Social viscosity, fluidity and turbulence in collective perceptions of color: an agent-based model of color scale convergence APPENDIX

Juan Salamanca Santiago Núñez-Corrales

University of Illinois at Urbana Champaign

1 Description of the Agent-based model of color proximity

In the description of the ABMS we loosely followed the *Overview, Design concepts, Details* (ODD) protocol.

1.1 Purpose

The purpose of the model is to replicate the dynamics observed in the participatory simulation of the self-organizing group of people arranging themselves by perceived color proximity. In particular we want to measure and study the evolution of social viscosity when agents share the same color mental model.

1.2 State variables and scales

Agents represent normal vision people and are characterized by the following state variables:

- ID: a unique identifier for this agent,
- Position: a vector with spatial coordinates,
- Color value: the unique color value 'impersonated' by this agent. By default the model uses the HSB color space.
- Tolerance: an scalar threshold between 0 and 1 to determine whether or not to move to a new self estimated position.
- Color mental model: an ordered collection of colors particular to each agent in the world.
- Spatial mental model: a mechanism to convert values from other mental models into spatial distances. For example, it serves to map the perceived proximity between two colors into a spatial proximity. See Submodels section for details.
- Visual perception angle: the scope of visual perception of each agent. It opens towards the direction agent is heading. By default it is set to $\pi * 3/4$.
- Shortest: a scalar used by the spatial mental model to determine how near the agent wants to be from the most similar agent.
- Farthest: a scalar used by spatial mental model to determine how far away the agent was to be from the most dissimilar agent.

The topology of the space where agents move is continuous, unbounded and unwrapped. Both the temporal and spatial resolution of the model is arbitrary.

1.3 Process overview and scheduling

The model proceeds in tick intervals of 100 milliseconds. At each tick agents store their current position in a trajectory collection, and filter out the set of agents with whom to interact according to experimenter's rule. If there are no interactants in the set, the agents set a boolean variable to 'done' and the interaction is terminated; else, they estimate the magnitude and direction of next step by adding all the anticipated vectors towards each interactant. See section Submodels for details on how the step is calculated.

If the estimated step is greater than the agent's tolerance threshold, they set the new bearing, set themselves to 'not-done', and execute the step. If the step magnitude falls below the tolerance threshold they ignore the move, set themselves to 'done' and terminate the current interaction. The boolean variable done/not-done is used to highlight who is inactive in the visualization.

1.4 Design concepts

Emergence: groups emerge from agents with proximal colors. Depending on the initialization settings groups may progressively merge together into a single one with circular shape.

Sensing: Agents perceive both the colors of their neighbors and the spatial distance to all of them. They have functions to estimate color proximity, distance proximity and translate color proximity into distance proximity. See Submodels section for details.

Observation For every tick the data collected for analysis from each agent are its spatial position, and a matrix of their interactions with a detailed description of each interactant. See Submodels section for the details of how social viscosity is computed from each matrix.

1.5 Initialization

The experimenter selects four parameters before running the model. First, the color palette from the Color Factory. That defines not only the color palette to be used by agent's color mental model but the size of the agent population. There are as many agents as color in the color palette. Second, the Interaction Rule sets the mechanism used by agents to choose their interactants. Third, a Sensibility function that defines how agents estimate their color proximity to each of their interactants. Fourth, the Tolerance for all agents.

In this research we used the following parameters: *Color palette*: Munsell color space with 20 colors (5RP, 10RP, 5R, 10R, 5YR, 10YR, 5Y, 10Y, 5GY, 10GY, 5G, 10G, 5GB, 10BG, 5B, 10B, 5PB, 10PB, 5P, 10P) converted into HSB values using the library Chroma.js[1]. *Interaction Rule* either All-to-all and N-nearest. *Sensibility*: Chordal distance. *Tolerance*: six values (0, 0.2, 0.4, 0.6, 0.8, 1.0).

1.6 Submodels

Perceived color proximity: returns a value between 0 and 1, where 1 is the farthest perceived distance. The function needs the target and reference color. In the case of *chordal distance* sensibility function, the proximity is estimated by $P = |i - j| * (2\pi/N)$, where i and j are the indexes of each colors in the default color palette, and N is the number of colors in the palette. To normalize the output, if P is grater than π then $P = (2\pi - P)/\pi$, else $P = P/\pi$.

Spatial mental model: a mechanism to map values from other mental models into spatial distances. The distance is estimated by $D = s + (f - s) * v$, where s and f are the agent's shortest and farthest parameters and v is the value within the range between 0 to 1 to be mapped.

Step calculation: An agent's step is the result of the sum of all the corrected spatial vectors to its interactants. More formally, $\sum_{i=1}^{n} \vec{v_i} * \Delta_i$, where $\vec{v_i}$ is the unit spatial vector to interactant i, and Δ_i is the difference between the current euclidean distance to i and the expected distance to i. The expected distance is estimated using the Spatial mental model.

[1] `https://vis4.net/chromajs/`

Social viscosity: is estimated at each simulation tick by $\sum_{n=1}^{i} |(c_t - e_t)|/e_t$, where c_t is the current distance between agents at tick t and e_t is the forecast distance between the same agents estimated with the information available at tick t. The result is then normalized by the total number of interactants i at tick t.

Global viscosity: is the average of the social viscosity sv of all agents i at time t, expressed also as $\sum_{n=1}^{i} sv_t/i$.