DECOHERENCE

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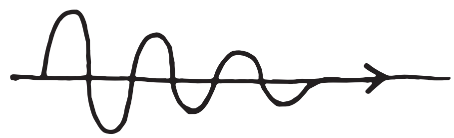
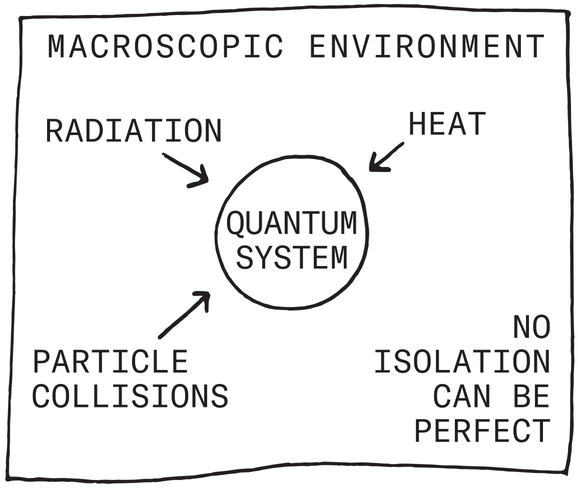


TIME →

Paloma Kop 2019

This book is a companion to an audio-visual composition

palomakop.tv/decoherence



Decoherence occurs because it is impossible to completely isolate a quantum system from its surroundings. It is the reason that macroscopic systems (such as things at the human scale) do not exhibit the same strange, paradoxical behaviors as the quantum realm.

Macroscopic systems are modeled classically; quantum systems are modeled using wave functions of probability,

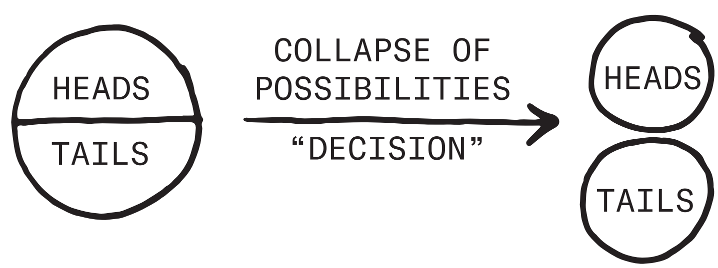
and these wave functions can interfere with each other.

Decoherence is currently the biggest obstacle in quantum computing. This is why quantum computers can only operate at extremely low temperatures. To the question of whether the human mind may be a quantum computer, some argue this is impossible

because it is too warm.

Coherence refers to a quantum object's wave-like nature and ability to interfere with itself, resulting in superposition: the ability to be in mutliple states at the same time.

In a universe containing only this object, it could exist in this way forever...

