

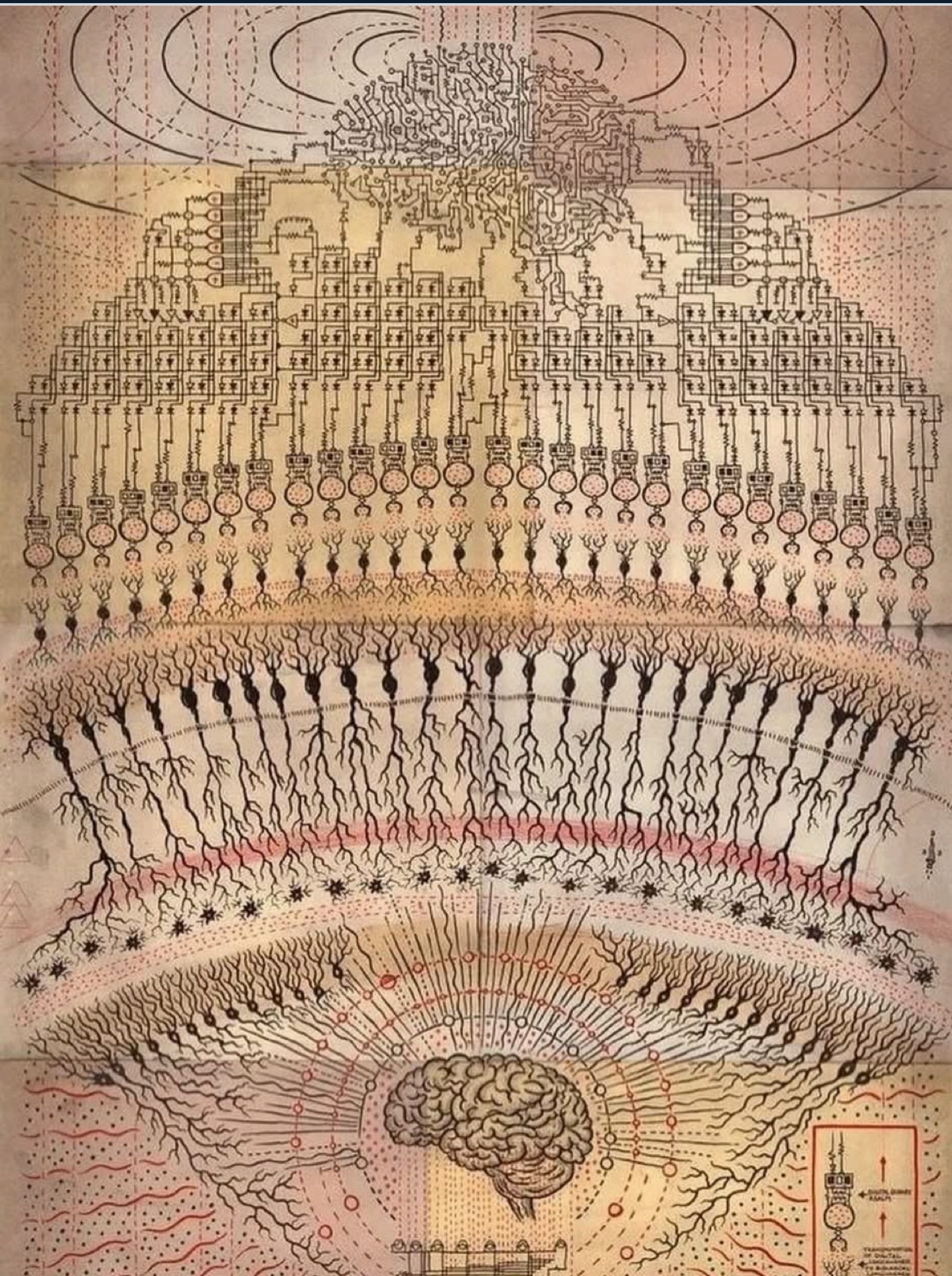
# How Spinning Dice Taught Me a Big New Idea About Hands and Minds

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## THE DICE GAME THAT STARTED EVERYTHING

I wanted to make surgery better. So I spun dice — many times — and wrote down what happened. Surgery has hard steps: picking tools and turning them just right, every single time. I designed a dice game to test an old idea about how mixed-up things are. The old idea is **Information Entropy** — Shannon's 1948 formula for measuring uncertainty. Von Neumann's quantum version ( $S = -\text{Tr } \rho \log \rho$ ) reduces to it in the classical limit. I guessed that the starting position of a die would predict exactly how long someone takes to spin it to an ending position. I tried it many times and wrote down every result. **The old math did not match the real times.** The experiment broke the explanation I started with. That break was the beginning. It made me doubt what I thought I knew — and that doubt made me ready to learn something completely new.

