Simulating the effects of social mimicking and peer pressure on mask usage during the COVID-19 pandemic.

B Cognitive Science and Artificial Intelligence

Multi-Agent Systems

1991 Words

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Problem Statement

COVID-19 is a highly infectious virus that can be transmitted through droplets that spread when people get too close to each other. The probability of getting infected through droplets can be reduced by wearing a mask (WHO, n.d.). However, a lot of people seem to avoid wearing a mask due to the minor inconvenience that it may cause them. Luckily, human beings are considered “pack animals” (Baaren et al., n.d.), which means that we value the opinion of others and adjust our behaviour to the status quo.

This means that people in our direct environment influence our willingness to wear a mask by asking us to wear a mask. Even if we are not asked to wear a mask, we tend to feel the social pressure to live by the status quo. This means that, as we see more masks around us, we start wearing them on our own initiative without anyone telling us to do so.

However, masks reduce the spreading of the virus, but they do not help build immunity to COVID-19. We currently have a vaccine for COVID-19 that is being mass manufactured and distributed. The vaccine has its distribution limitations and requires skilled staff to apply the vaccine, which means that there’s little to no room to adjust this parameter within our research. Our research is focused on the relationship between wearing a mask, the effect of social pressure to wear a mask and the spreading of COVID-19.

Our research question is stated as follows:

What is the effect of social pressure and social mimicking on the use of masks during the COVID-19 pandemic, whilst people are getting vaccinated?

Model Description

The purpose of our experiment is to measure the extent of the effect that social pressure has on mask usage and how that consequently affects the spread of COVID-19 in a select population. In order to successfully achieve this with realistic results we've created an Agent-Based Analytical Model in NetLogo.

The model works as follows: on setup, mostly white agents are generated, with some amount of masked and infected agents. On go, the agents start moving and interacting with each other, which will spread the virus from the initial infected population to the rest of the susceptible population. As the masked agents walk around, they attempt to "convince" other agents to wear masks. If they succeed, more and more agents will start using masks and the rate of infection should slow down. If infected agents recover, they cannot be infected again. If an agent dies, they cannot spread the virus. There is also a vaccine mechanic: on every tick, a random percentage of the population is vaccinated. This subset of the population cannot be infected again. The sliders and variables that govern agent behavior are explained below.

In order to realistically monitor the effects of social pressure and mimicking, we included factors such as *friends-recommendation* and *social-mimicking* into our model. Both these sliders range from 0 to 100 which determines the probability of successfully convincing an agent to wear a mask. The friends-recommendation aims to mimic the real life occurrence of people influencing their friends to wear masks. Agents within the range of one tile will receive recommendations of mask wearing agents to wear one as well. The *social-mimicking* factor aims to replicate the occurrence of people adjusting to their environment. Any agent not wearing a mask has a probability to start wearing one when a mask wearing agent is present within a range of 3 tiles. These options allow us to vary the total “influence” these factors have when “convincing” other agents to wear masks.

We also added a *vaccine* slider which determines the percentage of the population that gets vaccinated every tick. This slider ranges from 0% to 2%, as percentages within this range accurately reflect vaccination percentages within the EU at time of writing (Roser et al., *Coronavirus (COVID-19) Vaccinations* 2020). The agents in our model represent people normally interacting with each other during the COVID-19 pandemic and we monitor the agents and their current state.

We have set the *initial-population* slider to range from 0 to 1000 so that we have the option to measure social mimicking and recommendations in smaller groups where friend recommendations would play a bigger role, as well as in larger groups where social mimicking would be more prevalent. All unmasked agents are considered to be initially healthy and have the same probability of getting sick from COVID-19 in order to simplify the project.

The initial number of agents that wear a mask are determined by the *masked-pop* slider. This slider ranges from 0 to 100 and it determines how much of the initial population will be generated with masks. Since agents who wear a mask have a lower probability of getting infected, we also included the *mask-infection-prob* to help us set a different infection probability for agents that wear a mask. The *mask-infection-prob* slider ranges from 0% to 10% due to the low probability of getting infected when wearing a mask. All the other agents that are in the simulation rely on the normal *infection-prob* slider in order to get infected. We chose to let this slider range all the way from 0 to 100% in order to accommodate for future variants of COVID-19 that may be highly contagious, as well as for other viruses.

