Researchers use classical music to make protein songs more pleasant to listen to

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In recent years, scientists have created music based on the structure of proteins as a creative way to better popularize science to the general public, but the resulting songs haven't always been pleasant to the ear. In

a study appearing September 29 in the journal *Heliyon*, researchers use the style of existing music genres to guide the structure of protein song to make it more musical. Using the style of Frédéric Chopin's *Fantaisie-Impromptu* and other classical pieces as a guide, the researchers succeeded in converting proteins into song with greater musicality.

Creating unique melodies from proteins is achieved by using a protein-to-music algorithm. This algorithm incorporates specific elements of proteins—like the size and position of amino acids—and maps them to various musical elements to create an auditory "blueprint" of the proteins' structure.

"Existing protein music has mostly been designed by simple mapping of certain amino acid patterns to fundamental musical features such as pitches and note lengths, but they do not map well to more complex musical features such as rhythm and harmony," says senior author Yu Zong Chen, a professor in the Department of Pharmacy at National University of Singapore. "By focusing on a music style, we can guide more complex mappings of combinations of amino acid patterns with various musical features."

For their experiment, researchers analyzed the pitch, length, octaves, chords, dynamics, and main theme of four pieces from the mid-1800s Romantic era of classical music. These pieces, including *Fantasie-Impromptu* from Chopin and *Wanderer Fantasy* from Franz Schubert, were selected to represent the notable Fantasy-Impromptu genre that emerged during that time.

"We chose the specific music style of a Fantasy-Impromptu as it is characterized by freedom of expression, which we felt would complement how proteins regulate much of our bodily functions, including our moods," says co-author Peng Zhang, a post-doctoral fellow at the Rockefeller University

Likewise, several of the proteins in the study were chosen for their similarities to the key attributes of the Fantasy-Impromptu style. Most of the 18 proteins tested regulate functions including human emotion, cognition, sensation, or performance which the authors say connect to the emotional and expressive of the genre.

Then, they mapped 104 structural, physicochemical, and binding amino acid properties of those proteins to the six musical features. "We screened the quantitative profile of each amino acid property against the quantized values of the different musical features to find the optimal mapped pairings. For example, we mapped the size of amino acid to note length, so that having a larger amino acid size corresponds to a shorter note length," says Chen.

Across all the proteins tested, the researchers found that the musicality of the proteins was significantly improved. In particular, the protein receptor for oxytocin (OXTR) was judged to have one of the greatest increases in musicality when using the genre-guided algorithm, compared to an earlier version of the protein-to-music algorithm.

"The oxytocin receptor protein generated our favorite song," says Zhang. "This protein sequence produced an identifiable main theme that repeats in rhythm throughout the piece, as well as some interesting motifs and patterns that recur independent of our algorithm. There were also some pleasant harmonic progressions; for example, many of the seventh chords naturally resolve."

The authors do note, however, that while the guided algorithm increased the overall musicality of the protein songs, there is still much progress to be made before it resembles true human music.

"We believe a next step is to explore more music styles and more complex combinations of amino acid properties for enhanced musicality

and novel music pieces. Another next step, a very important step, is to apply artificial intelligence to jointly learn complex amino acid properties and their combinations with respect to the features of various music styles for creating protein music of enhanced musicality," says Chen.

More information: *Heliyon*, Chen et al.: "Protein Music of Enhanced Musicality by Music Style Guided Exploration of Diverse Amino Acid Properties" www.cell.com/heliyon/fulltext/ … 2405-8440(21)02036-3 , DOI: 10.1016/j.heliyon.2021.e07933

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