A Computational Model for Colour Categorization

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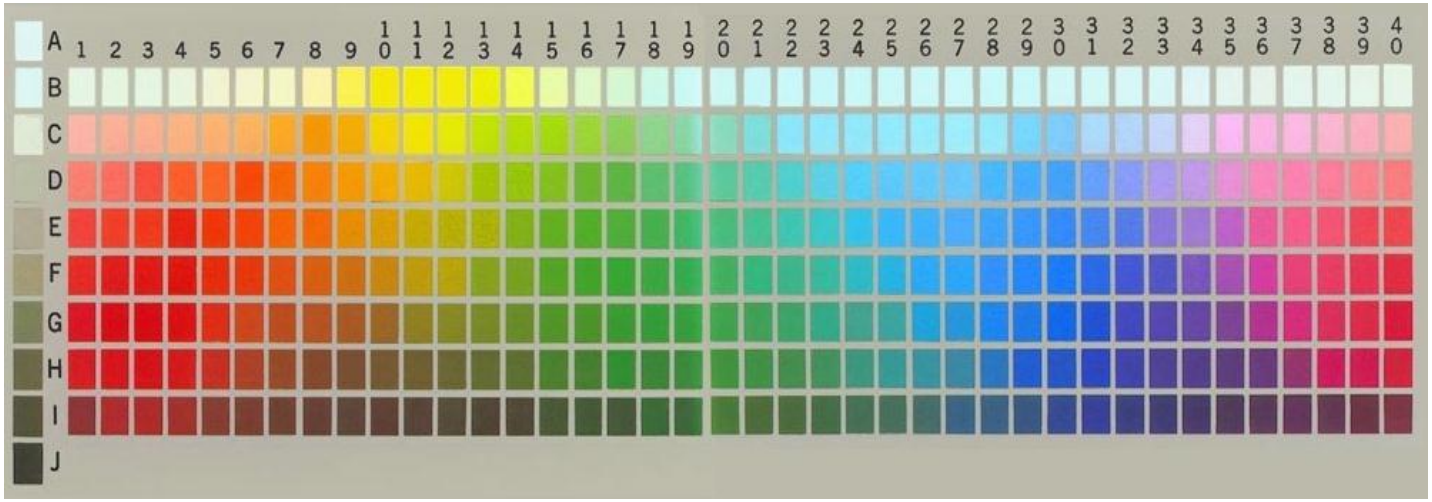
World Color Survey – Berlin & Kay

- The World Color Survey (WCS) was started in late 1970's to test Berlin and Kay's hypotheses about
  - The presence of universal constraints on color naming/categorization across cultures, and
  - The evolutionary progression through which languages gain color terms over time.



Objective

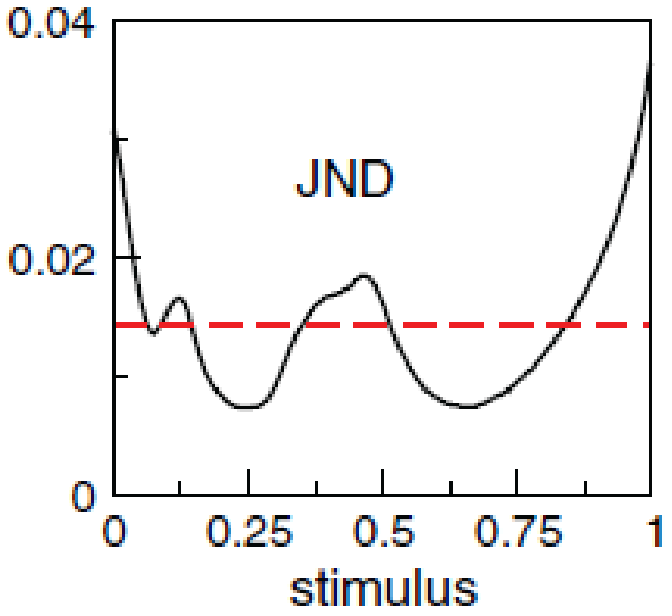
- Baronchelli et al. used a computational model to reproduce the WCS. Through elementary language games, different populations develop their independent categorization systems.

- Their model seemed to achieve the quantitative agreement with WCS data.

- Our objective is to replicate the work done by Baronchelli et al. and check its consistency with WCS data.

Human Just Noticeable Difference Function

- The human JND is defined as a function of the wavelength of various colours in the visible spectrum.
- In order to distinguish two stimuli from the same scene, they must be separated by at least the distance given by the JND function.



Human JND Function vs. uniform distribution

- It was found out that simulations based on human JND function showed more convergence than the uniform (neutral) JND function.

- Baronchelli et al. suggested that JND causes the emergence of universal patterns that cannot be produced through unconstrained cultural interaction.

Language Game

- The computational model involves a population of N=50 artificial agents.
- Through a number of language games, categories are generated from scratch, i.e., we begin without any predefined categories. As the language games are played, a pattern of linguistic categories for the visible light spectrum is generated.
- This pattern is consistent across the whole population.

Algorithm/pseudo-code

- In the beginning, all the agents (N=50) have a single category with no associated colour term.

- Two agents are selected (speaker and listener) at random and are shown M=2 stimuli at once. Each stimulus is represented by a real number in [0, 1) corresponding to its normalized wavelength and differ by at least the corresponding JND.

- The speaker discriminates the scene and produces an utterance (a new word is added in case of a newly formed category). Each word belonging to a category has an associated score which increases with the number of successes.

- The hearer looks up the word associations of his categories and if he points to the correct category containing the speaker's topic, it is a success and the corresponding word's score increases.

- In case of a failure, the hearer adds the word to his category (after discriminating the scene).

- At the end of all iterations, 10^4 games are played per agent.

Results

- We assumed two different JND functions.
  - Neutral: The average value = 0.0143 is used
  - Discrete approximation to human JND
- In the neutral case
  - The number of categories formed was larger (around 21).
  - The categories were less consistent across agents in this case.

- In discrete approximate JND:
  - Average number of categories per agent was approximately 17.
  - The category boundaries were more consistent across different agents.

Improvements

- The number of categories formed were still large for both the cases.
- Calculation of focal color points of different categories needs to be done.
- The agreement between the category boundaries of different agents needs to be established mathematically.

Reference

The research paper "Modeling the emergence of universality in colour naming patterns," authored by Andrea Baronchelli, Tao Gong, Andrea Puglisi, and Vittorio Loreto; Proceedings of the National Academy of Sciences 2010 vol. 107 no. 6 pg. 2403