugnacious. The gregariousness of a group of animals is explained by the fact that the animals in question are dogs, and dogs are empirically known to be gregarious.

As we have seen, it is possible to make concrete predictions of a sort on the basis of such generalizations, and so they have significance. Nevertheless this kind of procedure—the subsumption of a particular set of conditions under a category involved in a previously made empirical generalization—is not exactly what is regarded here as a scientific theoretical explanation.

For one thing, a theoretical explanation as here understood grows out of a problem, e.g., "What must be the shape of the heavenly bodies?" Secondly, it sets out from certain propositions or statements. These propositions are of two rather different kinds. Propositions of the first type required by an explanation are those stating the relevant initial or *antecedent conditions*. For example, an explanation of the shape of heavenly bodies might require the preliminary assumption of the existence of (1) a large mass of (2) more or less plastic, (3) more or less homogeneous matter, (4) initially of any shape at all, (5) the whole located in otherwise empty space. But a statement of the antecedent conditions is not enough; there must also be available a set of statements of *general principles* or rules of action relevant to the situation. Moreover, the particular principles to be utilized in a given explanation must be chosen from the set of principles generally employed by the theorist in explanations of this class of phenomena, the choice to be made strictly on the basis of the nature of the question or problem under consideration taken in conjunction with the observed or assumed conditions. For example, in the case of the shape of the heavenly bodies the chief principle employed is the Newtonian law of gravitation, namely, that every particle of matter attracts every other particle to a degree proportional to the product of their masses and inversely proportional to the square of the distances separating them. These principles are apt themselves to be verbal formulations of empirical generalizations, but may be merely happy conjectures or guesses found by a certain amount of antecedent trial-and-error to agree with observed fact. At all events they originate in one way or another in empirical observation.

The concluding phase of a scientific explanation is the derivation of the answer to the motivating question from the conditions and the principles, taken jointly, by a process of inference or reasoning. For example, it follows from the principle of gravitation that empty spaces which might at any time have existed within the mass of a heavenly body would at once be closed. Moreover, if at any point on the surface there were an elevation and adjacent to it a depression or valley, the sum of the gravitational pressures of the particles of matter in the elevation acting on the plastic material beneath would exert substantially the same pressure laterally as toward the center of gravity. But since there would be no equal lateral pressure originating in the valley to oppose the pressure originating in the elevation, the matter contained in the elevation would flow into the valley, thus eliminating both. This means that in the course of time all the matter in the mass under consideration would be arranged about its center of gravity with no elevations or depressions; i.e., the radius of the body at all points would be the same. In other words, if the assumed mass were not already spherical it would in the course of time automatically become so (*4*, p. 424). It follows that all heavenly bodies, including Neptune, must be spherical in form.

The significance of the existence of these two methods of arriving at a verbal formulation of the shape of the planet Neptune may now be stated. The critical characteristic of scientific theoretical explanation is that it reaches independently through a process of reasoning the same outcome with respect to (secondary) principles as is attained through the process of empirical generalization. Thus scientific theory may arrive at the general proposition, "All heavenly bodies of sufficient size, density, plasticity, and homogeneity are spherical," as a theorem, simply by means of a process of inference or deduction without any moons or planets having been observed at all. The fact that, in certain fields at least, practically the same statements or propositions can be attained quite independently by empirical methods as by theoretical procedures is of enormous importance for the development of science. For one thing, it makes possible the checking of results obtained by one method against those obtained by the other. It is a general assumption in scientific methodology that if everything entering into both procedures is correct, the statements yielded by them will never be in genuine conflict.

