

Expectations Versus Fantasies and Vaccine Hesitancy: How Suffering From COVID-19 Versus Suffering From Vaccines Interact

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Abstract

Background Previous research on COVID-19 vaccination highlights future thoughts associated with possible Coronavirus infection and vaccine side effects as key predictors of vaccine hesitancy. Yet, research has focused on independent contributions of such future thoughts, neglecting their interactive aspects.

Purpose We examined whether thoughts about two possible COVID-related futures (suffering from COVID-19 and vaccine side effects) interactively predict vaccine hesitancy and vaccination behavior among unvaccinated and vaccinated people. Importantly, we compared two forms of future thinking: beliefs or expectations (likelihood judgments) versus fantasies (free thoughts and images describing future events).

Methods In Study 1, we conducted a longitudinal study with an unvaccinated group ($N = 210$). We assessed expectations versus fantasies about the two COVID-related futures as predictors. As outcome variables, we measured vaccine hesitancy, and 9 weeks later we assessed information seeking and vaccine uptake. Study 2 was a cross-sectional study comparing vaccine hesitancy of an unvaccinated group ($N = 307$) to that of a vaccinated group ($N = 311$).

Results Study 1 found that more negative fantasies about COVID-19 impact and less negative fantasies about vaccine side effects interactively predicted lower vaccine hesitancy and more vaccine-related behaviors among unvaccinated people; no such interaction was observed between respective expectations. Study 2 replicated these results of Study 1. Additionally, for vaccinated people, low expectations of negative COVID-19 impact and high expectations of negative vaccine impact interactively predicted higher vaccine hesitancy, whereas no such interaction was observed for respective fantasies.

Conclusions Research on vaccine hesitancy should explore interactions between future thinking about disease and about vaccine side effects. Importantly, there is much to be gained by distinguishing expectations versus fantasies: vaccination interventions aiming to boost vaccine uptake among unvaccinated people should tap into their negative future fantasies regarding both disease and vaccine side effects.

Lay summary

In two correlational studies, we investigated the relationship between future thoughts about two possible COVID-related futures—suffering from COVID-19 and vaccine side effects—and vaccine hesitancy. Prior research has emphasized thoughts about these potential risks as significant predictors of vaccine hesitancy but has focused on their independent contributions, neglecting their interactive nature. Our research examined the interaction between the thoughts about disease and those about vaccine side effects, highlighting the two forms of future thinking: expectations (likelihood judgments) and fantasies (free-flowing thoughts and images describing a future event). In a longitudinal study (Study 1) with an unvaccinated group, we found that more negative fantasies about COVID-19 disease and less negative fantasies about vaccine side effects interactively predicted lower vaccine hesitancy and more vaccination behavior. There was no interaction between the expectations. Study 2, a cross-sectional study comparing another unvaccinated sample to a vaccinated sample, revealed a divergent pattern in the two groups; negative fantasies, not expectations, interactively predicted vaccine hesitancy among unvaccinated people while expectations, not fantasies, did so among vaccinated people. The research suggests the importance of considering interactions between future thoughts about disease and vaccine side effects in understanding vaccine hesitancy and distinguishing expectations and fantasies.

Keywords Future thoughts · Expectations · Fantasies · Vaccine hesitancy · COVID-19 vaccination

Introduction

Vaccine hesitancy refers to the delay in acceptance or refusal of vaccination despite the availability of vaccine services [1]. Vaccine hesitancy has always been a matter of concern in global health [2], but the advent of the COVID-19 pandemic has brought it into the research spotlight, sparking intensive

research aimed at identifying psychological factors contributing to it. Among the factors that have been found to be associated with vaccine hesitancy, two major predictors were people's future thoughts about two potential dangers they perceive in the context of the COVID-19 pandemic: dangers from the COVID-19 disease (e.g., shortness of breath, brain

fog, and loss of smell) and dangers of the vaccine side effects (e.g., muscle pain, headaches, and fever). Previous studies have found that the perceived risk of COVID-19 negatively predicts vaccine hesitancy whereas the perceived risk of vaccination positively predicts it [3, 4]. However, these studies have primarily focused on the independent predictability of each variable, leaving it still unknown how these two variables interact. Given that COVID-19 vaccines were introduced as a means to prevent serious illness from COVID-19, individuals necessarily consider both future possibilities when deciding whether or not to receive a vaccine shot. However, surprisingly little research has been done on how the thoughts about the two future possibilities interact to predict vaccine hesitancy.

Examining the interaction between future thoughts about suffering from COVID-19 and about suffering from vaccine side effects is critical as it may provide an important clue for designing effective vaccine interventions. Correlational studies have found that both perceived risk of suffering from COVID-19 and perceived harm of vaccination are significant predictors of vaccine hesitancy and vaccination intention [5, 6], but other studies showed that perceived harm of vaccines is a powerful predictor whereas perceived risk of COVID-19 is not [7–9]. Karlsson and colleagues advised, based on the weak predictability of perceived severity of suffering from COVID-19, that communicating the safety of the vaccines is more important in promoting vaccine uptake than underscoring the risks of COVID-19 disease [8].

This advice holds true only if the effects of the two variables are independent, and thus additively contribute to vaccine hesitancy. In that case, it seems more effective and efficient to reduce thoughts about vaccine side effects as they possess stronger predictive value. However, if the effect of perceived vaccine harm is contingent upon perceived risk of COVID-19, simply emphasizing vaccine safety might not suffice, and one needs to take into account both variables. Thus, investigating the interaction between thoughts about disease and those about vaccination is crucial for designing effective intervention programs.

The importance of examining the interplay between thoughts about disease and those about vaccine side effects has been highlighted within the framework of protection motivation theory (PMT). PMT delineates two appraisal processes that evoke protection motivation: threat appraisal and coping appraisal [10, 11]. Threat appraisal is centered on one's evaluation of factors associated with sources of threats (i.e., perceived severity, perceived vulnerability, and intrinsic and extrinsic rewards), while coping appraisal focuses on factors related to responses for coping with threats (i.e., response efficacy, self-efficacy, and response cost). PMT posits that interactive effects emerge when combining components from different appraisal processes. For example, severity or vulnerability (from threat appraisal) positively predicts protection motivation only when response efficacy or self-efficacy (from coping appraisal) is high [12]. Despite the proposition of PMT, only a handful of studies examined the interactive nature of predictors, with the prevailing approach in subsequent studies being the additive model, which focuses on main effects [13]. Research on COVID-19 vaccination is no exception; most studies have concentrated on main effects rather than examining the interactions among predictors. In the present research, we investigated the interaction between future thoughts regarding suffering from COVID-19

and suffering from vaccine side effects, which aligns with the proposition of the PMT highlighting the interaction among different appraisal processes.

Importantly, in line with existing literature on future thinking, we distinguished between the two forms of thinking about the future: expectations versus fantasies [14–16]. Expectations refer to beliefs or judgments about the likelihood of an event to occur; they are largely based on past experiences and performances [17–19]. On the contrary, fantasies are free-flowing thoughts and images that vividly describe what a future event may look like, and they play independently of expectation judgments [14, 15, 20, 21]. For instance, people who have never experienced vaccine side effects and thus have a low expectation of getting seriously ill from vaccination may still harbor fearful fantasies of themselves suffering from vaccine side effects. Fantasies are not constrained by expectation judgments that reflect past experiences. Rather they are based on people's needs, and on their states of deficiency; thus, they provide the direction to act [22–24].

Although the two forms of future thinking appear to overlap, they are distinct concepts. Expectations and fantasies were found to be only weakly or moderately correlated (e.g., $r = 0.09$ – 0.24 in Kappes et al.; $r = 0.21$ – 0.37 in Oettingen and Mayer; $r = 0.45$ in Oettingen and Wadden) [14, 18, 25]. More importantly, they predict behaviors and future outcomes in opposite directions. For example, expectations of hip replacement surgery patients regarding successful recovery positively predicted both the patients' efforts to recover and physical therapists' assessment of their recovery, while positive fantasies about successful recovery negatively predicted these outcomes [14]. These findings indicate that the two future thoughts have different implications on behavior and need to be distinguished conceptually.

While existing literature on future thinking suggests that incorporating both expectations and fantasies can enhance predictability on behavior [20], research on COVID-19 vaccination has predominantly focused on people's beliefs and expectations regarding COVID-19 and vaccination [3, 4]. Consequently, little is known about how free-flowing thoughts and images regarding the future possibilities of COVID-19 disease and vaccine side effects appear to people's minds. Additionally, it is unexplored how these free-flowing fantasies are associated with attitudes and behaviors toward vaccination. Research has found that unvaccinated people exhibit cognitive processes different from those of vaccinated people (e.g., impulsivity) [26]. Examining both expectations and fantasies among unvaccinated and vaccinated people may provide clues for understanding different psychological processes underlying the vaccine hesitancy in each group.

