



Analysis of Alzheimer's and Neurodegenerative Diseases including Dementia Utilizing Thermodynamic Principles, Fluid Mechanics, Energy Transfer, and Mathematical Modeling Techniques within the scope of Thermal & Fluid Sciences -(Frequency Interaction Model Proposed by Nây-ı Şerîf, Instrument of Ney (Ney: Turkish Reed Flute, Nay) and Saz-Bağlama Instrument)-

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Abstract

Alzheimer's disease should be viewed not merely as a process of biological degeneration but as a multifaceted dynamic system where various physical systems degrade simultaneously. This degradation manifests as disruptions in energy balance, irregularities in fluid dynamics, inconsistencies in heat distribution, slower diffusion processes, and diminished neural synchronization. Frequency-based analyses provide a novel approach to studying the behavior of this complex system, highlighting that the spectral patterns of brain activity may serve as valuable biomarkers in the progression of the disease. Alzheimer's disease can be conceptualized as the collective breakdown of interconnected physical interactions, an integrated process that begins with a loss of thermodynamic stability and ultimately leads to the narrowing of neural oscillatory spectra.

Alzheimer's disease and other neurodegenerative disorders including dementia represent some of the most intricate and multifaceted challenges in modern medicine. These conditions cannot be fully understood by attributing them solely to biochemical phenomena like protein accumulation or neuronal death. Instead, they must be analyzed as the outcome of multi-scale disruptions in the physical behavior of the brain. Neuroscience today increasingly regards the brain not merely as a biological organ but as a complex physical system engaged in energy transformations, fluid dynamics, heat generation, and electrical oscillations. From this perspective, the brain can be conceptualized as an open thermodynamic system—a fluidic environment involved in constant energy exchange and exhibiting time-varying nonlinear dynamics through its intricate network structure. Specifically, phenomena such as cognitive decline, loss of synaptic connections, and memory impairment seen in Alzheimer's disease are influenced by not just microscopic biochemical changes but also the entropic behaviors at macroscopic scales. This multidimensional complexity calls for a redefinition of the disease beyond traditional medical paradigms, adopting a physics-based perspective. The primary aim of this study is to reinterpret Alzheimer's disease as a system governed by multiple physical principles, drawing from thermodynamics, fluid mechanics, heat transfer, and mathematical modeling. It explores how these physical processes relate to frequency-based neural oscillations underlying brain function. Additionally, moving beyond conventional medical approaches, this research offers an original theoretical comparison by analyzing the analogies between neural oscillations and acoustic systems, juxtaposing them with the frequency structures created by musical instruments like the Ney and Saz-Bağlama.

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A significant portion of Alzheimer's disease research has traditionally centered on biochemical processes, such as beta-amyloid plaque buildup, tau protein hyperphosphorylation, and synaptic degradation. More recently, however, studies have highlighted the need to analyze this disease not only on a molecular scale but also through the lens of network dynamics and systems physics. Emerging evidence—like the loss of synchronization in brain networks, disrupted neural oscillations, and reduced energy efficiency—has prompted a reinterpretation of Alzheimer's as a “dynamic system breakdown.” From a thermodynamic perspective, the brain functions as an open system that continuously consumes energy while converting it into electrical activity. The inevitable production of entropy in this system is typically managed in a healthy state by homeostatic mechanisms. In Alzheimer's, this regulatory balance collapses, resulting in increased systemic disorder. According to the second law of thermodynamics, this rise in entropy drives irreversible structural changes within biological systems. From the viewpoint of fluid mechanics, cerebrospinal fluid (CSF) serves as a vital medium for transporting nutrients and waste between neural tissues. The movement of CSF is often modeled using concepts akin to the Navier–Stokes equations. However, due to the brain's structural complexity, CSF flow exhibits non-Newtonian behavior. In Alzheimer's, protein aggregation and increased cellular debris elevate the fluid's viscosity, which disrupts the flow patterns and impairs the clearance of toxins and waste products. With regard to heat transfer, the brain continuously generates heat as a byproduct of its metabolic activity. This heat is regulated via blood circulation and fluid flow to maintain thermal balance. In Alzheimer's disease, the uniformity of this heat distribution is compromised, leading to localized thermal variations. These micro-level temperature irregularities are closely linked to neural activity and can impair synaptic functionality. From a mathematical modeling perspective, the brain can be viewed as a complex system described by interconnected differential equations. By integrating neural network dynamics, diffusion processes, fluid flow behavior, and thermal transfer within a unified framework, researchers can develop a multivariate model. Such models are inherently nonlinear, time-dependent, and potentially chaotic, reflecting the intricate interplay of physical and biological processes within the diseased brain.