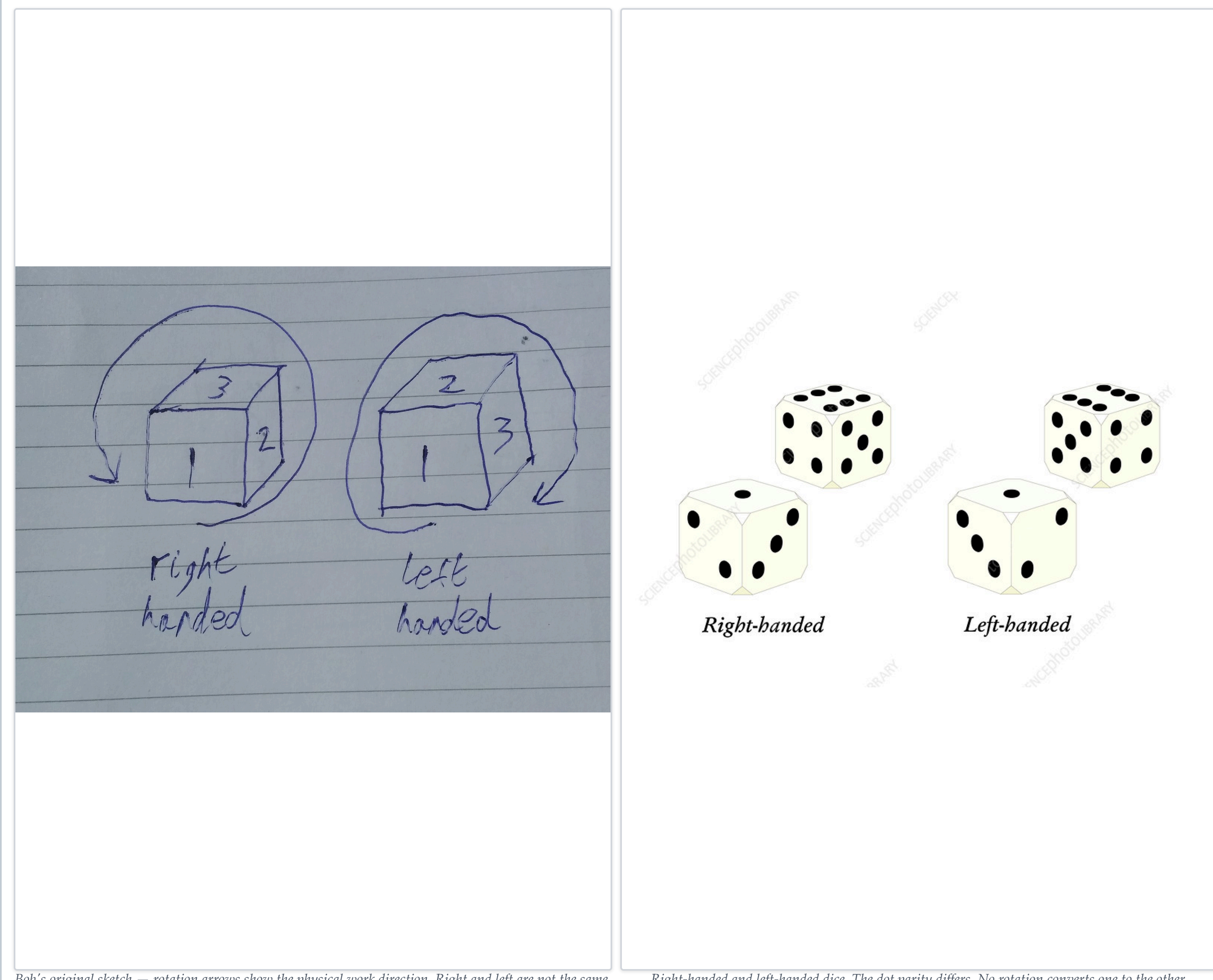


A cybernetic map of signal flow from world to brain — the architecture entropy cannot classify by handedness.

do(spin dice study) → old entropy explanation breaks → new knowledge begins

## THE DISCOVERY: HANDEDNESS OF DICE

Doing the dice study caused me to discover **handedness** — a geometric property of real objects in our world. Some dice are **right-handed** and some are **left-handed**. You cannot turn a left-handed die into a right-handed one by spinning or sliding it — no matter what you do. It is **impossible** in normal three-dimensional space. This is called **chirality**. Entropy — Shannon's classical formula and Von Neumann's quantum generalization alike — assigns the same value to both handednesses. Both measure probability distributions over states, not the geometry of state space. Chirality is invisible to the entire entropy framework. The do-action — spinning real dice, measuring real times — was the intervention that revealed what the math had been missing.



