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EMPIRICAL ARTICLE

Magical contagion beliefs operate in reactions of Americans to COVID-19

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Abstract

We assessed the reaction of American adults to scenarios involving explicit types of exposure to live COVID viruses in June 2020, in the first months of the COVID pandemic. Four features of magical contagion are physical contact focus, insensitivity to elapsed time ('permanence'), insensitivity to sterilization ('spiritual essence'), and insensitivity to dose. We demonstrated the operation of all four features in a majority of participants. We also report another dramatic demonstration of the principle of dose insensitivity. When asked for the minimal number of COVID viruses that would have to enter their lung to give them a 50% chance of contracting COVID, more than half of subjects responded with 'one'. Magical contagion should generally function to increase fear and perceived risk of COVID.

1. Introduction

It is easy to imagine a paralyzing and overwhelming reaction to the possibility of infection with COVID-19. After all, it is conceivable that a single COVID-19 virus, in the lung or other body location, on account of its ability to duplicate, could produce a full-scale infection. This fear could be reinforced by the dose-insensitivity feature of magical contagion beliefs; potentially contaminating entities can render a desirable food inedible after very brief contact with it.

The laws or features of magical contagion go back to anthropological texts around the turn of the 20th century (Frazer, 1890/1922; Mauss, 1902/1972; Tylor, 1871/1974), where magical contagion beliefs were considered part of thought in traditional cultures. In 1986, we demonstrated the presence of these beliefs in educated Americans (Rozin et al., 1986, 1989), a finding that has been replicated many times. We have reviewed this on a number of occasions (e.g., Nemeroff and Rozin, 2018; Rozin and Nemeroff, 2002). Lay beliefs in magical contagion (Nemeroff and Rozin, 1994; Rozin et al., 1986; Rozin and Nemeroff, 1990) are present to some degree in all adults who have been tested, including some hunter-gatherers or subsistence agriculturalists (Apicella et al., 2018) and also in children over 4 years of age in both the United States and India (Fallon et al., 1984; Hejmadi et al., 2004; Siegal, 1988).

Magical contagion is a feature of the disgust response to foods and other entities, including people from other groups and immoral people (Rozin et al., 1986, 1989). Many scholars believe that the emotion of disgust, and the associated magical contagion principles, evolved in humans as a protection against microbial contamination (e.g., Curtis, 2013; Oaten et al., 2009; Tybur et al., 2013).

We will describe magical contagion as a transfer of 'essence' from one object to another. Disgust has become an area of great interest in psychology, but contagion has not; much recent work on contagion has originated in marketing (Huang et al., 2017; Morales et al., 2018).

The features of magical contagion beliefs are as follows:

1. Physical contact is usually involved in contagion: Although it is neither necessary nor sufficient (Huang et al., 2017; Kim and Kim, 2011; Morales et al., 2018). It is not simply an association that is accomplished by contact, though that can occur. There is a transfer of essence over and above any associative effects (Fedotova and Rozin, 2018). The contact principle is most important in the context of infection. The contact principle might act to reduce fear of airborne pathogens which do not usually engage a sense of contact.
2. Dose insensitivity: Tiny amounts of transfer, operationalized as very brief contact or very low dose transfer, are sufficient to produce a full-blown negative response. Thus, less than a second contact between a dead cockroach and a desirable juice renders the juice disgusting and inedible (Nemeroff and Rozin, 1994; Rozin et al., 1986).
3. Permanence: Passage of time, including long intervals like months, does little to degrade potency. An entity, for example, a juice, contacted by a disgusting entity, typically remains disgusting indefinitely. Mauss (1902) describes this as 'Once in contact, always in contact'.
4. Spiritual transfer of essence: In many cases of contamination, the negativity to the contaminated entity remains even though all possible particles of the contaminated entity are removed, for example by repeated rinsing or filtering. When the contaminant remains, elimination of its potency (e.g., by sterilization) often does not completely eliminate negativity. Magical contagion may be indelible; no physical manipulations can eliminate it (Nemeroff and Rozin, 1994).
5. Backward contagion: In the anthropological literature, the classical instances of magical contagion involve the possession of a residue of a person A (e.g., hair, fingernail parings) by that person's enemy (person B). Person B then does harm to the residue of person A (e.g., burns it). This is believed to harm person A. The residue is believed to contain the essence of person A, and harming the essence harms the person. This is, of course, reverse causation, or backward contagion. We have established backward contagion beliefs in most American adults, although the effects are substantially smaller than forward contagion (Rozin et al., 2018).
6. Negativity dominance: Magical contagion effects can be positive or negative, in both cases consistent with the idea of passage of essence. However, negative contagion effects are more common and more potent (Rozin and Royzman, 2001).

These features of magical contagion may not be entirely independent of one another. For example, a spiritual, as opposed to physical essence, may be more likely to show permanence.

About three decades ago, with AIDS as a major threat, the operation of magical contagion beliefs in reactions to AIDS was assessed (Nemeroff et al., 1994; Rozin et al., 1992). In both studies, with American undergraduate participants, negative feelings to contact with sweaters that had been worn or forks that had been used, by men with AIDS (vs. healthy men) were measured. Evidence was presented showing the negative responses that would be predicted by physical contact, permanence, dose insensitivity, and backward contagion. Effects were substantial for all but backward contagion.

