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# Sensitivity of chemical reaction networks: A structural approach.

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## Abstract

In living cells a large number of reactions are connected by sharing substrates or product chemicals, forming complex network systems like metabolic network. One experimental approach to the dynamics of such systems examines their sensitivity: each enzyme mediating a reaction in the system is increased/decreased or knocked out separately, and the responses in the concentrations of chemicals or their fluxes are observed. However, due to the complexity of the systems, it has been unclear how the network structures influence/determine the responses of the systems. In this study, we present a mathematical method, named structural sensitivity analysis, to determine the sensitivity of reaction systems from information on the network alone. We investigate how the sensitivity responses of chemicals in a reaction network depend on the structure of the network, and on the position of the perturbed reaction in the network. We establish and prove a general law which connects the network topology and the sensitivity patterns of metabolite responses directly. Our theorem explains two prominent features of network in sensitivity: localization and hierarchy in response pattern. We apply our method to several hypothetical and real life chemical reaction networks, including the metabolic network of the E. coli TCA cycle. The theorem is useful, practically, when examining real biological networks based on sensitivity experiments.

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