This study's most significant contribution lies in its treatment of Alzheimer's disease as a multi-physics system, moving beyond a single-discipline perspective. By integrating thermodynamics, fluid dynamics, heat transfer, and neural network theory into a unified framework, it provides a more comprehensive understanding of the disease. Additionally, the frequency-based approach highlights that brain activity can be viewed not merely as a chemical process but also as a physical oscillatory system.

Alzheimer's disease is marked by a reduction in the brain's frequency spectrum, accompanied by a weakening of high-frequency components, particularly within the gamma band. This alteration results in diminished cognitive integration capacity. Analyzing frequencies reveals that the brain's ability to process information is closely linked to its spectral structure. In a healthy brain, the frequency distribution is broad and well-balanced. However, in Alzheimer's disease, this balance shifts toward lower frequencies, leading to a decline in spectral entropy.

The frequency structures of the ney and bağlama, as analyzed in this study, are not interpreted as direct physical equivalents to brain oscillations but rather as part of a mathematical analogy. Both systems generate signals that can be represented in Fourier space. However, a key distinction must be noted: while acoustic systems function in an external physical medium (air vibrations), the brain operates within an internal biophysical environment governed by ion channels and electrical potentials. As a result, the connection between these two systems is not causal but lies in their structural and spectral similarities. Consequently, the impact of musical frequencies on the neural system should be understood, not through direct resonance, but through mechanisms such as neuroplasticity and sensory synchronization. [1-105]

Keywords: Alzheimer's, Brain, Dementia, Neuron, Neurotransmitter, Neuro-engineering, Neuroscience, Medicine, Medical Technique, Neurodegenerative Diseases, Thermal and Fluid Sciences, Energy Transfer, Thermodynamics, Fluid Mechanics, Heat Transfer, Entropy, Music Therapy, Ney (Turkish flute), Acoustic Physics, Oscillator Synchronization, ELMAS' Theory of Thermodynamics, Fifth Law of Thermodynamics, Medical Thermodynamics, Medical Engineering, Neuroplasticity, Nây-ı Şerîf, Instrument of Ney (Ney: Turkish Reed Flute, Nay), Saz-Bağlama Instrument.

INTRODUCTION

Introductory

Alzheimer's disease and other neurodegenerative disorders including dementia constitute one of the most complex and multifaceted problem areas of modern medicine. These diseases cannot be explained solely by protein accumulation

or neuronal death processes at the biochemical level; they must also be considered as a result of multi-scale disruptions in the physical behavior of the system. Today, neuroscience views the brain not only as a biological organ but also as a complex physical system that undergoes energy transformation, possesses fluid dynamics, generates heat, and performs electrical oscillations. [1-104]

In this context, the brain can be modeled as an open thermodynamic system, a fluid environment constantly exchanging energy, and a network structure with time-varying nonlinear dynamics. In particular, processes such as cognitive decline, loss of synaptic connections, and memory impairment observed in Alzheimer's disease are related not only to microscopic biochemical changes but also to the entropic behavior of the system at the macroscopic level. This situation necessitates a re-examination of the disease with a physically based approach beyond classical medical models. The main objective of this study is to address Alzheimer's disease as a multi-physics system within the framework of thermodynamics, fluid mechanics, heat transfer, and mathematical modeling, and to relate the behavior of this system to frequency-based neural oscillations. Furthermore, beyond the traditional medical approach, the study will examine the analogical similarity of neurological oscillations to acoustic systems, making a theoretical comparison to the frequency structures generated by instruments such as the Ney and Saz-bağlama. [1-104]

Literature and Theoretical Background

A large portion of research on Alzheimer's disease focuses on biochemical mechanisms such as beta-amyloid plaque formation, tau protein hyperphosphorylation, and synaptic degeneration. However, some recent studies have shown that this disease should be examined not only at the molecular level but also at the level of network dynamics and systems physics. In particular, findings such as loss of synchronization in brain networks, disruption of neural oscillations, and decreased energy efficiency have led to the interpretation of Alzheimer's as a "dynamic system breakdown." [1-104]

