Surveying early warning signals of transitions using a large-scale collaborative experiment

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A model system enables new insights into collective behavior

Humans form **collaborative groups to achieve collective goals**, and conflict arises between groups with differing goals.

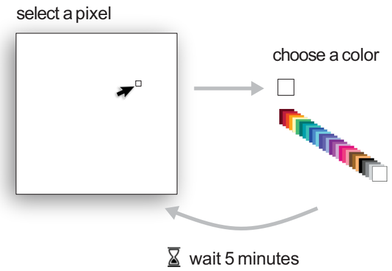
Conflicts between groups can **give rise to transitions**, or regime shifts, where control of a resource or territory passes from one group to another.

Determining the **mechanisms that drive transitions** in **a simple "gamified" online experiment** can help us begin to understand collective behavior in real-world social systems.

Finding **early warning signals of transitions** in a large, comprehensive dataset could enable us to deduce **generic knowledge of early warnings** applicable to various socio-ecological systems.

We use data from **Reddit's r/place social experiment as a model system** to study human collective behavior and early warning signals of critical transitions.

How to play

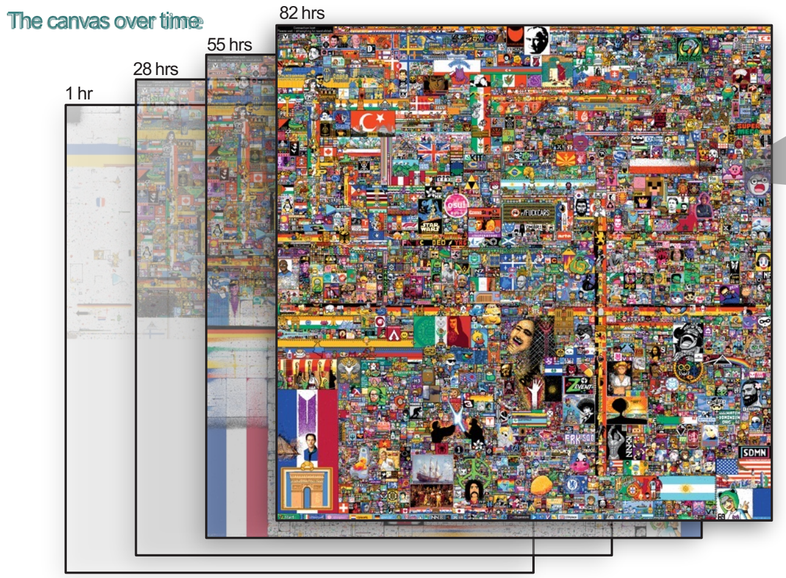


Over the course of the 3.5 day experiment, there were:

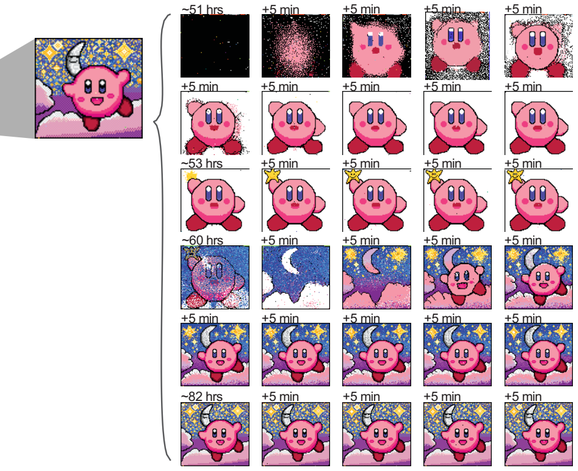
- 10.6 million users
- 160 million pixel changes
- over 10,000 compositions
- many opportunities for comparative studies of system dynamics

