Why we know more about the past: insights from statistical mechanics

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Background

- We only have direct access to the **present moment** (and state)
- Given the present, we typically **know more about our own past than our future**, since we remember our past experiences
- Even for real-life events we don't have memories of, we are better at **guessing about the unknown past than the unknown future** (Xu et al., 2023)
- Why do we **perceive time** as moving from the past to the future?
- Why do we **remember the past** (but not the future)?

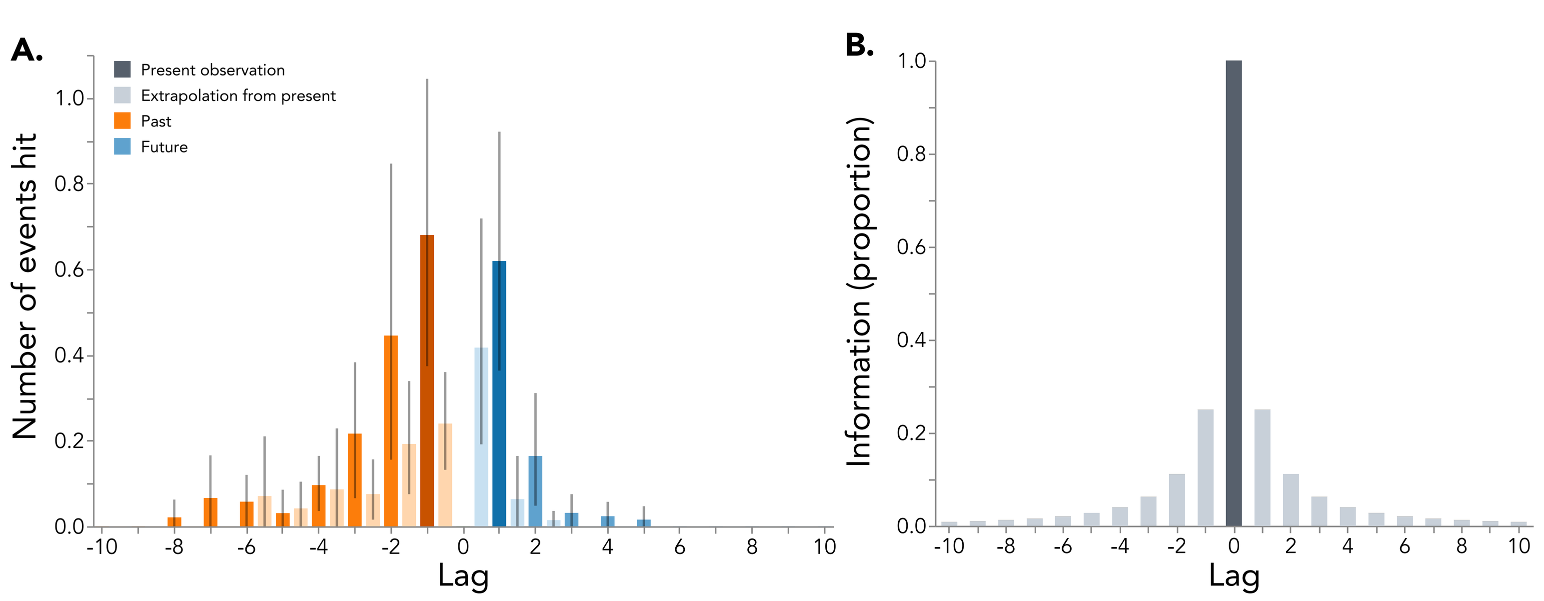

Figure 1. A. Participants more readily and accurately infer narrative events from the past (negative lags) than the future (positive lags) relative to a just-watched movie clip (Xu et al., 2023). **B.** Most previous sequence models either assume stationarity or only consider processes in equilibrium (Bialek et al., 2001). Stationary processes are time-symmetric (Cover, 1994; Bialek et al., 2001). *How might we reconcile the apparent discrepancy between A and B?*

Approach

- We used **simulations** to explore uncertainty about the past and future, through the lens of the **second law of thermodynamics**

