A Monte Carlo model for dynamics of applause

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Applause is frequently observed following concerts or speeches, and this social behavior can be attributed to individuals responding to the perceived pressure of others. The actions of a few individuals tend to influence everyone else, leading to a collective response. To explore this phenomenon, I have created a novel Monte Carlo model. The results obtained from this model align well with experimental findings. The analysis focuses on the impact of people's interactions, revealing that longer interaction length and stronger interaction strength facilitate the spread of contagion behavior.

I. STATEMENT OF THE PROBLEM

The sound of applause frequently erupts following a remarkable speech or exceptional concert. The applause typically commences with a few individuals and then crescendos into a resounding thunder, only to subside after several seconds.

It is straight forward to ask: how does a group of people start applauding, and what determines how many others join in and for how long the applause lasts?

The willing of individual's applause is quite affected by others. One theory is that audience applause is triggered by a few individuals who have a lower threshold of embarrassment than the rest of the crowd. The already clapping individuals lower the embarrassment cost for others which caused others more likely to start clapping. According to Mann's work[1], individuals' probability of starting clapping increased in proportion to the number of other audience already clapping.

As the effort of clapping began to exceed their enthusiasm, some individuals stopped clapping, raising the embarrassment cost for the remainder and giving them an incentive to stop. In Mann's work[1], the individuals' probability of stopping clapping are similarly affected by the number of other audience stopped.

II. METHOD

I developed a model based on the idea of Monte Carlo simulation of 2D Ising model[2, 3]. The dynamics of applause could be abstract as random clapping or not by each individual's own willing. That is to say, assuming that only a little fraction of individuals are likely to clap soon after the speech or concert, which denote as the start timet_0. Then influence could be regard as local interaction(the interaction can be any form, what I use in my simulation is Eq. (1) (3)), and it could raise the pressure or lower the embarrassment cost of other individuals who are not yet clapping. Then the willing of the rest individuals could raise up a little, and they are more likely to clap, which will leads to most of the individuals to clap. As for the already clapping individuals, their willing to clap is decayed as time passed, then eventually, the first clapping individual could stop clapping. The stop clapping individuals could raise the embarrassment cost of the clapping individuals(which also could be regard as a local interaction), then the clapping individuals could eventually stop for all.

My simulation is based on the above considerations. Every individual has a state(rest, started clapping and stopped clapping), I use one single map array to store the two matrices $M[0]$, $M[1]$.For $M[0]$, 0 represents rest and 1 represents started clapping, while for $M[1]$, 0 represents rest or clapping and 1 represents stopped clapping. At the initial time, all elements of M are 0, for they are all at rest. The willing of each individual is denoted as a random number which is normal distribution around threshold value + bias($\mathbf{B}$). For the individuals who are at rest, when the willing is larger than threshold value, the individuals would start clapping. Similarly, for the individuals who started clapping, when the willing is less than threshold value, the individuals would stop clapping. The initial bias matrix is all negative numbers $\mathbf{B}_{Min}$ except some 0, meaning that most individuals are embarrassed not to clap at first. Then use a interaction potential

$$V_{start}(r) = \sigma_{start} * \mathbf{exp}(-\frac{r^2}{\sigma_{start}^2}) \tag{1}$$

to act on every individual(as mentioned before, the form of interaction could be chosen arbitrarily). The σ_{start} is the interaction strength(coupling strength), r is the distance. The total potential could be regard as the convolution of map$M[0]$ with interaction matrix. Then the potential will be added as time passes by, therefore the individuals at rest would be more likely to start clap.

When the individuals start to clap, the willing would decrease as time pass by, the pressure from the individuals who stopped clapping would go up, then the bias would goes down. What I used in my code is liner function for decreasing willing:

$$\mathbf{B} = \mathbf{B}_{Max} - (\mathbf{B}_{Max} - \mathbf{B}_{Min}) * (t - t_{start}) / t_{cool} - V_{stop}, \tag{2}$$

which $\mathbf{B}_{Max}$ is some bias number to ensure the individuals to clap for a certain time period, the t_{start} is the time that each individual starts clapping, the t_{cool} is the time that every individual would last clapping, V_{stop} is the interaction potential from stopped individuals:

$$V_{stop}(r) = \sigma_{stop} * \mathbf{exp}(-\frac{r^2}{\sigma_{stop}^2}), \tag{3}$$

the σ_{stop} is the interaction strength(coupling strength), r is the distance. When the individuals stop clapping, they would never clap again. Notice that the interactions are realized in my codes by convolution, the interaction matrices have some certain length for the localization.