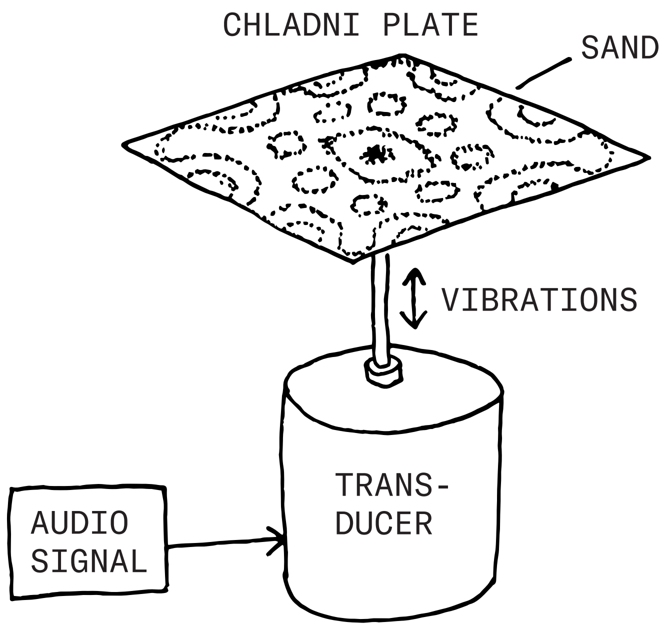


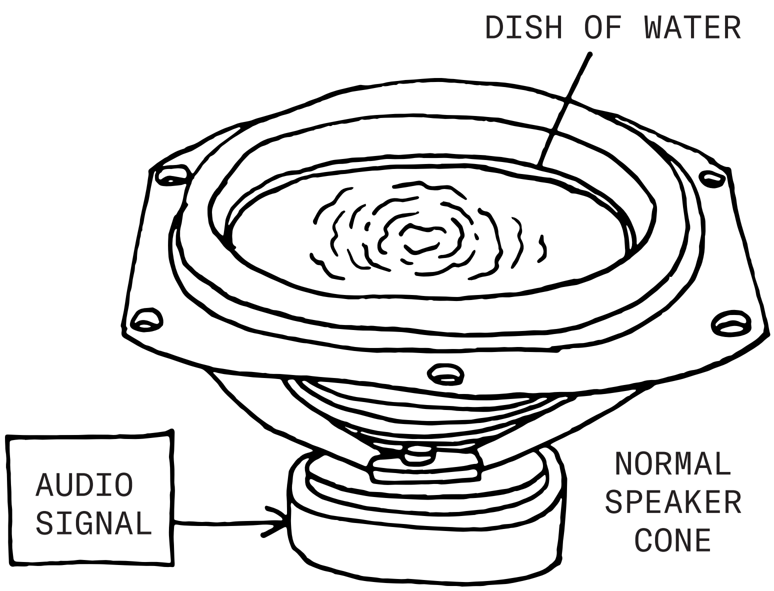
In our universe, when an inevitable disturbance occurs, the wave function collapses and the object is found to be in a single state

CYMATICS

Cymatics is a way of translating sound waves (pressure waves) into visual patterns, usually by vibrating a container of liquid or small grains of material (such as sand). The frequencies and harmonic content of the sounds influence the patterns produced.

The particles on the surface of the metal plate are scattered by the vibrations. Eventually they arrange themselves into different patterns depending on the sounds used.





As the speaker vibrates, the container of liquid moves up and down. Ripples appear on the surface of the water which take the form of symmetrical, nonlinear standing waves.