SCIENTIFIC EXPLANATIONS TEND TO COME IN CLUSTERS CONSTITUTING A LOGICAL HIERARCHY

This brings us to the important question of what happens in a theoretical situation when one or more of the supposed antecedent conditions are changed, even a little. For example, when considering the theoretical shape of heavenly bodies, instead of the mass being completely fluid it might be assumed to be only slightly plastic. It is evident at once, depending on the degree of plasticity, the size of the mass, etc., that there may be considerable deviation from perfect sphericity, such as the irregularities observable on the surface of our own planet. Or suppose that we introduce the additional condition that the planet revolves on its axis. This necessarily implies the entrance into the situation of the principle of centrifugal force, the familiar fact that any heavy object whirled around in a circle will pull outward. From this, in conjunction with other principles, it may be reasoned (and Newton did so reason) that the otherwise spherical body would bulge at the equator; moreover, this bulging at the equator together with the principle of gravity would, in turn, cause a flattening at the poles (*4*, p. 424). Thus we see how it is that as antecedent conditions are varied the theoretical outcome (theorem) following from these conditions will also vary. By progressively varying the antecedent conditions in this way an indefinitely large number of theorems may be derived, but all from the very same group of basic principles. The principles are employed over and over in different combinations, one combination for each theorem. Any given principle may accordingly be employed many times, each time in a different context. In this way it comes about that scientific theoretical systems potentially have a very large number of theorems (secondary principles) but relatively few general (primary) principles.

We note, next, that in scientific systems there are not only many theorems derived by a process of reasoning from the same assemblage of general principles, but these theorems take the form of a logical hierarchy: first-order theorems are derived directly from the original general principles; second-order theorems are derived with the aid of the first-order theorems; and so on in ascending hierarchical orders. Thus in deducing the flattening of the planets at the poles, Newton employed the logically antecedent principle of centrifugal force which, while an easily observable phenomenon, can itself be deduced, and so was deduced by Newton, from the conditions of circular motion. The principle of centrifugal force accordingly is an example of a lower-order theorem in Newton's theoretical system (*4*, p. 40 ff.). On the other hand, Newton derived from the bulging of the earth at its equator what is known as the "precession of the equinoxes" (*4*, p. 580), the fact that the length of the year as determined by the time elapsing from one occasion when the shadow cast by the winter sun at noon is longest to the next such occasion, is shorter by some twenty minutes than the length of the year as determined by noting the time elapsing from the conjunction of the rising of the sun with a given constellation of stars to the next such conjunction. This striking phenomenon, discovered by Hipparchus in the second century B.C., was first explained by Newton. The precession of the equinoxes accordingly is an example of a higher-order theorem in the Newtonian theoretical system.

From the foregoing it is evident that in its deductive nature systematic scientific theory closely resembles mathematics. In this connection the reader may profitably recall his study of geometry with (1) its definitions, e.g., point, line, surface, etc., (2) its primary principles (axioms), e.g., that but one straight line can be drawn between two points, etc., and following these (3) the ingenious and meticulous step-by-step development of the proof of one theorem after the other, the later theorems depending on the earlier ones in a magnificent and ever-mounting hierarchy of derived propositions. Proper scientific theoretical systems conform exactly to all three of these characteristics.[1] For example, Isaac Newton's *Principia* (*4*), the classical scientific theoretical system of the past, sets out with (1) seven definitions concerned with such notions as matter, motion, etc., and (2) a set of postulates consisting of his three famous laws of motion, from which is derived (3) a hierarchy of seventy-three formally proved theorems together with large numbers of appended corollaries. The theorems and corollaries are concerned with such concrete observable phenomena as centrifugal force, the shape of the planets, the precession of the equinoxes, the orbits of the planets, the flowing of the tides, and so on.

SCIENTIFIC THEORY IS NOT ARGUMENTATION

The essential characteristics of scientific theory may be further clarified by contrasting it with argumentation and even with geometry. It is true that scientific theory and argument have similar formal or deductive structures; when ideally complete both should have their terms defined, their primary principles stated,

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[1] The formal structure of scientific theory differs in certain respects from that of pure mathematics, but these differences need not be elaborated here; the point to be emphasized is that mathematics and scientific theory are alike in that they are both strictly deductive in their natures.

and their conclusions derived in an explicit and logical manner. In spite of this superficial similarity, however, the two differ radically in their essential natures, and it would be difficult to make a more serious mistake than to confuse them. Because of the widespread tendency to just this confusion, the distinction must be stressed. An important clue to the understanding of the critical differences involved is found in the objectives of the two processes.

