**Using Machine Learning to Generate Novel Hypotheses: Increasing Optimism about Covid-19 Makes People Less Willing to Justify Unethical Behaviors**

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**Supplementary Materials**

**Study 1: Variable Response Graph**

Figure S1. Shape of the relationship between three of the 10 top predictors from the deep learning model and the dependent variable.



**Supplementary Study 1: Conceptual Experimental Replication**

 Supplementary Study 1 tested the hypothesis that experimentally manipulating optimism would reduce people’s tendency to perceive unethical behaviors as justifiable. We did so in the context of the Covid-19 epidemic.

**Method**

**Participants.** As this was our first experiment on this topic, we assumed a medium effect size of Cohen’s *d* = .40 (Gervais, Jewell, Najle, & Ng, 2015). A power analysis with this effect size, α = .05 (two-tailed), and power = 80% indicated that we need to recruit 200 participants. A survey seeking 200 US residents was posted on Amazon’s Mechanical Turk. In response, 216 participants completed the survey (*M*age = 38.64, *SD*age = 12.91; 120 women, 95 men, 1 missing value). All responses came from unique IP addresses. Participants were randomly assigned to either the *optimism* conditionor the *pessimism* condition.

**Procedure.** We used the same experimental manipulation as in Study 3 in the main manuscript, but used a somewhat different dependent variable. Specifically, we asked participants to rate the extent to which they find five unethical behaviors related to the Covid-19 situation justifiable: (1) “it is OK to just go to work directly after returning from another country with infections without telling anyone,” (2) “it is OK for companies to not give employees sick leave,” (3) “it is justifiable to take masks and hand sanitizer from office to home,” (4) “it is OK for the government to cover up bad news about the coronavirus,” and (5) “if people are afraid of testing positive for the coronavirus, it is OK for them to just stay home and not go to the hospital to get tested” (see the full items on page 7). Participants were asked to respond on a 11-point scale ranging from “-5 = definitely express my disagreement” to “5 = definitely express my agreement” (α = .69).

**Results**

We excluded 24 participants from our final analyses because they provided gibberish or irrelevant responses to the open-ended question asking them to summarize the main point of the information provided in the scenario (see page 12 for the responses that were judged to be gibberish).

An independent-samples *t*-test revealed that participants in the *optimism* condition thought that the future of the coronavirus situation was more bright (*M* = 4.49, 95% CI [4.23, 4.76], *SD* = 1.28) than those in the *pessimism* condition (*M* = 3.47, 95% CI [3.17, 3.78], *SD* = 1.54), *t*(190) = 4.97, *p* < .001; Cohen’s *d* = .72, 95% CI [.42, 1.01]. This finding indicates that our experimental manipulation was successful.

Another independent-samples *t-*test found that participants in the *optimism* condition were more likely to express disagreement with the unethical behaviors (*M* = -3.03, 95% CI [-3.36, -2.70], *SD* = 1.62) than those in the *pessimism* condition (*M* = -2.36, 95% CI [-2.70, -2.00], *SD* = 1.75), *t*(190) = 2.77, *p* = .006; Cohen’s *d* = .40, 95% CI [.11, .68]. This experiment thus provided causal support for the hypotheses generated by the machine learning analysis: increasing participants’ optimism about the Covid-19 epidemic reduced the extent to which they justified unethical behavior related to the epidemic.

**Supplementary Study 2: Pre-registered Replication**

The goal of this study was to test whether the findings of Supplementary Study 1 replicate with a different group of participants. We thus run a pre-registered direct replication of Supplementary Study 1. We pre-registered the methods and results of this study at https://osf.io/4eaw9/.

**Method**

**Participants.** We conducted a power analysis based on the effect size found in Supplementary Study 1 (Cohen’s *d* = .40), α = .05 (one-tailed), and power = 88%, which indicated that we need to recruit 200 participants. A survey seeking 200 US residents was posted on Amazon’s Mechanical Turk. In response, 207 participants completed the survey (*M*age = 39.00, *SD*age = 12.69; 98 women, 106 men, 3 other). All responses came from unique IP addresses. Participants were randomly assigned to either the *pessimism* condition or the *optimism* condition.