In light of the great current threat of COVID-19, in this study, we determine whether magical contagion beliefs hold for the COVID-19 virus. In particular, we test for the belief in physical contact, dose insensitivity, permanence, and spiritual essence contagion. In comparison to the AIDS studies, in the present study, we add the spiritual essence feature but drop backward contagion, we use scenarios that explicitly involve exposure to specified numbers of viruses, and our subjects are American adults as opposed to students. The transmission situation is very different for AIDS and COVID, since COVID is principally airborne, a route that is not implicated in AIDS.

Understanding how people think about the COVID virus is of interest in itself, and may help in encouraging people to take precautions, or preventing them from overreacting. In general, magical

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contagion beliefs should operate to increase fear of contagion, particularly dose insensitivity, permanence, and spiritual contagion.

The applicability of the contact principle is problematic for COVID-19, since the most common route of transmission is airborne, so there is no obvious contact. But there is abundant information and a salient belief that physical contact with surfaces (usually exemplified by hand-surface contact followed by hand-mouth/face contact) is a major route for infection. The salience of this belief in the public and in earlier scientific communication about the virus resulted in many warnings about surface risks, and widespread procedures to wipe down surfaces with alcohol or other sterilizing agents. More recent scientific inputs (e.g., Randall et al., 2021; Zhang et al., 2021) have minimized the contact versus aerosol route of infection. We measure lay beliefs in the importance of surface contact, and suggest that the perceived prominence of contact as a route of infection is itself a manifestation of magical contagion beliefs.

2. Method

A questionnaire was assembled on Qualtrics and distributed to a sample of 198 American residents by Prolific. The data were collected on June 11 and 12, 2020.

The sample was designed to be at least moderately representative, in terms of politics, gender, and age (Section 3).

2.1. Questionnaire

The questionnaire was anonymous, and received approval from the University of Pennsylvania Institutional Review Board, under the 'exempt' category.

The categories of question sets on the questionnaire were as follows: (a) A few items on perceived risk and fear of contracting COVID-19. (b) Some items on exposure to COVID in terms of self, family and friends, and self-rated health. (c) Some items on how many viruses in the lungs or blood would give rise to a 50% chance of contracting COVID-19 or AIDS. (d) An extensive set of items probing the four features of sympathetic magical contagion (presented along with the results). These are the core items for this article, and all involved inhaling viruses under specific conditions in an imagined laboratory setting. (e) Some questions about knowledge of infections, and judgments about risks of exposure. (f) Assessment of relative importance of different routes for contracting COVID-19 (touch vs. inhalation). (g) Frequency of engagement in a variety of behaviors designed to avoid contracting COVID-19; (h) Existing measures of perceived vulnerability to disease (Duncan et al., 2009) and magical contagion sensitivity (Fedotova, 2013) and, (i) Extensive demographics. Three attention check items were included in the survey.

All items were presented in a fixed order except for the two scales near the end (Perceived Vulnerability to Disease, Magical contagion sensitivity), where the items within each scale were randomized.

3. Results

3.1. The sample

Overall, 198 participants took the survey. All completed virtually all items and all passed our criterion of being correct on at least two of three attention check items. The gender distribution was 58% female, with a total sample mean age of 48.0 years (s.d. = 16.8), with a median age of 50. The sample was selected to contain (33 participants in each of 6 groups): 20–39 years old, Republican; 20–39 years old Democratic; 40–59 Republican; 40–59 Democratic; ≥60 Republican; ≥60 Democratic.

Participants were well-distributed geographically: the four most common states of residence were California (25), Florida (24), Texas (12), and New York (11). In terms of education, 61% had at least a Bachelor's degree, while 93% self-classified as lower-middle, middle, or upper-middle class.

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Table 1. *Basic descriptive statistics for each of the reference and transformed stimuli (n = 195).*

Order[1]	Reference or Transform	Mean	S.D.	Median	*n*(%)0[2]	n(%)100[3]
1	RefCmf1000	90.7	17.4	100	0(0)	117(60)
2	RefProb1000	78.9	23.1	87	0(0)	54(28)
3	PalmCmf1000	87.0	20.8	100	0(0)	101(52)
4	PalmProb1000	72.1	26.9	80	1(1)	40(20)
5	FrzCmf1000	75.2	31.9	90	11(6)	76(39)
6	FrzProb1000	52.7	34.7	52	21(11)	23(12)
7	LabCmf1000	72.8	33.2	90	9(5)	77(40)
8	LabProb1000	46.0	35.2	50	25(13)	19(10)
9	MWCmf1000	44.0	37.5	44	26(13)	30(15)
10	MWProb1000	15.8	25.6	2	76(39)	4(2)
11	DICmf1000	46.8	37.2	50	22(11)	34(17)
12	DIProb1000	20.6	26.8	9	44(23)	5(3)
13	FilCmf1000	48.9	37.7	50	21(11)	38(20)
14	FilProb1000	24.7	29.5	10	41(21)	7(4)
15	Cmf1	76.2	31.5	97	2(1)	92 (47)
16	Prob1	53.1	36.4	50	9(5)	35(18)
17	Cmf100	82.9	25.7	100	1(0)	99(51)
18	Prob100	66.0	32.0	71	1(0)	47(24)
	CVLungLog	.89	1.42	0	110(56)	

[1]Order of scenario presentation.

