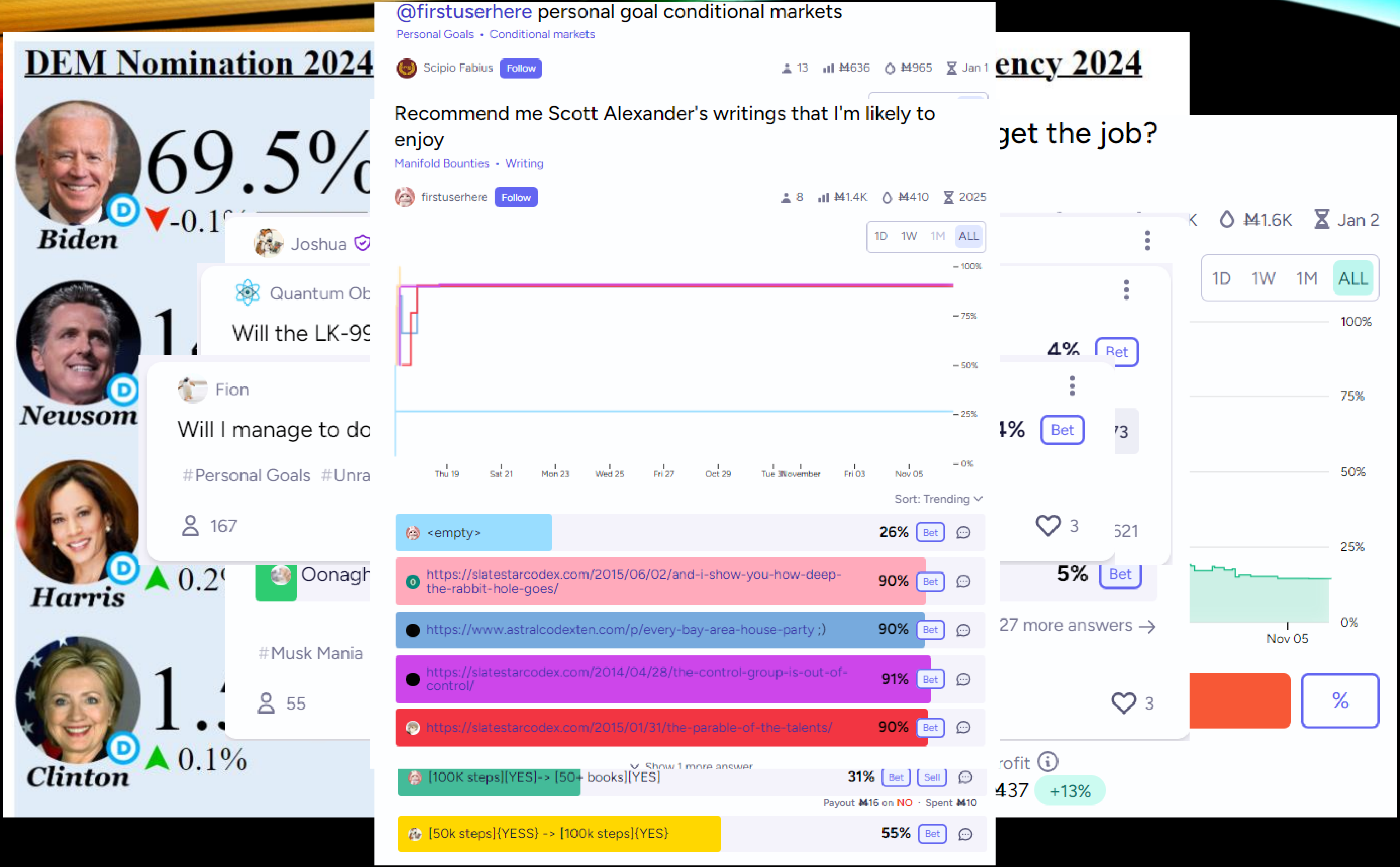
BETTING ON WHAT IS NEITHER VERIFIABLE NOR FALSIFIABLE

You might be willing to bet your life on it, but how?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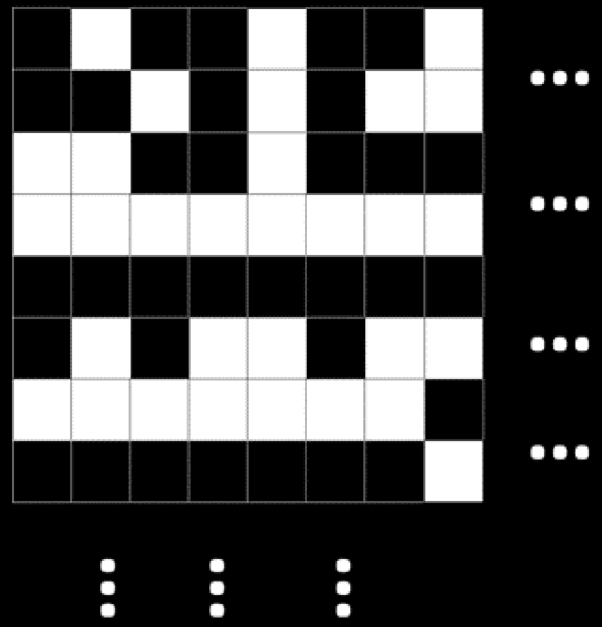
VERIFIABLE, FALSIFIABLE

- **Δ_0:** Questions whose answers we will find out at a definite point in time.
- **Verifiable:** Statements that will be confirmed (if true)
  - “There is at least one white swan”
  - “An asteroid will hit the Earth”