**Procedure.** The methodsof this study were identical to those of Supplementary Study 1.

**Results**

Participants’ responses to the five unethical behavior scenarios were highly intercorrelated (α = .72) and thus averaged. As per the pre-registered plan, we excluded 31 participants who provided gibberish or irrelevant responses to the open-ended question asking them to summarize the main point of the information provided in the scenario (see pages 13-14 for the responses that were judged to be gibberish).

An independent-samples *t*-test revealed that participants in the *optimism* condition thought that the future of the coronavirus situation was more bright (*M* = 4.49, 95% CI [4.19, 4.80], *SD* = 1.41) than those in the *pessimism* condition (*M* = 3.56, 95% CI [3.21, 3.92], *SD* = 1.69), *t*(174) = 3.97, *p* < .001; Cohen’s *d* = .60, 95% CI [.30, .90]. This finding indicates that our experimental manipulation was successful.

The five-item measure of justifiability of unethical behaviors had high reliability, α = .85. Another independent-samples *t-*test found that participants in the *optimism* condition were less likely to find unethical behaviors justifiable (*M* = -3.19, 95% CI [-3.47, -2.90], *SD* = 1.34) than those participants in the *pessimism* condition (*M* = -2.61, 95% CI [-3.06, -2.17], *SD* = 2.11, *t*(174) = 2.15, *p* = .016 (one-tailed, given the pre-registered directional hypothesis); Cohen’s *d* = .32, 95% CI [.03, .62]. This study thus provided a pre-registered direct replication of Supplementary Study 1.

**Experimental Manipulation of Optimism**

**[Optimism Condition]**

Imagine that you are in a restaurant or bar, chatting with a small group of your closest friends.

You and your friends are discussing the recent outbreak of the new coronavirus Covid-19 all over the world.

One of your friends says that the future of this epidemic is looking bright. She mentions that many countries have imposed lockdowns, preventing people from traveling and gathering in public places. China’s experience shows that locking down cities can practically stop the virus from spreading within two months. So within two months, the virus should be contained.

Another friend mentions that a vaccine will be developed much sooner than expected. Earlier scientists were saying that it will take 18 months to develop a vaccine, but a German company already has a vaccine ready. Within 6 months, everyone in the world can get the vaccine and end the coronavirus epidemic.

A third friend mentions that people and companies are taking steps to reduce contagion. She says that most companies have asked people to work from home. Most schools and colleges are closed. People are washing their hands more often and wearing masks in the public. People are going out less often. People are traveling less. Most people are staying at home. Because of these steps, the rate of new infections is guaranteed to go down.

You agree with your friends’ points. You argue that more and more countries are imposing lockdowns, prohibiting public gatherings and traveling, and producing more medical supplies, such as test kits. Very soon, we will be able to fight back the virus.

Overall, all of you agree that the future of the coronavirus situation is looking bright.

**[Pessimism Condition]**

Imagine that you are in a restaurant or bar, chatting with a small group of your closest friends.

You and your friends are discussing the recent outbreak of new coronavirus Covid-19 all over the world.

One of your friends says that the future of this epidemic is looking very bleak. She mentions that although many countries have imposed lockdowns, preventing people from traveling and gathering in public places, the lockdowns are not strict enough. Democratic countries cannot control their citizens like China can. So it will be very difficult to contain the virus.

Another friend mentions that a vaccine takes much more time to develop than expected. Earlier scientists were saying that it will take 18 months to develop a vaccine, but recent reports say that this estimate is too optimistic. Within that time, everyone in the world will catch the coronavirus, so the vaccine won’t be of any use.

A third friend mentions that people and companies are not taking enough steps to reduce contagion. She says that people are still going out of their home for various errands and coming into contact with others. People are not washing their hands often enough, and there is a severe shortage of masks and hand sanitizer. People are still traveling, although less so than before. Because of this, the rate of new infections is still pretty high.

You agree with your friends’ points. You argue that more and more countries are seeing an uncontrolled spread of infections, and don’t have enough medical supplies and test kits. It is very difficult to imagine how they will fight the virus.

Overall, all of you agree that the future of the coronavirus situation is looking very bleak.

**Dependent Measure Used in Study 3**

Next, the conversation between you and your friends turns to what people can do during this coronavirus period in your country.

