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"Getting to Grips with Musical Complexity"

SUPERPOSITION, ENTANGLEMENT AND COLLAPSE IN PERFORMANCE AND LISTENING: THE CASE OF BACH'S POLYPHONY

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a brief explanation of the content

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MUSIC AND QUANTUM THEORY

- In quantum physics, the wave function describes all potential states of a system until measured: $|\Psi\rangle = \alpha|A\rangle + \beta|B\rangle + \gamma|C\rangle \xrightarrow{\text{observation}} |B\rangle$
- Likewise, music exists as a field of possibilities until it is performed or heard:

$$|\Psi_{\text{music}}\rangle = \sum_i \alpha_i |\text{idea}_i\rangle \xrightarrow{\text{inner listening}} |\phi_{\text{choice}}\rangle$$

- Meaning in music unfolds retroactively; the full shape appears only after the final note: $|\Psi_{\text{music}}\rangle = \alpha|C\rangle + \beta|P\rangle + \gamma|L\rangle \xrightarrow{\text{observation}}$ Emergent musical form

COMPOSITION AS CONSCIOUS COLLAPSE

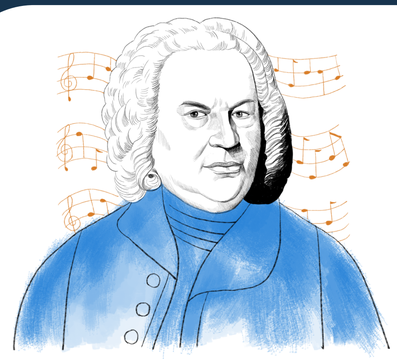
- In the Orch OR theory by Penrose and Hameroff, consciousness emerges from objective quantum collapses in neuronal microtubules.
- These collapses are not random, but orchestrated by meaning and context
- Each conscious moment is the result of a self-collapsing quantum state, influenced by internal coherence

- Musical composition is not linear computation but a series of inner perceptual collapses.
- Composers like Bach do not merely follow rules — they listen inwardly as the music unfolds.

THE SCORE AS A MUSICAL WAVE FUNCTION

Quantum Physics	Music
Superposition	Simultaneous musical possibilities
Observation	overt/inner listening
Wavefunction collapse	Conscious musical decision

- The musical score is a field of potential realization.
- Like a wave function, the score collapses into actual sound only through performance or listening.
- Each interpretation is a distinct collapse of the musical field.



BACH'S POLYPHONY

Recent models like DeepBach can generate chorales that are stylistically convincing. They accurately reproduce voice-leading, textural balance, and the rules of counterpoint, drawing from large corpora of Bach's works. Yet beneath these surface similarities lies a crucial difference in how musical choices are made.

While AI relies on statistical prediction, selecting likely continuations based on learned patterns, Bach composed by listening. Through inner audition, he imagined and evaluated each possibility, shaping the music as a temporal, embodied experience. This contrast echoes Roger Penrose's Orch OR theory, where each moment of consciousness arises from a self-collapsing quantum state, guided by internal coherence rather than randomness.

In this view, each of Bach's compositional choices reflects a conscious collapse, *i.e.* a moment of musical sense-making that reduces many potential paths to one, informed by memory, intention, and meaning.

References

Bohm, D. (2005). Wholeness and the implicate order. Routledge.

Clarke, E. (2005). Ways of Listening: An Ecological Approach to the Perception of Musical Meaning. Oxford University Press.

Dalla Chiara, M. L., Giuntini, R., Leporini, R., Hameroff, S., and Penrose, R. (2014). Consciousness in the universe: A review of the 'Orch OR'theory. Physics of life reviews, 11(1), 39-78.

Imberty, M. (2015). The stylistic perception of a musical work: an experimental and anthropological approach, Time in Contemporary Musical Thought (pp. 33-48). Routledge.

Negri, E., & Sergioli, G. (2015). Quantum information, cognition, and music, Frontiers in Psychology, 6, 1583.