The canvas displays complex dynamics over time

The canvas over time

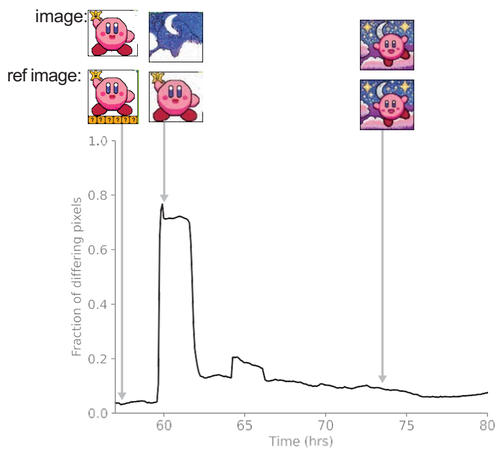


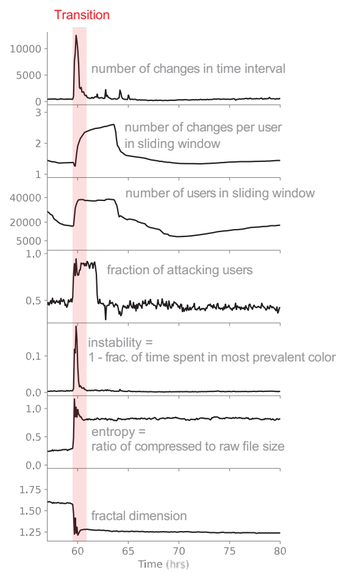
One composition over time



Transitions can be identified using many variables

We **characterize transitions** using the fraction of pixels (f_{diff}) that differ from a 3-hr **sliding reference image**.
A transition is identified when f_{diff}>0.4 close after a 2-hr stable (f_{diff}<0.15) period.

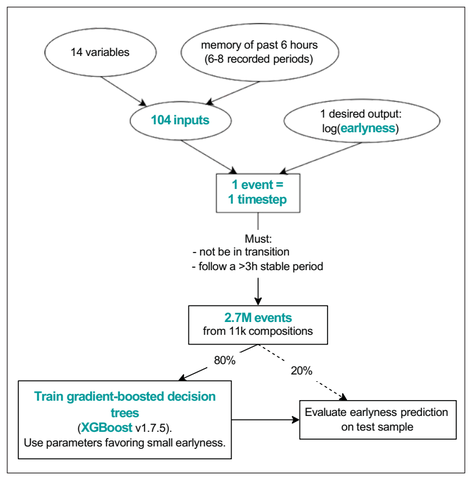




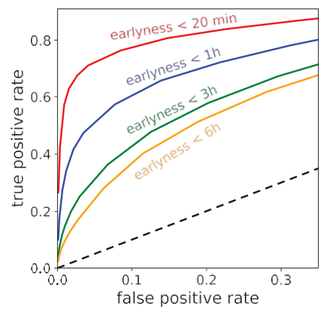
Finding early warning signals of transitions with machine learning

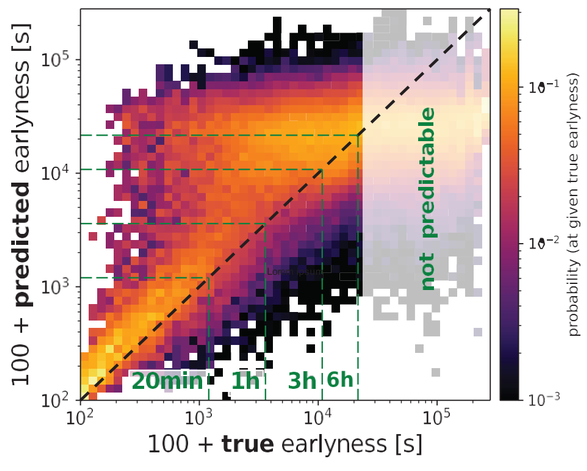
At each timestep, we aim at predicting the time of the next transition, which we call **earliness**. We use **machine learning to combine** the power of **early warning signal variables**.

We manage to detect **half of transitions** arriving within 20 minutes **with only 0.6% false positives**!



earliness condition	true positive rate	false positive rate
< 20 min	50%	0.6%
< 1 hour	50%	4.6%
< 6 hours	50%	18%





Future work

Understanding global trends through statistical mechanics

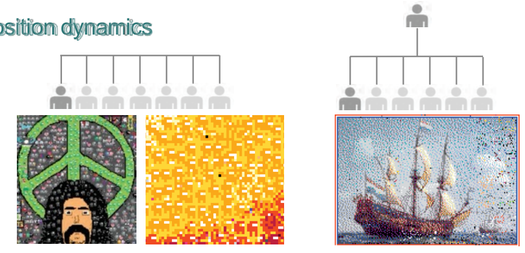
Can we model the dynamics of the whole canvas thanks to **thermodynamic analogies** (temperature / density / correlation length)?

Can it help to understand **emergent patterns** and larger-scale transitions?

The effect of organizational structure on composition dynamics

How does the **emergent social structure** (bottom-up, top-down, or a more complex hierarchy) impact the formation and stability of compositions?

Is external communication and vertical organization (on reddit subforums) necessary for **effective collaboration**?



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