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Plastic Minds, Elastic Years: Neuroplasticity and Adaptive Brain Dynamics in Aging

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Abstract

Neuroplasticity represents the brain's capacity to reorganize and adapt across the lifespan. In aging, this adaptive potential plays a critical role in maintaining cognitive function despite structural and biochemical changes. This manuscript provides a structured overview of neuroplastic mechanisms, age-related challenges, compensatory pathways, and emerging interventions, highlighting the concept of a plasticity–longevity axis in cognitive resilience.

1. Introduction

Neuroplasticity challenges traditional views of irreversible cognitive decline in aging by emphasizing adaptive neural mechanisms.

2. Mechanisms of Neuroplasticity

Synaptic, structural, and functional plasticity are mediated by molecular and cellular processes including BDNF signaling.

3. Neuroplasticity in Aging

Despite age-related decline, neural adaptation persists through compensatory network engagement.

4. Biological Challenges

Oxidative stress, inflammation, and mitochondrial dysfunction contribute to neural aging.

5. Cognitive Reserve

Educational and lifestyle factors enhance resilience and delay clinical decline.

6. Lifestyle and Plasticity

Exercise, sleep, and nutrition modulate neuroplastic processes.

7. Emerging Interventions

Neuromodulation, psychedelic research, and AI-assisted rehabilitation represent evolving therapeutic strategies.

8. Plasticity–Longevity Axis

Sustained neuroplasticity may underpin prolonged cognitive health.

9. Conclusion

Neuroplasticity provides a framework for understanding and optimizing brain aging.

References

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