need not greatly concern us, as, for example, the fate of the non-physical concepts which are deprived of their field of operation. We may regard the ultimate validity of the concept of volition (as, indeed, of that of the reflex) as beyond any immediate estimation. We are concerned with the reflex as a working concept. What is its nature and how shall it be defined? In particular, we have set ourselves to resolve certain difficulties of definition imposed by the extension to total behavior, where volition (or the practice which it represents) is important for its effects. But perhaps we have reviewed enough of its history and may turn directly to a statement of the argument.

In the history of the reflex one positive characteristic has always been given by the facts—the observed correlation of the activity of an effector (i.e., a response) with the observed forces affecting a receptor (i.e., a stimulus). The negative characteristics, on the other hand, which describe the reflex as involuntary, unlearned, unconscious, or restricted to special neural paths, have proceeded from unscientific presuppositions concerning the behavior of organisms. When Marshall Hall decapitated his famous newt, he pointed quite correctly to the reflex activity of the parts of the headless body, to the observed fact that movement followed, inevitably, the administration of specific stimuli. But his assumption that he had imprisoned in the head of the newt the source of another kind of movement was irrelevant and unsupported. The fact before him was a demonstrable necessity in the movement of the headless body; his failure to observe similar necessities in the movement of the intact organism was the accident of his time and of his capabilities.

Tentatively, then, we may define a reflex as an observed correlation of stimulus and response. When we say, for example, that Robert Whytt discovered the pupillary reflex,[1] we do not mean that he discovered either the contraction of the iris or the impingement of light upon the retina, but rather that he first stated the necessary relationship between these two events. So far as behavior is concerned, the pupillary reflex is nothing more than this relationship. Once given a specific stimulus-response correlation, we may, of course, investigate the physiological facts of its mediation. The information there revealed will supplement our definition, but it will not affect the status of the reflex as a correlation. These are matters, however, which will bear a more detailed treatment, for they present many problems.

V

The notions of both stimulus and response were, as we have seen, essential to the principle of irritability, so that the correlation which we are emphasizing was already present (in its most easily observed form) in the older con-

[1] Disregarding the supposed discovery by Galen and Descartes.

laws of the second sort. Conditioning, "emotion," and "drive," so far as they concern behavior, are essentially to be regarded as changes in reflex strength, and their quantitative investigation may be expected to lead to the determination of laws describing the course of such changes, that is, to laws of the second sort.[1]

It is difficult to discover any aspect of the behavior of organisms which may not be described with a law of one or the other of these forms. From the point of view of scientific method, at least, the description of behavior is adequately embraced by the principle of the reflex.

Summary

The present analysis of the reflex as a concept in the description of behavior follows the method first formulated with respect to scientific concepts by Mach and Poincaré. It examines the source of the historical definition and points out the incidental nature of most of its criteria. Eventually, it offers an alternative definition and considers in detail some of the questions which arise from the nature of the concept so defined.

I. Descartes "discovered the stimulus" and designed a mechanism which could account for animal movement upon the basis of the appropriate release of stored energy. But he was interested less in describing the action of the nervous system than in supporting metaphysical contentions of the automaticity of animals. He advanced the stimulus as a substitute for soul, but only within a field which omitted the greater part of the activity of man.

II. The notion of the reflex developed, independently of Descartes, from the investigation of "irritability." The action of a stimulus was implicit in the concept of irritability, which also assigned an autonomy of function to the parts of an organism. The concept of the reflex arose quite naturally when a stimulus and its related response were to be spatially distinguished. Robert Whytt made the first historically effective observations.

III. It remained for Marshall Hall to clear the concept of psychical counterparts. This he did by setting up a distinction between reflex and voluntary action, which resulted eventually in the unfortunate historical definition of the reflex as a form of movement unconscious, involuntary, and unlearned. Volition, in Hall's sense, was essentially the hypothetical antecedent of movement for which no corresponding stimulus could be observed, a definition which served to identify the reflex with scientific necessity and volition with unpredictability.

[1] The second half of my thesis, of which this paper was the first half, describes experiments on "hunger drive" from this point of view.

IV. The history of the reflex has known only one positive characteristic by which the concept may be defined: the observed correlation of two events, a stimulus and a response. The negative characteristics, on the other hand, which describe the reflex as involuntary, unconscious, and unlearned, have proceeded from unscientific presuppositions concerning the behavior of organisms. The reflex is tentatively defined herein as an observed correlation of stimulus and response.

V. Reflex physiology undertakes to describe the events which intervene between a stimulus and a response. The physiological usage does not question the definition of a reflex as a correlation, for the synapse is only a conceptual expression for the "reduced" characteristics of a given correlation.

VI. The essence of the description of behavior is held to be the determination of functional laws describing the relationship between the forces acting upon, and the movement of, a given system. The reflex is, by definition, the precise instrument for this description. Its analytical nature is discussed, and existing methods of analysis are examined. Current objections to analysis are held to have no scientific meaning.

VII. The experimental study of the reflex may be divided into two parts. There is, first, the investigation of the characteristics of a correlation—latency, threshold, after-discharge, and the order of variation of *S* and *R*. Secondly, there is the investigation of variations in these characteristics as functions of third variables. The notion of reflex strength is useful in dealing with this second group. The question of third variables is of extreme importance in the description of the behavior of intact organisms.

From the point of view of scientific method, any law describing the behavior of organisms must be reducible to one of the forms herein discussed. The description of behavior, that is to say, is adequately embraced by the principle of the reflex.