A NOCTURNAL DUEL · SCIENCE EXPLAINER

Two Choirs in the Dark

When two crowds clap in the same rhythm — are they hearing each other, or just both catching the same signal from outside? And can the two cases even be told apart by watching alone?

DATE	3 June 2026
TOPIC	Whether two mechanisms of synchronization can be told apart in principle from passive observation alone
MODELS AT ISSUE	A — synchronization by a shared external noise · B — synchronization by weak mutual coupling
SIDES	Athos — defending the thesis · Aramis — refuting it
FORMAT	six alternating moves; every claim backed by a computation; an independent final assessment

Picture two choirs singing in adjacent halls. At first each holds its own part, but a minute later you notice: they are singing in time. Their voices have synchronized. Then comes a deceptively simple question. There are two reasons this could have happened:

VERSION A · SHARED SIGNAL

The choirs **cannot hear** each other. But the same metronome is running in both halls (or the same hum drifts in from the street). Each choir locks onto a *shared external* signal — and so they end up matching each other.

VERSION B · MUTUAL COUPLING

There is no shared metronome. But the wall is thin, and the choirs **faintly hear** each other. That weak mutual coupling is what draws them into a common rhythm.

From the outside both pictures look identical: two synchronized choirs. The question of the duel — **can you tell, from a recording of their singing alone, with no intervention, which of the two causes is the true one?** Or must you intervene — say, switch off the metronome and see whether the synchrony falls apart?

> **What this is really about.** Physicists model such choirs as **oscillators** — objects each carrying a **phase** (where it currently sits in its cycle: inhale–exhale, step–step, beat). The classic equation for a large group of interacting oscillators is the **Kuramoto model**. A "choir" here is a group of such oscillators, and its collective rhythm is captured by a single number — the **order parameter**.

The stakes

Two step onto the stage. **Athos** defends a bold thesis; **Aramis** sets out to topple it. The thesis runs:

> *"Version A and version B are* **observationally equivalent**. *No passive statistic computed from recordings of the rhythms will tell a shared signal from mutual coupling. To separate them, you need an intervention."*

> **Two key terms.** A **passive statistic** is any quantity you can compute just by looking at a recording, touching nothing (how alike the rhythms are, whether one lags the other, and so on). **Observational equivalence** is when two different causes yield *indistinguishable* observations: the data are the same, the mechanism behind them differs. If that holds, a passive observer is powerless — an **intervention** is needed, an active interference with the system.

Athos (for the thesis) bets on **symmetry**: if both choirs are equal partners, neither leading the other, then the most obvious "clues" — who runs ahead of whom, which way the influence flows — cancel out for both versions at once. And if so, there is nothing left to tell them apart.

Aramis (on the attack) replies: "It isn't the pair of choirs that's blind — only *your particular clue* is. There is another, subtler one, and it does tell them apart."

The duel: not rhetoric, but arithmetic

What set this duel apart: every blow was backed not by words but by a computation. The duelists took turns running an honest simulation of the two choirs and measuring their clues on it. And the opening thrusts exposed a trap that is easy to fall into.

The false-comparison trap

For the comparison to be fair, both choirs must be synchronized *equally strongly*. The strength of synchrony is measured by a number from 0 to 1 — this is the order parameter between the choirs.

> **The synchrony measure (PLV).** If two rhythms keep the same phase difference throughout, this value is close to **1** (rigid synchrony). If the phase difference wanders at random, it is close to **0**. Formally this is the **phase-locking value**. Mechanisms can only be compared at equal PLV — otherwise you are not comparing "shared signal versus coupling" but "weak synchrony versus strong."

