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Simplicity and probability in causal explanation

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Abstract

What makes some explanations better than others? This paper explores the roles of simplicity and probability in evaluating competing causal explanations. Four experiments investigate the hypothesis that simpler explanations are judged both better and more likely to be true. In all experiments, simplicity is quantified as the number of causes invoked in an explanation, with fewer causes corresponding to a simpler explanation. Experiment 1 confirms that all else being equal, both simpler and more probable explanations are preferred. Experiments 2 and 3 examine how explanations are evaluated when simplicity and probability compete. The data suggest that simpler explanations are assigned a higher prior probability, with the consequence that disproportionate probabilistic evidence is required before a complex explanation will be favored over a simpler alternative. Moreover, committing to a simple but unlikely explanation can lead to systematic overestimation of the prevalence of the cause invoked in the simple explanation. Finally, Experiment 4 finds that the preference for simpler explanations can be overcome when probability information unambiguously supports a complex explanation over a simpler alternative. Collectively, these findings suggest that simplicity is used as a basis for evaluating explanations and for assigning prior probabilities when unambiguous probability information is absent. More broadly, evaluating explanations may operate as a mechanism for generating estimates of subjective probability.

Keywords: Causal explanation; Simplicity; Inference to the best explanation; Subjective probability

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1. Introduction

In everyday life as in science, data are inevitably consistent with multiple explanations. Does Mercury trace epicycles around the earth or follow an elliptical orbit around the sun? Is Hamlet's behavior due to love-sickness, insanity, or a sinister plot to avenge his father's death? Because the true state of the world is underdetermined, selecting the best explanation requires more than consistency with data. Sherlock Holmes, a master of underdetermined inference, advised that to evaluate explanations we "balance probabilities and choose the most likely" (Doyle, 1986b, p. 30). In the spirit of the rational detective, people may likewise evaluate explanations by comparing probabilities and choosing the most likely. But unfortunately for Holmes and the rest of us, explanations rarely come equipped with probabilities—even in fiction. Evaluating explanations therefore requires either a mechanism for generating probabilities or a non-probabilistic basis for selecting the best explanation.

Several scientists and scholars have advocated simplicity as a basis for evaluating explanations. In what has come to be known as Occam's Razor, William of Occam suggested that the number of entities invoked in an explanation should not be multiplied beyond necessity (Baker, 2004). Sir Isaac Newton described a similar maxim in the *Principia*, writing that "we are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances" (Newton, 1953/1686). These endorsements of simplicity illustrate a strategy that philosophers call "inference to the best explanation" (Harman, 1965; Lipton, 2002; Peirce, 1998): when multiple explanations are possible, choose the one that (if true) would best explain the evidence at hand. If simpler explanations are better explanations, then (all else being equal) one should select the simplest explanation.

Although simplicity can be evaluated in the absence of information about probability, simplicity and probability are intimately related. Newton advocated simplicity precisely because he believed simpler explanations were more probable, an assumption that stemmed from his belief that "nature is pleased with simplicity, and affects not the pomp of superfluous causes" (Newton, 1953/1686). Formal analyses of simplicity in philosophy, statistics and computer science likewise suggest that simpler explanations should be accorded higher probability, but where Newton turned to metaphysics, contemporary scholars consider the properties of probabilistic inference (e.g. Forster, 2000). In particular, complex hypotheses run the risk of fitting aspects of the data that result from noise or idiosyncratic properties of the data points that happened to be sampled. As a result, complex hypotheses may fit observed data very closely, but generalize to novel data more poorly than simpler alternatives. Formal metrics for simplicity, such as Minimum Description Length (Rissanen, 1978), Bayesian Occam's Razor (Jeffreys & Berger, 1992) and the Akaika information criterion (Forster, 2000), address this problem by assigning simpler hypotheses a higher prior probability—the probability assigned to a hypothesis before data has been observed. Once data is observed these probabilities are updated, so while simplicity and probability may correspond in the absence of data, complex hypothesis can be deemed more probable than simple alternatives as data accumulates.

Recent work in psychology supports the psychological reality of a preference for simplicity, as well as a role for simplicity in probabilistic inference. Chater (1996), for example, advocates a simplicity metric known as Kolmogorov Complexity, according to which simplicity is equivalent to being producible by a short program for a universal Turing machine (Li & Vitanyi, 1997). He shows that adopting this notion of simplicity implies a