[2]Number and percent of responses at 0.

[3]Number and percent of responses at 100.

Politically, 48% were Democrats, 6% were Independents, and 46% were Republicans. On a 7-point Liberal to Conservative scale ('In general, how liberal or conservative are you?'), the mean score was near neutral, 3.8. The three most common religion self-assignments were Protestant (32%), Atheist or Agnostic (26%), and Catholic (22%), and the most common religiosity rating (5-point scale: not at all to extremely) was 'not at all' (33%). Suburban was the most common residence (63%) and 81% of respondents were White.

Only 4 out of 198 participants had been diagnosed with COVID-19, and none had been hospitalized. In response to the question 'What do you think the percent odds are that you will get COVID-19 disease by June 1, 2021 (1 year from now)?—Please move the slider to indicate the percentage from 0 to 100'. A total of 194 respondents reported a mean of 31.2% (s.d. = 24.0). In response to the question 'How afraid are you of contracting COVID-19 disease? Please move the slider 0 = not at all 100 = as afraid as I can be about anything'. A total of 194 respondents reported a mean of 44.8 (s.d. = 32.7).

3.2. Transformations that determine belief in the laws of contagion

Given that we have a substantial number of subjects (195 or 198), we elected to use a minimal significance level of $p < .01$, 2-tailed. Almost all of the measures we use to determine presence of the four principles of contagion are based on a reference situation, presented first in the series of questions of the same format. The questions were presented in the fixed order indicated in Table 1. The reference scenario was:

> Imagine that there is an 8-ounce plastic squeeze bottle with 1000 intact COVID-19 viruses in the air inside. The bottle is squeezed once in front of your mouth and you immediately take one deep breath in.

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Table 2. *Changes from reference level for four representative transformations (n = 195).*

#	Reference minus transform	Mean diff	# no diff (%)	# diff ≤ 10 (%)[1]
3	PalmCmf1000[2]	3.7	110 (56)	164 (84)
4	PalmProb1000[2]	6.8	52 (27)	118 (61)
7	LabCmf1000	17.9	87 (45)	130 (62)
8	LabProb1000	32.9	27 (14)	67 (34)
9	MWCmf1000	46.7	29 (15)	50 (26)
10	MWProb1000	63.1	5 (3)	16 (09)
15	Cmf1	14.5	95 (49)	123 (63)
16	Prob1	25.8	29 (15)	70 (36)

[1]This is the number of subjects who show a drop of ≤10 points from reference levels, our criterion for magical contagion. This is the number of subjects who meet our strict criterion for magical contagion. This value includes the numbers from the previous column.

[2]Palm has a number of scores $< 0 > -10$: (discomfort: 4; probability: 18).

How uncomfortable would this make you feel?

0 as not uncomfortable at all, 100 as uncomfortable as I can imagine being—From 0 to 100, please move the slider.

What is the percent chance that you would get COVID-19 disease from this one experience?—From 0% to 100%, please move the slider

The discomfort (coded in the variable name as Cmf) and probability (Prob) questions were identical after each transformation. The codes for responses for these two questions were RefCmf1000 and RefProb1000 (where Ref stands for reference and 1000 for the number of viruses). For each transformation, as indicated below, we present the mean, standard deviation, median, and number of instances at the extremes (0 and 100) (Table 1).

The empirical question that the transformation scenarios explored was the degree to which different modifications of this initial high-exposure reference scenario reduced the rated probability of contraction of COVID and discomfort at the exposure experience. This type of transformation/elimination assessment was the basic procedure used for non-COVID exemplars in Nemeroff and Rozin (1994).

The question was varied in terms of the number of viruses, the route of exposure, or the processing of the viruses before spraying into the mouth or on the hand. The same fixed order of questions was used for all participants, beginning with the discomfort and probability measures for the initial, high-exposure situation. The order of presentation is indicated in Table 1.

We measure the effectiveness of each transformation as the reference value (for Cmf or Prob) minus the score for a particular transformation (Table 2). Positive values indicate a mean reduction in potency as a result of the transformation. Three respondents showed 0 discomfort and/or a 0 probability for our reference 1000 viruses into the mouth measures. Since we cannot measure any reduction in potency for a 0 baseline, we eliminated these three respondents from all of our analyses of transformations, yielding a total *n* of 195, There is nothing 'wrong' with respondents who score 0; they just cannot be used for generating meaningful difference scores. We provide statistics for the full reference sample (*n* = 195) on lines 1 and 2 of Table 1. The means in the third column of the first two rows in Table 1 are the two values from which the scores on each transformation are subtracted to indicate the magnitude of transformation reduction.

Our 1000 viruses in the mouth reference situation were very effective for our 195 baseline respondents. For discomfort (Table 1, line 1) the mean was 90.7 with a majority (117, 60%) scoring the maximum of 100). For probability, the mean was 78.9 with 54 (28%) scoring the maximum (100) probability.

