

How Communicative Pressure Shapes Social Networks: An Agent-Based Model of Language-Network Co-Evolution using the Naming Game

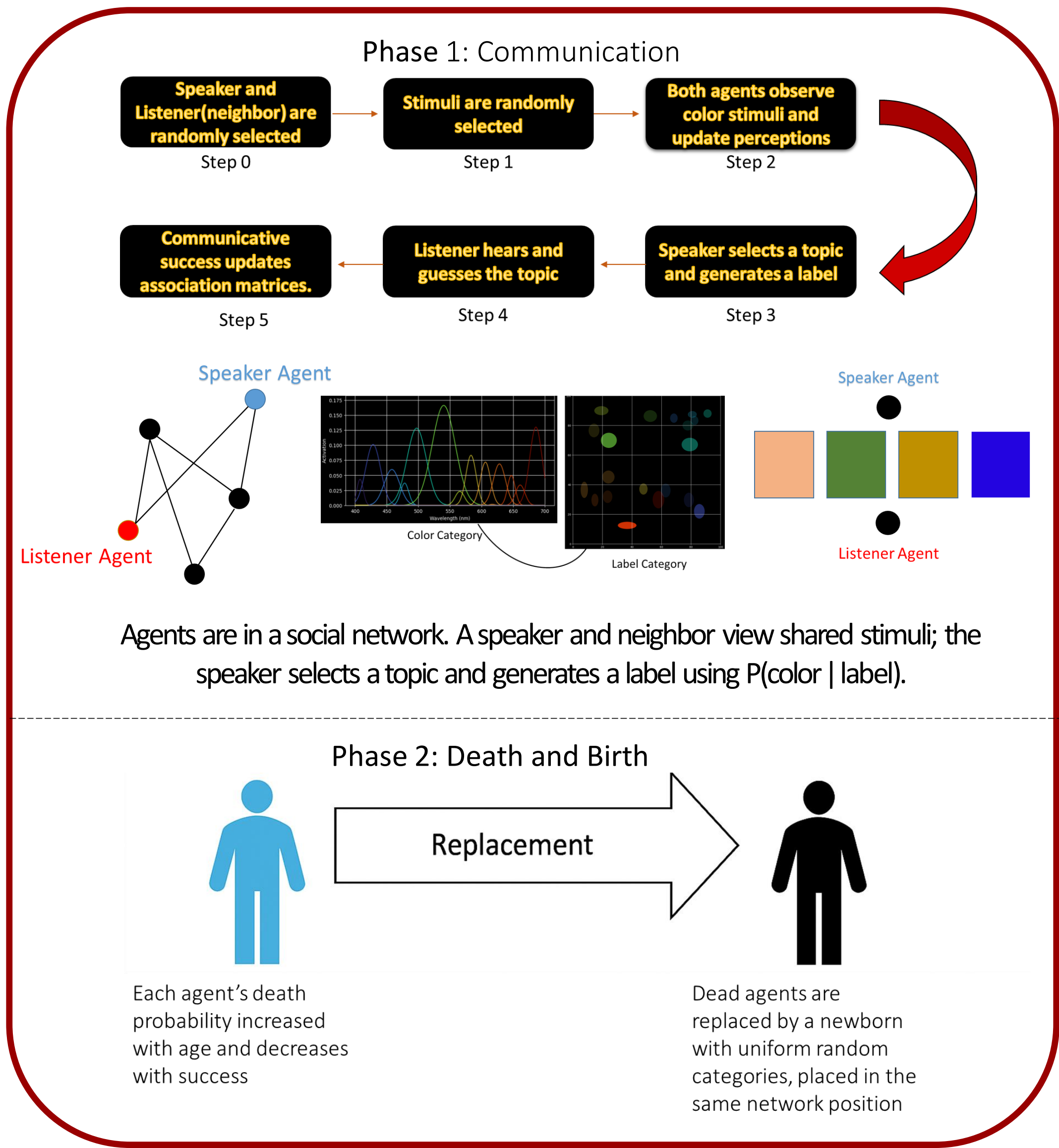
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Introduction & Motivation

- ❖ Cultural evolution is shaped by population size and network structure (Derex & Mesoudi, 2020). Few models explore how cultural and demographic structures co-evolve (Smolla & Akçay, 2019).
- ❖ Hypothesis: If (A) network structure shapes the flow of information, (B) communicative success influences who connects with whom, then (C) under selection pressure for communicative success, networks should evolve towards an optimal structure for supporting language.
- ❖ However, co-evolution did not reliably emerge in our simulations. As a result, we pivoted to exploring how communicative success and category formation vary across static network types.
- ❖ Agents play a Color Naming Game, using Bayesian inference to learn and map perceptual categories to linguistic labels.
- ❖ Findings: Some network structures support faster convergence, better alignment, and more stable cultural categories—especially under learning constraints.