In the current research, we investigated whether future thoughts about COVID-19 disease and vaccine side effects, in the form of expectations and fantasies, interactively or additively predict vaccine-related outcomes. Thoughts about COVID-related futures may take the form of either experience-based expectations or need-based fantasies (see Fig. 1). People may judge the likelihood (i.e., expectation) of getting seriously ill from COVID-19 or the likelihood of suffering from side effects if they get vaccinated, based on their relevant past experiences. Alternatively, people may picture themselves in vivid, free-flowing thoughts and images (i.e., fantasies). These fantasies can be hopeful and relatively positive, but they also can depict scenarios of becoming severely ill with COVID-19 or experiencing hardships from vaccine

		Two COVID-Related Future Possibilities	
		Suffering from COVID-19	Suffering vaccine side effects
Two Forms of Future Thought	Expectations	Expectations of negative COVID-19 impact	Expectations of negative vaccine impact
	Fantasies	Fantasies of negative COVID-19 impact	Fantasies of negative vaccine impact

Fig. 1. Conceptual framework describing predictors. *Note.* The interaction between the expectation of negative COVID-19 impact and the expectation of negative vaccine impact, as well as the interaction between fantasies of negative COVID-19 impact and fantasies of negative vaccine impact, were tested to examine whether thoughts about two COVID-related future possibilities interactively or additively predict vaccination-related outcomes.

side effects. These fearful fantasies, related to people's needs for safety and harm reduction, may depict threatening events or scenarios that may then further undermine people's sense of safety.

Although there have been a number of dispersed studies that examined different forms of beliefs in predicting vaccine hesitancy, such as the perceived severity or vulnerability to COVID-19 [27–29] or beliefs about the effectiveness or adverse effects of the COVID-19 vaccination [3, 7, 9, 30], research has not explicitly distinguished between experience-based expectations and need-based fantasies and investigated the two forms of future thoughts concerning the two COVID-related future possibilities in a single study.

The Current Research

Addressing the limitations of previous studies, we took an exploratory approach and examined whether future thoughts about two COVID-related possibilities—the possibility of suffering from COVID-19 and the possibility of suffering vaccine side effects—interactively or additively predict COVID-19 vaccine hesitancy and vaccination behavior. We focused on the two forms of future thoughts (expectations versus fantasies) and tested both interactions among expectations of suffering from COVID-19 and from vaccine side effects, and interactions among fantasies associated with suffering from COVID-19 and from vaccine side effects (Fig. 1). This approach allowed us to explore whether there are interactions between the thoughts about COVID-19 and vaccination, and if there are, which forms of future thoughts are underlying the interactions.

In two correlational studies, we measured expectations and fantasies about the two COVID-related future possibilities. The first study examined unvaccinated people who are the primary targets of vaccine interventions. Outcome variables were COVID-19 vaccine hesitancy, and 9 weeks later, we also measured two vaccine-related behaviors (i.e., information-seeking behaviors and actual COVID-19 vaccination) to examine the downstream consequences of vaccine hesitancy on future behaviors. The second study compared unvaccinated to vaccinated people in their vaccine hesitancy to better understand the distinct psychological principles underlying the readiness to get vaccines among the people who have versus have not yet received a vaccine shot. By investigating both forms of future thinking in unvaccinated and vaccinated people, we aimed to gain insights into how to subsequently intervene to motivate unvaccinated people toward

vaccination and maximize the effectiveness of vaccination programs.

Study 1: Predicting Vaccination Behavior in Unvaccinated People

Method

Transparency and openness

Both studies were conducted in compliance with the IRB at New York University, and all participants provided electronic informed consent. The data, code, survey materials, and [Supplementary Materials](#) are publicly accessible at the OSF repository (<https://osf.io/fvrha/>).

Study design

Study 1 was a longitudinal study consisting of two waves with a 9-week interval. The first wave was distributed in December 2021 (61.8% of the U.S. population had been fully vaccinated). We measured predictors (expectations and fantasies), an outcome variable (vaccine hesitancy), and demographic information. Nine weeks later, we assessed other outcome variables (the amount and direction of information seeking and whether people had gotten vaccinated).

Participants

Participants were MTurk workers residing in the U.S. who indicated that they had never received a COVID-19 vaccine and had no plan to receive one. An *a priori* power analysis using G*Power indicated that at least 222 participants are required to detect a small-to-medium-sized effect ($f^2 = 0.058$) with a statistical power of .90 for testing two predictors in a fixed multiple regression model [14]. We aimed to recruit 280 participants assuming that there would be substantial dropouts at Time 2. As a result, we received 282 complete responses at Time 1, and among them, 210 participants (74.5%) responded to the Time 2 survey (55.2% female, 44.8% male; 72.4% White or Caucasian, 13.3% Black or African American, 5.7% Multirace, 4.8% Asian, 2.9% Hispanic or Latino, 0.5% Native American or American Indian, 0.5% Pacific Islander or Native Hawaiian; age $M = 39.97$, $SD = 11.61$, range: 19–78; annual household income $M = 63,821$, $SD = 48,904$, range: 5,000–250,000; see [Table 1](#)). The dropout was independent of key variables measured at Time 1, $ps > .382$. In terms of demographics, participants who responded to the Time 2 survey, compared to those who did not respond, were older in age, $F(1,280) = 17.89$, $p < .001$, and were less likely to have had experiences in vaccination other than COVID-19 vaccines, $\chi^2 = 6.34$, $p = .012$.

Table 1 Demographic Characteristics of the Samples (Study 1 and Study 2)

Variables	Study 1		Study 2			
	Unvaccinated		Unvaccinated		Vaccinated	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	39.97	11.61	39.11	11.15	39.89	12.31
Subjective socioeconomic status (1–10)	4.72	1.95	4.85	1.88	4.83	1.70
Annual household income	63,821	48,904	63,160	47,290	65,129	44,105
Variables	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Female	116	55.2	149	50.5	153	49.2
Male	94	44.8	155	48.5	153	49.2
Other			1	0.3	3	1.0
Prefer not to say			2	0.7	2	0.6
Racial/Ethnic identity						
White or Caucasian	152	72.4	229	77.1	235	77.6
Black or African American	28	13.3	37	12.5	23	7.6
Multirace or Other	12	5.7	3	1.0	3	1.0
Asian	10	4.8	9	3.0	24	7.9
Hispanic or Latino	6	2.9	13	4.4	15	5.0
Native American or American Indian	1	0.5	1	0.3	1	0.3
Pacific Islander or Native Hawaiian	1	0.5				
Prefer not to say			5	1.7	2	0.7
Education						
Less than a High School Diploma	3	1.4	1	0.3	0	0.0
High School Degree or Equivalent	92	43.8	126	41.0	101	32.5
Bachelor's Degree (e.g., BA, BS)	95	45.2	150	48.9	156	50.2
Master's Degree (e.g., MA, MS, MEd)	16	7.6	26	8.5	49	15.8
Doctorate (e.g., PhD, EdD)	4	1.9	4	1.3	5	1.6
Parent education						
Elementary School (Kindergarten–4th Grade)	1	0.5	0	0.0	1	0.3
Middle School (6th Grade–8th Grade)	7	3.3	6	2.0	7	2.3
High School (9th Grade–12th Grade)	78	37.1	101	32.9	94	30.3
College—Did Not Graduate	42	20.0	54	17.6	53	17.1
Graduated from College	82	39.0	146	47.6	155	50.0
Have you ever been diagnosed with COVID-19?						
No	183	87.1	263	82.4	260	83.6
Yes	27	12.9	54	17.6	51	16.4
Do you consider yourself belonging to a high-risk group?						
No	182	86.7	265	86.3	235	75.6
Yes	28	13.3	42	13.7	76	24.4
Have you ever had any kind of vaccination in the past other than COVID-19 vaccines?						
No	64	30.5	88	28.7	29	9.3
Yes	146	69.5	219	71.3	282	90.7

Measures

Expectations of negative impact: COVID-19 versus vaccine.

Participants answered an item measuring their *expectation of negative COVID-19 impact* (“If you got COVID-19, what is the likelihood that you will have long-term negative physical or mental consequences?”) and another question measuring the *expectation of negative vaccine impact* (“If you got vaccinated,

what is the likelihood that you will have long-term negative physical or mental consequences from the vaccine?”), using a 7-point scale (1 = *not likely at all*, 7 = *very likely*).