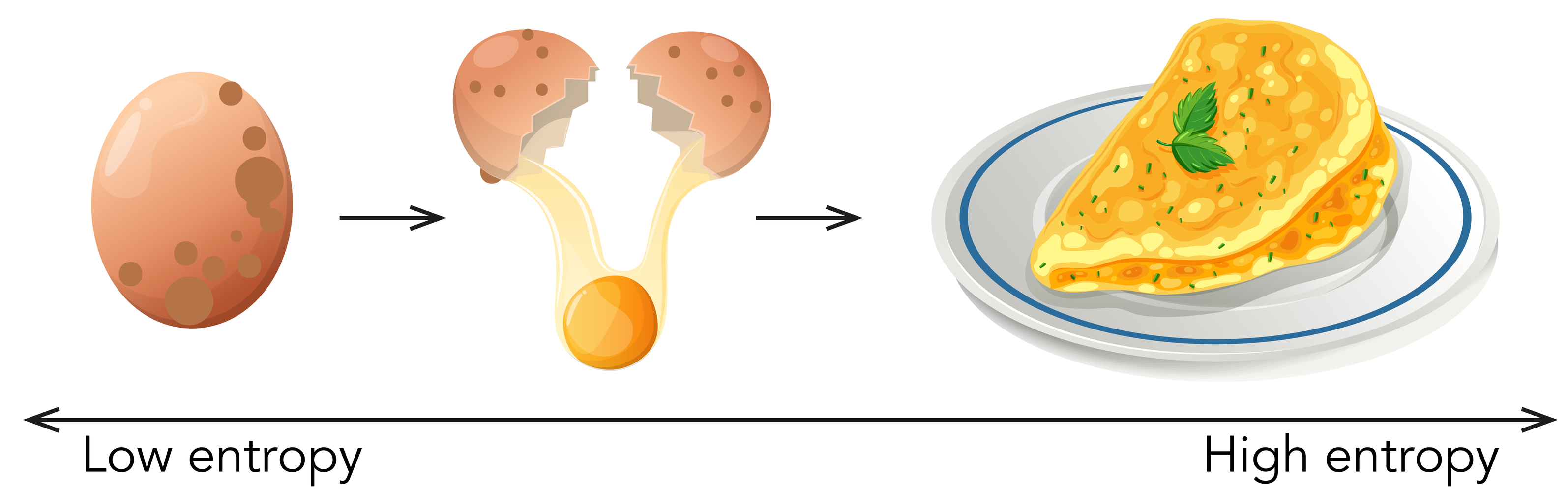

Figure 2. Natural processes are not time-reversible.

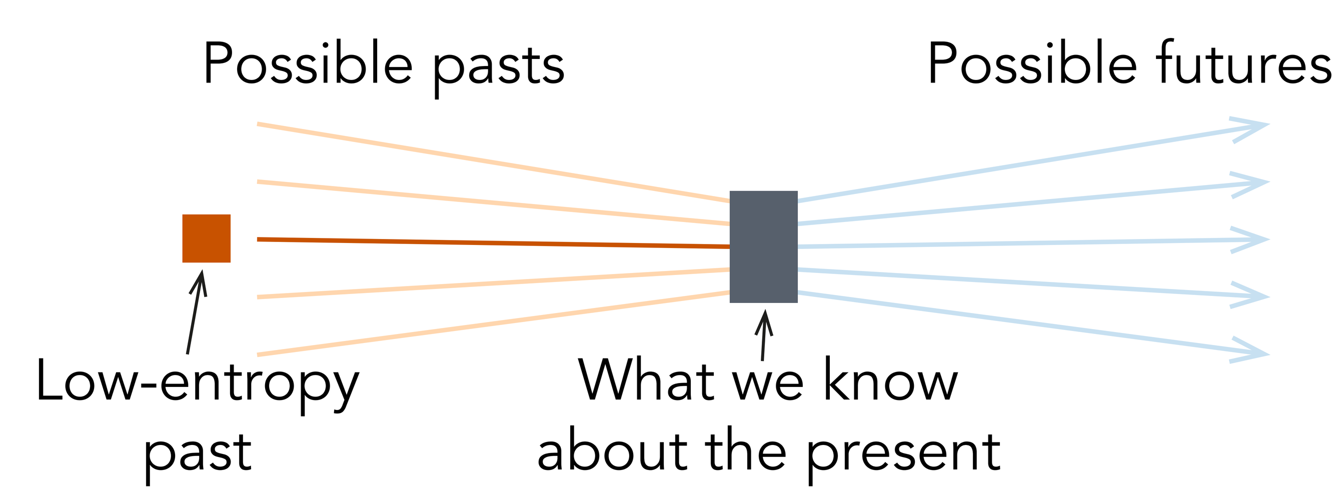

Figure 3. If we assume that the present arose from a low-entropy past state, this implies that the past is more "constrained" than the future.