These are called Faraday waves

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M   M Y   Y     EEEE X   X PPPP  EEEE RRRR  III M   M EEEE N   N TTTTTT  SSS
MM MM  Y Y      E     X X  P   P E    R   R  I  MM MM E    NN  N   TT   S
M M M   Y       EEE    X   PPPP  EEE  RRRR   I  M M M EEE  N N N   TT    SSS
M   M   Y       E     X X  P     E    R R    I  M   M E    N  NN   TT       S
M   M   Y       EEEE X   X P     EEEE R  RR III M   M EEEE N   N   TT   SSSS
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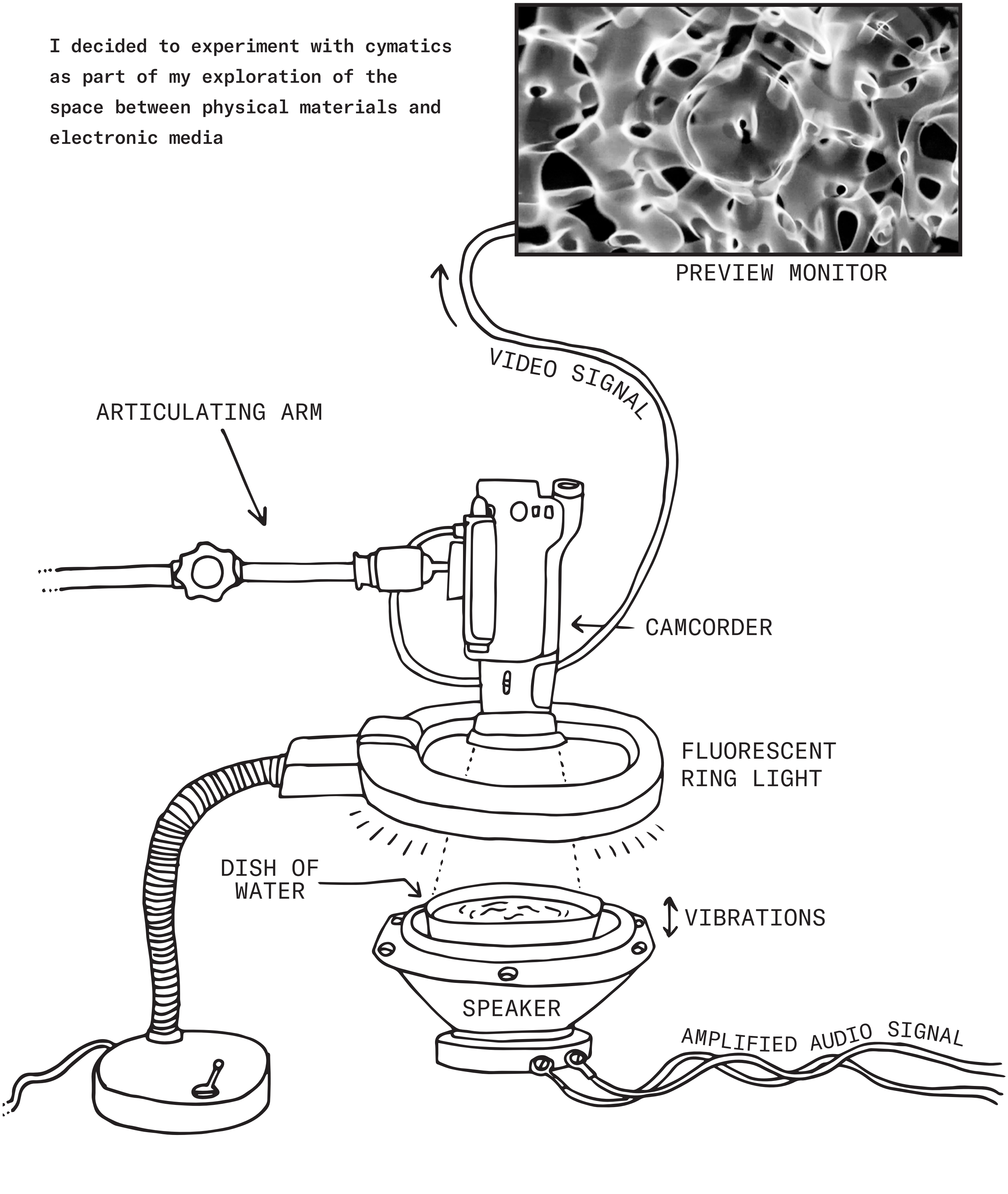
I decided to experiment with cymatics as part of my exploration of the space between physical materials and electronic media



I developed a setup that allowed me to control the frequency and amplitude of a sine wave which vibrated a dish of water. The vibrations created ripples, and the ripples distorted the reflection of the ring light which pointed down at the water. The camera recorded the distorted reflection at 30 frames per second. The preview monitor allowed me to see as the camera did while I explored the system I had created.

Here is the image that the camera showed when no sound was played through the speaker; it's just a cropped reflection of the doughnut-shaped fluorescent light bulb.

I painted the water dish black so that it would be mostly invisible behind the bright reflection.

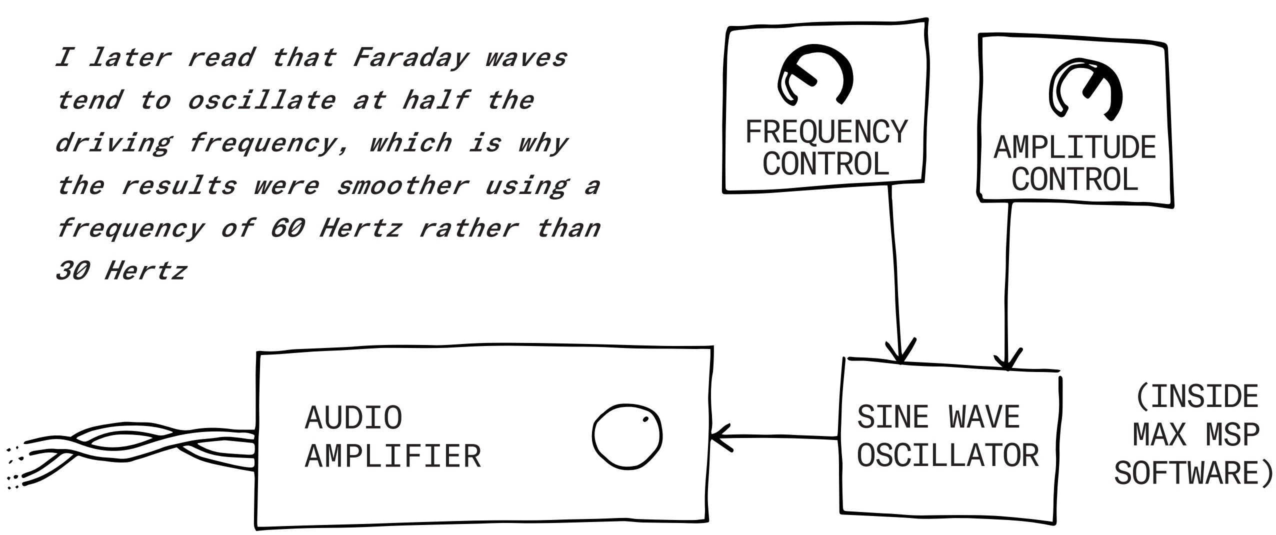
Throughout the process, dust from my studio ceiling fell into the dish. I eventually accepted it as part of my image