Fantasies of negative impact: COVID-19 versus vaccine.

We utilized the semi-projective scenario method to measure the valence of the fantasies about COVID-19 suffering.

Participants were instructed to focus on their thoughts and images [14]. Then they were presented with a hypothetical situation in which they tested positive for COVID-19:

You have not been feeling well recently and went to a COVID-19 test site nearby to get a test for it. The day after you got the test, you got the result for the test and the test result says that you have COVID-19. After getting the result that you have COVID-19, you...

Participants imagined themselves experiencing the given situation and were asked to complete the story with any thoughts and images that come to mind (i.e., fantasies). For example, participants wrote “(I) go home and rest for a few days. After I start to feel better I feel relieved knowing that I’m more resistant to the virus than people vaccinated with the mRNA vaccines,” or “I would immediately quarantine and make sure I was getting plenty of rest and staying away from anyone I could potentially infect. I would not be happy and would be somewhat scared, but I think I would be ok.” (see Supplement 1 for the content analysis). Then they reported the positivity (“How positive were these thoughts and images?”) and negativity (“How negative were these thoughts and images?”) of their fantasies on a 7-point scale (1 = *not positive/negative at all*, 7 = *very positive/negative*). The two items were negatively correlated ($r = -0.65, p < .001$), so we made an index of *fantasies of negative COVID-19 impact* by subtracting the positivity score from the negativity score (ranging from -6 to +6). A higher score indicated more negative fantasies about COVID-19.

Then, we measured the valence of fantasies about the COVID-19 vaccination. Since our sample consisted of unvaccinated people, many of whom resisted to get vaccinated and held strong beliefs that getting vaccinated went against their choices, we anticipated that they might find it challenging, or even resist, immersing themselves in the hypothetical situation of them choosing to receive a vaccine. Therefore, to avoid giving them the impression that they were forced to imagine a choice that they did not want to make, we simply asked about their thoughts and images when thinking of themselves receiving a vaccine. The instruction was:

What are your thoughts and images that come to mind when you think of you getting a COVID-19 vaccine? What would happen if you got a vaccine? Write down all of your thoughts and images that come to mind. Give your thoughts and images free reign.

For example, participants wrote “I may not experience immediate symptoms of some bad medical condition, but it’s just a matter of time before I did,” or “I would be scared of how it would affect me in the future. I would be scared of the virus still. I would be sad for turning back on my beliefs.” (see Supplement 1). Participants reported the positivity and negativity of their fantasies ($r = -0.77, p < .001$), and we made an index of *fantasies of negative vaccine impact* by subtracting the positivity score from the negativity score, with a higher score indicating more negative fantasies about vaccination. (The main results remained the same when the original negativity scores were used. The results using the negativity scores are reported in Supplements 2 [Study 1] and 3 [Study 2].)

This operationalization of fantasies enabled us to examine the experienced tone of participants’ fantasies regarding the

potential futures of suffering from COVID-19 and of getting vaccinated, respectively. Importantly, these measures of fantasies were conceptually distinct from individuals’ evaluations of COVID-19 and vaccination (i.e., how negatively participants judge the consequences of COVID-19 disease or getting vaccinated) in that they specifically captured the thoughts and images that freely emerged in the stream of participants’ consciousness. While evaluations of COVID-19 and vaccination are judgments that take into account realities, fantasies are an ever-moving stream of consciousness unrestricted by considerations of reality [14, 31].

Outcome variable (Time 1): COVID-19 vaccine hesitancy.

To measure vaccine hesitancy, we adapted Vaccine Hesitancy Scale by Shapiro and colleagues [32]. Participants responded to nine items, for example, “I am concerned about serious adverse effects of the CDC-approved COVID-19 vaccines” ($\alpha = 0.91$), using a 5-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*).

Outcome variables (Time 2): Information seeking.

Nine weeks later, we assessed the amount of information seeking with three items (e.g., “During the past two months, how much did you try to get information about the COVID-19 vaccines?” $\alpha = 0.88$) using a 7-point scale (1 = *not at all*, 7 = *very much*), and the direction of information seeking with one item (“Did the information you got/shared make you lean more toward getting a COVID-19 vaccine or not getting a COVID-19 vaccine?”) using a 7-point scale (1 = *toward not getting a vaccine*, 4 = *neither toward getting nor not getting a vaccine*, 7 = *toward getting a vaccine*).

Outcome variables (Time 2): COVID-19 vaccination.

Participants indicated whether they had received both the first and the second vaccine shot (= 3; 26.7%), had received only the first shot (= 2; 4.8%), had made an appointment but had not yet received it (= 1; 0.5%), or had not received it nor made an appointment (= 0; 68.1%). A higher score reflects more steps taken toward vaccination.

Results

Multiple regressions

We conducted a series of multiple regressions on each outcome variable entering mean-centered expectations and their interaction and mean-centered fantasies and their interaction as predictors (see Tables 2 and 3).

Time 1: COVID-19 vaccine hesitancy.

Expectation of negative COVID-19 impact predicted lower vaccine hesitancy, $b = -0.12, SE = 0.04, t(203) = -3.36, p < .001, 95\% CI = [-0.19, -0.05]$, and expectation of negative vaccine impact predicted higher vaccine hesitancy, $b = 0.02, SE = 0.03, t(203) = 4.96, p < .001, 95\% CI = [0.23, 4.96]$, but the interaction of expectations about the two future possibilities was not significant, $p = .178$, suggesting that expectations independently predicted vaccine hesitancy. On the other hand, we observed a significant interaction of fantasies about the two future possibilities, $b = 0.01, SE = 0.004, t(203) = 2.30, p = .022, 95\% CI = [0.001, 0.02]$. To probe the nature of the significant interaction, we conducted a simple slope analysis at a high (+1 *SD*) and a low level (-1 *SD*) of fantasies of negative vaccine impact (see Fig. 2). The more

Table 2 Means, Standard Deviations, and Correlations among Variables (Study 1 and Study 2)

	Study 1									
			Correlations							
	M	SD	1	2	3	4	5	6	7	8
1. Exp_COVID	2.67	1.58	–							
2. Exp_Vaccine	4.32	1.69	0.27***	–						
3. Fantasy_COVID	0.20	3.46	0.22***	–0.00	–					
4. Fantasy_Vaccine	1.77	3.55	–0.04	0.12	0.23**	–				
5. Vaccine hesitancy	3.62	0.82	–0.20**	0.32***	–0.18**	0.16*	–			
6. Information-seeking amount	3.66	1.82	0.15*	0.08	0.08	0.05	–0.10	–		
7. Information-seeking direction	3.33	2.10	0.14*	–0.26**	0.16*	–0.12	–0.42***	0.27***	–	
8. COVID-19 Vaccination	0.90	1.34	–0.01	–0.17*	0.03	–0.11	–0.17*	0.25***	0.66***	–

	Study 2									
	Unvaccinated group		Vaccinated group		Difference	Correlations				
	M	SD	M	SD	t	1	2	3	4	5
1. Exp_COVID	2.93	1.73	3.16	1.54	–1.79	–	0.27***	0.10	–0.03	–0.00
2. Exp_Vaccine	4.59	1.87	1.89	1.26	21.03**	0.16*	–	–0.05	0.31***	0.61***
3. Fantasy_COVID	0.53	3.57	1.87	3.50	–4.72**	0.24***	–0.06	–	0.11	0.00
4. Fantasy_Vaccine	2.15	3.47	–1.30	3.46	12.37**	–0.08	0.32***	0.14*	–	0.50***
5. Vaccine hesitancy	3.63	0.96	1.71	0.72	28.14**	–0.33***	0.46***	–0.19**	0.44***	–

Note. *Exp_COVID* = expectation of negative COVID-19 impact, *Exp_Vaccine* = expectation of negative vaccine impact. *Fantasy_COVID* = fantasies of negative COVID-19 impact, *Fantasy_Vaccine* = fantasies of negative vaccine impact. For fantasies of negative COVID-19 impact and fantasies of vaccine impact, a higher score indicates more negative fantasies and a lower score indicates more positive fantasies. For information-seeking direction, a higher score indicates seeking information in favor of getting a vaccine rather than not getting a vaccine. Correlations presented below the diagonal are for unvaccinated group and those above the diagonal are for vaccinated group. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3 Summary of Multiple Regressions (Study 1 and Study 2)

