Reduced Dynamical Complexity of Speech in Psychosis: A Lyapunov Perspective

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We propose a statistical-physics and dynamical-systems approach to the analysis of speech in psychiatric conditions by representing sequences of semantic embeddings as trajectories in a high-dimensional phase space. In this framework, discourse is treated as an evolving dynamical process rather than as a static linguistic object. This makes it possible to investigate speech using concepts from nonlinear dynamics, stability theory, and effective dimensionality analysis [1]. The central idea is that the temporal organization of language carries information about the structure of the underlying cognitive dynamics, and that this structure may be altered in pathological states.

Starting from transcribed structured clinical interviews, we construct time-ordered trajectories in embedding space and compute their finite-time Lyapunov spectra. From these spectra we extract the maximal Lyapunov exponent, the number of positive exponents, and the Kaplan–Yorke dimension. These quantities provide a compact characterization of local instability, directional expansion, and the effective number of active dynamical degrees of freedom. In this way, discourse can be analyzed as a high-dimensional nonequilibrium process whose evolution reflects the balance between variability, instability, and constraint.

Our results indicate a systematic reduction of dynamical complexity in psychosis. Relative to healthy controls, speech trajectories associated with psychosis exhibit smaller maximal Lyapunov exponents, fewer unstable directions, and lower Kaplan–Yorke dimensions. From the viewpoint of dynamical systems, this suggests that psychotic discourse explores a more restricted region of phase space and evolves on a lower-dimensional effective manifold. Thus, the difference is not only linguistic or semantic, but dynamical: psychosis appears as a regime of reduced instability and reduced exploration of admissible semantic configurations.

This interpretation connects naturally with broader questions in statistical physics concerning complexity reduction, constrained dynamics, and the geometry of high-dimensional evolving systems. In particular, Lyapunov-based quantities offer a way to distinguish between richer and more restricted dynamical regimes without assuming a specific low-dimensional mechanistic model of cognition. The proposed framework therefore provides a bridge between nonlinear physics and computational psychiatry, suggesting that psychiatric disorders may be studied through changes in stability, dimensionality, and phase-space exploration. More generally, it illustrates how methods developed for complex physical systems can be extended to language-derived trajectories in order to probe the dynamical organization of cognitive processes.

References:

[1] J. Vasić, B. Andjelić, A. Mančić, D. Filipović Djurdjević, Lj, Mihić, A. Kovačević, N. Marić and A. Maluckov, Lyapunov Spectral Analysis of Speech Embedding Trajectories in Psychosis, arXiv:2602.16273 (2026)