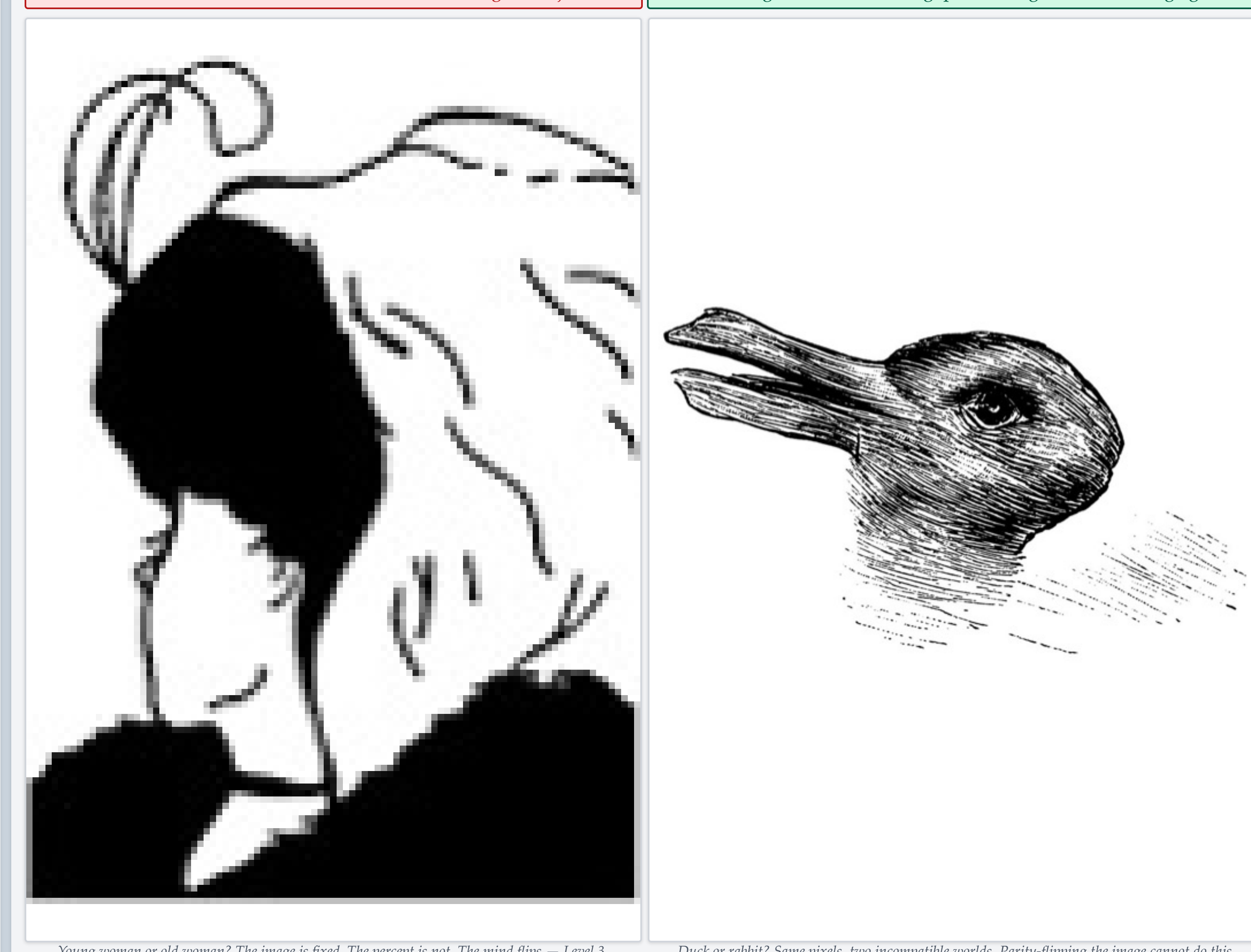
Bob's original sketch — rotation arrows show the physical work direction. Right and left are not the same. Right-handed and left-handed dice. The dot parity differs. No rotation converts one to the other.

## THE CONJECTURE: WHAT HANDEDNESS MEANS

Handedness creates tasks that are impossible for physical objects — but a human mind can imagine doing them. There is a gap between what a real object can do and what a mind can think about. A real die — at the scale we hold and touch — **cannot be converted** from left-handed to right-handed by any rotation or translation. No constructor exists for this in normal 3D space. But your mind *can* imagine a **720° twist** — a move from SU(2) spinorial geometry that returns a spinor to its original state. Real macroscale objects cannot perform this.