The primary objective of argumentation is persuasion. It is socially aggressive; one person is deliberately seeking to influence or coerce another by means of a process of reasoning. There is thus in argumentation a proponent and a recipient. On the surface the proponent's objective often appears to be nothing more than to induce the recipient to assent to some more or less abstract proposition. Underneath, however, the ultimate objective is usually to lead the recipient to some kind of action, not infrequently such as to be of advantage to the proponent or some group with which the proponent is allied. Now, for the effort involved in elaborate argumentation to have any point, the proposition representing the objective of the proponent's efforts must be of such a nature that it cannot be substantiated by direct observation. The recipient cannot have made such observations; otherwise he would not need to be convinced.

Moreover, for an argument to have any coerciveness, the recipient must believe that the definitions and the other basic assumptions of the argument are sound; the whole procedure is that of systematically transferring to the final culminating conclusion the assent which the recipient initially gives to these antecedent statements. In this connection it is to be noted that systems of philosophy, metaphysics, theology, etc., are in the above sense at bottom elaborate arguments or attempts at persuasion, since their conclusions are of such a nature that they cannot possibly be established by direct observation. Consider, for example, Proposition XIV of Part One of Spinoza's *Ethic* (*5*):

> "Besides God no substance can be, . . ."

The primary objective of scientific theory, on the other hand, is the establishment of scientific principles. Whereas argumentation is socially aggressive and is directed at some other person, natural science theory is aggressive towards the problems of nature, and it uses logic as a tool primarily for mediating to the scientist himself a more perfect understanding of natural processes. If Newton had been a scientific Robinson Crusoe, forever cut off from social contacts, he would have needed to go through exactly the same logical processes as he did, if he were *himself* to have understood why the heavenly bodies are spherical rather than cubical. Naturally also, argumentation presupposes that the proponent has the solution of the question at issue fully in hand; hence his frequent overconfidence, aggressiveness, and dogmatism. In contrast to this, the theoretical activities of science, no less than its empirical activities, are directed modestly toward the gradual, piecemeal, successive-approximation establishment of scientific truths. In a word, scientific theory is a technique of investigation, of seeking from nature the answers to questions motivating the investigator; it is only incidentally and secondarily a technique of persuasion. It should never descend to the level of mere verbal fencing so characteristic of metaphysical controversy and argumentation.

Some forms of argumentation, such as philosophical and metaphysical speculation, have often been supposed to attain certainty of their conclusions because of the "self-evident" nature of their primary or basic principles. This is probably due to the influence of Euclid, who believed his axioms to be "self-evident truths." At the present time mathematicians and logicians have largely abandoned intuition or self-evidentiality as a criterion of basic or any other kind of truth. Similarly, scientific theory recognizes no axiomatic or self-evident truths; it has postulates but no axioms in the Euclidian sense. Not only this; scientific theory differs sharply from argumentation in that its postulates are not necessarily supposed to be true at all. In fact, scientific theory largely inverts the procedure found in argument: *whereas argument reaches belief in its theorems because of antecedent belief in its postulates, scientific theory reaches belief in its postulates to a considerable extent through direct or observational evidence of the soundness of its theorems* (*2*, p. 7).

THEORETICAL AND EMPIRICAL PROCEDURES CONTRIBUTE JOINTLY TO THE SAME SCIENTIFIC END

No doubt the statement that scientific theory attains belief in its postulates through belief in the soundness of its theorems will come as a distinct surprise to many persons, and for several reasons. For one thing, the thoughtful individual may wonder why, in spite