  - “You are mortal”
  - “P halts”
- **Falsifiable:** Statements that will be refuted (if false)
  - “All swans are white”
  - “An asteroid will never hit the Earth”
  - “You are immortal”
  - “P doesn’t halt”

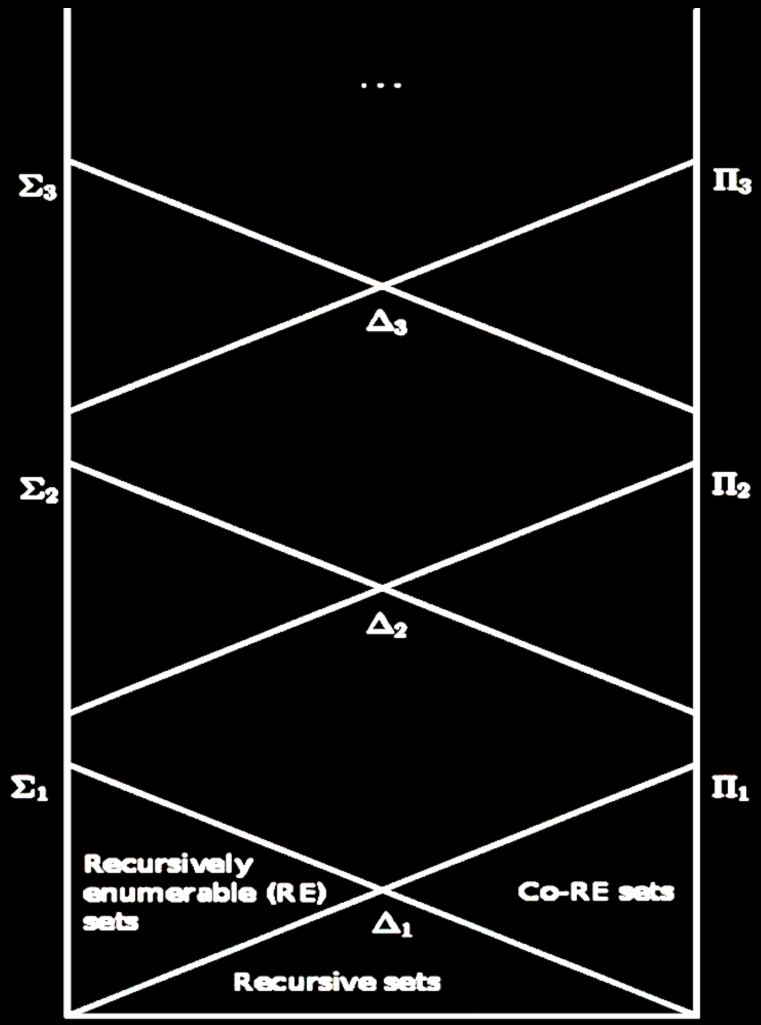
NI

- "All men are mortal"
- "Every swan will grow a white feather"
- "This infinite checkerboard has a completely shaded horizontal row"
- "There are an infinite number of primes"
- "The limit of this sequence is *L*"