Model Overview



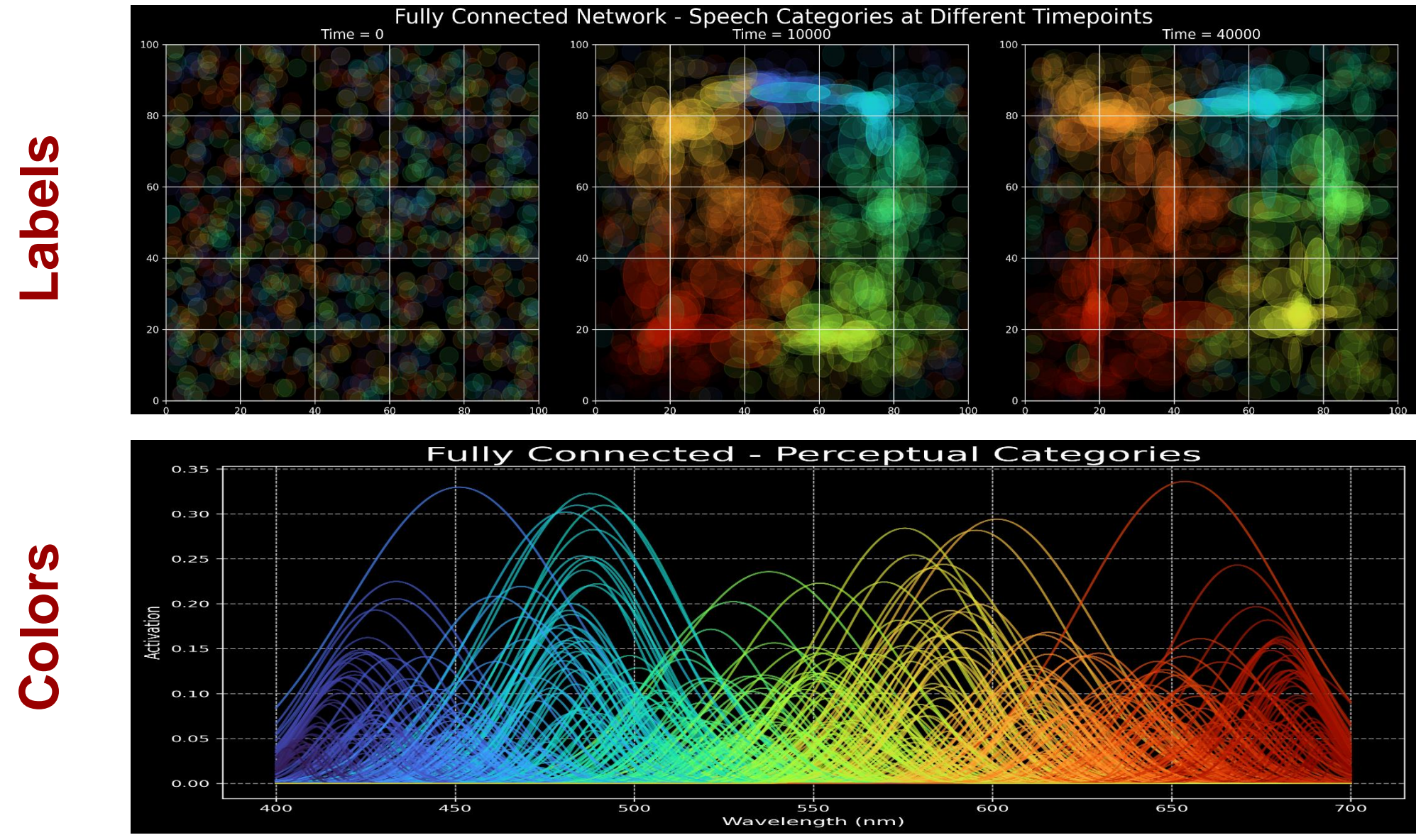
Parameters

Parameter	Values	Description
Network Setups	Fully Connected, Connected Caveman, Small World, Net of the Nets	Who agents are connected to in the social network
Transmission Error	0, 2.5, 5.0	Environmental uncertainty during communication.
Expected lifespan	2500, 5000, 10000	Expected lifespan
Population Size	10, 50, 100	Number of agents
Critical Perception	0.25, 0.5, 0.75, INF	A limited early-life window for learning perceptual categories