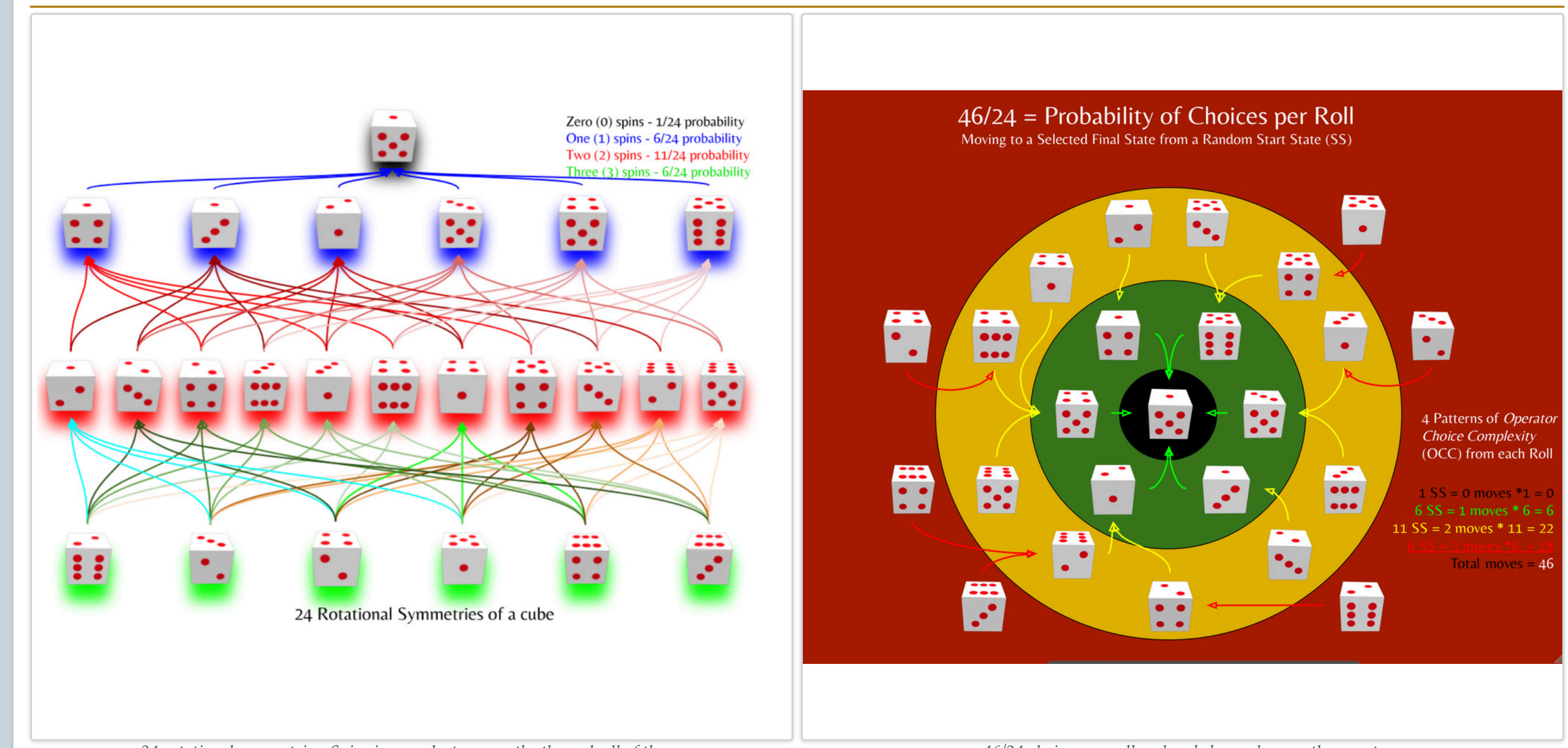
**IMPOSSIBLE IN 3D**  
Converting a left-handed die to a right-handed one by rotation or translation. No constructor can do this without breaking the object.

**POSSIBLE IN MIND**  
Imagining a 720° twist. Holding both handedness states simultaneously and reasoning about them. This gap is the engine of knowledge growth.



Young woman or old woman? The image is fixed. The percept is not. The mind flips — Level 3. Duck or rabbit? Same pixels, two incompatible worlds. Parity-flipping the image cannot do this.

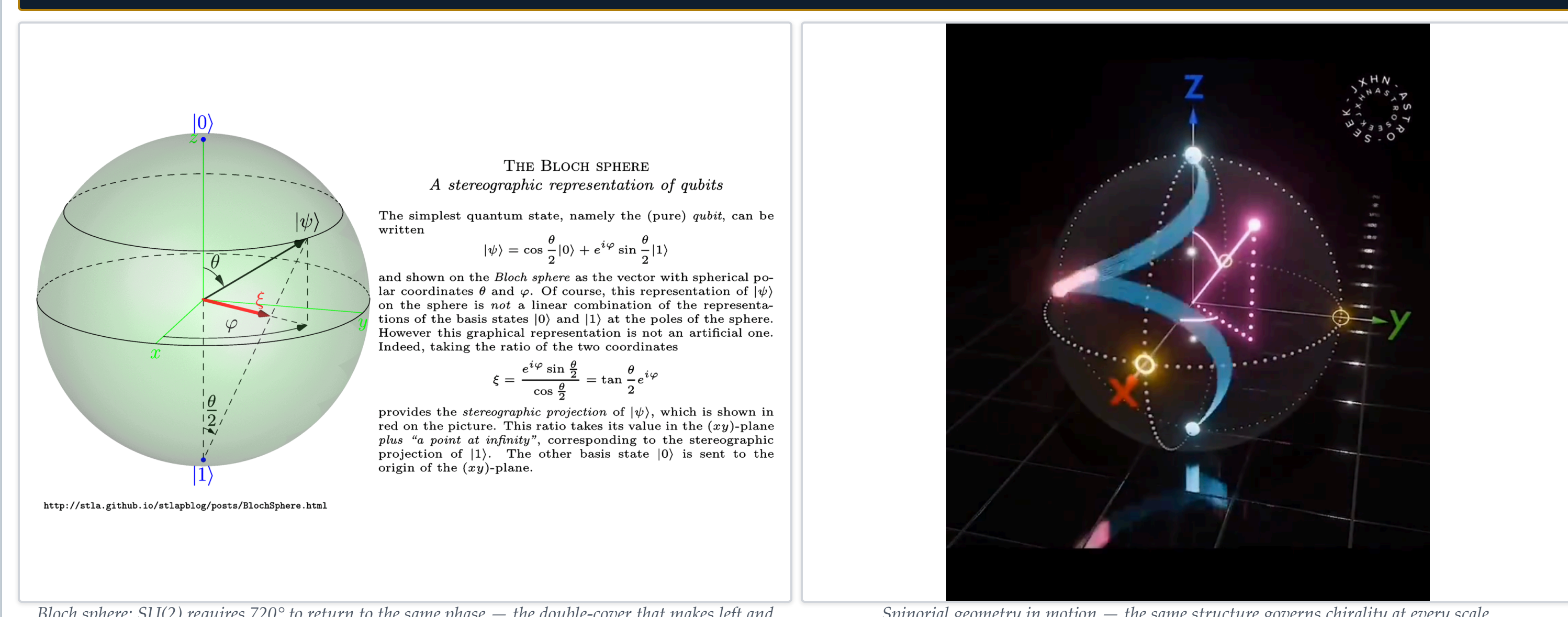
## AHA!