From a thermodynamic perspective, the brain is an open system that constantly consumes energy and simultaneously converts this energy into electrical activity. Entropy production is inevitable in this system; however, in a healthy state, the organism balances this entropy through homeostatic mechanisms. In Alzheimer's disease, this balance is disrupted, and the system becomes increasingly disordered. This situation can be explained by the increase in entropy under the second law and leads to structural changes in biological systems that are difficult to reverse. From a fluid mechanics perspective, cerebrospinal fluid (CSF) is a critical medium for transporting substances between neural tissues. The flow dynamics of this fluid can be modeled similarly to the Navier-Stokes equations, but due to the complex structure of the brain environment, this flow exhibits non-Newtonian behavior. In Alzheimer's disease, protein accumulation and increased cellular debris increase the viscosity of the fluid, disrupting the flow regime and thus weakening the clearance mechanisms. From a heat transfer perspective, the brain continuously generates heat as a result of metabolic activity, and this heat is balanced by blood circulation and fluid flow.

In Alzheimer's disease, the homogeneity of this thermal distribution is disrupted, and local temperature variations occur. These micro-scale thermal abnormalities are directly related to neural activity and can affect synaptic functions. From a mathematical modeling standpoint, the brain can be considered a system of interconnected differential equations. Neural network dynamics, diffusion processes, fluid motion, and thermal transfer are coupled within the same system to obtain a multivariate model. This model has a nonlinear, time-varying, and potentially chaotic structure. [1-105]

System Definition and Physical Framework

In this study, the brain is defined as a combination of four fundamental physical subsystems. The first system is thermodynamic energy balance, encompassing energy production and consumption within the brain. The second system is fluid dynamics, describing the movement of cerebrospinal fluid. The third system is heat transfer, explaining the distribution of metabolic heat. The fourth system is a dynamic network structure involving neural oscillations and electrical activity.

These four systems are not independent of each other; on the contrary, they are strongly interconnected. Neural activity affects energy production, while energy production alters heat distribution. Heat distribution, in turn, can affect fluid viscosity. Fluid dynamics, by altering the transport of metabolites, creates feedback on neural activity. Therefore, the system is a completely nonlinear and non-closed structure.

Alzheimer's disease can be defined not as a "loss of balance" in this system, but more accurately as a "simultaneous disruption of multiple physical interactions." This disruption grows over time, eliminating the overall stability of the system and leading to a transition to a chaotic regime. [1-105]

MATERIAL, METHOD AND DISCUSSION

Thermodynamic Fundamentals, Energy Balance, and the Multi-Physical System Model

Definition of the Brain as a Thermodynamic System

The brain is an open thermodynamic system that constantly consumes energy and simultaneously converts this energy into electrical, chemical, and mechanical work. This system is in constant exchange of matter and energy with its environment. The transport of oxygen and glucose, the production of energy through metabolic reactions, and the release of this energy as heat to the environment cause the brain to exhibit open system behavior, unlike classical closed systems. [79-104]

From a thermodynamic perspective, the brain can be described as follows:

$$\frac{dE}{dt} = Q_{in} - Q_{out} + W_{met}$$

Here, E represents the system's internal energy, Q' represents heat transfer, and W_{met} represents metabolic work production. In a healthy brain, this balance is dynamically maintained. However, in Alzheimer's disease, this balance is disrupted, and the energy flow becomes irregular. [1-78]

The Relationship between Entropy and Neurodegeneration

Entropy is a measure of the disorder of a system and, according to the second law of thermodynamics, tends to increase continuously in isolated systems. Although the brain is not an isolated system, local entropy production occurs continuously. In a healthy state, this entropy is controlled by homeostatic mechanisms, while in Alzheimer's disease, these control mechanisms weaken. The change in entropy can be expressed as follows: [79-104]

$$\frac{dS}{dt} = \sigma_{gen} - \sigma_{diss}$$

Here, σ_{gen} represents entropy production, and σ_{diss} represents entropy distribution. In Alzheimer's disease, σ_{gen} increases while σ_{diss} decreases, and the system gradually becomes more disordered. This manifests as loss of synchronization in neural networks, energy inefficiency, and a decrease in information processing capacity. [1-78]

Fluid Mechanics and Cerebrospinal Fluid

Cerebrospinal fluid (CSF) is a critical fluid within the brain tissue that provides both mechanical support and plays a role in removing metabolic waste products. The movement of this fluid can be modeled by the Navier-Stokes equations: [1-105]

$$\rho \left(\frac{\partial v^{\rightarrow}}{\partial t} + v^{\rightarrow} \cdot \nabla v^{\rightarrow} \right) = -\nabla p + \mu \nabla^2 v^{\rightarrow} + f^{\rightarrow}$$

However, the brain environment differs from classical Newtonian fluid dynamics. In Alzheimer's disease, protein accumulation and cellular waste increase the viscosity of the fluid, and the effective viscosity can be modeled as follows: [79-104]

$$\mu_{eff} = \mu_0 (1 + \alpha C_{amyloid})$$

Here, $C_{amyloid}$ represents amyloid protein density. As this density increases, the mobility of the fluid decreases, and the intracranial cleaning mechanism weakens.