	Study 1						Study 2			
	COVID-19 vaccine hesitancy (Time 1)		Information-seeking amount (Time 2)		Information-seeking direction (Time 2)		COVID-19 vaccination (Time 2)		COVID vaccine hesitancy	
	B	SE	B	SE	B	SE	B	SE	B	SE
Group									–0.81***	0.07
Exp_COVID	–0.12***	0.04	0.10	0.09	0.21*	0.10	–0.01	0.06	–0.14***	0.02
Exp_Vaccine	0.16***	0.03	0.10	0.08	–0.33***	0.09	–0.10	0.06	0.28***	0.02
Fantasy_COVID	–0.04**	0.02	0.03	0.04	0.10*	0.04	0.03	0.03	–0.03***	0.01
Fantasy_Vaccine	0.04*	0.01	0.02	0.04	–0.08	0.04	–0.05	0.03	0.08***	0.01
Group*Exp_COVID									0.00	0.04
Group*Exp_Vaccine									0.19***	0.04
Group*Fantasy_COVID									0.07***	0.02
Group*Fantasy_Vaccine									–0.04**	0.02
Exp_COVID*Exp_Vaccine	–0.03	0.02	0.09	0.05	0.04	0.06	0.06	0.04	–0.04***	0.01
Fantasy_COVID*Fantasy_Vaccine	0.01*	0.004	–0.00	0.01	–0.02*	0.01	–0.02*	0.01	0.01***	0.002
Group*Exp_COVID*Exp_Vaccine									–0.04*	0.02
Group*Fantasy_COVID*Fantasy_Vaccine									–0.01**	0.004
R ²	0.246***		0.042		0.154***		0.071*		0.785***	

Note. *Exp_COVID* = expectation of negative COVID-19 impact, *Exp_Vaccine* = expectation of negative vaccine impact, *Fantasy_COVID* = fantasies of negative COVID-19 impact, *Fantasy_Vaccine* = fantasies of negative vaccine impact. Exp_COVID, Exp_Vaccine, Fantasy_COVID, and Fantasy_Vaccine were mean-centered. For Group, unvaccinated group = –0.5, vaccinated group = 0.5. For fantasies of negative COVID-19 impact and fantasies of vaccine impact, a higher score indicates more negative fantasies and a lower score indicates more positive fantasies. For information-seeking direction, a higher score indicates seeking information in favor of getting a vaccine rather than not getting a vaccine. * $p < .05$, ** $p < .01$, *** $p < .001$.

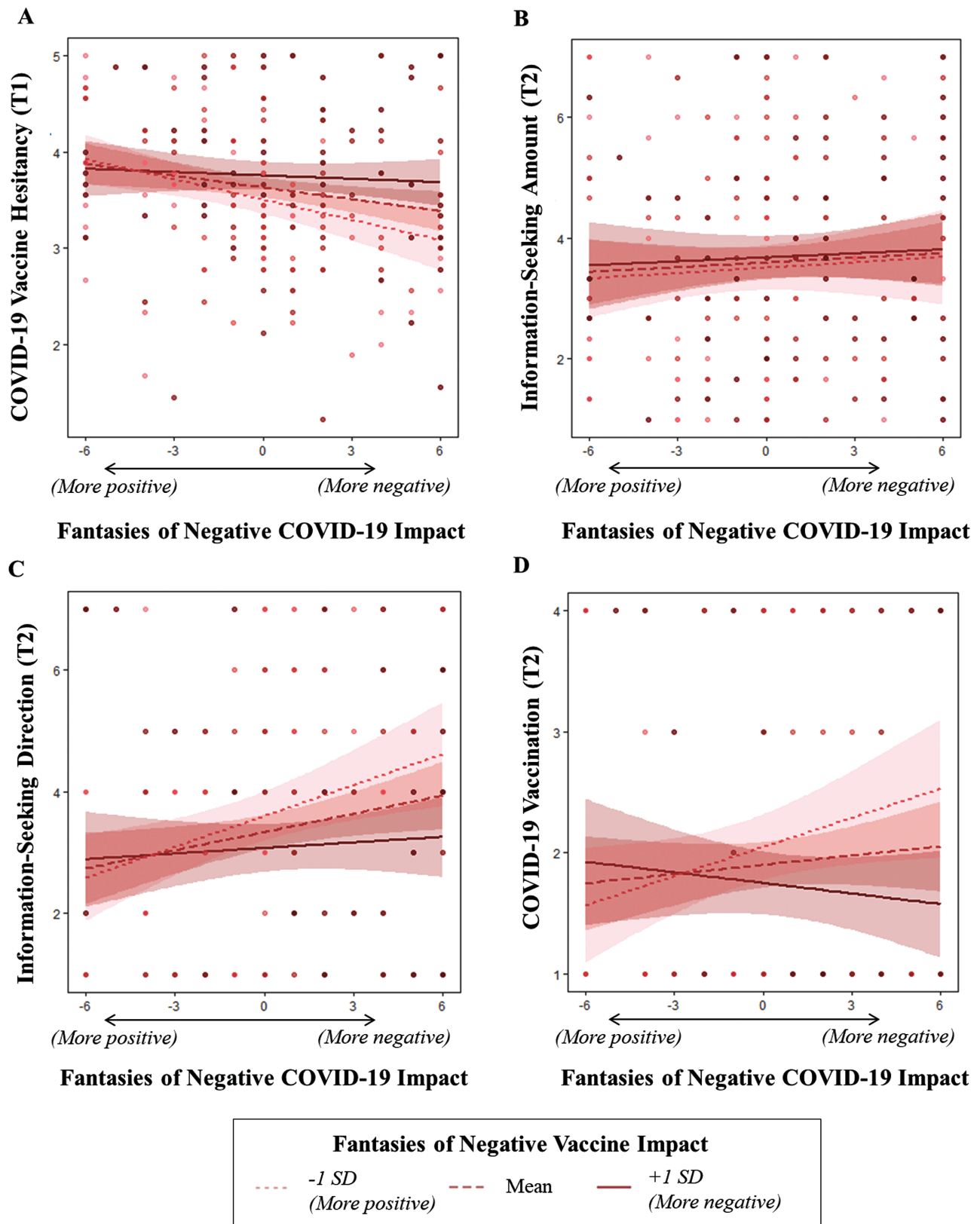


Fig. 2. Outcome variables as a function of fantasies of negative COVID-19 impact and of negative vaccine impact (Study 1). *Note.* For information-seeking direction, a higher score indicates seeking information in favor of getting a vaccine rather than not getting a vaccine. Shaded areas represent 95% confidence intervals.

negatively people fantasized about suffering from COVID-19, the less hesitant they were to get vaccinated, but this pattern was present only among the participants who fantasized

less negatively about the COVID-19 vaccination ($-1\ SD$), $b = -0.07$, $SE = 0.02$, $t(203) = -3.35$, $p = .001$, $95\% \text{ CI} = [-0.11, -0.03]$. For participants who fantasized more negatively

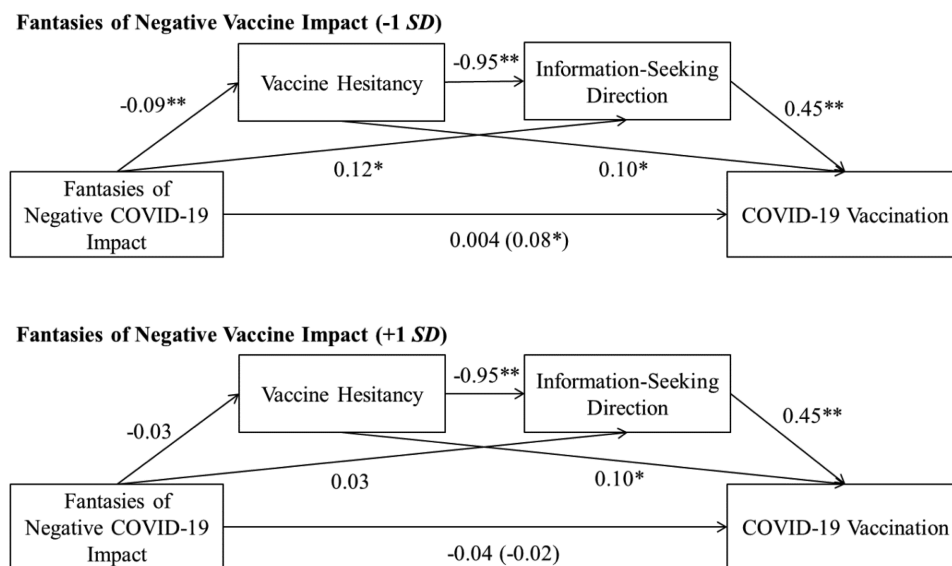


Fig. 3. Moderated serial mediation paths (Study 1). Note. The model depicts the indirect effect of fantasies of negative COVID-19 impact on COVID-19 vaccination behavior through vaccine hesitancy and information-seeking direction, at a low ($-1 SD$) and high ($+1 SD$) level of fantasies of negative vaccine impact.

about the future of getting a vaccine, fantasies about COVID-19 was not associated with vaccine hesitancy ($+1 SD$), $b = -0.01$, $SE = 0.02$, $t(203) = -0.62$, $p = .536$, $95\% CI = [-0.05, 0.03]$. Thus, it was the combination of more negative fantasies about suffering from the virus and less negative fantasies about vaccination that predicted less hesitancy to get vaccinated.