III. MAIN RESULTS AND DISCUSSIONS

The simulation result are shown in fig.1. Both the onset and the cessation of clapping follow a sigmoidal curve, with an initially slow uptake of the new behaviour followed by a phase of rapid change and eventual saturation. The result is quite identical to the result of Mann's work[1]. The parameters are chosen carefully to get the same result.

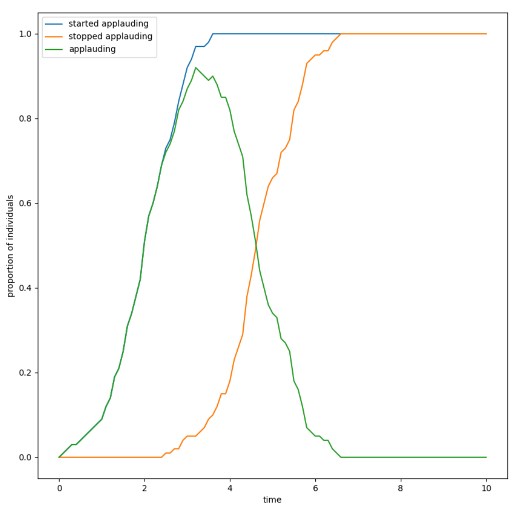


FIG. 1. Simulation results. The plot shows the proportion of individuals who have started clapping (blue line), stopped clapping (orange line) and are currently clapping (green line).

What's more, my simulation has the potential of analysis the effect of different parameters. Above all, the influence of the interaction is most interesting. The coupling strength and the interaction length influence both on the speed and the highest clapping proportion. As shown in fig.2, short interaction length means the individuals could hardly be influenced by others, therefore, the speed of social contagion is slow, then the individuals need more time to start clapping or stop clapping. Since the clapping individuals would stop clapping as long as they clap for certain time, they stop clapping while quite large fraction of individuals still at rest. Therefore, the total clapping proportion is low. For the long interaction length, the situation is quite on the contrary. As shown in fig.3, for low coupling strength, although individuals need more time to accumulate willing to start clapping, they could feel the influence of most individuals, then they could have synchronization action, which means the proportion of clapping individuals is somewhat large.