The patterns in the water looked jumpy, because it was moving faster than the camera could capture. But when I oscillated the speaker at 60 Hertz (twice the frame rate), they seemed to sync up and the movement became smooth.

As I increased the amplitude, the smooth patterns became increasingly unstable; they began to fluctuate erratically, as though pushing and shoving against each other.

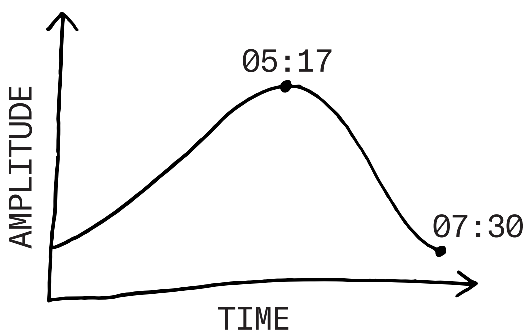
Eventually the smooth harmonic forms fully disappeared and droplets of water broke the surface, flying towards the camera lens

I later read that Faraday waves tend to oscillate at half the driving frequency, which is why the results were smoother using a frequency of 60 Hertz rather than 30 Hertz



In the video recording which became my piece, *Decoherence*, I kept the frequency locked in at 60 Hertz to maintain the smooth motion.

The main gesture in the piece is the transition from the slow undulations of the standing waves, toward transient, spasmodic randomness when the amplitude is pushed to its peak, and then back.

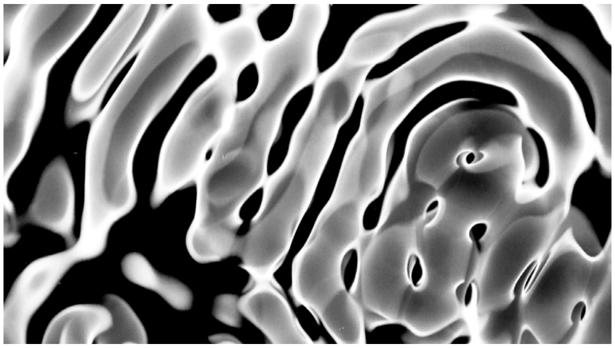


The transition between these states is a gradient. It is impossible to pinpoint an exact moment as the turning point. When the movement is slow, the patterns seem almost organized, though they are still unstable. The frame appears to be filled with clusters of overlapping torroidal forms, which fluidly snap together or separate from each other. When viewing the footage frame by frame, the morphing of each shape can be tracked as each frame differs only slightly from the last. By contrast, at the peak amplitude, the movement is too fast and hectic to be seen at 30 frames per second; while each frame may contain similar patterns to the last, they appear to rearrange themselves completely between the time of each frame, with a frenetic cadence like a rapidly boiling pot on the stove.

The gradual change from smooth to turbulent was mesmerizing to me. As the energy of the waves grew, their height increased, causing the torroidal forms to turn “inside out” and form what looked like small nodes connected by tubes. As these tubes shuddered, twitched, and grew faster, I observed macroscopic patterns that emerged from the movements of large numbers of these nodes, which seemed to form a network of energy exchange.