Time 2: Information seeking.

Regarding the amount of information seeking, none of the predictors reached significance, $ps > .082$. Regarding the direction of information seeking, a higher expectation of negative COVID-19 impact predicted an inclination toward information in favor of vaccination, $b = 0.21$, $SE = 0.10$, $t(203) = 2.17$, $p = .031$, $95\% CI = [0.02, 0.40]$, while a higher expectation of negative vaccine impact predicted an inclination toward information opposing vaccination, $b = -0.33$, $SE = 0.10$, $t(203) = -3.72$, $p < .001$, $95\% CI = [-0.51, -0.16]$. The interaction of these two expectations was again not significant, $p = .465$. On the contrary, the interaction of fantasies was significant, $b = -0.02$, $SE = 0.01$, $t(203) = -2.02$, $p = .045$, $95\% CI = [-0.04, -0.001]$. The more negatively people fantasized about the future of suffering from COVID-19, the more they sought information in favor of getting a vaccine, but this pattern was present only for those who fantasized less negatively about vaccination ($-1 SD$), $b = 0.17$, $SE = 0.06$, $t(203) = 2.98$, $p = .003$, $95\% CI = [0.06, 0.28]$, not among those who fantasized more negatively about vaccination ($+1 SD$), $b = 0.03$, $SE = 0.05$, $t(203) = 0.59$, $p = .554$, $95\% CI = [-0.07, 0.13]$.

Time 2: COVID-19 vaccination.

In terms of vaccination behavior, we found that neither the expectations of the two future possibilities nor their interaction significantly predicted vaccination, $ps > .111$. However, we again found a significant interaction of fantasies about the two future possibilities, $b = -0.02$, $SE = 0.01$, $t(203) = -2.38$, $p = .018$, $95\% CI = [-0.03, -0.003]$. The simple slope analysis

showed that people who fantasized more negatively about the future of suffering from COVID-19 took more steps toward the COVID-19 vaccination, but this pattern was shown only among the people who fantasized less negatively about the COVID-19 vaccination ($-1 SD$), $b = 0.08$, $SE = 0.04$, $t(203) = 2.11$, $p = .036$, $95\% CI = [0.01, 0.16]$, not among the people who fantasized more negatively about vaccination ($+1 SD$), $b = -0.03$, $SE = 0.03$, $t(203) = -0.85$, $p = .397$, $95\% CI = [-0.10, 0.04]$. (The results remained the same when we coded vaccination behavior as a dichotomous variable, dividing people into those who received vaccine shot(s) and those who did not receive any vaccine shots. The frequency table of vaccination behavior and results on the dichotomized variable are reported in Supplement 4.)

Exploratory moderated serial mediation analysis

During the COVID-19 pandemic, a great deal of information or misinformation about COVID-19 vaccines has been disseminated via social media, spreading vaccine hesitancy among the public [33–35]. People's hesitancy about COVID-19 vaccination may guide them to selectively attend to the information that confirms their attitudes, and the information people gain about COVID-19 vaccines will shape their minds and lead them to the respective decision to get or not get a vaccine. Thus, we conducted an exploratory moderated serial mediation analysis testing whether the indirect predictive effect of COVID-19 fantasy on COVID-19 vaccination through vaccine hesitancy and information-seeking direction is moderated by fantasies of vaccine impact (see Fig. 3). We conducted the analysis using Process macro (Model 85) with a 5,000 bootstrapped sample [36]. The results confirmed the moderated serial mediation path, $b = -0.003$, $SE = 0.002$, $95\% CI = [-0.008, -0.002]$; for people with less negative vaccine fantasies ($-1 SD$), negative COVID-19 fantasies was associated with lower vaccine hesitancy which led them to seek information encouraging vaccine uptake, and then to get vaccinated, $b = -0.004$, $SE = 0.01$, $95\% CI = [0.017, 0.064]$. On the other hand, for those

who had more negative vaccine fantasies (+1 *SD*), the sequential mediation was not observed, $b = 0.013$, $SE = 0.01$, 95% CI = [−0.005, 0.033].

Discussion

In Study 1, across the three vaccine-related outcome variables, and over a period of 9 weeks (Time 1: vaccine hesitancy, Time 2: information-seeking direction and vaccination behavior), we observed that participants who harbored more negative COVID-19 fantasies and, at the same time, less negative vaccine fantasies were less hesitant about COVID-19 vaccination, sought information in favor of getting vaccinated, and subsequently, received vaccines. On the other hand, interactions of expectations about the two future possibilities were not observed on any of the outcome variables. However, there were main effects of expectations; a high expectation of negative COVID-19 impact and a low expectation of negative vaccine impact independently predicted lower vaccine hesitancy and a preference for information favoring vaccination, but none of them predicted vaccine uptake. The findings showed that future thoughts about both COVID-19 and vaccination interactively predict successful vaccination behavior, in the form of fantasies rather than expectation judgments, in unvaccinated people.

Study 2: Comparing Unvaccinated People to Vaccinated People

Study 2 was conducted to serve two purposes; first, we attempted to replicate the findings from Study 1, and second, we examined whether the pattern of results found in Study 1 is unique to unvaccinated people or whether it would be observed among vaccinated people as well. To serve these purposes, we compared unvaccinated and vaccinated people in terms of vaccine hesitancy.

Method

Study design

The study was a cross-sectional study and was conducted in March 2022 (66.1% of the U.S. population had been fully vaccinated). We first measured predictors (expectations and fantasies), then the outcome variable (vaccine hesitancy), and lastly, demographic information.

Participants

We conducted an *a priori* power analysis based on the average effect size of Study 1. Because we were interested in replicating the interaction of the fantasies, we used the average effect size of the interactions between the fantasies of negative COVID-19 impact and negative vaccine impact. The power analysis indicated that at least 304 participants are required to detect an effect size of $f^2 = 0.026$ with a statistical power of .80 for a single regression coefficient in a fixed model. Thus, we aimed to collect 304 participants each for the vaccinated and unvaccinated group.

Participants were MTurk workers residing in the U.S. The unvaccinated group consisted of people who indicated that they had not yet received a COVID-19 vaccine and had no plan to receive it, and the vaccinated group consisted of those who reported having received a single-dose vaccine or two shots of double-dose vaccines. Sixteen participants who took both surveys, one designed for unvaccinated people and another one designed for vaccinated people, were excluded as it was uncertain

whether they were vaccinated or not. Two participants who failed an attention check were additionally excluded, leaving 307 unvaccinated participants (50.5% female, 48.5% male, 0.7% prefer not to say, 0.3% other; 77.1% White or Caucasian, 12.5% Black or African American, 4.4% Hispanic or Latino, 3.0% Asian, 1.7% prefer not to say, 1.0% Multirace, 0.3% Native American or American Indian; age $M = 39.11$, $SD = 11.15$, range: 19–71; annual household income $M = 63,160$, $SD = 47,290$, range: 5,000–250,000) and 311 vaccinated participants (49.2% female, 49.2% male, 1.0% other, 0.6% prefer not to say; 77.6% White or Caucasian, 7.9% Asian, 7.6% Black or African American, 5.0% Hispanic or Latino, 1.0% Multirace, 0.7% prefer not to say, 0.3% Native American or American Indian; age $M = 39.89$, $SD = 12.31$, range: 19–76; annual household income $M = 65,129$, $SD = 44,105$, range: 5,000–250,000) in the final dataset (see Table 1).

Measures

Expectations of negative impact: COVID-19 versus vaccine.

We used the same item as in Study 1 for the expectation of negative COVID-19 impact. The item measuring the expectation of negative vaccine impact needed to be modified so that the responses from two groups are comparable. Specifically, we asked unvaccinated people the likelihood of being negatively impacted if they got *two or more* vaccine shots and asked vaccinated people the likelihood of being negatively impacted if they got *another* shot. This way, we ensured that both groups referred to the similar amount of vaccine shots when judging the likelihood.

Fantasies of negative impact: COVID-19 versus vaccine.

