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## **Pianist Lang Lang performing the music of Beethoven — which, according to mathematical analysis, tends to follow a more 'predictable' rhythm than Mozart.**

**Photograph by: Submitted photo , Vancouver Symphony Orchestra**

Love music, but hate math? Here's news: a new study suggests there are deep-rooted ties between one series of mathematical equations and some of the most beloved and well-known musical arrangements of all time.

The study, led by McGill professor Daniel Levitin, showed that the equation known as the "power law" or the "one-over-f" law has direct links to the rhythmic structure of nearly 2,000 songs composed over a 400-year period. That same equation is tied to many real-world events, ranging from the human heartbeat and solar flares to natural disasters on earth.

Levitin said Tuesday that the equation can also determine the "fingerprint" each composer puts on musical arrangements.

That fingerprint could be found in one part of the equation, called the exponent, that differentiates each composer and can actually determine how predictable their arrangements are.

"The composer has a sonic or statistical fingerprint — a mathematical fingerprint — describing the rhythmic structure of their work," said Levitin, a professor of psychology and neuroscience at McGill. "Now that you have these different parameters, you can rank-order them.

"It turns out the parameter indicates how predictable the music is, so one of the big findings here was that Beethoven employs among the most predictable rhythm, compared to, say, Mozart, who employs among the least predictable rhythms."

After "several years of analysis" using nearly 2,000 pieces of music composed between 1500 and 1900, the researchers were able to make a number of links between music and the equation.

"We found all this classical music can be characterized by this power law," Levitin said.

In the 1970s, it was determined the equation had a relation to pitch structure in classical music, but rhythm was not explored at the time.

"I went into it with a hunch that it would work out for the rhythm . . . but the big bonus was finding out that the exponents allowed us to show which composers were which and to be able to say which had the most predictable rhythms," he said.

While Beethoven was found to be most predictable, Levitin said it hardly takes away from his skills as a composer. Music, he said, often comes down to the "Goldilocks effect," which requires a fine balance of predictability and surprise to appeal to an audience.

Although the study looks at classical music exclusively, Levitin said he is confident it also would apply to modern music.

"I think if it's Adele or John Coltrane or Oscar Peterson, that would conform to the rule as well," Levitin said.

The paper was published Monday in the Proceeding of the National Academy of Sciences. Levitin was scheduled to present the study at the California Institute of Technology on Wednesday in Pasadena, Calif.

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