Stochastic Properties of Musical Time Series

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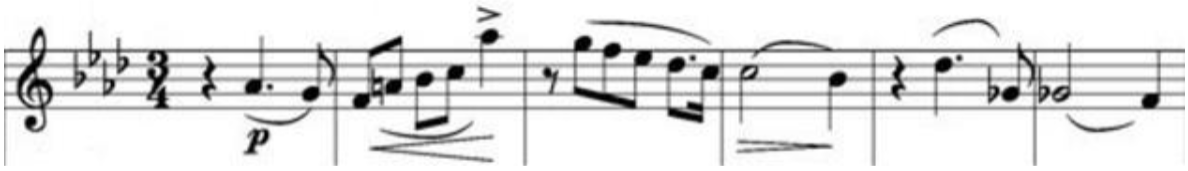
Music philosophers and psychologists have argued that emotions and meaning in music depend on an interplay of expectation and surprise in the musical progression. Using stochastic methods we aimed to quantify the variability of musical pieces empirically by considering them as correlated dynamical processes. By means of a multi-taper method we determined power spectral density (PSD) estimates for more than 550 classical compositions and jazz improvisations down to the smallest possible frequencies [1].

The PSDs of pitch sequences typically follow inverse power laws ($1/f^{\beta}$-noise) with exponents near $\beta = 1$ for classical compositions, yet only down to a cutoff frequency, where they end in a plateau. Correspondingly the pitch autocorrelation function exhibits slow power law decays only up to a cutoff time, beyond which the correlations vanish abruptly. We determined cutoff times between 4 and 100 quarter note units serving as a measure for the degree of persistence and predictability in music. They tend to be larger in Mozart's compositions than in Bach's, which implies that the anticipation and expectation of the musical progression typically tends to last longer in Mozart's compositions than in Bach's.



References:

[1] C. Nelias and T. Geisel, Nature Comm. 15, 9280 (2024)