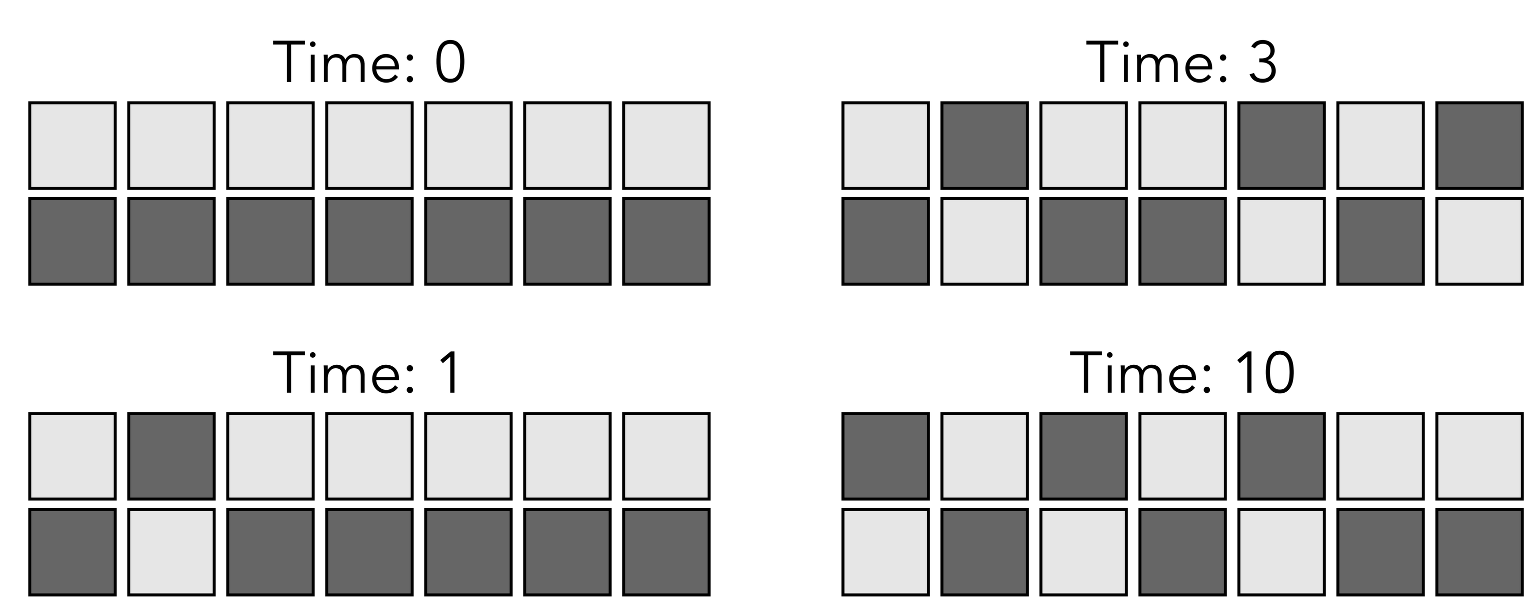

Figure 4. We simulate an entropy-increasing process. We start with seven "molecules" of each of two types, represented by light and dark squares. In each time step we "mix" the system by vertically exchanging two randomly chosen molecules.

Results

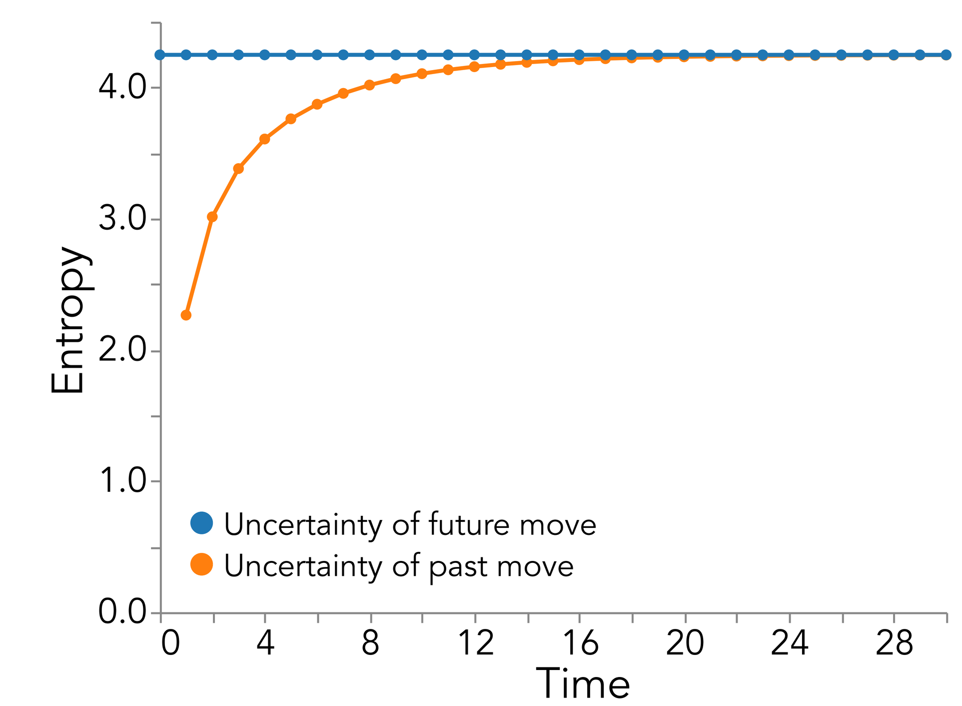

Figure 5. Simulation results. We examined how uncertainty about the past and future (given the present) change over time. We observed an asymmetry in early moments of the simulation such that there was greater uncertainty about the future than the past. As the process reaches equilibrium, this asymmetry disappears.

Future directions

- Simulate **event sequences** through the lens of the second law of thermodynamics
- Probe the potential relation between the **thermodynamic arrow of time** and the **psychological arrow of time**. Do we remember the time direction where entropy is lower (e.g., Mlodinow & Brun, 2014)

Bibliography

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