24 rotational symmetries. Spinning a cube traces paths through all of them. 46/24 choices per roll — handedness changes the count.

## WHY THIS MATTERS FOR STATISTICAL METHODS IN IMAGING

Most imaging models see patterns. The dice study shows why seeing is not enough. Current pipelines — AI classifiers, network models, spatiotemporal maps — match patterns in data. That is Pearl Level 1: useful, and incomplete. **What it misses:** left and right are not the same. A model that averages over handedness loses the signal that only one orientation was physically possible. The old entropy math made this exact error on the dice data. The same chirality is in your imaging data — molecular structure, brain laterality, bone architecture, vascular trees. Entropy (Shannon/Von Neumann): left = right. Constructor theory: they are not the same world. Discovery in imaging requires do-actions — not just better pattern matching.



Bloch sphere: SU(2) requires 720° to return to the same phase — the double-cover that makes left and right physically distinct. Spinorial geometry in motion — the same structure governs chirality at every scale.

## THE CAUSAL CHAIN — HOW THE NEW KNOWLEDGE GREW

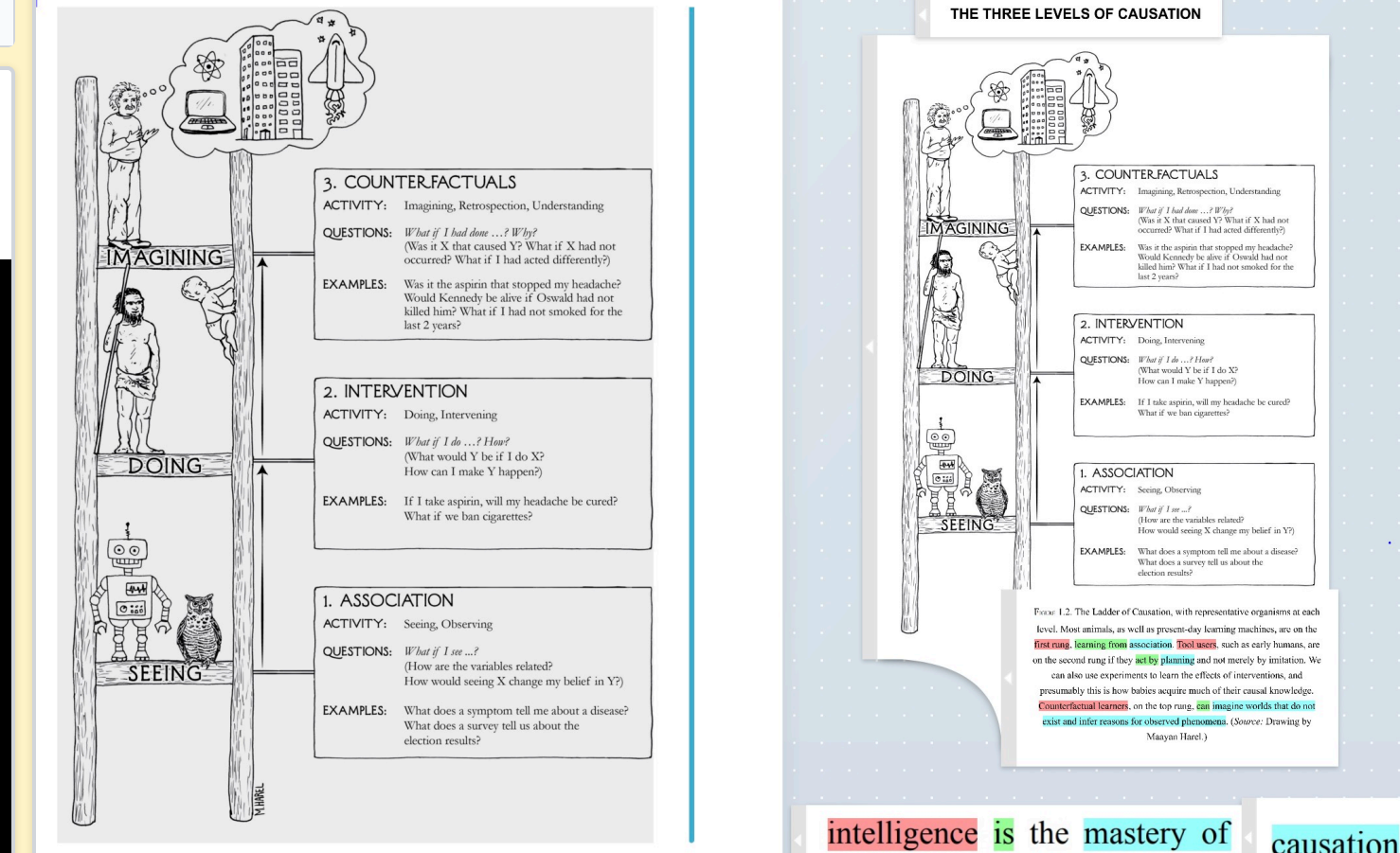
- Each step is a **do-action** — an intervention, not merely an observation. Each caused the next.
- do(surgical dice study)** — Spinning real dice and measuring real times produced data that did not match the entropy prediction.
- Entropy mismatch discovered** — Shannon and Von Neumann entropy both measure probability distributions over states, not geometric structure. The break was a causal signal: something real had been missed.
- Handedness discovered** — Dice have chirality — left and right cannot be interconverted by any rotation. Entropy is blind to this because chirality is geometric, not distributional.
- Productive doubt** — The broken explanation opened the path to Deutsch's Constructor Theory: knowledge exists as a real pattern in the world, independent of any mind holding it.
- The conjecture** — The gap between what bodies can do and what minds can imagine is the engine of knowledge growth. The dice study is where that gap first became visible.