There were eight transformations. We present the results from all in Table 1. We used more than one transformation to measure three of the four contagion features. However, for economy in text

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presentation, we only present one exemplar pair (both discomfort and probability) for each contagion feature, and use that transform to stand for its corresponding feature. As can be seen in Table 1, results were very similar for transformations designed to measure the same contagion feature. We always selected the most extreme transformation, that is the transformation most likely to reduce negativity.

3.3. Permanence

We employed two transformations to represent the idea that the COVID potency is resistant to decay over time. One was freezing the 8 ounce bottle with 1000 viruses for 1 year, and then squeezing it in front of the mouth (with inhalation) and the other was leaving the bottle on a shelf in a laboratory for 1 year, and, then squeezing it.

Here is the exact wording: 'Imagine another 8-ounce plastic squeeze bottle with 1000 intact COVID-19 viruses in the air inside. The bottle is placed in a freezer for 1 year. It is then squeezed in front of your mouth and you immediately take one deep breath in'. The standard Cmf and Prob question followed. For the lab version, the words 'placed in a freezer' are replaced by 'placed on a shelf in a clean laboratory'.

The results are presented on lines 5–6 for Freeze (coded Frz), and lines 7–8 for lab shelf (coded Lab; Table 1). We present in text only the results for 'Lab', and include only 'Lab' in Table 2, which displays the differential effect of selected transformations.

The lab condition, exposure at room temperature for 1 year, would destroy all of the viruses according to the data shared publicly on virus survival. (However, our participants may not have known that, and unlike in the subsequent microwave example, we did not state that science tells us all viruses would be destroyed. In retrospect, we should have stated that all viruses, according to science, would be destroyed. The result is that we may have exaggerated the contagion belief for lab, since cases might have believed that there were still live viruses after a year.) Lab showed a reduction in *discomfort* of 17.9 points or 20% ($t(194) = 8.284$, $p < .001$). Forty-five percent (87) of respondents show no change in score from reference level to 1 year in the lab, showing total permanence. A majority (62%) showed less than or equal to a 10-point drop, which we set as a criterion for magical contagion. There is some arbitrariness in selecting a criterion for contagion (essentially, no change). This decision to classify drops of 10 points as equivalent to no change was based on our general experience that changes of this magnitude on the 100-point scale would often appear on reratings of the same stimulus, so that such drops could reasonably be thought to be an error rather than a true reduction. In addition to indicating the percent of subjects showing contagion by the ≤10 point drop, in each case, the percent showing contagion is indicated with the absolute criterion of zero change.

For *probability*, lab caused a larger mean reduction of 42% ($t(194) = 12.588$, $p < .001$) (Table 2). There was no change between reference and lab conditions for 27 (14%) of respondents. Our criterion for a probability permanence effect (≤10 point drop) was met by 34% of respondents.

The two discomfort scores (freeze and lab) correlated .73 (Pearson r) and the two probability scores correlated .58. The lab comfort and probability scores correlated .60. The lab (room temperature) procedure was more effective than freezing by 2.4 points for discomfort ($t(194) = 1.430$, n.s.). and for 6.7 points for probability ($t(194) = 2.909$, $p < .01$. We conclude that there is strong evidence for permanence.

3.4. Spiritual essence

We employed three scenarios to completely eliminate virus risk by sterilization or removal from the inhaled air. Microwave (heat) destroys the viruses, as does disinfection. Filtration removes the viruses. Here are the three scenarios we used, each embedded in the 'standard' squeeze bottle scenario, all eventually squeezed in front of the participant's mouth.

Microwave (MW): 'The bottle is heated in a microwave to 400°F (over the boiling point of water) for one-half hour. This amount of heat is more than twice as much as is needed to destroy any virus.

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The bottle is then exposed to intense ultraviolet light for twice the length of time that will destroy any virus'.

Disinfect (DI): 'The bottle is washed out with anti-virus disinfectant five times, and then rinsed with bottled water 20 times'.

Filter (FI): 'The air in the bottle is then forced through a filter which traps anything bigger than a water molecule and hence all the viruses. The air is sent through a clean filter three times in a row and then enters a NEW squeeze bottle'.

Microwave showed the largest reduction of the three treatments, and is selected here for presentation in the text. The reduction in discomfort for microwave (lines 1 and 9, Table 1; line 9, Table 2) was 46.7 points (52% reduction) ($t(194) = 17.382$, $p < .001$). The median score after the MW transformation was 44. Thirteen percent lost all discomfort (0 score), so that the heat sterilization was totally effective. For microwave, a total of 26% of subjects met the spiritual contagion criterion.

The reduction in probability for microwave (lines 2 and 10) was 63.1 points (80% reduction) ($t(194) = 16.474$, $p < .001$) (line 10, Table 2). The median score after the MW transformation was 2, and 76 (30%) labeled it zero, no chance of infection. Only 9% met our criterion for magical spiritual contagion. Overall, the microwave transformation, for both measures produces the lowest percentage of people who met our criterion for magical contagion, the only case (compared to transformations other than spiritual essence) that falls well below the majority.

