

EMPIRICAL AND COUNTERFACTUAL CONDITIONS FOR SUFFICIENT CAUSE INTERACTIONS

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The sufficient-component cause framework makes reference to the actual causal mechanisms, referred to as sufficient causes, involved in bringing about an outcome. Sufficient-component causes are discussed within the deterministic potential outcomes framework so as to formalize notions of sufficient causes, synergism and sufficient cause interactions. When two or more binary causes participate in the same causal mechanism, synergism is said to be present. Synergism sometimes cannot be identified from data or even from the potential outcomes; when the potential outcomes or the data do imply that synergism is present, a sufficient cause interaction is said to be present. It is shown that for a binary outcome and binary causes, any set of potential outcomes can, within the sufficient-component cause framework, be replicated by a set of sufficient causes. Empirical and counterfactual conditions are given which imply the presence of 2-way and 3-way sufficient cause interactions. Conditions are given both for cases in which all causes under consideration affect the outcome monotonically and for cases in which this monotonicity assumption does not hold. Prior literature suggested that no progress could be made without monotonicity assumptions and it is shown that this is in fact not the case. The empirical conditions derived for sufficient cause interactions are compared with and contrasted to interaction terms in standard statistical models. It is shown that the conditions for a 2-way sufficient cause interaction correspond to a 2-way statistical interaction in a Bernoulli regression model with linear link only when the monotonicity assumption holds. For 3-way sufficient cause interactions, neither the conditions with nor without the monotonicity assumption correspond to a test for a 3-way statistical interaction in a Bernoulli regression model with linear link. The theory and methods developed in this paper constitute empirical tests for the joint presence of two or more causes in a single causal mechanism.