The dice study is the starting do-action. Every idea on this poster traces causally back to it.

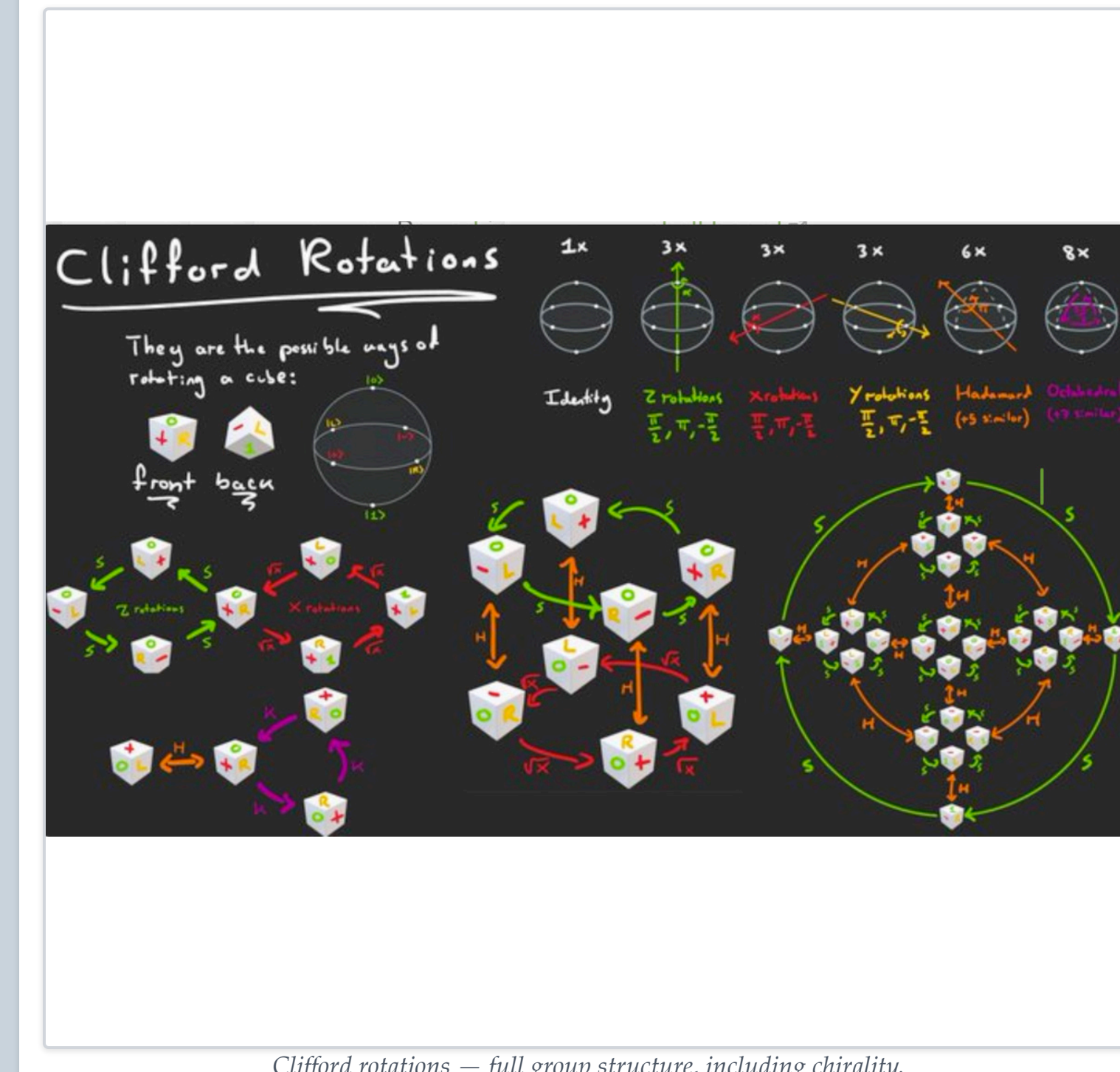
## PEARL'S THREE LEVELS

- 1 - SEE Association:** Noticing patterns in image voxels. No intervention. No new causal knowledge about handedness.
- 2 - DO Intervention:** Performing the experiment. The do-action caused the entropy mismatch to become visible. *Operative level.*
- 3 - IMAGINE Counterfactual:** What if the dice study had never been done? The Counterfactual:chirality discovery would not have occurred. This poster would not exist.

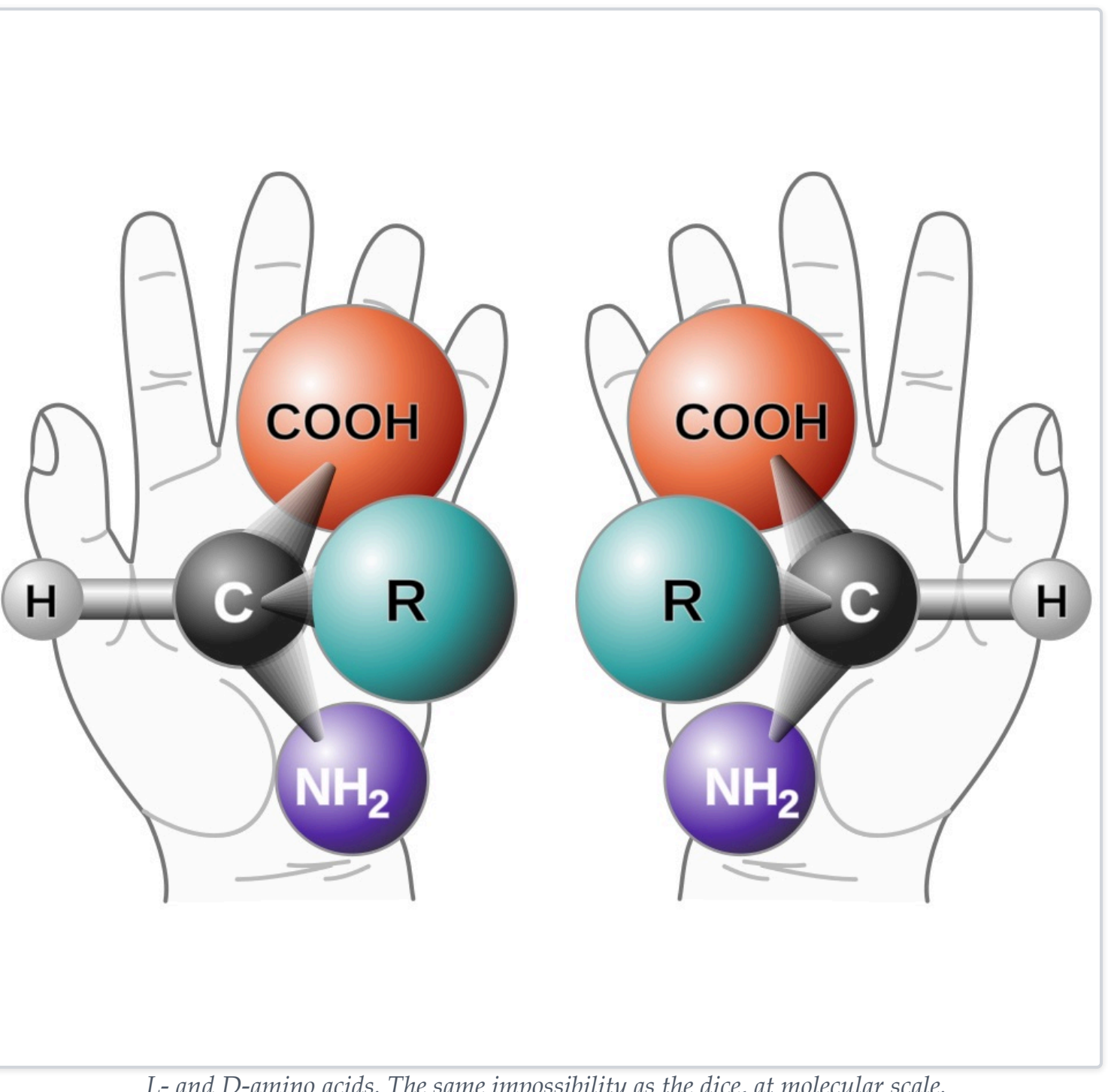
not. The framework I use to show this goes back to **Alan Turing**, the pioneer of research in artificial intelligence (AI), who **proposed to identify a cognitive system in terms of the questions it can answer**. This approach is exceptionally fruitful when we are talking about causality because it bypasses long and unproductive discussions of what exactly causality is and **focuses attention on the concrete and answerable question "What can one causal system do?"** Or more precisely, **What can one system possessing a causal model construct that one machine with a model cannot?**



Intelligence is the mastery of causation.

