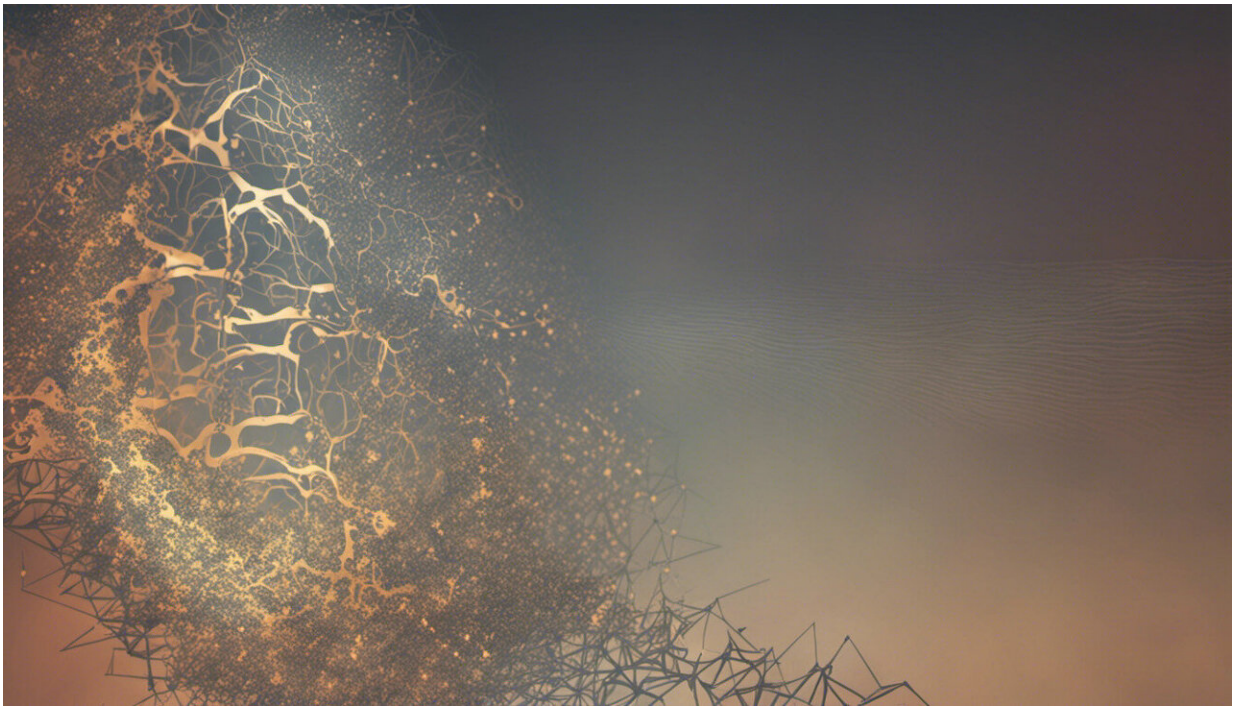
Fractals patterns in a drummer's music

August 28 2015



Credit: AI-generated image (disclaimer)

Fractal patterns are profoundly human – at least in music. This is one of the findings of a team headed by researchers from the Max Planck Institute for Dynamics and Self-Organization in Göttingen and Harvard University in Cambridge, Massachusetts following an analysis of the drumming of Jeff Porcaro who played in the band Toto and who many fans believe set new standards. In both the rhythm and the loudness of his hits on the hi-hat, the researchers discovered self-similar patterns

with structures in longer periods of time that resemble the structures present in shorter time intervals. People evidently prefer exactly this type of variation: totally precise percussion or hits varied purely at random were perceived as less agreeable. The sequence of our heartbeats also has fractal properties, and too much precision can even be life threatening here.

Jeff Porcaro (1954 – 1992) achieved a considerable amount of fame in his short life: the American drummer was a founding member of the Californian rock group Toto and also played with many other stars in the music business – including Pink Floyd, Michael Jackson, Madonna, Bruce Springsteen and Frank Sinatra. He was famous for his characteristic one-handed playing on the hi-hat, a pair of cymbals which produce particularly high tones.

Scientists from the Max Planck Institute for Dynamics and Self-Organization, the University of Tampere in Finland and Harvard University used the song "I Keep Forgettin'" to help them discover what exactly made Porcaro's drumming so appealing. "It contains a famous pattern of 16th notes and a large number of hi-hat hits which we were able to analyze with millisecond accuracy," said Holger Hennig, who conducts research at the Max Planck Institute for Dynamics and Self-Organization and Harvard University, explaining the team's choice. The theoretical physicist, Hennig played the piano and African drums in his spare time and had discovered fractal patterns in music earlier. A conversation with fellow physicist Esa Räsänen from Tampere – himself a keen drummer – led to the decision to take a closer look at Porcaro's hi-hat beats.

Similar patterns appear in two bars and throughout the whole piece

The team analyzed the digital data from the compact disc, which involved them first to develop a method to detect the onsets of Porcaro's hi-hat hits with very high precision. "In future, this method will enable us to analyze the characteristic features of the timing and the loudness dynamics of other virtuosos," said Hennig. It turned out that irregularities in Porcaro's hits exhibit a typical fractal (also called self-similar) pattern in both rhythm and loudness. "They are similar on various time scales – just as a fractal coastline looks similar on different length scales," explained Hennig.

Physicists use the word scale to describe the order of magnitude. Different time scales are therefore different lengths of time, such as an interval of several minutes and an interval of several seconds. "Porcaro's patterns can be found on several scales, beginning with two bars and extending to the whole piece." So in his rhythm, Jeff Porcaro speeds up and slows down in a few beats according to the same pattern as he does throughout the whole of the song. Surprisingly, the variations in timing and pitch are not analogous – which indicates that they originate from different processes in the brain.

Hennig firmly believes that "the fractal patterns are part of the magic of Porcaro's playing". This finding is supported by a number of earlier studies on music listening that he conducted together with Theo Geisel, Director at the Max Planck Institute for Dynamics and Self-Organization, which found that people can intuitively detect whether a rhythm comes from a musician or a machine – even when a randomizer makes the computer-generated drumming deviate slightly from the precise pattern with each hit. Consequently, the findings about Porcaro's playing are likely to be applicable to music in general: "We assume that the fractal patterns in the rhythm and in the loudness fluctuations are universal, meaning that they occur whenever a person holds a rhythm over a longer period of time," says Holger Hennig. He and his colleagues are now analyzing other pieces of music to demonstrate this and also to

detect the characteristic features of Porcaro's drumming.

Pianists with Parkinson's lose the fractal patterns

The great importance of fractals is also evident in other areas: "Variations in intervals between heartbeats normally exhibit fractal patterns – but pioneering works from the 1990s have shown that the fractal patterns are missing in a life-threatening form of heart disease where the heart beats too precisely," as Hennig points out. "Recently, we found that the fractal patterns in rhythms get lost in the playing of professionally trained pianists with Parkinson's disease."

Just how the fractal patterns arise in Porcaro's playing has not yet been clarified. It could be a reflection of neural firing patterns, which have also been demonstrated to have fractal properties. Going forward, the scientists at the Max Planck Institute for Dynamics and Self-Organization plan to continue this line of research: in a follow-up project they study the question, how musicians' sense of time works and when a band has found their shared groove. It would be no surprise if fractals also played an important role there.

More information: "Fluctuations of Hi-Hat Timing and Dynamics in a Virtuoso Drum Track of a Popular Music Recording." *PLoS ONE* 10(6): e0127902. DOI: 10.1371/journal.pone.0127902

Provided by Max Planck Society