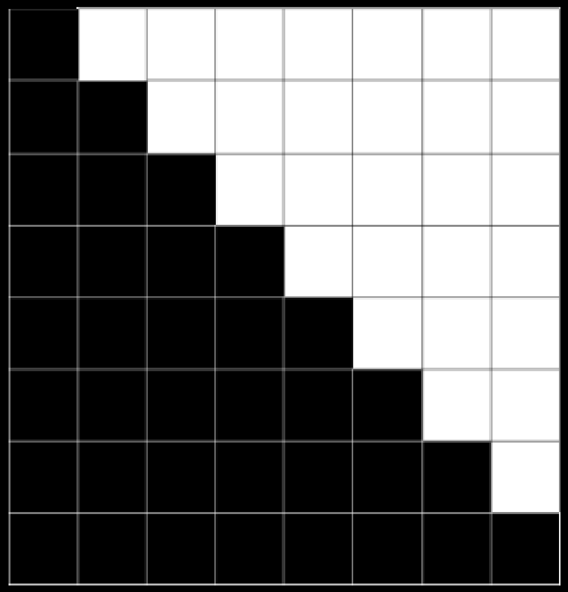


- This feels like it should be meaningful!

ARITHMETICAL HIERARCHY



An obvious, immediate solution might look something like an inductive construction, where for P a Π_n sentence, you can give a trader the asset $\bigvee_{x\leq n} P(x)$ on day n, taking it back the next day, ad infinitum, so the asset value approaches the Σ_{n+1} asset $\exists x, P(x)$ over infinite time.



AAAAHHH

Theorem 0 (the problem is hard). Let $P(x_1, \dots x_n)$ be an n-ary primitive relation (denote its Σ_n and Π_n quantifications as ΣP and ΠP respectively), let $D : \mathbb{N} \to \text{list}\ \mathbb{N}^n$ be some fixed "enumerator" of $\mathbb{N}^n$ (i.e. $\text{set}(D_{t+1}) \supseteq \text{set}(D_t)$, $\bigcup_{t\in\mathbb{N}} \text{set}(D_t) = \mathbb{N}^n$), and allow vectorizing P on finset $\mathbb{N}^n$, i.e. $P(\langle \mathbf{x}_1, \dots \mathbf{x}_n \rangle) = \langle P(\mathbf{x}_1), \dots P(\mathbf{x}_n) \rangle$. A "mechanism" for ΣP (respectively ΠP) can be either:

- [asset] a computable sequence of computable functions $v_t : \text{Bool}^{D_t} \to \mathbb{R}$ such that $\lim_{t\to\infty} v_t(P(D_t)) = \begin{cases} \$1 & \text{if } \Sigma P \\ \$0 & \text{if } \neg\Sigma P \end{cases}$ (respectively ΠP).
- [score] a computable sequence of computable functions $s_t : (0,1) \to \text{Bool}^{D_t} \to \mathbb{R}$ such that $\lim_{t\to\infty} s_t(p, P(D_t)) = \begin{cases} \log(p) & \text{if } \Sigma P \\ \log(1-p) & \text{if } \neg\Sigma P \end{cases}$ (respectively ΠP).

Then for $n > 3$, there is no computable procedure that, given some n-ary P, gives a mechanism for ΣP (respectively ΠP).

Proof. Suppose such a computable procedure existed, denote it by ϕ. Then for all n-ary primitive relations P, the sentence ΣP would be equivalent to either $\lim_{t\to\infty} \phi(P)_t(P(D_t)) = 1$ or $\lim_{t\to\infty} \phi(P)_t(0.3, P(D_t)) = \log(0.3)$, depending on the type of mechanism. However, both of these sentences are Π_3, and for every Σ_n sentence were equivalent to a Π_3 one would contradict Tarski's theorem.

LET'S PLAY A GAME.

GAME SEMANTICS

FBAFAKJDJFNSF

- Wait
- How about this game
- "$\forall x, \exists (y,z), BB(z) = y \land y > x$"

CONSTRUCTIVISM

“ The Probability that *WE WILL CONSTRUCT* an *x* such that for all y *WE WILL CONSTRUCT, P(x, y)*

SOFT NON-CONSTRUCTIVISM

An event I that gives no information on A or on B, but gives information on $A \cup B$.

I have two children; A is "my eldest is a boy"; B is "my youngest is a boy"; I is "I have a boy and a girl".