1. A friend says that it is OK to go to a park that is closed for some fresh air and exercise, especially because there are likely to be very few people in a closed park.

2. Another friend says that it is justifiable to hoard face masks and hand sanitizers given how hard it is to buy them anywhere.

3. A third friend says that we must buy as many groceries as possible and stock up because who knows when supermarkets will run out of food.

4. A fourth friend says that despite all the social distancing guidelines, it is OK to shake hands when meeting someone because otherwise one would appear extremely rude.

5. Another friend suggests that despite the social distancing guidelines, it is OK to get together with a few friends for a drink, as long as everyone doesn’t show any respiratory symptoms.

**Dependent Measure Used in Supplementary Studies 1 and 2**

Next, the conversation between you and your friends turns to how the citizens and the government should do to fight against the coronavirus in your country.

1. One friend says that it is OK to just go to work directly after returning from another country with infections without telling anyone, as long as you don’t show any respiratory symptoms.

2. Another friend says that it is OK for companies to not give employees sick leave given the financial losses that companies are facing.

3. This friend also says that it is justifiable to take masks and hand sanitizer from office to home given how hard it is to buy them anywhere.

4. A third friend suggests that to avoid unnecessary panic, it is OK for the government to cover up bad news about the coronavirus.

5. Another friend suggests that if people are afraid of testing positive for the coronavirus, it is OK for them to just stay home and not go to the hospital to get tested.

**Gibberish or Irrelevant Responses Excluded in Study 2**

After the dependent variable, participants were asked, “Please summarize the main point of the statements that you just responded to in this survey.” The following responses were deemed as gibberish or irrelevant:

1. academic survey

2. DIFFERENT TASK

3. main point was an good.

4. The survey related to ask my daily activities so i give the best of my daily routine.

5. The survey asking my daily routine works so i reply the answer.

6. THIS SURVEY ABOUT THE LIFE MOMENTS

7. ABOUT FOOD RESTAURANT

8. i like this study.

9. That statement contain many social issues in human life.

10. no

11. several task main

12. psychological consequences of exposing people to variability.

13. This survey make me think a lot of my personal opinion. i like it very much for this type of survey. mainly this survey take a decision of each and every one of self confident and personal opinion.

14. good

15. vary use full

16. na

17. To write a survey report, you'll need to include an executive summary, your background and objectives, the methodology, results, and a conclusion with recommendations. In the executive summary, write out the main points of your report in a brief 1-2 page explanation.

18. NOTHING

19. good

20. The way stuff happens in my life

21. good survey

22. marketing

23. How likely you are to go along with the sorority/fraternity

24. [Blank]

25. [Blank]

26. [Blank]

27. [Blank]

28. opinion on different tasks

29. [Blank]

30. [Blank]

**Gibberish or Irrelevant Responses** **Excluded in Study 3**

After the experimental manipulation, participants were asked, “Please summarize the main idea expressed in this scenario in a sentence or two.” Responses that mentioned that the future of the coronavirus was looking bright, bleak, optimistic, or pessimistic were considered valid. The following responses were deemed invalid:

1. stay home. safe everyone

2. In this chapter, please refer to the following grammar key: ... Although both sentences use the same verb, the two sentences have completely different meanings.

3. none

4. The topic is the general subject of a paragraph or essay. Topics are simple and are described with just a word or a phrase. The main idea is a complete sentence; it includes the topic and what the author wants to say about it. If the author states the main idea in his paragraph it is called a “topic sentence.”

5. stay at home

6. Three ways to prevent and contain the Coronvaris.

7. A group of friends gave dissenting views on the coronavirus epidemic, but you were able to come to a conclusion, after careful discussion

8. Basically it talks about the measure being taken buy different governments to reduce the spread of the corona virus and to completely eradicate it..

9. this study are very useful and great information get in

10. it's work is very easily and get more information.

11. it's work very easily and get more information

12. After talking with my friends, we discussed how lockdowns, like the ones in China, would be beneficial to our health and our moving forward with the virus. A vaccine in Germany may already be available .

13. The world is taking steps towards stopping or reducing the spread of carona virus

14. The group is discussing variable things we heard or have heard bout the virus since It first came to light. No one truly knows the outcome.