Diffusion Processes and Protein Accumulation

One of the key biophysical features of Alzheimer's disease is the abnormal accumulation of beta-amyloid and tau proteins. This process can be modeled by the diffusion equation: [79-104]

$$\frac{\partial C}{\partial t} = D \nabla^2 C - kC + R(x,$$

Here:

- C: protein density
- D: diffusion coefficient

- k: natural dissolution/clearance rate

- R(x,t): production term

In healthy brains, diffusion and clearance are balanced. However, in Alzheimer's, k decreases, R(x,t) increases, and the system gradually evolves towards the accumulation of toxic proteins. This process should be considered not only as a biochemical but also as a physical "mass transport disorder." [1-78]

Heat Transfer and Thermal Balance Disruption

The brain constantly produces heat due to metabolic activity, and this heat is distributed through the bloodstream and CSF. Heat transfer is generally expressed by the following equation: [79-104]

$$\rho c \frac{\partial T}{\partial t} = k \nabla^2 T + Q_{met}$$

In Alzheimer's disease, metabolic activity is not homogeneous. Therefore, Q_{met} becomes irregular depending on space and time. This leads to the formation of local temperature gradients: [1-78]

$\nabla T \neq \text{constant}$

These micro-thermal differences can affect neural membrane potentials, leading to disruptions in synaptic transmission.

Multi-Physical Couple Model

The fundamental scientific contribution of this study is that it combines all these processes into a single system. The brain is defined as the following coupled system: [79-104]

- Thermodynamic energy balance
- Fluid dynamics
- Diffusion (mass transport)
- Heat transfer
- Neural electrical activity

This system is expressed in the following general form: [1-105]

$$\frac{dX}{dt} = F_{thermal}(T) + F_{fluid}(v) + F_{diff}(C) + F_{neural}(x)$$

Here, each function has feedback mechanisms that influence the others. The system is nonlinear and includes parameters that vary over time.

Critical Conclusion

In this model, Alzheimer's disease is defined as:

- not a single biological disorder
- a simultaneous collapse of multiple physical processes
- feedback-driven nonlinear system instability

Neural Network Dynamics, Chaos Theory, and Frequency (Eeg) Modeling

Representation of the Neuronal System as a Dynamic Network

The brain can be modeled as a high-dimensional dynamic network system in which numerous neurons are connected to each other by synaptic connections. This network contains time-varying node (neuron) activations and weighted connections. The state of each neuron can be expressed by a continuous-time differential equation. The general neural activity equation is written as: [79-104]

$$\frac{dx_i(t)}{dt} = -ax_i(t) + \sum_{j=1}^N w_{ij}(t)f(x_j(t)) + I_i(t)$$

Here:

- $x_i(t)$ neuron activity
- a : damping coefficient
- $w_{ij}(t)$: synaptic connection weight
- $f(x)$: activation function
- $I_i(t)$: external inputs

This system is nonlinear and exhibits complex dynamic behavior due to its high-dimensionality. [1-78]

Weakening of Synaptic Connections in Alzheimer's Disease

One of the most fundamental changes in Alzheimer's disease is the decrease in synaptic connection density. This is mathematically expressed as the gradual decay of the connection matrix over time: [79-104]

$$w_{ij}(t) = w_{ij}^0 \cdot e^{-\gamma t}$$

Here, γ represents the rate of degeneration. This decrease leads to the following consequences:

- The global communication capacity of the network decreases
- Information transfer slows down
- Synchronization is lost

This process also reduces the network's "clustering coefficient," and the brain functionally transforms into a fragmented structure. [1-105]

Chaos Theory and Brain Dynamics

Because the brain system is highly nonlinear, small parameter changes can lead to large behavioral differences. This is studied within the scope of chaos theory. A dynamic system is expressed as follows: [79-104]

$$\frac{dX}{dt} = F(X, \mu)$$

Here, μ is the system parameter (e.g., disease progression level). System behavior is evaluated using the Lyapunov exponent:

$$\lambda = \frac{1}{t} \ln \ln \frac{|\delta X(t)|}{|\delta X(0)|}$$

If:

