# Early warning signals in rumor models: distinguishing organic growth from astroturfing

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We study the emission and control of a rumor using the modified Maki-Thomson model. This model has recently been shown to exhibit a phase transition, challenging longstanding assumptions derived from mean-field approximations [1]. This finding has important implications, particularly for the study of early warning signals (EWS), statistical indicators used to detect critical transitions and widely applied in epidemiology [2] and other complex systems [3]. Specifically, we examine whether EWS can provide insights into the dynamics of rumor propagation. In particular, we assess their capacity to distinguish between a natural increase in transmissibility and an artificial injection of rumor spreaders through broadcast events or astroturfing.

Using stochastic simulations, we compare two scenarios: one with an increase in the spreading parameter, representing the organic growth (Fig. 1a); and another with externally injected spreaders, representing a broadcast event or astroturfing (Fig. 1b),. We analyze the resulting time series of infected individuals by calculating lag-1 autocorrelation and mutual information to characterize the system dynamics.

Although both scenarios lead to high autocorrelation, only the organic growth produces oscillatory patterns in autocorrelation at multiple lags, an effect we can analytically explain using the N-intertwined mean-field (NIMFA) approximation. This distinction offers a practical tool to identify the origin of rumor virality and also infer its transmissibility. Our approach is validated analytically and tested on real-world data from Twitter during the announcement of the Higgs boson discovery. In addition to emission detection, we also explore control strategies. We show that the average lifetime of a rumor can be manipulated through targeted interventions: placing spreaders at specific locations in the network. Depending on their placement, these interventions can either extend or shorten the lifespan of the rumor [4].

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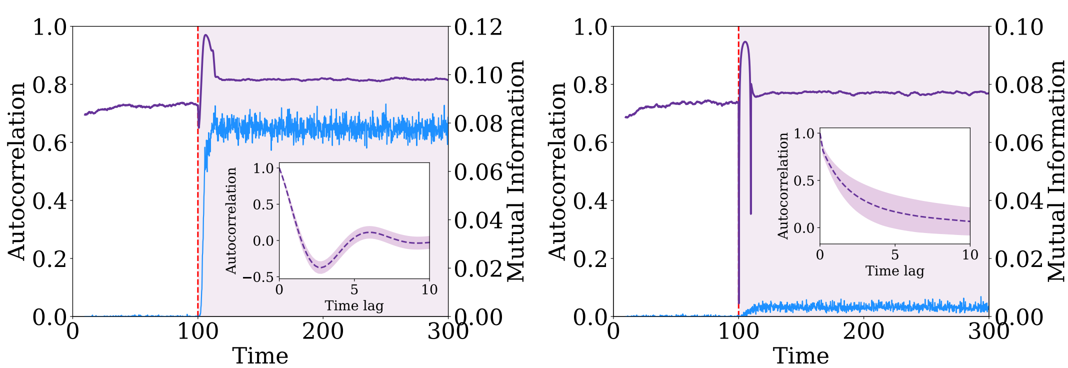
[4] Rifà, E., Vicens, J., & Cozzo, E. (2025). Early warning signals in rumor models. arXiv. https://doi.org/10.48550/arXiv.2505.24795




**(a)** Organic growth

**(b)** External injection

Figure 1: **(Main plot)** Time evolution of lag-1 autocorrelation and mutual information for Maki-Thompson model simulated with Gillespie's algorithm. We compare two scenarios: (a) a dynamically increased spreading rate, for organic rumor growth and (b) a fixed spreading rate with an external injection of new spreaders, representative of broadcasting-like processes. Simulations were performed on a random regular network of degree 10, with averaged values from 1000 realizations and analyzed with a rolling window. **(Insets)** Autocorrelation as a function of time lag that show oscillations in the case of organic growth.