HARD NON-CONSTRUCTIVISM

An event I that is independent of every finite union $\bigcup_{i \in S} A_i$ but informs the countable union $\bigcup_{i \in \mathbb{N}} A_i$

(Not really possible in probability theory)

PROBABILISTIC CONSTRUCTIVISM

Definition 1 (Probabilistic constructivism). Define $\Omega = \{0,1\}^{\mathbb{N}}$, i.e. the set of binary sequences, to be our "sample space". We define our "constructible algebra" Ψ on this space as the smallest set such that:

- every subset $\overline{\pi}_i = \{w \in \Omega \mid w_i = 0\}$ and $\pi_i = \{w \in \Omega \mid w_i = 1\}$ is in Ψ.
- The finite unions and intersections of $\pi_i, \overline{\pi}_i$ are in Ψ; these are called its "propositional sets"
- Ψ is closed under unions and intersections over the its computably enumerable subsets, i.e. for $p : \mathbb{N} \to \Psi$ computable, $\bigcup_{x \in \mathbb{N}} p(x)$ and $\bigcap_{x \in \mathbb{N}} p(x)$ are in Ψ.

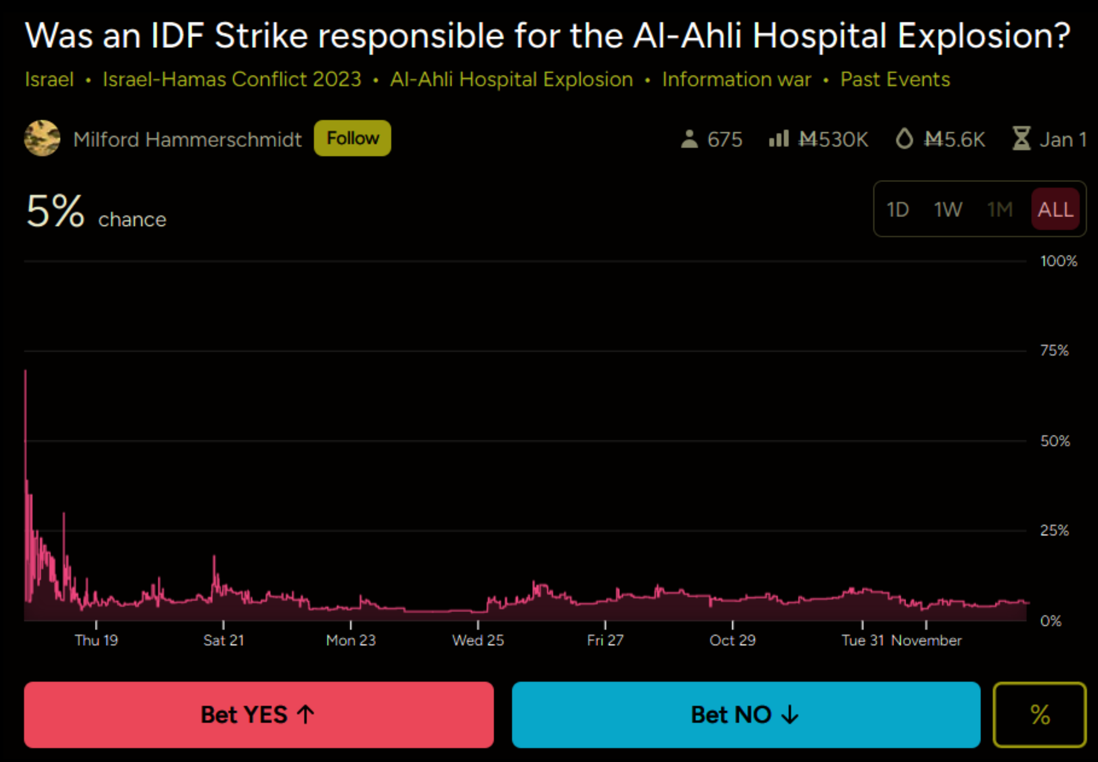
(*Notes:* This differs from "monadic algebras", "quantifier algebras" and "polyadic algebras" but is good enough for us.)

Then a "constructivist probability assignment" $\mathbf{Pr}$ on Ψ is any such that the probabilities of propositional sets satisfy the usual rules, and for any set whose membership can be expressed as some (hyper-)arithmetical sentence P:

$$\mathbf{Pr}[P] = \sup_{\aleph} \inf_{\beth} \mathbf{Pr}[\mathrm{Game}(P, \aleph, \beth)]$$

THE REAL REASON THIS IS IMPORTANT

- "If a tree falls down in the forest, and no one's there to bet on it … does it make a sound?"



What caused the Late Bronze Age Collapse?