- $\lambda < 0$ → system stable
- $\lambda = 0$ → neutral
- $\lambda > 0$ → chaotic behavior

As Alzheimer's progresses, the system's λ value approaches positive, and brain dynamics become disordered. [1-78]

Eeg Frequency Structure and Oscillation Model

Brain electrical activity consists of different frequency bands that can be measured by electroencephalography (EEG). These bands are classified as follows: [79-104]

- Delta (0.5-4 Hz): deep sleep
- Theta (4-8 Hz): memory and learning
- Alpha (8-12 Hz): resting state
- Beta (12-30 Hz): active thinking
- Gamma (30-100 Hz): high cognitive integration

The brain signal consists of multiple harmonic components:

$$x(t) = \sum_k A_k \sin(\omega_k t + \phi_k)$$

In Alzheimer's disease, a significant decrease in gamma band activity is observed. This is directly related to a decline in cognitive integration capacity. [1-105]

Spectral Analysis and Frequency Density

The frequency content of EEG signals is analyzed using the Fourier transform: [79-104]

$$X(f) = \int_{-\infty}^{\infty} x(t)e^{-i2\pi ft} dt$$

Power spectrum:

$$P(f) = |X(f)|^2$$

In a healthy brain, the spectrum is broad and balanced. In Alzheimer's disease, however, the spectrum narrows, and low frequencies become dominant. This is interpreted as follows:

- Information processing capacity decreases
- Neural synchronization is disrupted
- The system enters a low-energy regime

Loss of Frequency Synchronization

Communication between brain regions is achieved through

phase synchronization of oscillations. The phase difference between two oscillators is: [79-104]

$$\Delta\phi = \phi_1 - \phi_2$$

If $\Delta\phi$ remains constant, synchronization exists. In Alzheimer's, this phase relationship is disrupted, and a phase shift occurs in the system. This leads to a decrease in functional connectivity.

General System Behavior

The entire neural system can be described by the following combined dynamic:

$$\frac{dX}{dt} = F_{synaptic}(X) + F_{oscillation}(f) + F_{diffusion}(C) + F_{thermal}(T)$$

The behavior of this system is classified as: [79-104]

- regular at low disease level
- metastable at moderate level
- chaotic at advanced level.

Ney-Baglamma Frequency Spectrum, Brain Oscillations and Resonance Models

Physical Model of Acoustic Systems

Musical instruments such as the ney and bağlama are complex oscillators that operate through physically vibrating air columns and string systems. These systems have specific natural frequencies, and the sound they produce consists of multiple harmonic components. The general acoustic signal is expressed as follows: [79-104]

$$y(t) = \sum_{n=1}^N A_n \sin \sin (2\pi f_n t + \phi_n)$$

Here:

- f_n : harmonic frequencies
- A_n : amplitude components
- ϕ_n : phase information

While the ney produces a more "continuous spectral structure" due to the constant airflow, the bağlama creates a "richer and broader spectrum" due to both string vibration and body resonance. [1-78]

Comparison of Brain Frequency Spectrum and Acoustic Spectrum

Brain EEG signals and music signals can be analyzed using the Fourier transform within the same mathematical framework: [79-104]

$$X_{brain}(f) = F\{x(t)\}$$

$$X_{music}(f) = F\{y(t)\}$$

In this case, the spectral similarity between the two systems can be defined as follows:

$$\eta = \frac{\int X_{brain}(f) \cdot X_{music}(f) df}{\sqrt{\int X_{brain}^2(f) df \cdot \int X_{music}^2(f) df}}$$

This expression represents the normalized correlation between the two systems. [1-78]

Mathematical Definition of Resonance Conditions

Physical resonance is the condition in which the natural frequency of a system coincides with the frequency of an external stimulus. For a simple oscillator: [79-104]

$$x'' + \omega_0^2 x = F_0 \sin \sin (\omega t)$$

Resonance condition:

$$\omega \approx \omega_0$$

However, the brain system is not composed of a single frequency. Therefore, the resonance condition is generalized to a multi-frequency system: [1-104]

$$\exists f_i \in Brain, So |f_i - f_j^{music}| \rightarrow 0$$

In this case, local resonance regions may form.