15. A group or specially and intentionally related sentences; a thought unit; sentences that ... 2. Elaboration of the main idea and supporting details. 3. Restatement of the main idea-summary of main ideas or conclusions.

16. first one we will adjust the restaurant because the corona is a not simple virus it is affect the human body so we will preference the lock down second think we start small scale business that use of the restaurant

17. peoples are stay at home for main idea.

18. proposed ways to contain the virus

19. vaccine will come soon

20. The main idea in the scenario presented about COVID 19 and what the future will be. each one presented his/her beliefs about this epedimic.

21. jukljoj

22. scientists were saying that it will take 18 months to develop a vaccine, but a German company already has a vaccine ready

23. Talking with friends about coronavirus and they all have their own valid points about covid19 like lockdowns, vaccines, and wearing medical equipment.

24. Stay at home is the best way to drop spare the coronavirus, in Germany already have the vaccine and within 6 months we are all shall be ready to fight COVID-19 back.

25. it is trying to find a way to stop the spread of the coronavirus.

26. Discussing the future of the coronavirus with some friends. The expectations and hopes within the next 2 months.

27. The main idea is to convince people the fight against Coronavirus is looking bright. There is no vaccine ready so I don't agree with that.

28. Steps are being made to mitigate or end covid-19

29. The main idea was that coronavirus is going to go down based on how much the Country is doing to stop the spread of the coronavirus. My friends and I were discussing the different viewpoints.

30. corona 19

31. corona virus and bank savings

32. Yes the future seems bleak but if every country starts recognizing it sooner than later, it'll be easier to contain it. All countries need to be aware that there's a high possibility of new infections being discovered if we keep going at this rate. So we should all practice quarantining ourselves until the vaccine is completed or the virus has taken it's course.

33. The uncontrolled spread of the virus is going to make a vaccine obsolete due to quarantine standards not being strict enough.

34. People are having to adjust because of the CoronaVirus. Things are no the same as usual.

35. VERY IMPORTANT ONE

36. The topic is the general subject of a paragraph or essay. Topics are simple and are described with just a word or a phrase. The main idea is a complete sentence; it includes the topic and what the author wants to say about it. If the author states the main idea in his paragraph it is called a “topic sentence.” /

37. People with COVID-19 generally develop signs and symptoms, including mild respiratory symptoms and fever, on an average of 5-6 days after infection (mean incubation period 5-6 days, range 1-14 days). Most people infected with COVID-19 virus have mild disease and recover.

38. it's good service and covid-19 is the hospitalized doctors scenario.

39. sOME AMERICANS ARE TAKING COVID19 SERIOUS AND OTHERS ARE NOT. IT MY SEEM LIKE A CURE IS TO FAR AWAY.

40. The new coronavirus is a respiratory virus which spreads primarily through droplets generated when an infected person coughs or sneezes, or through droplets of saliva or discharge from the nose. To protect yourself, clean your hands frequently with an alcohol-based hand rub or wash them with soap and water. /

41. The corona virus is a serious threat to people's health. It is very contagious and stopping the spread will be difficult.

42. The main idea is the threat of the coronavirus and the outlook of those in the restaurant on how the future with the virus looks.

43. The topic of the precautions being taken over the world surrounding the coronavirus epidemic

44. The world is coming to an end.

45. We are discussing the recent COVID-19 outbreak, and what has been done and whether it's enough.

46. The main idea is trying to stop the spread of COVID-19

47. The outlook of covid-19. The fact that people aren't taking the proper precautions

48. That vaccines arent as looked into as they seem.

49. I am hanging out in a bar with my friends. We are rather hypocritically discussing why we think that COVID-19 is going to get out of hand in part because folks keep leaving their houses and hanging out JUST LIKE WE ARE.

50. That corona's effects are going to last longer than initially though.

51. The future is not totally hopeless, but it looks bad. Each of my friends makes a different comment about how the virus is being fought, and I understand the points each is making.