Key Metrics

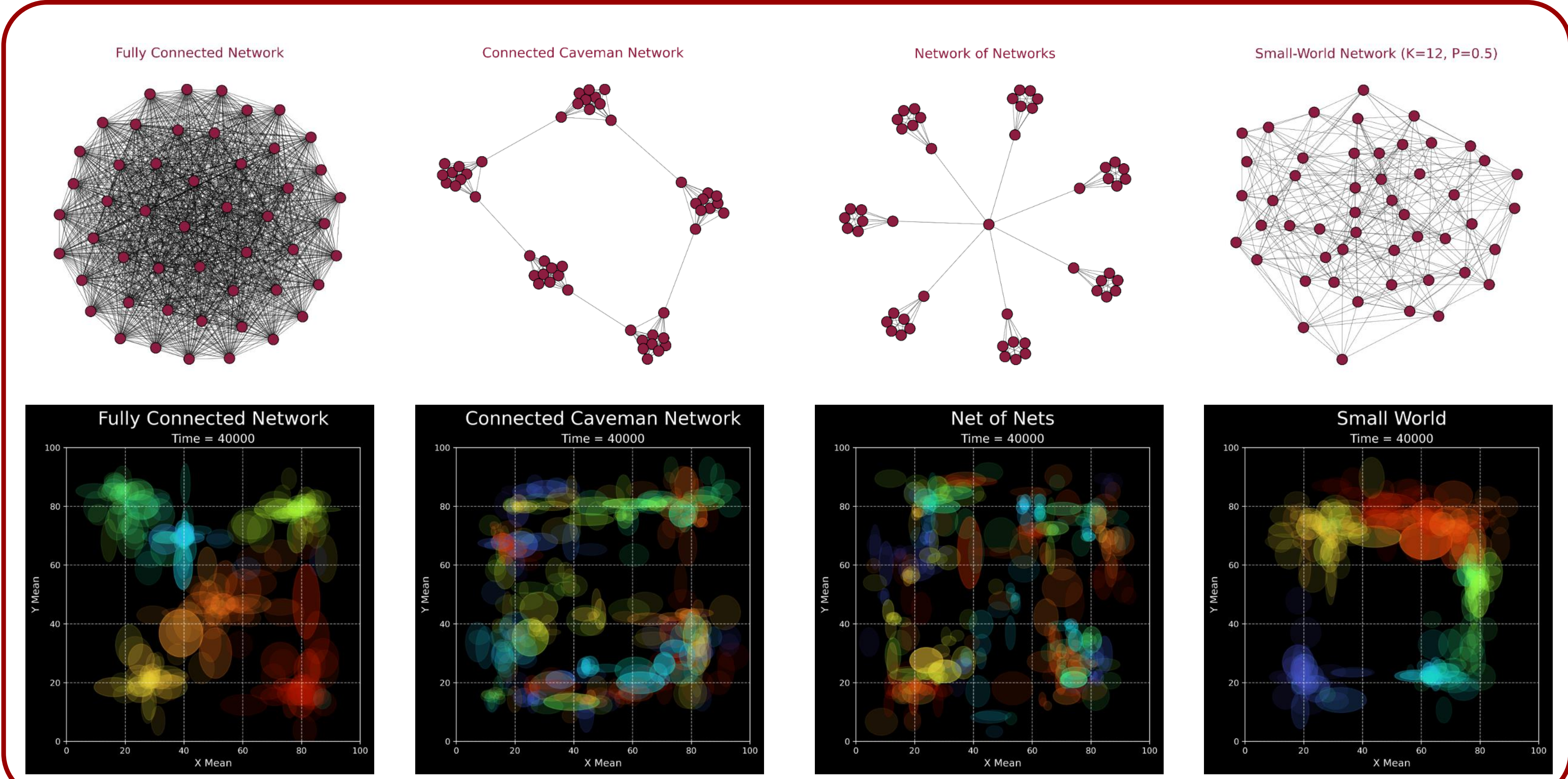
Measuring	Description
Communicative Success	Whether a listener correctly identifies the speaker's intended meaning during the game.
Complexity - # Clusters	Number of category clusters (via KMeans + Gap Statistic)
Complexity - Entropy	Weighted entropy of category distribution across clusters
Stability	Mean Earth Mover's Distance across 1,000-step windows, indicating change in the population's category distribution.
Cognitive Alignment	Mean EMD between each agent's categories and the population average at final time.
Relaxation	When communicative success stabilizes—first point it approaches its long-run value.

Categories Over Time



Results

Networks and Categories



Model Analysis