Masked and unmasked agents both rely on the same *severity-rate* and *recovery-prob* sliders that range from 0 to 100% in order to die or recover after they get infected. Dead agents remain in the simulation in order to preserve the total count but they cannot interact with or be affected by any other agents. The same holds true for agents that have been vaccinated. Each tick in our model represents the passing of one day and we intend to monitor and interpret the results after 50 ticks. We also added a graph to help visualize the progression of the virus by keeping track of the number of each agent type over time until the stop condition is met or the simulation is manually stopped. The stop condition for our model is when all agents are either vaccinated or dead.

We decided to use multiple colors in order to highlight the state of each agent and to make it easier to understand the stages the simulation is going through. The colors we decided to use and what they represent are explained below:

Color	State
White	Initial state (unaffected)
Violet	Mask wearing agents
Yellow	Infected with mask
Orange	Infected
Green	Recovered
Blue	Dead
Brown	Vaccinated Agents

Our model can also be modified to accommodate different variations of COVID-19 or any other potential airborne viruses because of the sliders we chose to implement.

Results

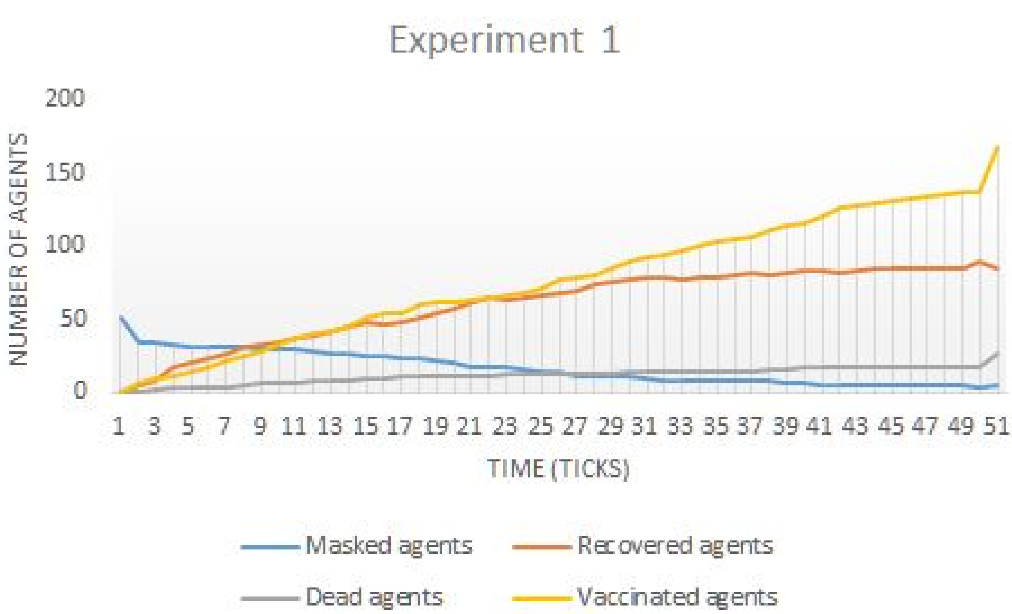
We decided to divide our experiments in three categories. Experiment 1 would simulate a scenario where there is absolutely no social pressure; therefore *friend-recommendation* and *social-mimicking* were set at 0. The other parameters were fixed throughout the all three experiments:- *infection-prob : 15, vaccine : 1, mask-infection-prob : 2, recovery-prob : 10, severity-rate : 2 and masked-pop : 10.*

We gathered data regarding the accurate statistics about COVID-19 (WHO, n.d.) and we decided to implement said statistics and use them as our default values so that we limit the chance of getting random errors. Experiment 2 would simulate moderate social pressure and mimicking and will act as our control group. We will be setting *friend-recommendation* and *social-mimicking* at 10 each because we assume that to be the median scenario. Finally, Experiment 3 will simulate a best case scenario where we drastically increase *friend-recommendation* and *social-mimicking* by setting them to 25. We will run 10 behavior space simulations for each experiment and set their ticks to 50 to get values that may be more representative of the actual scenario. We chose to set our initial population to 400 because we feel it was an appropriate amount where social mimicking and friend recommendations would occur without overshadowing the other.