Fantasies of negative COVID-19 impact was measured using the same scenario method we used in Study 1. After completing the hypothetical Coronavirus infection scenario, participants reported the positivity and negativity of their fantasies. To measure fantasies of negative vaccine impact, again, we needed to modify the question to make the two groups comparable; the question for unvaccinated people did not change, but for vaccinated people, we asked them to imagine what would happen if they got *another shot* of the COVID-19 vaccine (see Supplement 5 for the content analysis). Participants then reported the positivity and negativity of their fantasies. We calculated the negativity–positivity difference scores for fantasies of negative COVID-19 impact ($r = -0.79$, $p < 0.001$) and for fantasies of negative vaccine impact ($r = -0.78$, $p < .001$), with a higher score indicating more negative fantasies. (We measured frequencies of fantasies of negative COVID-19 impact and vaccine impact and found no difference between the two groups in terms of the frequencies of those fantasies, $ps > .375$.)

Outcome variable: COVID-19 vaccine hesitancy.

COVID-19 vaccine hesitancy was measured using the same nine items as in Study 1 ($\alpha = 0.97$).

Results

Multiple regression

We ran a multiple regression testing a 3-way interaction of the two expectations and group, and a 3-way interaction of the two fantasies and group to see if the interactions of the two expectations and of the two fantasies statistically differed by

group. By doing so, we examined if the nonsignificant 2-way interaction of expectations and the significant 2-way interaction of fantasies found among unvaccinated people also holds for vaccinated people.

COVID-19 vaccine hesitancy.

Regarding expectations, we found a significant 3-way interaction of the two expectations and group, $b = -0.04$, $SE = 0.02$, $t(604) = -2.41$, $p = .016$, $95\% \text{ CI} = [-0.08, -0.01]$,

indicating that the 2-way interaction between expectations of negative COVID-19 impact and vaccine impact differed by group. For the unvaccinated group, the simple interaction of expectations about the two future possibilities was not significant, $b = -0.02$, $SE = 0.01$, $t(604) = -1.48$, $p = .139$, $95\% \text{ CI} = [-0.04, 0.01]$, replicating the findings of Study 1 (see Fig. 4). For unvaccinated people, expectations independently predicted vaccine hesitancy, with a higher expectation of negative COVID-19 impact being associated with

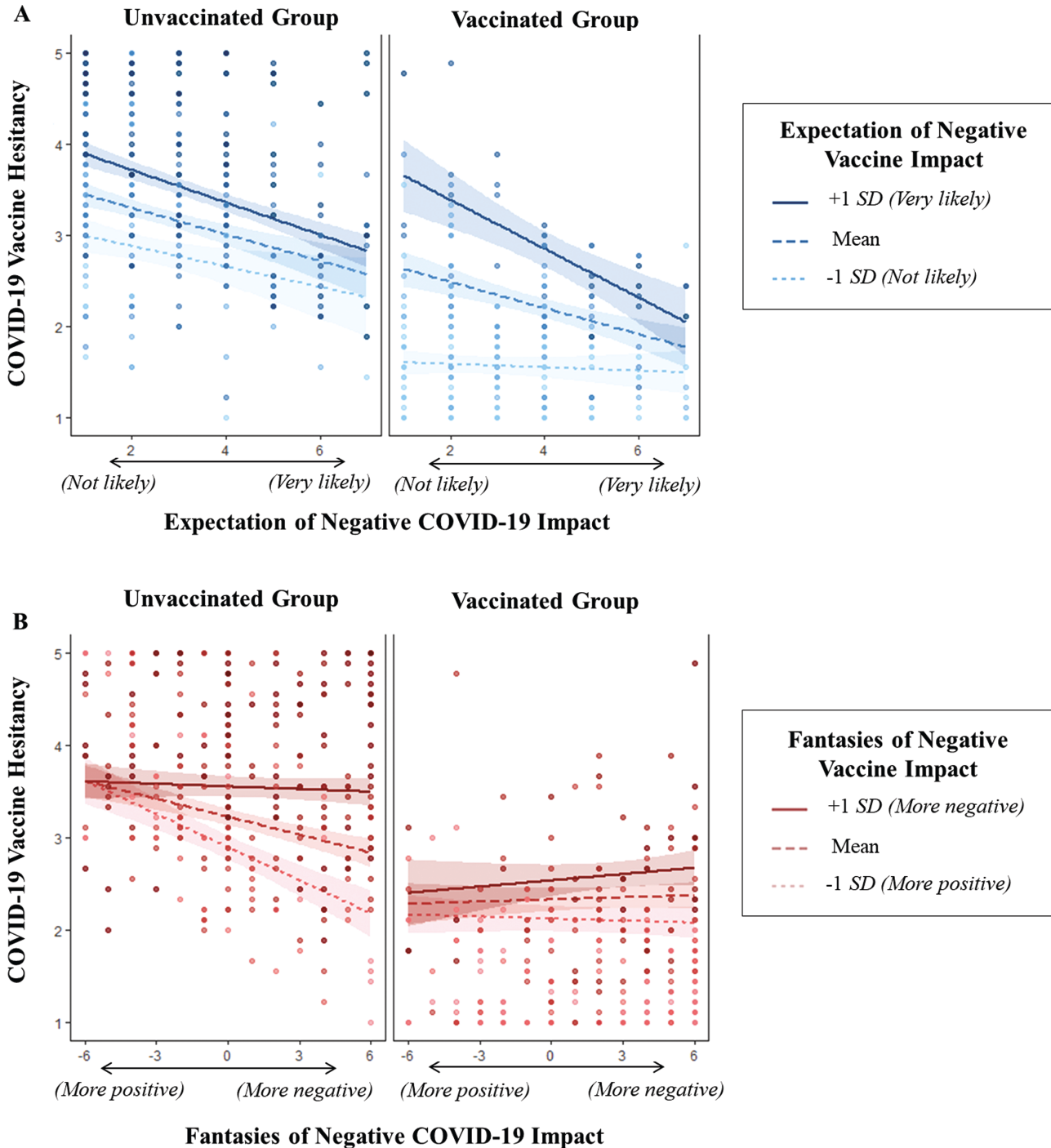


Fig. 4. Vaccine hesitancy as a function of expectations of negative COVID-19 impact and of negative vaccine impact (A) and as a function of fantasies of negative COVID-19 impact and of negative vaccine impact (B) by group (Study 2). Note. Fantasies of negative COVID-19 impact, fantasies of negative vaccine impact, expectations of negative COVID-19 impact, and expectations of negative vaccine impact represent original scores before mean-centering. Shaded areas represent 95% confidence intervals.

lower vaccine hesitancy and a higher expectation of negative vaccine impact being associated with higher vaccine hesitancy (see Table 4 for a summary of decomposed effects). For the vaccinated group, the simple interaction of the two expectations was significant, $b = -0.06$, $SE = 0.02$, $t(604) = -3.98$, $p < .001$, 95% CI = [-0.09, -0.03]; the less vaccinated people expected that COVID-19 would negatively affect them, the more hesitant they were about the COVID-19 vaccination, but only for the people with a high expectation of being negatively affected by the vaccination (+1 SD), $b = -0.27$, $SE = 0.06$, $t(604) = -4.82$, $p < .001$, 95% CI = [-0.38, -0.16], not for those who had low expectations (-1 SD), $b = -0.02$, $SE = 0.03$, $t(604) = -0.69$, $p = .491$, 95% CI = [-0.07, 0.03]. In other words, vaccinated people who expected that they were not likely to suffer from vaccine side effects had a low level of vaccine hesitancy regardless of their expectations to seriously suffer from COVID-19. However, those who expected that the vaccine will make them suffer from its side effects considered their likelihood of suffering from COVID-19; they were more hesitant to get vaccinated when they expected not to seriously suffer from COVID-19.

Regarding the fantasies, we found a significant 3-way interaction of the two fantasies and group, $b = -0.01$, $SE = 0.004$, $t(604) = -2.78$, $p = .006$, 95% CI = [-0.02, -0.003], indicating that the 2-way interaction between fantasies of negative COVID-19 impact and vaccine impact differed by group. For the unvaccinated group, the simple interaction of the two fantasies was significant, $b = 0.01$, $SE = 0.003$, $t(604) = 5.64$, $p < .001$, 95% CI = [0.01, 0.02]; consistent with Study 1, the more negatively unvaccinated people fantasized about the future of suffering from COVID-19, the less hesitant they were to get a vaccine, but only for those who fantasized less negatively about the future of getting a vaccine (-1 SD), $b = -0.12$, $SE = 0.02$, $t(604) = -6.53$, $p < .001$, 95% CI = [-0.16, -0.08], not for those who fantasized more negatively about it (+1 SD), $b = -0.09$, $SE = 0.01$, $t(604) = -0.85$, $p = .396$, 95% CI = [-0.03, 0.01]. In contrast, for vaccinated people, the simple interaction of fantasies was not significant, $b = 0.004$, $SE = 0.003$,

$t(604) = 1.40$, $p = .162$, 95% CI = [-0.002, 0.01], and only the fantasies about vaccines significantly predicted vaccine hesitancy, $b = 0.06$, $SE = 0.01$, $t(604) = 5.21$, $p < .001$, 95% CI = [0.01, 0.04], whereas fantasies about COVID-19 did not, $p = .519$.

