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Research article

A repetitive modular oscillation underlies human brain electric activity

Arturo Tozzi[a,f,*], James F. Peters[a,b,c,d], Norbert Jaušovec[e]

[a] Computational Intelligence Laboratory, University of Manitoba, Winnipeg R3T 5V6 Manitoba, Canada
[b] Department of Electrical and Computer Engineering, University of Manitoba, 75A Chancellor's Circle, Winnipeg MB R3T 5V6, Canada
[c] Department of Mathematics, Adıyaman University, 02040 Adıyaman, Turkey
[d] Department of Mathematics, Faculty of Arts and Sciences, Adıyaman University, 02040 Adıyaman, Turkey
[e] Department of Psychology, University of Maribor, Koroska Cesta 160, 2000 Maribor, Slovenia
[f] Center for Nonlinear Science, Department of Physics, University of North Texas, Denton, Texas 76203, USA, 1155 Union Circle, #311427, Denton, TX 76203-5017, USA

HIGHLIGHTS

- Modular functions are widespread in physics and biology.
- We examined a modular function in electric brain activity.
- We found a modular function, the J-function, embedded in human EEGs.

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ABSTRACT

The modular function j, central in the assessment of abstract mathematical problems, describes elliptic, intertwined trajectories that move in the planes of both real and complex numbers. Recent clues suggest that the j-function might display a physical counterpart, equipped with a quantifiable real component and a hidden imaginary one, currently undetectable by our senses and instruments. Here we evaluate whether the real part of the modular function can be spotted in the electric activity of the human brain. We assessed EEGs from five healthy males, eyes-closed and resting state, and superimposed the electric traces with the bidimensional curves predicted by the j-function. We found that the two trajectories matched in more than 85% of cases, independent from the subtending electric rhythm and the electrode location. Therefore, the real part of the j-function's peculiar wave is ubiquitously endowed all over normal EEGs paths. We discuss the implications of such correlation in neuroscience and neurology, highlighting how the j-function might stand for the one of the basic oscillations of the brain, and how the still unexplored imaginary part might underlie several physiological and pathological nervous features.

Significance statement

Our results point towards the brain as ubiquitously equipped with j-function's oscillations, which movements take place on the plane of the complex numbers. It means that there must be, in brain electric activity, also a veiled complex part, which can be assessed with the help of imaginary numbers. The modular j-function provides further dimensions to the real numbers, in order to enlarge their predictive powers: it suggests the possible presence of hidden (functional or spatial) brain extra-dimensions. Furthermore, j-oscillations could be disrupted during pathologies, paving the way to novel approaches to central nervous system's diseases.

1. Introduction

The j-function describes intertwined, repetitive elliptic trajectories taking place on the so-called *plane of the complex numbers* [1]. Such plane can be exemplified as a plot displaying on the x axis the real numbers (e.g., 1, 2, −1, −2) and on the y axis the imaginary part (e.g., a component that satisfies the equation $i^2 = -1$). The intersection of a real and an imaginary number in the graph is termed a *complex number* (Fig. 1A). The role of complex numbers in mathematics is to enlarge the concept of the one-dimensional number line

* Corresponding author.
E-mail addresses: tozziarturo@libero.it, tozziarturo@libero.i7 (A. Tozzi), james.peters3@umanitoba.ca (J.F. Peters), norbert.jausovec@um.si (N. Jaušovec).