The results after running Experiment 1:

	Vaccinated	Masked	Recovered	Dead	Infected (no mask)	Infected (mask)
Minimum	0	4	0	0	0	0
Median	87	20	61	15	14	2
Mean	82.1	20.9	54.3	13.8	16.4	2.7
Maximum	168	51	90	27	47	9
Standard Deviation	44.8	9.8	22.9	6.8	12.4	1.9

Table 1.1

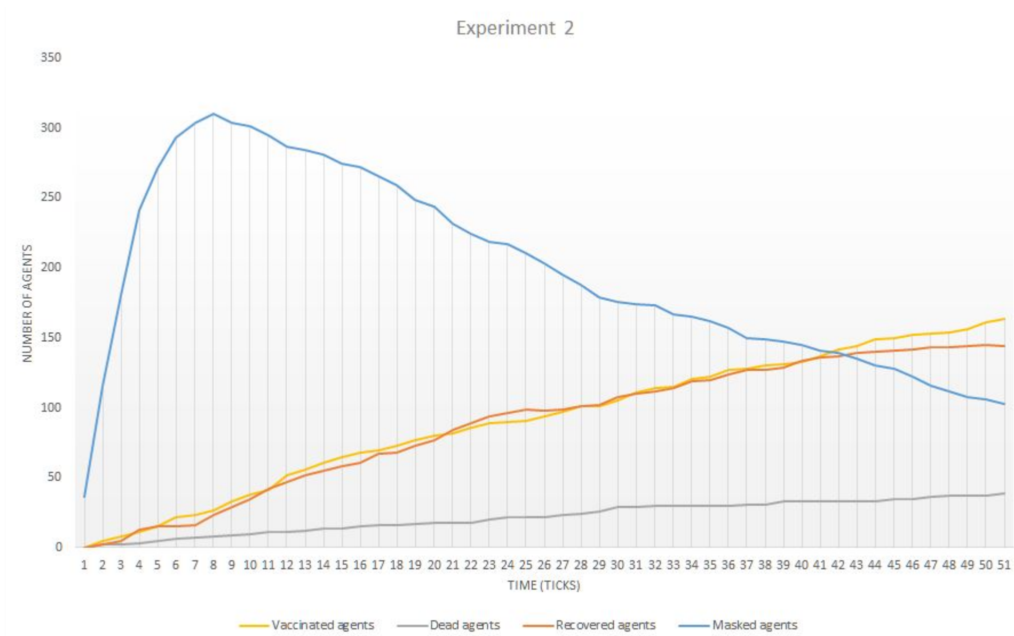


Graph 1.1

The results after running Experiment 2:

	Vaccinated	Masked	Recovered	Dead	Infected (no mask)	Infected (mask)
Minimum	0	36	0	0	0	0
Median	86	162	88	17	2	22
Mean	81.4	171.1	78.2	17.4	8.5	21.5
Maximum	164	310	145	39	46	42
Standard Deviation	44.2	65.9	38.3	10.8	11.3	9.7