52. Many people are spreading the virus because they are going about as if it is business as usual. They are not taking the precautions that are necessary to prevent it’s spread

**Gibberish or Irrelevant Responses Excluded in Supplementary Study 1**

After the experimental manipulation, participants were asked, “Please summarize the main idea expressed in this scenario in a sentence or two.” The following responses were deemed invalid:

1. Every paragraph should include a topic sentence that identifies the main idea of the paragraph

2. That if the corona virus is gonna affect us in the future and to see if its safe to come outside and live our lives.

3. I am discussing the current Coronaviruos out break.

4. preventing the spread of the virus to other people and how to limit spread in popular places

5. Locking down the country can expedite the end to this pandemic. I also read about a vaccination that I'm not personally willing to get.

6. i was at a bar with friends and was exposed

7. place the use the mask, 5 mts once hand wase

8. Every paragraph should include a topic sentence that identifies the main idea of the paragraph. A topic sentence also states the point the writer wishes to make about that subject. Generally, the topic sentence appears at the beginning of the paragraph. It is often the paragraph's very first sentence

9. The pace at which the virus will spread and the restrictions imposed upon us.

10. All three friends have different opinions. But they are not mutually exclusive and all 3 seem to be true and valid.

11. That people all over the world are working together to prevent and stop the spread of covid19

12. world integration to maintain peace and harmony

13. HOW TO STOP THE CORONAVIRUS FROM SPREADING.

14. the world is taking precautions and steps to control and defeat the virus.

15. We will soon get a vaccine for the virus

16. There are numerous ways to combat the Corona virus. Washing hands, vaccines and social distancing are all ways to fend off the illness.

17. I think No ideas into this scenario.

18. Many people in my peer group have a contextual belief that the Coronavirus epidemic is nearing its influential apex.

19. The friends all have differing opinions and ideals on Coronavirus and when it will be over. They have all heard different things about vaccines and isolation.

20. that there is not cure and we are running out of supplies and we are all going to die

21. People think that they can't be helped, because people are not following directions. But, they are in a public place.

22. Chatting with your friends and each giving their opinions about the Coronavirus.

23. nothing

24. The topic is the general subject of a paragraph or essay. Topics are simple and are described with just a word or a phrase

**Gibberish or Irrelevant Responses Excluded in Supplementary Study 2**

After the experimental manipulation, participants were asked, “Please summarize the main idea expressed in this scenario in a sentence or two.” The following responses were deemed invalid:

1. all hands are on deck to tackle the pandemic and to prevent subsequent outbreak

2. Idea to protect all over the world people from corona virus. To lock down cities

3. safe home

4. Different opinions on what other countries are doing to contain the Covid virus and they differing methods that people agree on the best method.

5. it was vaccine with 6 months

6. She says that most companies have asked people to work from home. Most schools and colleges are closed. People are washing their hands more often and wearing masks in the public. People are going out less often. People are traveling less. Most people are staying at home.

7. NO COMMENTS

8. nice

9. awareness of covid-19..hoe to fight for corona .

10. No idea

11. no idea

12. about virus

13. good action great

14. The summarize in very including in to the survey for accurate of this expressed the idea survey.

15. only note the most important points, using key words and phrases. / read the original text multiple times, ensuring you don't miss any critical points. /

16. outbreak of corona virus 19 all over the world and how much it will take to cure.

17. Ways to stop the pandemic of the corona virus were being discussed.

18. yes

19. The main idea expressed in the scenario is in relation to the COVID-19 virus. Everyone has a different opinion about how the virus outbreak should be handled.

20. one two

21. In this chapter, please refer to the following grammar key: ... Although both sentences use the same verb, the two sentences have completely different meanings. ... A fragment may include a description or may express part of an idea, but it does not ... In other words, summary paragraphs should be succinct and to the point.

22. Everybody is irrational and allowing themselves to be led by the emotions that the press is provoking by giving excessive focus to the issue.

23. corona virus spread all over the world. we will wash hand frequently

24. this is expressed as a corona virus. that is very important know.

25. The different opinions on the coronavirus that are all still in agreement with one another.

26. You are at a bar with your friends discussing the Covid 19 pandemic. One says that we are forced to stay home.

27. The threat of the coronavirus is impacting many countries due to the fact that many people are not following recommendations to stay home.

28. If we want this virus to stop we have to stay indoors and not come in contact with others. We need to find a vaccine soon.

29. That there is no way to stop the spread of the Coronavirus and that everyone will end up getting it.

30. Main idea is to prevent virus from spreading. They are giving different point and examples how to fight it.

31. good