The recording of the 60 Hetrz sine wave became the underlying sound in the piece. In the beginning and end, where the movements of the wave patterns morph slowly, the ripples spreading across the surface reach the edge of the container and are reflected back in, where they interfere with the original waves. To reflect this in the sound, I duplicated the original sine wave and modulated its frequency slightly, so that it created a sonic interference pattern called beating, which also grew in speed and intensity.

For the most intense and random section of the visual patterns, I brought in more layers of sound by running the original wave through spectral and granular processing. These sounds are higher pitched, and rather than smooth and morphing, they are composed of tiny snippets of sound which flit in and out of existence rapidly as the water droplets spew forth. They are brought in gradually so that they blend and transition together with the visual composition.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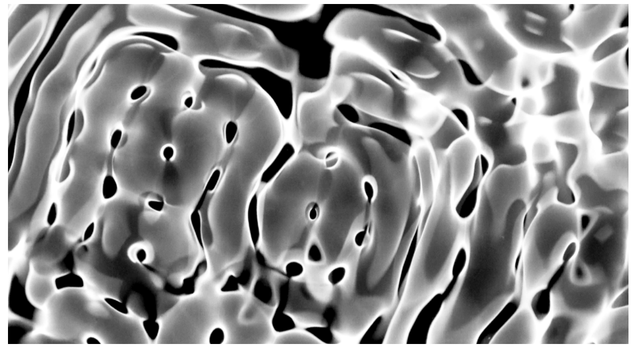
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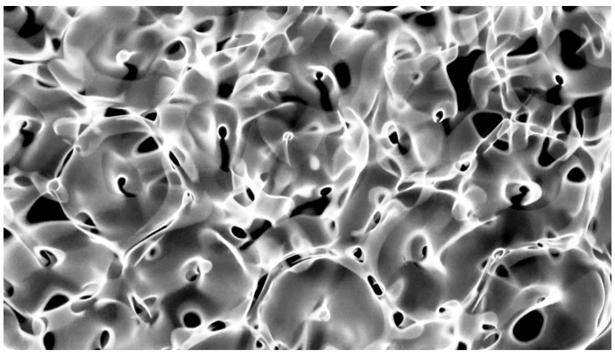
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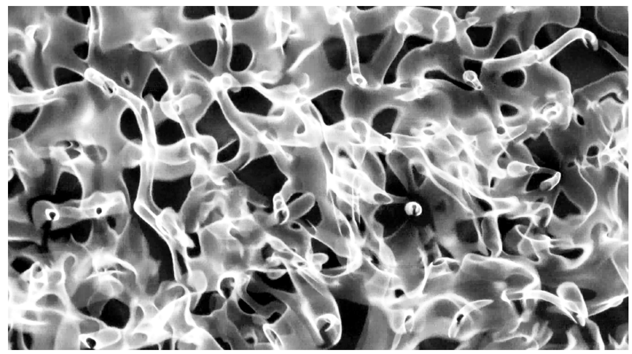
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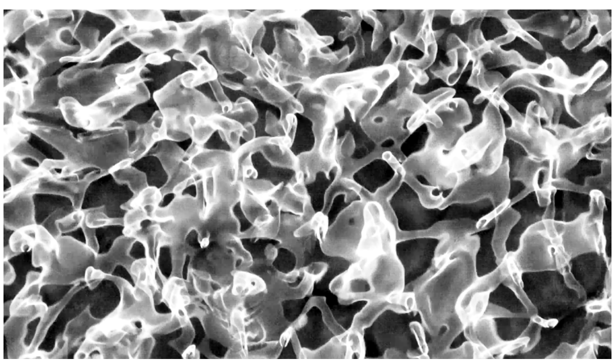
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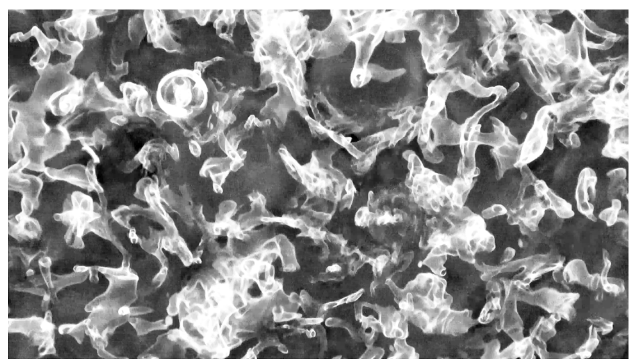
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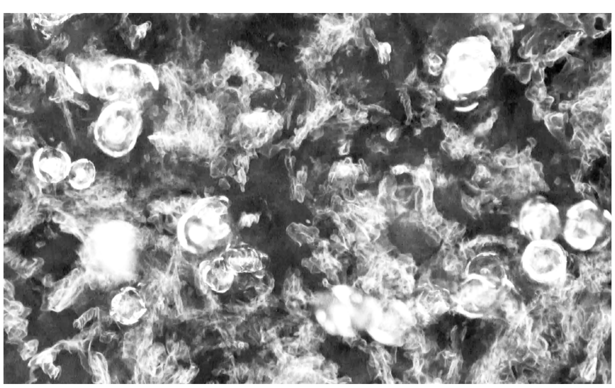
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07:30