The basic results were similar for the three transforms, with a somewhat larger percent of subjects showing magical spiritual contagion for disinfect and filter correlations across comfort and probability for the same transformation varied between .41 and .67.

3.5. Dose insensitivity

We have five measures of dose insensitivity. Four are in the squeeze bottle, discomfort, and probability framework, varying the amount of viruses in the exposure: 1 and 100 in comparison to the reference item of 1000 viruses. A fifth item is of a different sort, asking about the potency of viruses. Here are the standard format four questions, remembering that each of the squeeze bottle sets represents two questions, one about discomfort and one about probability.

> Imagine another 8-ounce plastic squeeze bottle with a single (1) intact COVID-19 virus in the air inside. The bottle is squeezed once in front of your mouth and you take one deep breath in. The single virus enters your lungs.

This item was repeated with 100 viruses in the bottle instead of 1.

The 100 virus item falls between the 1000 and 1 virus questions on all measures (Table 1) showing some overall dose sensitivity. We only discuss the one virus question and the how many viruses question.

The reduction in discomfort for 1 versus 1000 viruses (Table 1: lines 1 and 15) was only 14.5 points (16% reduction) ($t(194) = 8.348$, $p < .001$) (Table 2, line 15). The median score for 1 virus was 97, almost maximal discomfort. For 95 subjects (49%), there was no change in discomfort, and a total of 63% met our criterion for presence of magical contagion.

The reduction in probability for 1 virus (lines 2 and 16) was 25.8 points (33% reduction) ($t(194) = 10.926$, $p < .001$) (Table 2, line 16). The median score for one virus was 50, in comparison to 100 for 1000 viruses. Only 9 (5%) rated the probability of infection as 0, whereas 35 (18%) rated it 100, an extreme version of dose insensitivity, while 36% met our magical contagion dose insensitivity criterion.

3.5.1. The number of viruses question

The question 'How many COVID-19 viruses would have to be in your lungs to give you a 50% chance of contracting COVID-19 disease' gave rather surprising results that strongly indicate dose insensitivity. Five subjects wrote '0' viruses, and their data were discarded for the analysis. The range

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of responses was large, going from 0 to millions, so we used the Log base 10 of the number to contain the range. The mean (as log) was .89 (where 1.00 would stand for 10 viruses), but the median was 0 (1 virus). A total of 110 (56%) scored 1 virus (log = 0), showing a massive example of dose insensitivity. Fortunately, we asked a second question, which was 'How many HIV (AIDS) viruses would have to be in your blood to give you a 50% chance of contracting AIDS?' The answer here reinforces the COVID results: the mean for AIDS was lower (.79) and more opted for the 1 virus response (119 (60%)). The correlation between the AIDS and COVID questions was .92.

3.5.2. Relation of the questions

The validity of surprising results from the 1 virus exposure squeeze bottle format is supported by the number of viruses to result in a 50% chance of infection. The Pearson correlation between the 1 virus probability question and the number of viruses question (both about probability) is −.50. Of the 35 people who rated the probability of getting COVID from 1 virus as 100, 31 also rated 1 virus as sufficient to produce a 50% chance of infection.

Overall, from all questions, there is strong evidence for dose insensitivity in most participants. The average drop from 1000 to 1 is only 14% for discomfort and 26% for probability. On discomfort, 63% of respondents met our criteria and on probability, 36%. On 'How many viruses', 56% met the strictest criterion of 1 virus.

3.6. Physical contact

Contact is the most difficult magical principle to demonstrate. The problem is (a) that we have to assume that breathing in by the air route does not psychologically represent 'contact', and (b) we don't actually know the percent of COVID-19 cases that are caused by airborne as opposed to contacted viruses. It is our sense that the great majority of cases result from airborne viruses. and this is supported by recent estimates (Randall et al., 2021; Zhang et al., 2021). Psychologically and physiologically, the fact that the primary site of infection is the lung, makes the airborne route more salient and likely. On the other hand, magical contagion would produce a bias to physical contact. So contact contagion would argue for exaggeration of the potency or incidence of physical contact as a cause of disease. In that spirit, we have three measures of the relative potency of contact, in comparison to the airborne route. For two of these measures (discomfort and probability), we compare the reference, direct inhalation of 1000 viruses, to a 'comparable' physical contact ('palm') condition which followed it immediately (items 3 and 4 in Table 1).

'Imagine another 8-ounce plastic squeeze bottle with 1000 intact COVID-19 viruses in the air inside. The bottle is squeezed once onto the palm of one of your hands, and then you touch your lip with the palm of that hand'. This was, of course, followed by the discomfort and probability ratings.

This 'palm' condition introduces many fewer viruses into the lung: some sprayed viruses do not land on the palm, some remain on the palm when it touches the lip, and some may not be inhaled from the lip. According to the magical contagion view, the indirect hand-to-lip route should be somewhere between almost as potent as the direct inhalation to even more potent.

The mean discomfort score is 87.0, (line 5 in Table 1) just slightly below 90.7 (line 3 in Table 1) for the reference situation (4% below the reference level; $t(494) = 9.653$, $p < .001$). For 110 (56%) respondents, the comfort scores were identical, and 164 (84%) were within ±10 points (Table 2, line 15), suggesting that for 84% of subjects, the more indirect but real physical contact route was about as upsetting as direct breathing.