Dynamic System Model of Brain-Music Interaction

Brain-music interaction can be expressed as a bidirectional coupled system: [79-104]

$$\frac{dx}{dt} = F(x) + \alpha y(t)$$

$$\frac{dy}{dt} = G(y)$$

Here:

- $x(t)$: brain state
- $y(t)$: acoustic stimulation
- α : interaction coefficient

This system is a forced nonlinear dynamic system.

$$M(f) = X_{brain}(f) \cdot X_{music}(f)$$

Total interaction: [1-104]

$$E = \int M(f) df$$

If:

- E is greater than \rightarrow strong interaction
- E is less than \rightarrow weak interaction

In Alzheimer's disease, this overlap may decrease because the brain spectrum is narrowed.

Physical Characteristics of the Ney and Bağlama Spectrum

Ney:

- continuous flowing air column
- low harmonic distortion
- “smoother” frequency distribution

Saz- Bağlama:

- string vibration + body resonance
- wide harmonic spectrum
- more complex frequency structure

Therefore, the saz-baglrama has a mathematically higher Shannon spectral entropy: [1-78]

Frequency Overlapping Analysis (Spectral Matching)

The harmony between brain and music systems is measured by the spectral overlap function: [79-104]

$$H = - \sum P(f) \ln P(f)$$

Neurophysical Interpretation (Critical Point)

An important distinction must be made at this point: [79-104]

- EEG frequencies are biological oscillations
- music frequencies are acoustic oscillations

These two systems are not in the same physical environment. However, mathematically, both are signals that can be represented in Fourier space. Therefore, the similarity is:

- ➔ not physical
- ➔ mathematical and structural similarity

Physical Limitations of the Resonance Model

Although frequency overlap can be defined, biological systems have the following limitations: [79-104]

- high nonlinearity
- noise is dominant
- adaptive system behavior exists
- frequencies are not constant

Therefore, the real system:

$$f(t) \neq \text{sabit}$$

in other words, it is not “static resonance” but “time-dependent adaptive resonance”.

In other words, it's not “static resonance” but “time-dependent adaptive resonance” that's the issue. [1-78]

“Emin Taner Elmas” Mode

Emin Taner Elmas's work is integrated with the existing frequency model.

Elmas's “Nây-ı Şerîf-based Alzheimer's approach” is based on the following fundamental assumptions: [1-104]

- Brain activity is an oscillatory system
- Cognitive functions are affected when the frequency structure is disrupted
- External acoustic frequencies can interact with biological rhythms
- Music systems (especially the “Ney” instrument) produce a regular spectral structure

This approach is partially consistent with “music and neuroplasticity” studies in modern literature. However, there is an important distinction here: this model is not a direct treatment claim, but a biophysical interpretive framework based on the frequency-oscillation analogy.

General Model Result

The combined result of this section is as follows:

Brain and music systems: [79-104]

- are not the same physical system
- but can be analyzed with the same mathematical tools
- may show partial overlap in the frequency domain

In the context of Alzheimer's:

- the brain spectrum narrows
- synchronization decreases
- the effect of external rhythmic stimulation may theoretically change

CONCLUSION

General Conclusion, Model Integration, and Academic Evaluation

General Integration of the Model

Throughout this study, Alzheimer's disease and neurodegenerative diseases have been considered not merely as biological disorders, but as complex systems where multi-scale physical processes are simultaneously disrupted. This system has been modeled as a multi-physical structure where thermodynamic energy balance, fluid mechanics, heat transfer, diffusion processes, and neural network dynamics are strongly interconnected. In this approach, the brain is not a structure that can be explained by a single discipline. Rather, it is a system where different physical fields are simultaneously active and constantly interact with each other through feedback. Therefore, Alzheimer's disease cannot be reduced to a single mechanism; it should be considered as a loss of balance at the system level. [1-105]

Multi-Physical Deterioration Mechanism

The main output of the model is to show that Alzheimer's disease arises from the simultaneous deterioration of the following processes: [79-104]

From a thermodynamic perspective, the entropy of the system increases and the energy distribution becomes disordered. From a fluid mechanics perspective, the viscosity of the cerebrospinal fluid increases and the flow regime is disrupted. In terms of heat transfer, local temperature gradients are formed and thermal homogeneity is lost. In diffusion processes, protein clearance slows down and toxic accumulations increase. At the neural network level, synaptic connections weaken and loss of synchronization occurs. While each of these processes is important on its own, when considered together, they form a chain reaction that destroys the overall stability of the system. [1-105]

System Behavior at the Frequency Level

In terms of neural oscillations, Alzheimer's disease is characterized by a narrowing of the brain frequency spectrum and weakening of high-frequency components (especially the gamma band). This leads to a decrease in cognitive integration capacity.

