

An iterative model of experimental science

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In many areas of science the development of hypotheses goes hand in hand with the development of the experiments that elaborate, extend, verify or falsify them. Science studies scholars have noted the complex history of experimental work subsequently identified in terms of a final, definitive versions. They have also shown how experiments involve a dialectical play of ideas, instruments and phenomena in which each ingredient -- concepts, models, designs, instruments - - may go through many versions. On this view, the representation of experiments should refer both to the hypotheses that it is designed to explore or test and to those that are invoked during the process of learning to improve the 'fit' of theory and experimental results.

The specificity of an hypothesis is an important factor in experimental design, although the discriminatory power of experiment often lags behind what is required to discriminate between hypotheses. Proponents of inductive and deductive models of inference agree that the more specific an hypothesis is, the stronger the relationship between the hypothesis and the data that confirms or falsifies it. Falsificationist methodology considers only one hypothesis at a time, yet scientists typically have at least one alternative hypothesis (and sometimes several) in play. Moreover, falsification assumes that the objective is to eliminate hypotheses by deriving phenomenal consequences that can be negated by experimental results. This is accomplished by making the hypotheses (or predictions derived from them) as specific and as precise as possible. In practice the strict logical relationship of negation is achieved only in thought-experiments, rarely (if ever) in real ones. Nevertheless, we can take Popper's falsification proposal as an idealization in that the objectives of real-world experimentation are to bring results to bear on hypotheses as unambiguously as possible and to eliminate faulty assumptions and theories, as well as to evaluate and confirm plausible ones. This calls for improvements to experimental design so that trials match the degree of precision demanded by theory.

This paper describes a fully-implemented system for simulating inferences about evidence from experiments whose designs can be varied. The system allows simulation both of individual inferences and collaborative (multiple-agent) inferences. This enables us to explore the impact both of changing evidence and of social interaction on scientific inferences over time, showing how, at each iteration, an investigator's evaluation of the decisiveness of an experiment and of the bias of other investigators affects the selection of experiments and the overall pattern of confidence in different hypotheses.