The mean for palm probability was 72.1 compared to mouth 78.9, a 6.8 point (9%) drop ($t(194) = 4.963$, $p < .001$) (lines 2 and 4, Table 1). Overall, 27% (52) of respondents showed no change, and 61% (118) showed changes within 10 points, for a total of 61% showing minimal change. There were 44 subjects who showed negative scores, that is the probability after the palm transformation was *higher* than the reference level. Thus, for a moderate number of individuals, palm was actually worse than reference level, strong evidence for the potency of contact.

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Table 3. *Estimates of contraction of COVID by breathing, eating, and touching hand to face.*

Response	Prolific (%) $n = 178$	Datassential (%) $n = 1{,}000$
Breathing	66	51
Eating	8	15
Touching, hand to face	26	32
(Eating plus touching)	34	47

Note: Prolific sample Column 2, and Datassential sample, Column 3.

We consider these results to weakly support the magical principle of contact: the mediation of the palm and the loss of many viruses in this transfer has almost no effect, that is, the contact seems to make up for these losses. Of course, with full-dose insensitivity, one would not expect a difference between direct inhalation and palm contact.

3.6.1. Route of entry

We have a third measure to assess the importance of contact. In a later part of the questionnaire, we posed the following question:

> COVID-19 might be contracted in three different ways: (a) by breathing in air that is contaminated with COVID-19 viruses; (b) by touching viruses on a surface with your hand and then touching your face; (c) by eating food containing the virus.

'What percent of all COVID-19 cases are contracted by_(breathing/touching/eating)_ _:(Place a number from 0 to 100 in each space corresponding to the three ways, such that all three add up to 100)' The results for this question are presented in the second column of Table 3. Of the 195 respondents used in our analysis for the results section, 178 provided three numbers that added up to 100. We were able to get this identical question included on a weekly survey of 1,000 representative Americans distributed by the marketing firm, Datassential on June 3, 2020. The results from this source are in the third column of Table 3. The last row of the table is our sum of the numbers in the Eat and Touch rows, which we use in the analysis as the 'contact' number.

For our Prolific sample, 34% was the mean percentage for a contact source of viruses (touch plus eating), while the corresponding number was 47% for the larger sample. We do not have an accurate source for actual frequency of routes of transmission, but we think these numbers are higher than what are probably the true values (Randall et al., 2021; Zhang et al., 2021). Insofar as that is correct, these numbers could be taken as evidence for some operation of contact contagion. All of our data (including the Datassential survey) were collected within the first 6 months of the public realization of cases in the USA, and at a time when medical sources communicated serious dangers of surface transmission. The professional exaggeration of surface risks may itself have been influenced by magical contagion principles.

3.6.2. Relations of contact scores

For the percent touch + eat, score, the correlation with palm discomfort was $r = .00$ (n.s.) but the correlation with palm probability was $r = .30$ ($p < .001$). The results for the contact measures provide some support for the physical contact principle of magical contagion.

3.7. Discomfort versus probability across all transformations

The discomfort measure taps a self-report of a psychological state, while the probability measure is more of a cognitive assessment of a biological risk. Both are measured on 100-point scales, but the

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Table 4. *Relations among four different types of magical contagion.*

	Contact/palm	Permanence/lab	Spirit/microwave	DoseIns/1 virus
Contact/palm	xx	.32	.23	.35
Permanence/lab	.28	xx	.55	.42
Spirit/microwave	.21	.48	xx	.45
DoseIns/1 virus	.31	.31	.37	xx

Note: Partial correlations for reference minus Transformations scores (n = 195). Discomfort upper R, Probability lower left for palm, lab, MW, and 1 virus. (Partial correlations after partialing out appropriate reference level (comfort or probability)).

scales are incommensurable. It is striking that for all nine of the situations we assess, the probability score is lower by 12 to 28 points, and the difference is largest for microwave, in which the certainty of no surviving virus is highest. This suggests informally that the probability measure is more rational and attuned to the actual risk. There is one way that we can compare the two scales, and that is for zero scores (probability of zero, no discomfort).

We can compare, for the most relevant situations (where there would be a fair number of zero scores), the number of cases where probability is zero and discomfort is above zero, with the number where discomfort is zero and probability is greater than zero. We examined the year in the laboratory, microwave, and exposure to a single virus condition. A significantly higher number of probability zeros to discomfort zeros would indicate that there is at least residual discomfort, sometimes substantial, when there is no perceived risk. For lab shelf, there were 14 cases where only probability was zero and no cases where only discomfort was zero ($p < .001$ by exact binomial, 2-tailed). For microwave, the corresponding scores were 50 probability zeros to 2 discomfort zeros ($p < .001$). For one virus, which was not a sterile condition there were many fewer zeros, with 7 for probability and only 1 for discomfort only ($p < .05$, not significant by our standard, but in the predicted direction). We can conclude that there is residual fear in some people where their own subjective risk is zero.