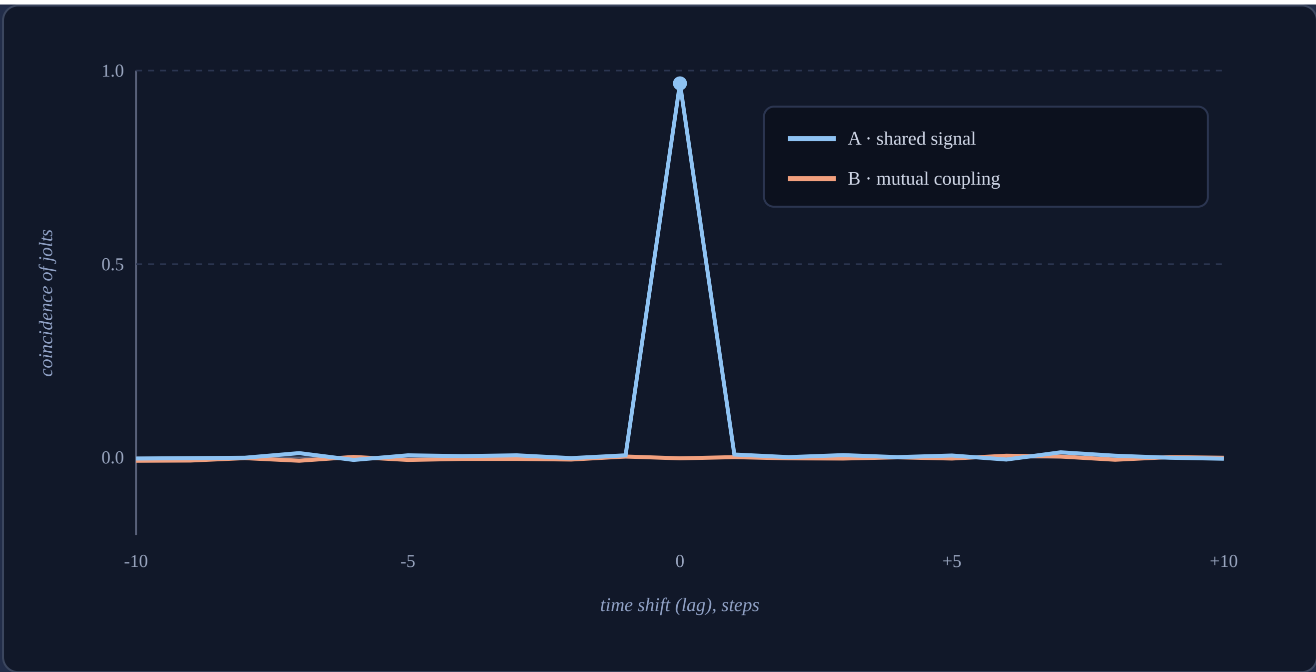
This is exactly where both repeatedly stumbled: in the simple model, mutual coupling drives synchrony almost instantly to the ceiling (PLV ≈ 1), whereas a shared signal holds it at an intermediate level. Equalizing the PLV of the two mechanisms never quite worked — and that in itself is a substantive fact, one the defender kept pointing to. So the decisive move had to find a difference that did *not* rely on the strength of synchrony.

The decisive thrust

Aramis measured not the rhythm itself but its **instantaneous speed** — how sharply each choir speeds up and slows down from moment to moment — and asked: do these jolts coincide in the two choirs *at the very same instant*?

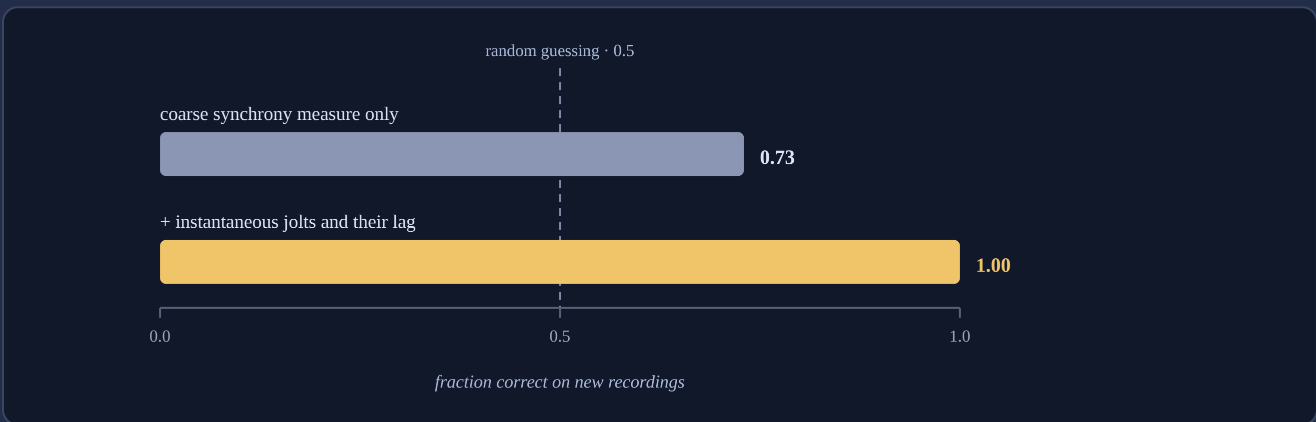
> **Where the difference comes from — the physical core.** A shared signal strikes both choirs *at once*: the same metronome push accelerates both together. So their instantaneous jolts coincide **with no delay**. Under mutual coupling, by contrast, the choirs merely tune their overall rhythm to each other, while each keeps its **own** moment-to-moment jitter — the small jolts of one are not passed to the other instantly.