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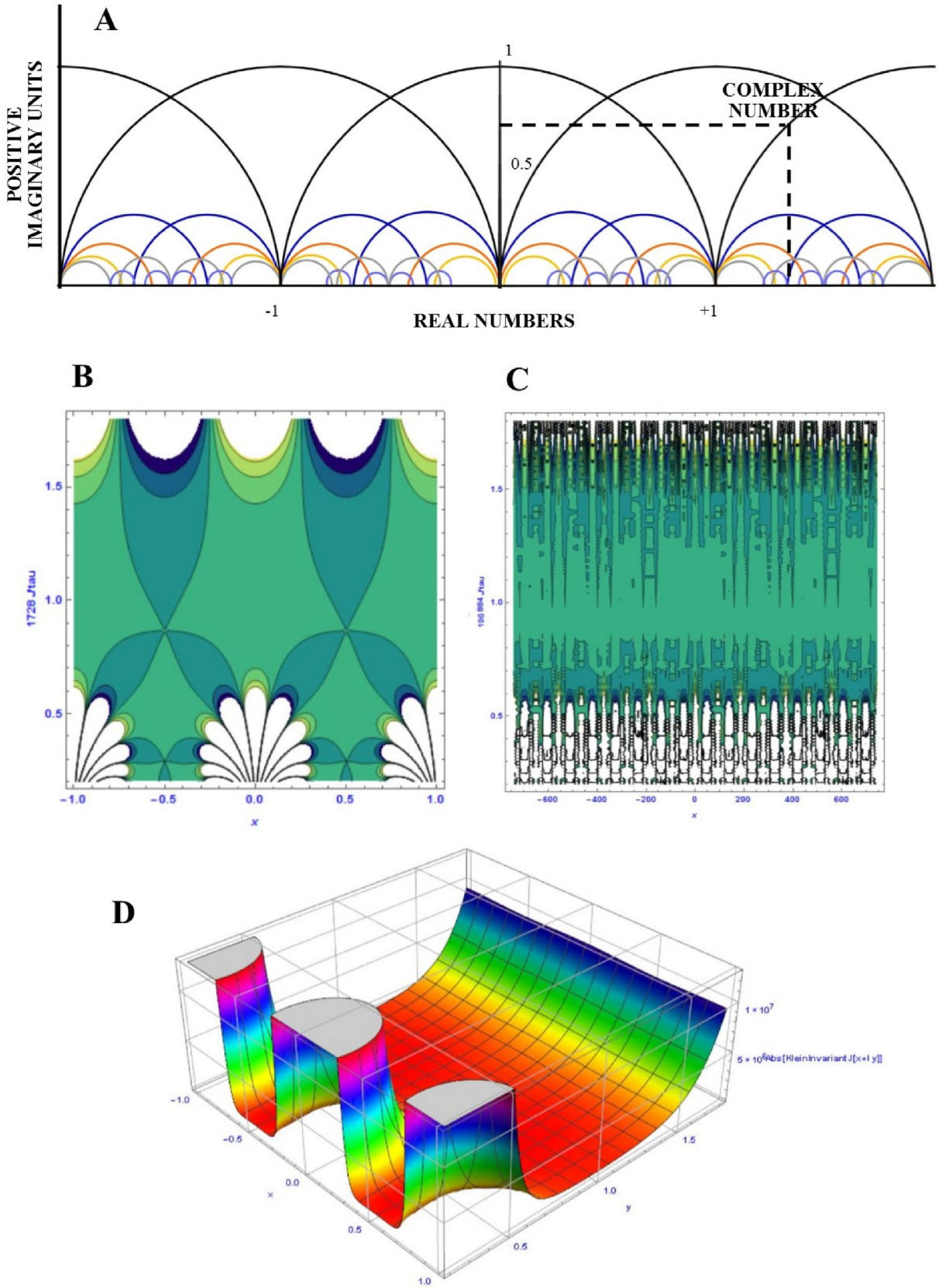

Fig. 1. Plots of Klein j-functions and their different possible paths. Fig. 1**A** depicts the general scheme of the elliptic oscillations on the upper half plane of the complex numbers. For sake of clarity, the locations of imaginary units and of real and complex numbers are provided. Fig. 1B and C shows the 2D plots achieved for $j = 1728$ and 196,884, respectively. Note the different coarse-grained appearance of the two plots. Fig. 1**D** displays the 3D plot, in case of $j = 196{,}844$. The plots in Figs. 1B–D were obtained using Mathematica® 10.