Table 2.1

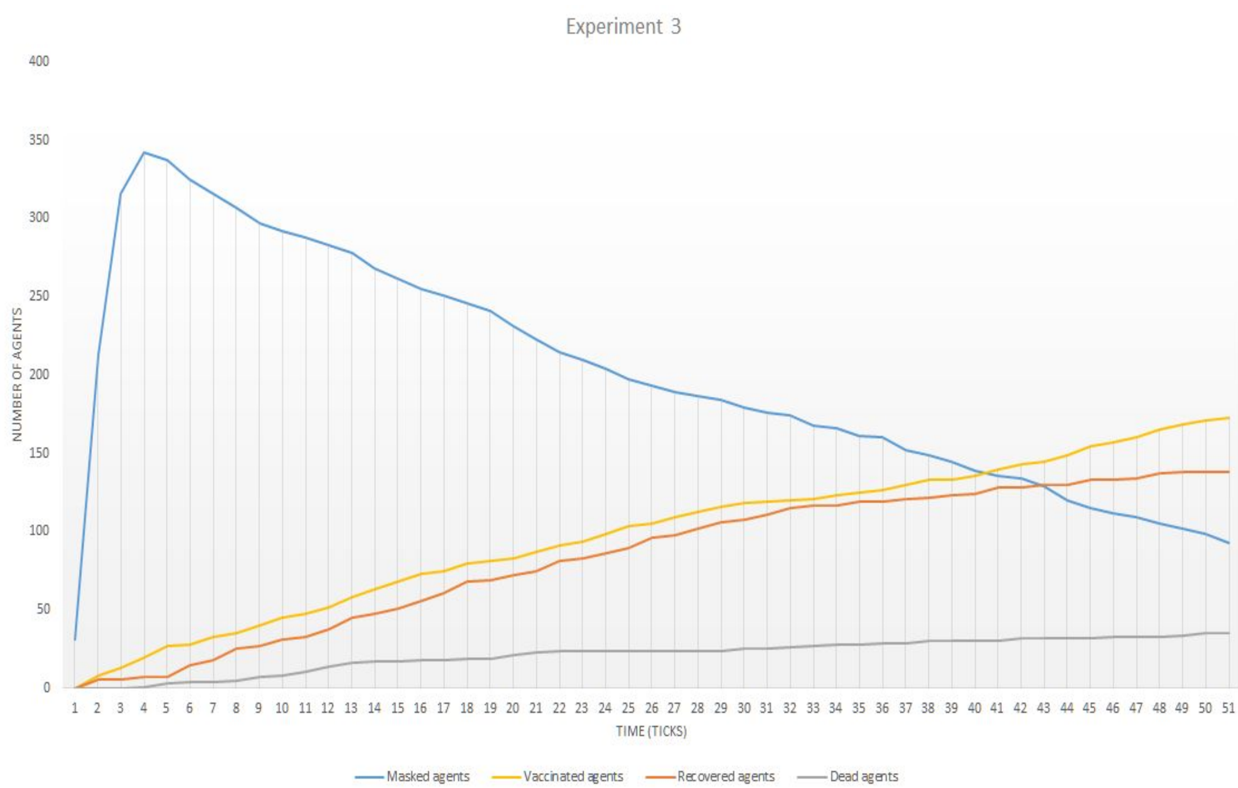


Graph 2.1

The results after running Experiment 3:

	Vaccinated	Masked	Recovered	Dead	Infected (no mask)	Infected (mask)
Minimum	0	31	0	0	0	0
Median	88.5	171.5	89	18	1	22
Mean	84.2	180.9	79.8	17.3	6.6	20.7
Maximum	173	342	138	35	42	35
Standard Deviation	44	75.7	38.9	9.8	10.1	7.3

Table 3.1



Graph 3.1

From the results after running the three experiments we do notice that there does exist a correlation between social pressure, mimicking and the number of masks that our agents wear. As the number of masks worn increases we know that the number of COVID-19 cases drop due to the restrictions of transmission methods. We also noticed rather similar means for Vaccinations through all 3 Experiments which are 81, 84 and 82.

Our results demonstrate that the mask usage significantly increases as we double down upon *friend-recommendation* and *social-mimicking* but after a certain point it seems like additional social pressure only results in small increases in mask usage with respect to ticks. This is highlighted by graphs 3.1 and 2.1, where we see the right skewed distribution for the masked agents line. The cumulative mean of the total infected agents were approximately the same in the control group and Experiment 3 and they were approximately 26 and 28 respectively. Since the mask usage in Experiment 3 and Experiment 2 were approximately the same it also makes sense that the amount of infections would approximately be the same. General social pressure did aid in spreading mask usage. However, after a certain point, additional social pressure did not seem to have a significant additional effect on the number of masks worn.

With our resultant data we have successfully demonstrated that *friend-recommendation* and *social-mimicking* have been successful in urging agents to wear masks. Along with the widespread usage of masks we can look at the mean results for infected masked agents throughout the experiments and state that the number of cases go down as wearing a mask is proven to be effective in reducing the spread of COVID-19. However, the results did vary from our expectations. We did not expect to see the total number of infected people between the control group and Experiment 3 to approximately remain the same. The final tick results for infected masked agents and infected non masked agents for all three experiments *(Experiment 1: mask 2 and no mask 7; Experiment 2: mask 14 and no mask 0; Experiment 3: mask 12 and no mask 0)* also gave us results that we may not have expected. However, the results proved that there is a limit to the effectiveness of social pressuring and mimicking. On a larger scale we believe that a limit may exist, however it may be drastically higher due to higher maximum population and lower chance of agent interaction for persuasion.

Conclusion

After our experiments and simulations, we can conclude that social pressure and mimicking do have a positive relationship with the amount of masks being worn by agents which in turn results in fewer cases of COVID-19. The findings seemed to be consistent with our primary research question. However, one could question their validity when the other means from the experiments are taken into account. Our experiments were also run with 400 agents, this number is a very small representation and we believe our findings are suitable for smaller scenarios. If one were to use our findings and generalize them to a much larger population we would probably have inaccurate results. Our model had our agents interacting with each other on a daily basis (every tick) and we lacked social distancing measures. Taking these downsides into account, we can conclude that our model is effective for smaller communities that consist of agents that rely on each other in order to function or communities such as schools or universities where people are constantly interacting with each other.