3.8. Relation of the different features of sympathetic magical contagion

The relation of the measures of the four features of magical contagion can be most directly made by correlating the difference score between the reference level and each transformation, corresponding to either discomfort or probability. These scores are displayed in Table 2. As indicated above, we use lab for permanence, microwave (MW) for spiritual, 1 virus for dose insensitivity, and palm for contact. So the permanence comfort score would be the reference comfort score minus the lab comfort score. Note that *lower* scores mean more magical contagion for all four features of contagion. The raw correlation between the four magical contagion types is likely to be inflated, because higher reference levels generally lead to higher feature differences, since there is more room for a feature to drop with a high reference score (correlations between raw reference and the corresponding raw transformation scores vary from .06 to .81). For this reason, in Table 4, we have partialed out the reference level score (discomfort or probability) from the correlations between difference scores.

The partial correlations are all positive and substantial (.21 to .55), which indicates a significant positive relation between the four types of magical contagion. It also justifies our calculation of a total magical contagion score, the mean of all four scores for each participant. The mean score for 195 participants is 20.7 (s.d. = 19.8) for discomfort and 32.2 (s.d. = 22.8) for probability. The overall magical contagion discomfort and probability measures correlate r = .42. Note that our magical contagion score is inverted: the more a transformation reduces negativity, the more positive the score. A person who was totally controlled by magical contagion beliefs would show no reduction in negativity, and would score zero. It is important to note that the reference score, which involves discomfort or risk resulting from breathing in 1000 viruses is itself, in part a function of contagion beliefs. So our difference scores are partial, additional measures of the features.

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3.9. Relation between COVID magical contagion variables and more general attitudes to COVID and contagion

Since magical contagion beliefs (except perhaps for contact) enhance the perception of infection, we predicted a negative correlation between the extent of belief in the features (measured as a smaller difference score) and some measures we collected about attitudes and concerns about COVID and infections, in general. We have single-item general measures of likelihood of contracting COVID within a year (from June 2020) and fear of COVID, as well as composite measures of behaviors engaged in to limit the risk of infection, and scales to measure perceived vulnerability to infection, and degree of sensitivity to physical and spiritual contagion.

In general, the results were disappointing. Risk of getting infected or perceived vulnerability to disease did not correlate significantly with any of 13 of our magical contagion variables. There were altogether 14 significant ($p < .01$ or better) correlations (out of 52) between our 13 magical contagion measures and fear of COVID, precautionary behaviors, and sensitivity to spiritual or physical contagion. The pattern of significant findings is not interpretable, by us, and is presented in the Supplementary Material, along with descriptions of our measures.

4. Discussion

We have demonstrated the operation of four basic features of the principle of magical contagion in a substantial percentage of American adults with respect to beliefs and attitudes about possible infection with COVID-19. Only a minority of subjects completely lose their discomfort about inhaling viruses after they have been certainly killed by massive sterilization or filtration (spiritual essence). Massive sterilization by heat (microwave) is the most effective transformation we have explored, such that only a minority of our subjects (26%) qualify for magical contagion-based discomfort by our *t* criterion of showing transfer of spiritual essence contagion, but for only 13% of subjects is discomfort completely eliminated. We also find a great deal of discomfort at the prospect of inhaling a single virus (dose insensitivity) in most individuals, and a tendency to overestimate the potency of physical contact in virus transmission (contact salience). For many individuals, discomfort is barely decreased,

Using probability of contracting COVID, as opposed to discomfort, we find similar results, but probability judgments reduce and sometimes eliminate magical contagion effects. We report many cases where, after a manipulation, individuals judge their risk as 0, but still feel discomfort. Probability judgments seem to enhance a 'rational' framework, and hence reduce, but rarely eliminate magical contagion effects.

We also report that beliefs in the four features of magical contagion are substantially correlated with one another, that is, there is some coherence in the beliefs. We did not assess backward contagion in this study. That would be manifested, for example, by discomfort if something a person threw away was used by a person with COVID, or most simply, a bandage removed from a person was thrown in a waste vessel that contained live COVID viruses. The anthropological work on magical contagion and a recent study of ours (Rozin et al., 2018) suggest that we might find some modest evidence for this particularly irrational feature of magical contagion, and we reported a weak backward contagion effect with respect to exposure to AIDS in prior studies (Nemeroff et al., 1994; Rozin et al., 1992).

The contact salience situation is different, because we do not have precise actual knowledge of the importance of physical contact, as opposed to direct open-air inhalation in COVID transmission. There was a lot of press about contact COVID transmission early in the pandemic, with discussion of the importance of wiping or sterilizing fomite, and thorough and frequent hand washing. These salient warnings may themselves be manifestations of magical contagion beliefs and they may be part of the reason we report judgments of rather high levels of infection via the surface transfer routes. Most modern estimates put surface as opposed to air transmission as a small percentage of cases (Randall et al., 2021; Zhang et al., 2021).