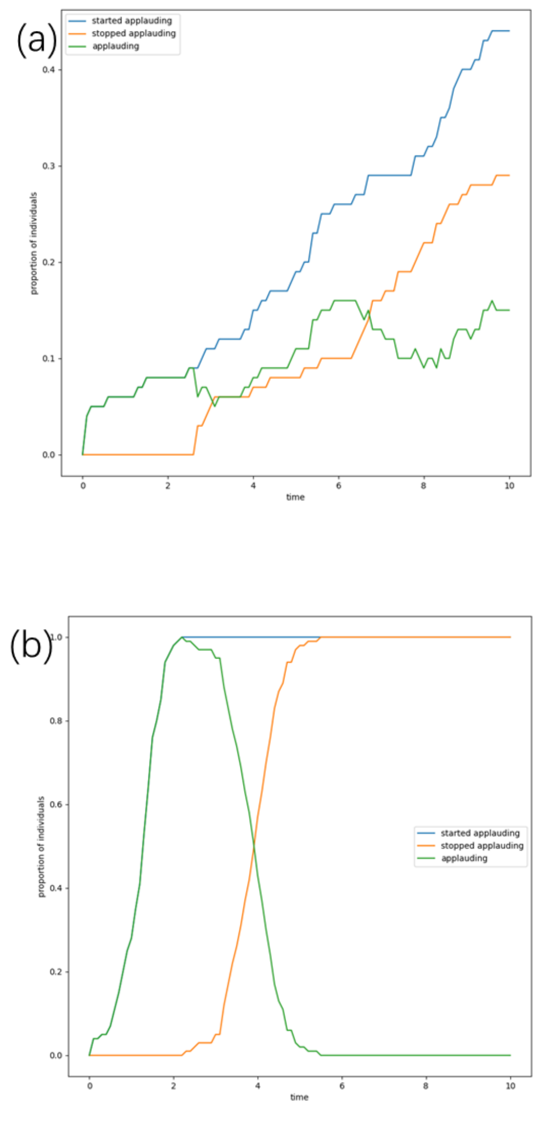
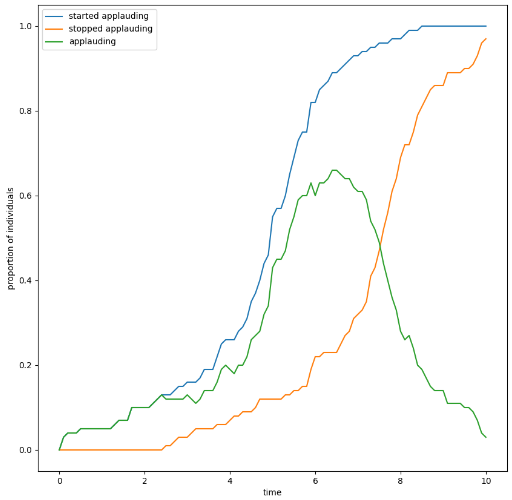


FIG. 2. Simulation results. The plot shows the proportion of individuals who have started clapping (blue line), stopped clapping (orange line) and are currently clapping (green line). (a) short interaction length, individuals need more time to start clapping or stop clapping. And the highest clapping proportion is low. (b) long interaction length, individuals need less time to start clapping or stop clapping. And the highest clapping proportion is 1.



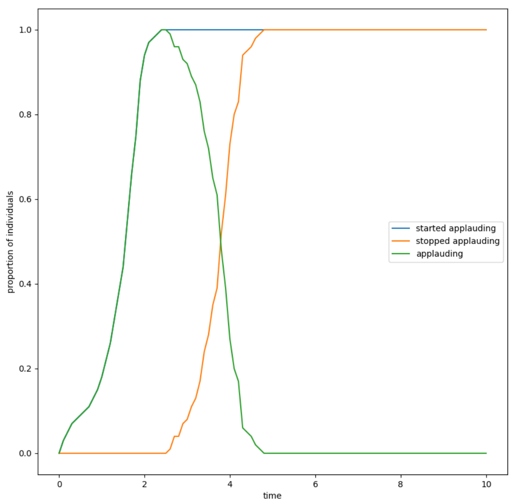


FIG. 3. Simulation results. The plot shows the proportion of individuals who have started clapping (blue line), stopped clapping (orange line) and are currently clapping (green line). (a) low coupling strength, individuals need more time to start clapping or stop clapping. And the highest clapping proportion is low. (b) high coupling strength, individuals need less time to start clapping or stop clapping. And the highest clapping proportion is 1.

Some other parameters are also taken into consideration. For fixed fraction of individuals who have low embarrassment threshold, as the size of group goes up, the contagion behaviour is similar. For fixed number of individuals who have low embarrassment threshold, as the size of group goes up, the contagion behaviour is quite different–the contagion is harder. The t_{cool} can influence the highest applause lasting time.

IV. CONCLUSION

I develop a new Monte Carlo model to investigate the dynamics of applause. The result quite agree with the experiment results of Mann's work. And this new model has more potential to help understanding the social contagion behaviour. The source code could be viewed or downloaded on Github. https://github.com/DCInb/project.git.

[1] R. P. Mann, J. Faria, D. J. Sumpter, and J. Krause, The dynamics of audience applause, Journal of the Royal Society interface **10**, 20130466 (2013).

[2] E. Ising, Beitrag zur theorie des ferromagnetismus, Zeitschrift für Physik **31**, 253 (1925).

[3] N. Metropolis and S. Ulam, The monte carlo method, Journal of the American statistical association **44**, 335 (1949).