Frequency-based analysis shows that the information processing capacity of the system is directly related to its spectral structure. While a healthy brain has a broadband and balanced frequency distribution, in Alzheimer's disease this distribution shifts to lower frequencies and spectral entropy decreases. [1-78]

Academic Interpretation of the Ney and Bağlama Models

The frequency structures of the ney and bağlama discussed in this study are evaluated not as a direct physical equivalence with brain oscillations, but within the framework of a mathematical analogy. Both systems produce signals that can be represented in Fourier space.

However, there is an important point here: while acoustic systems operate in external physical environments (air vibration), the brain operates in an internal biophysical environment (ion channels and electrical potentials). Therefore, the relationship between the two systems is not directly causal, but rather at the level of structural and spectral similarity. In this context, the effect of musical frequencies on the neural system should be explained not directly through resonance, but rather through neuroplasticity and sensory synchronization mechanisms. [1-78]

Strengths of the Model

The most important contribution of this study is that it addresses Alzheimer's disease as a multi-physics system rather than a single-discipline approach. Combining thermodynamics, fluid dynamics, heat transfer, and neural network theory within the same framework allows for a more holistic understanding of the disease. Furthermore, the frequency-based approach demonstrates that brain

activity can be considered not only as a chemical but also as a physical oscillation system. [1-78]

Limitations and Criticism of the Model

However, the model also has some limitations. First, the relationship established between music frequencies and Alzheimer's neural activity should be considered as an analytical analogy, not as a direct therapeutic mechanism. Furthermore, the highly nonlinear and stochastic nature of the brain system leads to limitations in deterministic models.

Real biological systems have much more complex adaptive mechanisms than the mathematical models presented here.

CONCLUSION

In conclusion, Alzheimer's disease should be considered not only as a biological degeneration process but also as a complex dynamic system in which multi-scale physical systems degrade simultaneously. This degradation is characterized by energy imbalance, fluid movement disorder, irregularities in heat distribution, slowing of diffusion processes, and loss of neural synchronization.

Frequency-based analyses offer a new perspective on understanding the behavior of this system and demonstrate that the spectral structure of brain activity can be an important biomarker in disease processes.

Overall Conclusion: [1-105]

Alzheimer's and Neurodegenerative Diseases including Dementia can be defined as a combined collapse of multi-physical interactions, and this collapse is an integrated process that begins with a loss of thermodynamic equilibrium and culminates in spectral narrowing of neural oscillations.

BIOGRAPHY OF AUTHORS

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Asst.Prof. Dr. Emin Taner ELMAS is a Mechanical Engineer having degrees of B.Sc., M.Sc., Ph.D., and was born in Sivas in 1974. He completed his doctorate at Ege University, Graduate School of Natural and Applied Sciences, Mechanical Engineering Department, Thermodynamics Science Branch, and his master's degree at Dokuz Eylül University, Mechanical Engineering Department, Energy Science Branch. He also

completed his undergraduate education at Hacettepe University, ZEF, Mechanical Engineering Department and graduated from the faculty with honors in 1995 and became a mechanical engineer. He was awarded a non-refundable scholarship by the Turkish Chamber of Mechanical Engineers in his 4th year because he was the most successful student during his first 3 classes study at the faculty. He graduated from İzmir Atatürk High School in 1991.

Asst. Prof. Dr. ELMAS has completed his military service as a NATO Officer in Bosnia and Herzegovina. He was a "Reserved Officer" as a "2nd Lieutenant" as an "English-Turkish Interpreter". He was also a "Guard Commander" and served in Sarajevo, Camp Butmir within the SFOR task force of NATO. He has been awarded with 2 (two) NATO Medals and Turkish Armed Forces Service Certificate of Pride (Bosnia & Herzegovina).

In addition to his academic duties at universities, he has worked as an engineer and manager in various industrial institutions, organizations and companies; He has served as Construction Site Manager, Project Manager, Management Representative, Quality Manager, Production Manager, Energy Manager, CSO-CTO, CBDO, Factory Manager, Deputy General Manager and General Manager.

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He has served as a scientific referee and panelist for ASME, TUBITAK and many scientific institutions, organizations and universities, including NASA.

He has published numerous international and national academic scientific articles, books, and book chapters, and serves as an editor for international academic journals. He also serves on the scientific committees of many international conferences, publishing conference and congress proceedings and giving presentations.

