Improving musical synchronization with mathematical modeling

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Music functions as a universal connector that pervades most cultures. More specifically, rhythm and synchronization - both within and beyond the realm of music - are forms of communication that stimulate brain activity.

In a recently-published paper in the *SIAM Journal on Applied Mathematics*, authors Donald Drew, Kevin Dolch, and Maury Castro propose a stochastic differential equation model that simulates how musical performers in a large ensemble sustain tempo and phase while responding to a conductor, other musicians, and additional distractions modeled as "noise." In an ideal situation, musicians would be able to perfectly coordinate the rate of change at which pitch and relative loudness occur while simultaneously ignoring noise and the distractions of the other musicians. However, the authors recognize that the aforementioned stimuli cause execution errors from each individual.

The authors assume that individual performers preserve an internal tempo when responding to the conductor, who offers the correct rhythm sequence. Their phase correction model assumes that the correction of a rate of error is contingent on the ratio of tempo variation to a performer's ability to resist noise distraction and concentrate solely on the conductor. The correction model is based on deliberate responses of the human brain when determining tempo and phase, rather than assuming error correction based on biochemical oscillators, as in other models.

The authors acknowledge that musical performances involve a certain amount of individual tempo variations to achieve a sense of artistry. But their proposed models offer a means by which to manage tempo discrepancies, improve synchronization, and thus enhance the overall quality of performed music.

More information: Donald Drew et al. A Model for Tempo Synchronization in Music Performance, *SIAM Journal on Applied Mathematics* (2015). DOI: 10.1137/140992357

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