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The complex evolution of chess openings

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Chess is a board game that demands deep positional understanding from the very first move of the opening to the end of the game. The initial moves, by both White and Black, contain information at the individual level about each player's strengths, knowledge of the adversary, and personal preferences, as well as broader insights into the state of the art of the game itself. The evolution of chess can be traced back to the fifteenth century, with major transformations linked to the formal establishment of rules—such as Ruy López's treatise—, the beginning of organized tournaments in London, the formation of FIDE—Fédération Internationale des Échecs or International Chess Federation, and the establishment of the Chess Olympiads. Several tournaments have been reserved for high-level players, with selection processes ranging from direct invitations, such as the Hastings call, to eliminatory systems like the Chess Olympiads and the World Championship Candidates Tournament. Participants in these events bring well-established strategies and techniques, and innovations that emerge from the global practice of chess.

In this study, we analyze the development of chess openings over the course of a century, using the complete dataset of matches played in the Olympiads from 1924 to 2024. We combine two theoretical and methodological approaches: on one hand, we represent matches and tournaments using graphs; on the other, we apply entropy measures and complexity indices to explore and trace the organizational processes underlying the evolution of the game. Graphs are constructed by adding directed dyads corresponding to the first move of each match, with nodes representing Black's responses to White's moves using Descriptive Notation (e.g., Pawn to King 4 as PK4), recorded in a 20×20 matrix. We compute the following measures of complexity: Shannon entropy, Tsallis entropy, the Shiner-Davison-Landsberg complexity index, and the López-Ruiz-Mancini complexity index—based on both degree and strength of the nodes. These are analyzed across three match outcomes: White wins, Black wins and draws. In- and out-degree and strength are associated with the player's perspective (White or Black), while outcomes are treated as subsystems to estimate Tsallis entropy. Our results show that chess has evolved towards increasing diversity, due to broader explorations and preferences for rare strategies, reflecting both innovation and adaptation to evolving winning patterns: While Shannon entropy captures the growing dispersion of opening choices and shifts in player´s preferences, and complexity indices highlight rising interdependence between moves, assuming superadditivity Tsallis entropy parameter (q), ranges from 1.1 to 3.0, signals a transition toward correlated structures.

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