"Mechanical Engineering, Energy Transfer, Thermodynamics, Fluid Mechanics, Heat Transfer, Higher Mathematics, Evaporation, Heat Pipes, Space Sciences, Automotive, Bioengineering, Medical Engineering Applications, Neuroengineering, Medical Technique" are his academic and scientific fields of study; "Heating-Ventilation Air Conditioning Applications, Pressure Vessels, Heat Exchangers, Energy Efficiency, Steam Boilers, Power Plants, Cogeneration, Water Purification, Water Treatment, Industrial Equipment and Machinery, Welding Manufacturing, Sheet Metal Forming, Machining" are his industrial experience fields.

As of 2026, he has been awarded the Nobel Scientist Award by the international platform organization Scientific Laurels.

Asst. Prof. Dr. Emin Taner ELMAS is also a musician, saz (bağlama) virtuoso player and ney (Nay, Turkish Reed Flute) performer. He plays also cümbüş instrument and performs darbuka, drum rhythm instruments. He has a YouTube Music Channel (Emin Taner ELMAS) which includes some of his sound recordings of him playing the saz-bağlama and blowing the ney. He composed the poem written by the great poet Âşık Veysel ŞATIROĞLU under the name of "Raşit Bey" in memory of his father Judge (Hâkim) Raşit ELMAS as "Raşit Bey Türküsü", wrote it down, notated and published it as an academic article and broadcasted this song on his own music channel. He wrote the poems entitled "Canım Babam" and "Geldim Babam" which he wrote also in memory of his father and published in an academic literature journal, and composed instrumental musics for these poems. He also composed an instrumental song called "Annem Annem Türküsü" and gave it to his mother, Lawyer Tuna ELMAS, as a gift on Mother's Day, 11.05.2025. He also has a poem titled "Ney and Neyzen." He also wrote and presented a poem titled "Esra Kardeşim" to his sister, Esra ELMAS, an archaeologist and English teacher. He has published books including "Saz-Bağlama Tuning System Method" ("Saz- Bağlama Akort Sistemi Metodu") and "Ney and Neyzen; Ney's Pitches, Frets, Sound Stages, Octaves, Structure, Performance, Ney Maintenance and Basic Music Theory" (Ney ve Neyzen; Ney'de Perdeler, Ses Devreleri, Oktavlar, Yapısı, İcrası, Ney Bakımı ile Temel Musiki Nazariyatı) and My Collection of Literary and Musical Art Works - I Story / Anecdote / Essay / Poetry / Verse / Prose / Humorous; witty - satirical; poetic stories / Lyrics / Composition (Edebiyat ve Musiki Sanat Eserleri Külliyyatım - I Hikâye / Anekdote / Deneme / Şiir / Manzume / Nesir / Mizahi; nükteli - hicivli; şiirsel hikâyeler / Güfte / Beste). He continues his artistic studies by writing various articles, books, poetry, lyrics and also realizing musical composition and repertoire works.

İbrahim DAĞ²

Born in Şanlıurfa in 1995, İbrahim Dağ discovered his interest in engineering at a young age and shaped his educational life accordingly. He was accepted to the Civil Engineering Department at Iğdır University in 2016 and graduated in 2020. With the goal of combining different fields of engineering with an interdisciplinary perspective, he studies master's degree (M.Sc.) in Bioengineering and BioSciences Major Science Branch of Graduate School of Natural and Applied Sciences at Iğdır University.

During his graduate studies, he focused on scientific research, particularly on Alzheimer's disease and biomechanical approaches. Thanks to his multidisciplinary approach to mechatronic engineering, he conducts literature reviews

and field research on topics such as artificial intelligence-assisted early diagnosis methods and structural biology modeling in neurodegenerative diseases. He also aims to develop an alternative treatment method for Alzheimer's disease by utilizing the therapeutic effects of sound waves generated by the ney flute in his graduate project with his advisor, Asst. Prof. Dr. Emin Taner ELMAS. This project, which he and his advisor are conducting on Alzheimer's treatment, serves as a significant example of the application of technical engineering skills in the healthcare field.

In the summer of 2017, he worked as a civil engineer intern at Bak Yapı, a company operating in Bursa, gaining hands-on experience in a construction site environment. As of 2024, Dağ has been working as a Construction Manager at Doğu Yapı Denetim, where he continues to contribute to scientific projects by balancing his engineering practices with his academic pursuits. Dağ is an advanced user of AutoCAD, IdeCAD, and Microsoft Office programs, and also has experience in technical reporting, field data analysis, and project management.

İbrahim Dağ, who has B1 level reading, writing and speaking proficiency in English, aims to develop technical solutions for Alzheimer's and similar diseases and advance his academic career in this field as a solution-oriented, researcher and disciplined engineer.

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