Discussion

Study 2 replicated the findings of Study 1 with another sample of unvaccinated people. For them, fantasies about the two future possibilities interactively predicted vaccine hesitancy; those with more negative COVID-19 fantasies were less hesitant about COVID-19 vaccination, but only when they harbored less negative vaccine fantasies. On the other hand, expectations about the two future possibilities additively predicted vaccine hesitancy rather than multiplicatively; higher expectation of negative COVID-19 impact and lower expectation of negative vaccine impact independently predicted lower vaccine hesitancy among unvaccinated people.

In contrast, vaccinated people showed a different pattern. For them, the interaction of expectations, rather than fantasies, predicted vaccine hesitancy; those who expected not to seriously suffer from COVID-19 and expected to suffer from vaccine side effects were more hesitant about the COVID-19 vaccination. Although the interaction of fantasies was not significant for vaccinated people, negative fantasies about getting vaccinated independently predicted higher vaccine hesitancy. Because vaccinated people had low baseline vaccine hesitancy, the effect was observed on what makes them more hesitant, whereas for unvaccinated people who had high baseline vaccine hesitancy, the effect was found on what makes them less hesitant. In sum, the findings suggest that different psychological principles are at play for unvaccinated versus vaccinated people.

General Discussion

In the present research, we examined whether future thoughts about two COVID-related future possibilities interactively or additively predict COVID-19 vaccine hesitancy and vaccine-related behaviors, highlighting experience-based

Table 4 Decomposition of 3-Way Interactions (Study 2)

		Study 2 COVID-19 vaccine hesitancy				
		Unvaccinated group		Vaccinated group		
		<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	
Simple 2-way interactions	Exp_COVID*Exp_Vaccine	-0.02	0.01	-0.06***	0.02	
	Fantasy_COVID*Fantasy_Vaccine	0.01***	0.003	0.004	0.003	
Simple slopes	Exp_COVID			High Exp_Vaccine	-0.27***	0.06
	Exp_COVID			Low Exp_Vaccine	-0.02	0.03
	Fantasy_COVID			High Fantasy_Vaccine	-0.01	0.01
	Fantasy_COVID			Low Fantasy_Vaccine	-0.12***	0.02
Simple main effects	Exp_COVID	-0.15***	0.03	-	-	
	Exp_Vaccine	0.18***	0.02	-	-	
	Fantasy_COVID	-	-	0.01	0.01	
	Fantasy_Vaccine	-	-	0.06***	0.01	

Note. Exp_COVID = expectation of negative COVID-19 impact. Exp_Vaccine = expectation of negative vaccine impact, Fantasy_COVID = fantasies of negative COVID-19 impact, Fantasy_Vaccine = fantasies of negative vaccine impact. Exp_COVID, Exp_Vaccine, Fantasy_COVID, and Fantasy_Vaccine were mean-centered. For significant simple 2-way interactions (i.e., 2-way interactions within each group), simple slopes (i.e., simple slopes at each level of moderators within each group) were reported. For nonsignificant simple 2-way interaction effects, simple main effects (i.e., main effects of variables within each group) were reported. * $p < .05$, ** $p < .01$, *** $p < .001$.

expectations and need-based fantasies. In Study 1, we found with a sample of unvaccinated people that fantasies regarding COVID-19 and fantasies regarding vaccines interactively predicted vaccine-related outcomes; more negative fantasies about suffering from COVID-19 and less negative fantasies about suffering from vaccine side effects, in combination, predicted less vaccine hesitancy, greater inclination toward information related to getting a vaccine, and more actions taken to get a vaccine. On the other hand, no significant interaction was observed between expectations about the two future possibilities on any of the outcome variables. There were significant effects of expectations on vaccine hesitancy and information-seeking direction, with higher expectations of negative COVID-19 impact and lower negative vaccine impact independently predicting less vaccine hesitancy and inclination toward information in favor of vaccination. Regarding vaccination behavior, neither main effects nor interaction effects of expectations were found significant in Study 1.

Study 2 replicated this pattern in a different sample of unvaccinated people; in addition, we found that the pattern of results observed among unvaccinated people did not apply to the vaccinated people. For vaccinated people, expectations about the two future possibilities interactively predicted vaccine hesitancy, whereas the interaction of fantasies failed to do so, although there was a significant independent effect of negative fantasies about vaccines which was associated with higher vaccine hesitancy.

Reducing Vaccine Hesitancy Among Unvaccinated and Vaccinated People

The findings regarding vaccine hesitancy highlight the necessity for a nuanced approach to addressing hesitancy among both unvaccinated and vaccinated people. For unvaccinated people, their hesitancy was found to be interactively predicted by their fantasies about both disease and vaccines, suggesting that solely focusing on either promoting negative fantasies about disease or mitigating negative fantasies about vaccines would not suffice. Instead, effectively addressing vaccine hesitancy in this group requires leveraging both the negative fantasies about suffering from COVID-19 and the negative fantasies about vaccination. In contrast, expectations of suffering from disease and from vaccine side effects independently, not interactively, contributed to vaccine hesitancy. The effect sizes of both expectations were even larger than those of the fantasies, indicating that both of them are significant and strong predictors of vaccine hesitancy. This aligns with previous research adhering to the framework of PMT, which observed independent effects of threat appraisal factors and coping appraisal factors on health behaviors [11, 13]. Thus, interventions aimed at reducing vaccine hesitancy among unvaccinated people would benefit from targeting and modifying their expectations about either disease or vaccine side effects, and simultaneously addressing the negative fantasies about both the disease and vaccine side effects.

An effective intervention for vaccinated people might look different from that for unvaccinated people. For vaccinated people, the interaction pattern was reversed; expectations about disease and vaccines interactively predicted vaccine hesitancy, whereas fantasies did not. The significant interaction among expectations about disease and vaccines resonates with the original proposition of PMT, which assumes a

multiplicative function of the threat appraisals and coping appraisals [12]. While empirical evidence supporting the multiplicative function has been largely missing in past research [11, 13], the present research suggests that the interaction between predictors may vary depending on the subgroup being examined. Our findings revealed that vaccinated people showed interactive effects of expectations, contrasting with unvaccinated people who demonstrated additive effects of expectations. This suggests that interventions aimed at reducing vaccine hesitancy among vaccinated people should focus on emphasizing both the high likelihood of suffering serious illness from COVID-19 and the low likelihood of experiencing adverse effects from the vaccines. In contrast, regarding fantasies, only negative fantasies about vaccines significantly predicted vaccine hesitancy. Thus, interventions should focus on diminishing negative fantasies about vaccines, as it has been observed that negative fantasies about COVID-19 disease rarely predict vaccine hesitancy among vaccinated people.

Promoting Vaccination Among Unvaccinated People

Although vaccine hesitancy is recognized as a significant psychological factor hindering vaccine uptake, our study found only a weak correlation between vaccine hesitancy and vaccination behavior nine weeks later, $r = -0.17$, $p = .012$. Furthermore, the pattern of results found in Study 1 on vaccination behavior did not mirror that of vaccine hesitancy; while expectations about both COVID-19 and vaccines were significant predictors of vaccine hesitancy, they were not significant predictors of vaccination behavior, nor was their interaction. However, fantasies interactively predicted vaccination behaviors, mirroring the findings on vaccine hesitancy and information-seeking behavior. This suggests the importance of considering fantasies about both disease and vaccine side effects when designing vaccine interventions, especially those targeting the vaccine uptake of unvaccinated people.

Our results do not directly explain why fantasies interactively predicted vaccination behavior among unvaccinated people whereas expectations did not. One possible reason for the better predictability of fantasies on vaccination behavior might be the lack of vaccine-related experiences among the unvaccinated group. Expectations are grounded in past experiences, and thus they predict future behaviors only when people have had the chance to actually accumulate relevant experiences [14, 17–19]. Unvaccinated people might lack relevant experiences on which to base their expectations regarding the future of getting vaccinated. Indeed, in our study, unvaccinated people not only lacked experiences with COVID-19 vaccination, but also had fewer experiences with other vaccines in the past (71.3%) compared to vaccinated group (90.7%, $\chi^2 = 37.65$, $p < .001$). The absence of relevant experiences might have driven them to focus on their fantasies that are rooted in their needs and desires (i.e., to prevent the feared vaccination and stay safe) rather than experience-based expectations when deciding whether to get vaccines. This could explain the stronger predictability of fantasies over expectations on vaccine uptake among unvaccinated people.