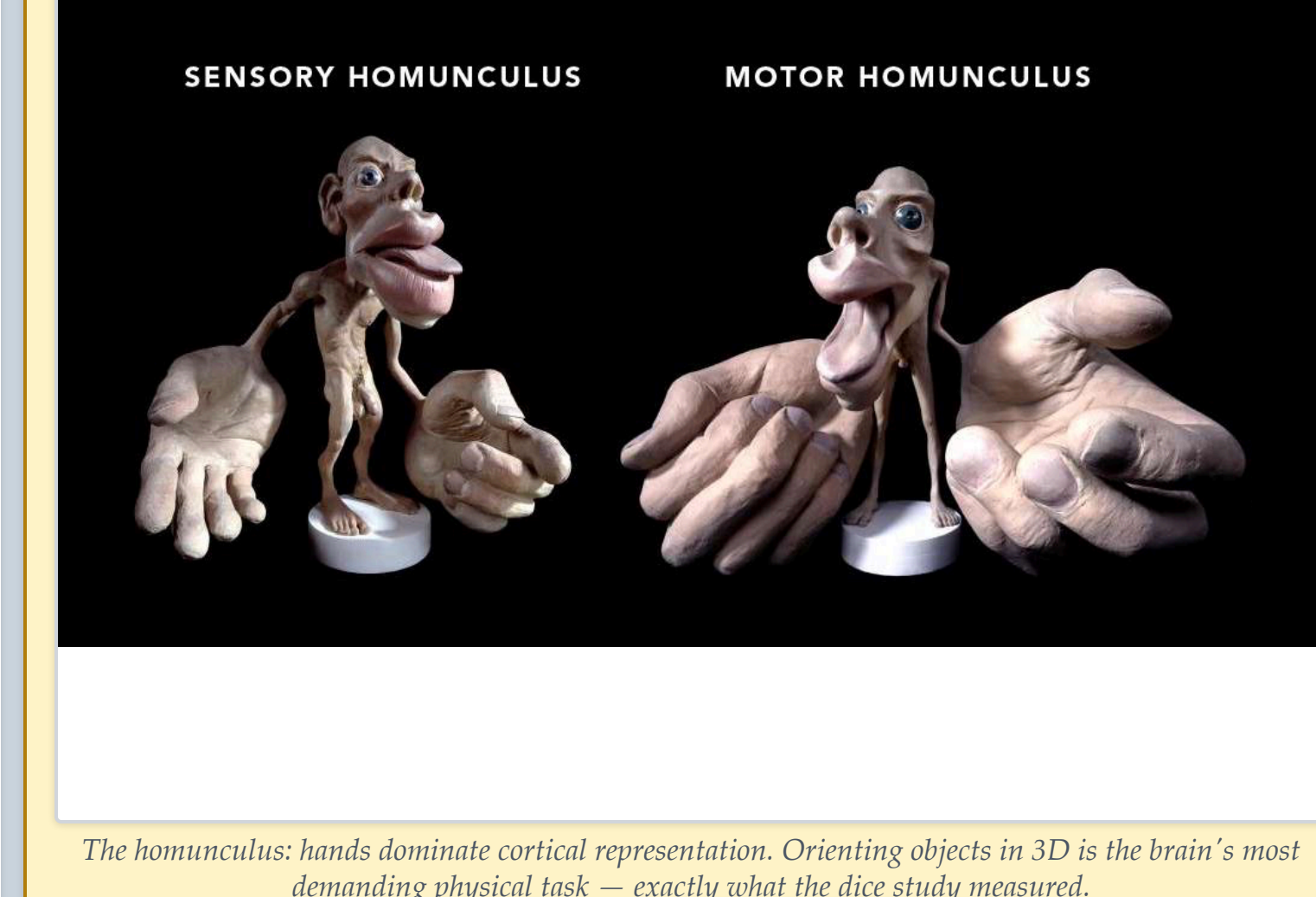


Clifford rotations — full group structure, including chirality.



L- and D-amino acids. The same impossibility as the dice, at molecular scale.

Quantum coherence in microtubules (Penrose-Hameroff OR): if biological computation exploits quantum geometry, chirality is operational at the scale of cognition — not just chemistry.



The homunculus: hands dominate cortical representation. Orienting objects in 3D is the brain's most demanding physical task — exactly what the dice study measured.

Pearl's Ladder of Causation (The Book of Why). Most current AI operates only at rung 1. The dice study operated at rung 2. The gap is the engine of knowledge growth.

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