Overall the experiment did help us answer our research question: yes, social pressure does result in increased mask usage. However, it does raise many other questions in regards to how effective social pressure and mimicking is in larger groups where some agents may advocate against masks and at what point does increasing social pressure result in diminishing returns. For a future experiment it could be interesting to experiment with a group of agents who advocate against masks and measure these agents' impact on the population's mask wearing habits, as well as the spread of COVID-19 within that population.

References

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Berezow A. (2020). *Covid infection fatality rates by sex and age*. American council on science and health. Retrieved from: https://www.acsh.org/news/2020/11/18/covid-infection-fatality-rates-sex-and-age-15163

WHO. (n.d.). *"WHO Coronavirus Disease (COVID-19) Dashboard".* Retrieved from: https://covid19.who.int.

Yang, C. and Wilensky, U. (2011). NetLogo epiDEM Basic model. http://ccl.northwestern.edu/netlogo/models/epiDEMBasic. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL

Roser, M., Ortiz-Espina, E., Dr, Ritchie, H., Dr, Hasell, J., Giattino, C., Dr, & MacDonald, B., Dr. (2020). Coronavirus (COVID-19) Vaccinations. Retrieved January 14, 2021, from https://ourworldindata.org/covid-vaccinations

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Appendix A

```
turtles-own [
  infected?
  mask-use
  severe?
  cured?
]

to setup
  clear-all
  reset-ticks

  create-turtles initial-population [
      set shape "person"
      set color white
      setxy random-xcor random-ycor
  ]

  ask turtles [
      if random 10 < 1 [
      set color orange
      ]
  ]

ask turtles [
      if random 100 < masked-pop [
      set color violet
      ]
   ]
end

to go

  ask turtles [
      rt random-float 361
      fd 1
  ]


;;this part of the code was referenced from
;;https://netlogoweb.org/web?https://raw.githubusercontent.com/Sumidu/covid
19shiny/master/infections.nlogo
```

```
      ask turles [
      if (color = orange) or (color = yellow) [
      ask turtles in-radius 1 [
      if random 100 < infection-prob [
      if color = white [
      set color orange
            ]
           ]
          ]
         ]
        ]

  ask turtles [
      if (color = orange) or (color = yellow) [
      if random 100 < severity-rate[
      set color blue
      ]
    ]
  ]
;We expect the infection probability of an agent wearing a mask to be
different than an agent who is not wearing one.
;Therefore, violet agents will have a different probability of getting
infected.
  ask turtles [
      if (color = violet) [
      if random 100 < mask-infection-prob [
      set color yellow
      ]
    ]
  ]
   ask turtles [
      if (color = yellow) or (color = orange) [
      if random 100 < recovery-prob [
      set color green
      ]
    ]
  ]
  ;This procedure will mimic the social influencing effect. Agents who are
in the habit of wearing a mask will ask
  ;or recommend their friends to also wear a mask to limit the probability
of getting infected.
;;this part of the code got inspired from
;;https://netlogoweb.org/web?https://raw.githubusercontent.com/Sumidu/covid
```

```
;;19shiny/master/infections.nlogo
;; we've modified the code regarding the in-radius range, color used, and
friends-recommendation parameter.


ask turtles [
      if (color = violet) [
      ask turtles in-radius 1 [
      if random 100 < friends-recommendation [
      if (color = white) [
            set color violet
           ]
        ]
      ]
    ]
  ]

  ;This procedure aims to mimic the social influencing effect, but
different from the previous procedure.
 ;the code below aims to mimic the "social herd" effect, which means that
people will behave like others do.
 ;the people in the model will have a chance to mimic the behaviour of
others by seeing them wear a mask (being in range).
 ;This effect is considered less effective than close friends (see
procedure above) and therefore has a different slider.

ask turtles [
  if (color = violet) [
      ask turtles in-radius 3 [
      if random 100 < social-mimicking [
      if (color = white) [
            set color violet
        ]
      ]
    ]
  ]
]

ask turtles [
      if (color = white) or (color = yellow) or (color = orange) or (color
= violet) or (color = green) [
      if random 100 < vaccine [
      set color brown
```

```
      ]
    ]
  ]

  if complete? [
      stop
  ]
tick

end
;; Report procedure code obtained from
https://netlogoweb.org/web?https://raw.githubusercontent.com/Sumidu/covid19
shiny/master/infections.nlogo
to-report complete?
  if (count turtles with [color = orange] = 0) and
  (count turtles with [color = yellow ] = 0) and
  (count turtles with [color = violet ] = 0) and
  (count turtles with [ color = green ] = 0)

  [ report true]
  report false
end
```

Appendix B - Netlogo interface