However, this explanation does not fully explain why unvaccinated people, in the first place, avoided vaccine-related experiences. An alternative explanation is that there might be preexisting differences between the two groups. For example, research showed that unvaccinated people tend to be more

impulsive, prioritizing immediate rewards, than vaccinated people [26]. It might be that people who were more impulsive and driven by immediate needs (e.g., need for safety) avoided the potential vaccine risks by not exposing themselves to such experiences. As a result, unvaccinated people's expectations might have been "empty," that is, not based on vaccine-related experiences. If this is the case, people with little experience may demonstrate a similar pattern (i.e., significant interactions of fantasies and nonsignificant interactions of expectations) in domains other than COVID-19 vaccination, if the domain relates to their needs and desires. Future research will have to explore this possibility.

The two interpretations suggested above lead us to an intriguing research question: What happens when unvaccinated people eventually receive a vaccine, gaining relevant experiences? Would the interaction of expectations become a better predictor of vaccine hesitancy than without having received vaccines? A longitudinal study testing the interactive effects among the fantasies and among the expectations before and after the vaccination can help determine whether the differences between the two groups come from the presence or absence of relevant experiences or from an existing, stable difference between the groups.

From the interventionist perspective, our findings suggest that fantasies, which have received relatively little attention in the literature on health behavior, may play a critical role in vaccination behavior of unvaccinated people. Thus, intervention programs aimed at promoting vaccination of unvaccinated people may benefit from addressing their fantasies. One way to leverage negative fantasies for promoting vaccination is by employing the mental contrasting strategy [20, 21]. Previous studies have shown that mentally contrasting negative fantasies about a feared future (e.g., xenophobic fears, health fears, etc.) with a positive reality standing in the way of the negative future occurring helps people overcome unjustified fears and approach a feared future [37, 38]. Unvaccinated people may more readily approach vaccination once they mentally contrast their negative fantasies regarding vaccine-related future outcomes with vivid mental elaborations of the positive reality standing in the way of these negative outcomes (e.g., reports of others not suffering from the vaccines).

Another line of research demonstrated that mentally contrasting fantasies about a negative, feared future with a precious positive reality that could be lost by the feared future occurring facilitates preventative behaviors (e.g., physical distancing during COVID-19, immediate steps to quit smoking) [39, 40]. Applying this notion to vaccination behaviors, Kim and colleagues, in two unpublished studies, found that mental contrasting of a feared future of falling severely ill with COVID-19 with the precious present reality led vulnerable people to seek more information on vaccination and eventually get COVID-19 vaccines. In sum, following these two lines of research, vaccine interventions may address spontaneous fantasies that unvaccinated people have about feared futures to instill either approach behavior of unjustified fears (e.g., suffering severe side effects of the vaccine) or avoidance behavior of justified fears (e.g., suffering from COVID when unvaccinated).

Theoretical Implications

The present research provides several important theoretical insights into the existing literature on health behaviors

and behavior change. First, the research underscores the significance of exploring both the independent effects and interactions between people's thoughts about disease and those about vaccines. Although there have been propositions advocating for investigation of the interplay between key predictors in health behaviors [10–12], most research on health behaviors, especially on COVID-19 vaccination, has assumed an additive model, focusing solely on the independent predictability of each variable without considering interactions among them. While studying individual predictor effects offers valuable insights into their relative importance, examining interactions among predictors provides additional insights for developing effective interventions, such as whether one should simultaneously intervene in multiple variables or should focus on the most influential predictor to be more efficient. Neglecting the dynamic interactions between people's thoughts underlying health behaviors could hinder gaining such insights. Therefore, to better understand vaccine hesitancy and develop effective interventions, it is crucial to investigate both the interactions and independent contributions of people's thoughts about disease and vaccination.

Second, it is noteworthy that different subgroups exhibited distinct pattern of results. Among unvaccinated people, fantasies about suffering from COVID-19 and fantasies about potential side effects of vaccination interactively predicted vaccine hesitancy, whereas expectations of suffering from COVID-19 and expectations of potential side effects of vaccination independently predicted vaccine hesitancy. On the other hand, for vaccinated people, expectations, rather than fantasies, interactively predicted vaccine hesitancy. This contrasting pattern observed among the unvaccinated and vaccinated group highlights the necessity of tailoring vaccine interventions to specific target groups and underscores the importance of investigating different psychological principle at play within each group.

Lastly, the findings demonstrate that it is theoretically important to distinguish between the two forms of future thoughts. In our study, the interaction among need-based future thoughts (fantasies) and that among experience-based future thoughts (expectations) predicted vaccine hesitancy in the unvaccinated versus vaccinated group, respectively. These findings highlight the unique predictive value of both forms of future thinking and suggest that we will gain important insights into understanding each group by studying both. When predicting unvaccinated people's attitudes and behavior toward vaccines, it might be informative to explore their needs, fears, and desires, which are the basis of their fantasies, in addition to their experience-based expectations. In contrast, when predicting vaccinated people's attitudes and behaviors, one may look at their past experiences and expectations.

Limitations and Future Directions

There are several limitations that require future research. First, the sample was constrained to the U.S. population, thereby limiting the applicability of the findings beyond the population in the U.S. Future research should include diverse samples in various cultural settings to test the generalizability of the findings. Second, it remains a question why unvaccinated and vaccinated people showed different patterns of results. Research further investigating the psychological processes underlying the distinctive patterns of the

two groups will provide insights into better understanding and addressing vaccine hesitancy. Third, the present findings do not provide answers regarding what kinds of needs underlie the fearful fantasies people have about potential health threats. We speculate that people's needs for safety and harm reduction may underlie these fearful fantasies, similar to positive and idealized fantasies that arise from needs and desires [22]. Future research may directly test this idea by examining when a deficiency in the sense of safety prompts people to generate fearful fantasies about potential harms and when such needs prompt hopeful fantasies about satisfying one's needs for safety. Fourth, the insights from the present research may not be limited solely to the COVID-19 vaccination. Future research may replicate the findings in the context of other viruses and diseases (e.g., HPV). Lastly, researchers may find the distinction between expectations and fantasies useful in other life domains than health behavior where people entertain fantasies and expectations regarding various contents (e.g., politics when it comes to elections; business when it comes to investment behavior). Future research may incorporate both expectations and fantasies to examine their distinctive roles in predicting future behaviors in various domains.

Conclusion

We examined unvaccinated and vaccinated people's future thoughts—expectations and fantasies—about two COVID-related futures and their links to COVID-19 vaccine hesitancy and vaccine-related behaviors. Our research highlights the value of examining not only the independent contributions but also the interaction between future thoughts about disease and vaccine side effects. It also suggests that researchers may gain more insights by distinguishing between experience-based expectations and need-based fantasies. To reduce vaccine hesitancy among unvaccinated people, it is important to address both fantasies about COVID-19 and vaccine side effects. In addition, tackling their expectations about COVID-19 and vaccine side effects can independently add value. Vaccine programs may maximize the effectiveness in boosting vaccine uptake by intervening in unvaccinated people's fantasies, rather than their expectations.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards Authors SunYoung Kim, Peter M. Gollwitzer, and Gabriele Oettingen declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Authors' Contributions SunYoung Kim (Conceptualization [Equal]; Data curation [Lead]; Formal analysis [Lead]; Investigation [Lead]; Methodology [Equal]; Visualization [Lead]; Writing – original draft [Lead]), Peter M. Gollwitzer (Conceptualization [Supporting]; Methodology [Supporting]; Supervision [Supporting]; Writing – review & editing [Supporting]), and Gabriele Oettingen (Conceptualization [Equal]; Methodology [Equal]; Supervision [Lead]; Writing – review & editing [Lead])

Ethical Approval Ethics approval for the studies was obtained from the University Committee on Activities Involving Human Subjects (UCAIHS) at New York University. Both studies were conducted in accordance with the ethical standards of UCAIHS at New York University. All participants provided electronic informed consent prior to their participation.

Transparency Statements This study and analysis plan was not formally registered. De-identified data from this study, analytic code used to conduct the analyses presented in the study, all materials, and [Supplementary Materials](#) are available in a public archive: <https://osf.io/fvrha/>.

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