The Brain's 'Prediction Machine' Anticipates the Future When Listening to Music

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Summary: *We live our lives in real time, watching events unfold moment by moment. To make better sense of the world, however, our brains automatically predict how some events will unfold moments into the future. New research published in* Psychological Science *explores the brain's "prediction machine" capabilities by examining how we experience music.*

Whether listening to a concerto by Bach or the latest pop tunes on Spotify, the human brain does not wait passively for the song to unfold. Instead, when a musical phrase has an unresolved or uncertain quality about it, our brains automatically predict how the melody will end.

Past ideas on how the human brain processes music suggested that musical phrases are perceived by looking backward rather than forward. New research published in the journal Psychological Science, however, suggests that the human brain considers what has come before to anticipate what comes next.

"The brain is constantly one step ahead and matches expectations to what is about to happen," said Niels Chr. Hansen, a fellow at the Aarhus Institute of Advanced Studies and one of two lead authors on the paper. "This finding challenges previous assumptions that musical phrases feel finished only after the next phrase has begun."

Hansen and his colleagues focused their research on one of the basic units of music, the musical phrase—a sequence or pattern of sounds that form a distinct musical "thought" within a melody. Like a sentence, a musical phrase is a coherent and complete part of a larger whole, but it may end with some uncertainty about what comes next in the melody. The new research shows that listeners use these moments of uncertainty, or high entropy, to determine where one phrase ends and another begins.

"We only know a little about how the brain determines when things start and end," said Hansen. "Here, music provides a perfect domain to measure something that is otherwise difficult to measure—namely, uncertainty."

To study the brain's musical predictive power, the researchers had 38 participants listen, note by note, to chorale melodies by Bach. Participants could pause and restart the music by pressing the space bar on a computer keyboard.

The participants were told that they would be tested afterward on how well they remembered the melodies. This allowed the researchers to use the time participants dwelled on each tone as an indirect measure of their understanding of musical phrasing.

In a second experiment, 31 different participants listened to the same musical phrases and then assessed how complete they sounded. The participants judged melodies that ended on high-entropy tones to be more complete—and lingered on them longer.

"We were able to show that people have a tendency to experience high-entropy tones as musical-phrase endings. This is basic research that makes us more aware of how the human brain acquires new knowledge not just from music, but also when it comes to language, movements, or other things that take place over time," said Haley Kragness, a postdoctoral researcher at the University of Toronto Scarborough and the paper's second lead author.

Over the long term, the researchers hope that the results can be used to optimize communication and interactions between people—or, alternatively, to understand how artists are able to tease or trick audiences.

> Additional research on music and psychological science can be found in our Research Topic on Music.

"This study shows that humans harness the statistical properties of the world around them not only to predict what is likely to happen next, but also to parse streams of complex, continuous input into smaller, more manageable segments of information," said Hansen.

Other collaborators on the study were Laurel Trainor (McMaster University), Peter Vuust (Aarhus University), and Marcus Pearce (Queen Mary, University of London).

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Reference: Hansen, N. C., Kragness, H., Vuust, P., Trainor, L., & Pearce, M. (2021) Predictive uncertainty underlies auditory boundary perception. *Psychological Science*. Advance online publication. https://doi.org/10.1177/0956797621997349

Parts of Bach's chorale "In allen meinen Taten" (BWV 367) were included in the study. A sample is here: https://www.youtube.com/watch?v=kPrSwsHTGQU. BWV stands for "Bach-Werke-Verzeichnis," the universal catalogue system for Bach's oeuvre. The title of this chorale is usually translated into English as "In all my undertakings."