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The above findings come almost entirely from one set of hypothetical manipulations. However, two of the four features (dose insensitivity and contact) are confirmed here by very different measures. For dose insensitivity, we report that these same subjects estimate that a median of one inhaled virus will result in a 50% chance of contracting COVID. Frankly, this degree of dose insensitivity surprised us. We are confident that we could rationally convince most of our subjects that infection with such a low dosage is extremely unlikely, and that virtually everyone in a community with substantial infections would inhale at least a few viruses. People, in response to fear or other threats, in some situations, may report positions that they do not really mean (Royzman et al., 2019). However, the fact that people even think of the great potency of a single virus is telling. We are also concerned about the lack of a consistent relation between our measures of magical contagion beliefs and attitudes and measures of general fear of COVID, assessments of personal COVID risks, COVID avoidance behaviors, and general measures of contagion (see Supplementary Material for more discussion of this and relevant data). Further research is necessary to address this situation.

We report evidence for magical contagion with respect to COVID. There are many ways to demonstrate or fail to demonstrate this, and our single simulated lab method, with two other lines of evidence, is just a beginning. It is also important to explore whether many people who demonstrate magical contagion features actually believe there is a risk, and that they are being rational. How can we be sure that all viruses will die if kept in a bottle for a year or are boiled for a long time? One virus could, in principle produce a full infection. On this point, it is sobering that we get considerable discomfort from many people who report zero risk in a particular instance.

What we report in this study is reactions in our subjects which are predicted by magical contagion. It is possible that some or all of these reactions are simply a product of public ignorance of how COVID or any infectious agent is transmitted. However, we showed that four out of four specific predictions of magical contagion are supported. Ignorance could lead to a wide range of beliefs, such as exaggerated potency for permanence or sterilization. Indeed, the magical contagion types of responses in the face of ignorance of the facts suggest that magical contagion is a basic part of a default mode of thought about infection. Dose insensitivity can reasonably be thought to be a special case of people's frequent behavioral indifference to different levels of a variable. This has been described as 'scope insensitivity' (Frederick and Fischhoff, 1998). One difference is that dose insensitivity specifically involves exaggeration of the effect of low doses, not just indifference to quantity.

Unlike AIDS, cholera, malaria, and many other infectious agents, COVID is principally transmitted by the airborne route. It may be that the potentially protective effects of the magical physical contact bias are not operative for airborne, 'invisible' routes of infection. Physical contact sensitivity, while clearly protective for pathogens that are transmitted by contact, may be maladaptive for pathogens spread principally by the airborne route. Air itself is a much more abstract and imperceptible medium than physical contact. Further study of the psychology of contagion might profitably attend to the route of transmission.

Much of the decision psychology literature is about failures of rationality. The present contribution falls under that description. But, as with many of its predecessors, there is a minority of participants who behave rationally. For many of our subjects, there is a conflict between systems 1 and 2, indicated in part by disparities in risk judgments (more system 2) and discomfort (more system 1) (Kahneman, 2011). Kahneman (2011), in a general treatment of decision making, calls system 1 an intuitive, rapid, feeling-based, often innate system, and system 2 a slower, more cognitive and rational system). For our most severe degradation of COVID potency, the 'overkill' microwave sterilization procedure, 50 subjects report a rational 0 risk, whereas only 2 report 0 discomfort. Zero risk reports are much less frequent for a year on a shelf or a single virus, but there might be a tiny risk in those cases. Based on risk judgments, we can say that a fair number of subjects are very low in magical contagion beliefs, but only a small number seem immune to magical contagion reactions based on affective, discomfort judgments. It would be interesting to determine that if subjects who report zero probability but discomfort would elect not to engage with a zero-risk entity (honoring their irrational discomfort) would reverse this decision if they had to pay to avoid the zero-risk entity (Rozin et al., 2007). We

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(Fincher and Rozin, unpublished findings) have shown dose insensitivity for noncontagious entities; people are upset at consuming tiny amounts of a noncumulative poison, sodium cyanide. Unlike germs, there is no possibility of reproduction here, but there is perhaps some generalization from the contagious cases.

We still face serious possibilities of COVID infection, along with infections of older infectious agents such as influenza. It is likely that we will experience new infectious agents of various sources and potencies. It is really important to understand how people think and feel about infections, both to be able to promote appropriate safety/avoidance behaviors, and on the other side, to avoid panics and potentially crippling over-concerns and behaviors. It is notable that in a recent year, before COVID, American deaths from influenza surpassed 60,000, and there was little public concern or precautions, and many did not get vaccinations. Magical contagion beliefs should serve to enhance risk perceptions, and perhaps cause us to take precautions, and be more inclined to develop panics, fears, and display stigmatization of those we suspect are carrying a disease, On the other hand, the contact principle, demonstrated in the present research and in the work on AIDS (Nemeroff et al., 1994; Rozin et al., 1992) may cause us to maladaptively minimize risks from airborne infections. And a good proportion of infections are passed through the air and breathing.

We now face a situation where a significant minority of Americans are reluctant to receive vaccinations for COVID or to wear masks. In our Supplementary Material discussion, we show that Republicans believe that they are less likely to get COVID and show less fear of it. However, we do not find that they are different from Democrats in magical contagion beliefs. Political or religious beliefs, misinformation, and magical contagion beliefs can all contribute to over or under-reaction to infection risks. We would do well to sort this out, en route to understanding the psychology of infectious transmission, the related exaggeration or minimization of risk or discomfort, and the refusal to take preventive action or taking too much preventive action.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/jdm.2023.4.

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