C-O-M-P-O-S-I-T-I-O-N

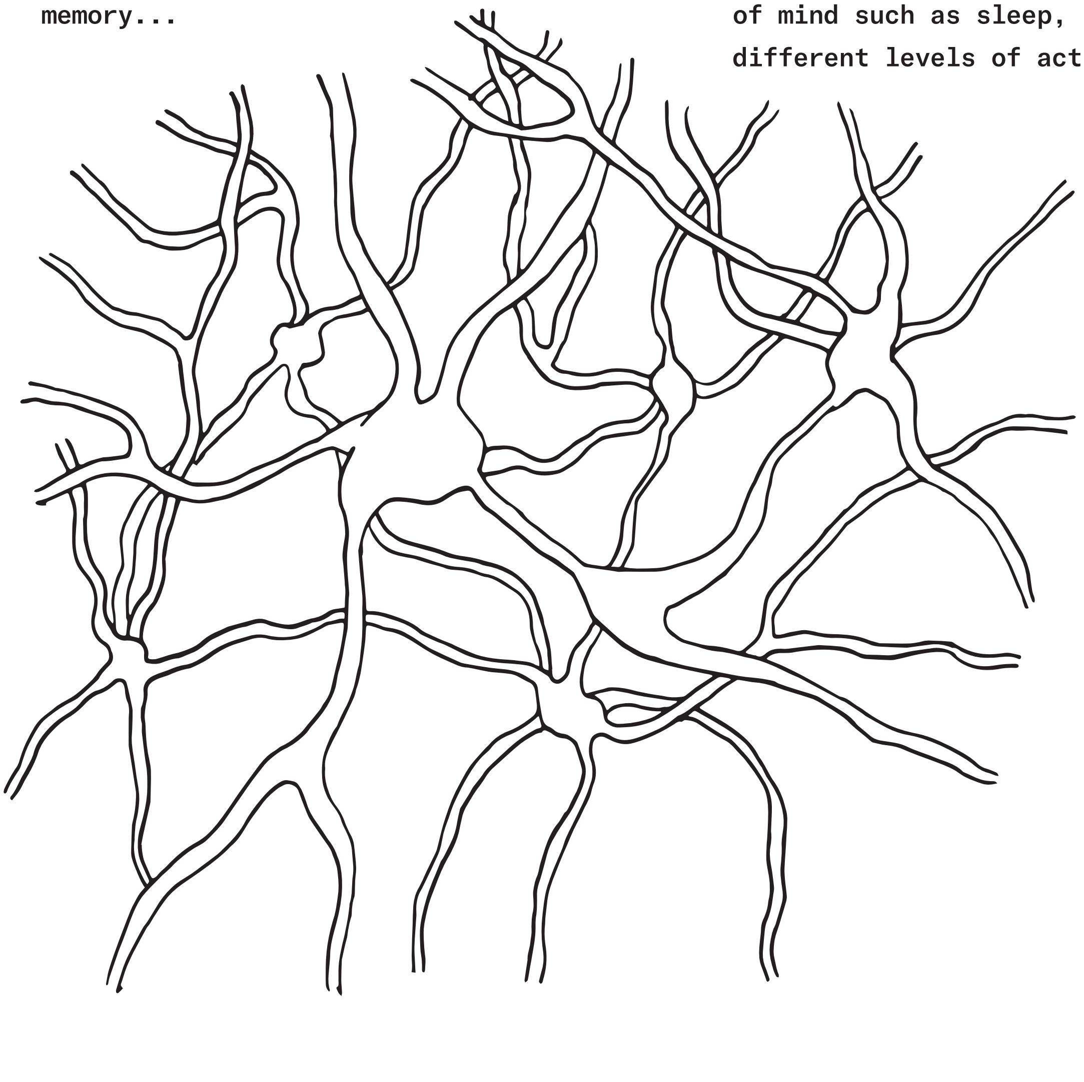
It is difficult to reconcile our understanding of the human brain on the microscopic scale versus the macroscopic.