And here is what makes the result especially convincing. In this run, coupling (B) is phase-synchronized even *more* strongly than the shared signal (PLV ≈ 0.97 against ≈ 0.72) — and yet its instantaneous jolts do **not** coincide at all. While the more weakly synchronized shared signal gives an almost perfect instantaneous match of jolts. So it is not the strength of synchrony that matters: the jolts reveal the **mechanism** itself, regardless of which choir is more tightly "locked."



Coincidence of the two choirs' instantaneous jolts as a function of the time shift between them. The shared signal (blue) shows a sharp peak right at zero: the jolts coincide instantly (0.97). Mutual coupling (orange) stays an almost flat line near zero at any shift: there is a common rhythm, but the moment-to-moment jolts are independent. Both versions are in a strong-synchrony regime (PLV ≈ 0.72 and ≈ 0.97). Simulation parameters in the appendix.

The picture leaves no room for argument in this particular round: a simple automatic classifier given only the coarse synchrony measure confused the versions (accuracy ≈ 0.73 — barely better than a coin flip). The same classifier, handed the subtle clue about instantaneous jolts and their lag, separated the versions **flawlessly**.



Accuracy of recognizing the mechanism from a recording (fraction correct, leave-one-out validation; the random-guess baseline is 0.5). The coarse synchrony measure is nearly useless; the subtle clue about instantaneous jolts separates the versions completely.

Verdict

Aramis wins — the one attacking the thesis. On the quality of argument and on the decisive numerical result, he is closer to the truth: the universal claim that "nothing can tell them apart" proved **too strong**.

But a qualified win. Aramis himself at times compared choirs in different synchrony regimes, and his early clues were an artifact of that skew. The purely phase-based "directional" clues the defender bet on truly are blind — here Athos is right. The versions could be separated only by the finer statistic of instantaneous jolts.

Where the defense held

The losing thesis kept an honest line of defense, and the duel laid it bare. The whole result rests on the "shared signal" being *simple*: the same instantaneous push to both choirs. Allow it to be richer — delayed, with its own structure, affecting the loudness of the singing too — and it begins to reproduce the very clues used to convict it. Then the boundary between "shared signal" and "mutual coupling" blurs again.

So the precise statement of the conclusion is this: **within two simple, honestly posed versions, a passive fingerprint does exist** — the instantaneous jolts reveal the mechanism. But **the wider the class of admissible shared signals, the closer we come to the original thesis** of indistinguishability. Exactly where the boundary lies is an open question — and a more interesting one than the duel's outcome.

Why this matters beyond the hall of choirs. The same question arises wherever two systems "move in step": brain regions, market prices, populations, power grids. Seeing coordination, we want to know — do they influence each other, or are they simply driven by a shared invisible factor? An important caveat: the model examined here is two specific idealized versions, and no general law about all systems follows from it. But it poses the question cleanly: for each pair of "shared factor versus mutual influence," it is worth checking separately whether the mechanism leaves a passive fingerprint — or whether it can be distinguished only by intervention. Here a fingerprint was found for a simple shared factor; how far it survives added complexity is the matter for the next duel.

Appendix · simulation parameters

Model. Two groups of 120 phase oscillators each (Kuramoto model) with intra-group coupling; natural frequencies ~ normal (mean 1.0, spread 0.08), integration step dt = 0.05, series length 5000 steps (the first 1500 discarded as burn-in).

Version A (common noise). The same random push is applied to both groups simultaneously (intensity 0.3) plus independent intra-group noise (0.6); no inter-group coupling.

Version B (mutual coupling). Weak symmetric coupling between the groups (strength 0.02), no common noise; the same intra-group noise (0.6).

Operating point and averaging. Both versions are in a strong-synchrony regime (PLV: A ≈ 0.72, B ≈ 0.97; perfect equality cannot be reached — see "the false-comparison trap"). The jolt-coincidence curve is averaged over 8 independent runs (random seeds 0–7).

Recognition (lower chart). Accuracy obtained on the final move of the duel: a logistic classifier, leave-one-out validation, ~30 runs per version; the random-guess baseline is 0.5.

The numbers are illustrative: they reproduce the duel's key result and do not claim to be a full paper. Full reproducibility requires the simulation source code.

The duel's direction was inspired by the paper *"Common Noise-Induced Group-Level Synchronization Between Uncoupled Groups of Oscillators"* (arXiv:2605.29529). The dispute was not about the paper itself but about a stronger hypothesis it suggests: the in-principle (in)distinguishability of common noise and weak coupling from passive observation. All numbers in the charts come from simulating the Kuramoto model for two groups of oscillators.