Each neuron transmits electrochemical signals on a time scale much faster than we can perceive

Meanwhile at the scale of the entire organ, all these tiny interactions coalesce into patterns of conscious and subconscious thought, experience, memory...

EEG machines can monitor electrical activity in the brain. Neural oscillations, or brainwaves, are patterns formed by large numbers of neurons firing together.

The frequency and amplitude of these waves correspond to different states of mind such as sleep, relaxation, or different levels of activity



THOUGHTS

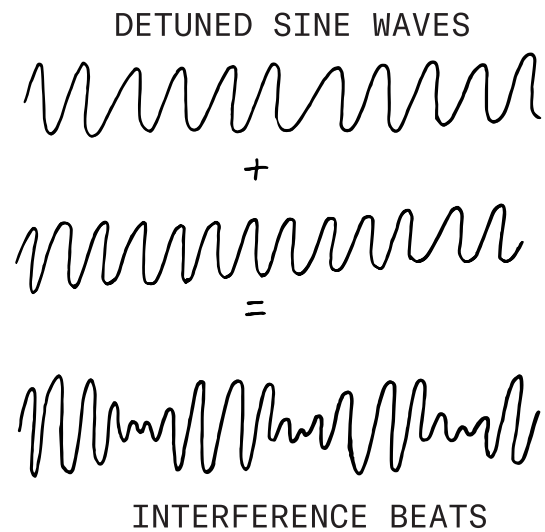
MRI scan of a human brain

When I inject a dish of water with simple sine waves of kinetic energy, complex structures forge an unpredictable path across its surface

Different patterns appear on mutliple scales at the same time; as we shift through phase space, they shift in and out of our perception

A transition between two points on a continuum, a movement between two extremes: cells, molecules, ions to conscious beings, biological organs, thought patterns

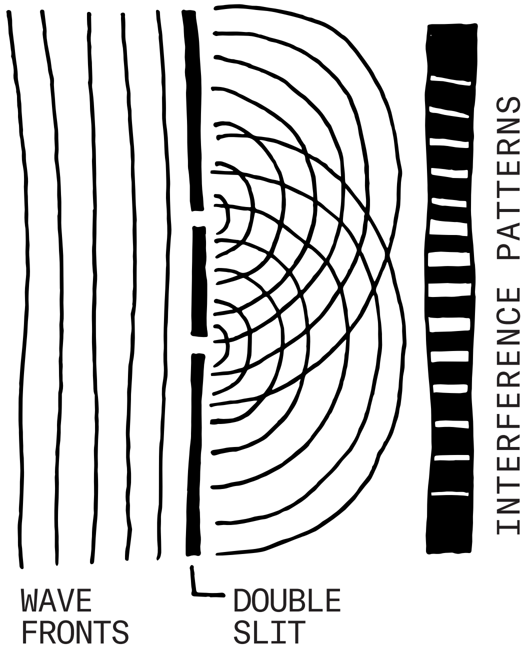
All smaller components combine into emergent macroscopic phenomena: new properties and complexities emerge from the whole



A simple system
sets in motion
a wide set of
emergent behavior

A gradual transformation
from calm folds
to a chaotic soup
of bouncing energy

Like sweeping through
the activity inside a
human brain
from the scale of the macro
to the micro
and back



The double slit experiment, first conducted by Thomas Young in 1801, demonstrated light's wave-like nature and ability to interfere with itself