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Reducing COVID vaccine hesitancy by inducing a comparative mindset

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ABSTRACT

Objective: To investigate if a behavioral nudge comprising a vaccination opportunity that employs *a comparative probe* first (i.e., which vaccine to take) versus the more commonly-used *deliberative probe* (i.e., willingness to take a vaccine), reduces vaccine hesitancy, while controlling for political partisanship.
Methods: In a randomized study, conducted on Amazon Mechanical Turk and Prolific, we varied the manner in which the vaccination offer is posed. In one group, participants were asked to compare which vaccine they would like to take (i.e., the comparative probe), while, in another group, participants were asked to deliberate whether they would like to take the vaccine (i.e., the deliberative probe). Participants' political preferences were also measured. The primary outcome variable was vaccine hesitancy.
Results: A LOGIT regression (N = 1736), was conducted to test the research questions. Overall, the *comparative probe* yielded a 6% reduction in vaccine hesitancy relative to the typical *deliberative probe*. Additionally, while vaccine hesitancy varies due to individual political views, the *comparative probe* is effective at reducing vaccine hesitancy even among the most vaccine hesitant population (i.e., Pro-Trump Republicans) by almost 10% on average.
Conclusions: Subtly changing the manner in which the vaccination offer is framed, by asking people to compare which vaccine to take, and not deliberate about whether they would like to take a vaccine, can reduce vaccine hesitancy, without being psychologically taxing or curtailing individuals' freedom to choose. The nudge is especially effective among highly vaccine hesitant populations such as Pro-Trump Republicans. Our results suggest a costless communication protocol in face-to-face interactions on doorsteps, in clinics, in Pro-Trump regions and in the mass media, that might protect 5 million Americans from COVID-19.

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> "Now we need to go … community by community, neighborhood by neighborhood, and oftentimes, *door-to-door — literally knocking on doors* — to get help to the remaining people (protection) from the virus." (italics added).
> *Remarks by President Biden, July 6, 2021.*

1. Introduction

All adults became eligible for COVID vaccinations over a year ago, yet the full vaccination rates for adults in half of the fifty states in the U. S. are still languishing below the 65 % benchmark. Nationally, roughly 32 % of the U. S. population has yet to be fully vaccinated against the Coronavirus, as of this writing. This circumstance, despite easy access to vaccinations, has obvious adverse consequences for the health and well-being of the unvaccinated as well as the vaccinated, since the unvaccinated might serve as incubators for the development of COVID-19 variants, thus potentially creating another public health hazard for the vaccinated in the future. Further, recent polling indicates that 37 % of Americans are "vaccine hesitant" [10], and Republicans display greater vaccine hesitancy than Democrats [19,21]. These numbers are especially concerning in light of more recent, and more preventable spreads of infectious diseases, such as the recent Monkeypox outbreak in the U. S. among "men who have sex with men" communities. Clearly, public healthcare successes depend not only on technology or knowledge among experts, but also on the cooperation of the public.

To combat the vaccine hesitancy that many Americans display, policy makers have been experimenting with various tools ranging from incentives (e.g., dollars, lotteries, to name a few) to "mandates" (e.g., organizations requiring employees and customers to provide proof of vaccination). These approaches suffer from drawbacks – incentives are costly and might backfire [2], and mandates

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might also result in a backlash. In fact, the "door-to-door" approach mentioned by President Biden in the opening vignette above received immediate backlash from Republicans. Further, the door-to-door approach and associated employment of credible messengers – primary care physicians, political figures, and the like – while laudable, emphasize source credibility, but are silent on precisely what message the messengers ought to convey. That is, while the message source is important, so are message characteristics [32], such as social nudges [22], and the credibility and impact of messages from credible messengers varies by recipient [6]. This lacuna – the content of the message and how it is received by various groups of recipients (i.e., partisans) – is the focus of our inquiry.

2. Literature review

Vaccine hesitancy has been defined by the WHO as "delay in acceptance or refusal of vaccination despite availability of vaccination services" [15], p. 4163). Many cognitive biases are involved in vaccine hesitancy [7], such as the bias to prefer potentially more harmful inaction over potentially harmful action (omission bias). Several behavioral science-based approaches have been advocated to overcome these biases, ranging from emphasizing loss aversion to collective responsibility [12]. Most of these approaches rely on persuasion that focuses on getting people to accept the benefits of vaccination (e.g., [24]), which can be psychologically taxing for individuals [28]. We adopt a different approach to reduce vaccine hesitancy. Research in behavioral economics demonstrates that subtle changes to the environment or process by which individuals make a decision can help guide their behavior [25] without restricting their options, unlike mandates. Hence, such "nudges" are not only less psychologically taxing, but are also comparatively more ethically acceptable [5]. Recent healthcare applications of such nudges have also been successful [16]. We propose a similar nudge by changing the way in which the vaccination question is posed. Drawing from the theory of comparative mindsets, we propose that asking people to *compare* among available vaccine options rather than *deliberate* about whether they will take the vaccine, yields a reduction in vaccine hesitancy.

The reason the *comparative probe* reduces vaccine hesitancy is based on research on mindsets [34]. When contemplating a choice, such as a purchase, individuals' decision architecture typically comprises three steps [33]. First, during a "Deliberative" stage, individuals consider whether they should engage in a certain course of action. Next, if the first step yields an affirmative outcome, in a second, "Comparative" stage, individuals compare among options and select one. Finally, in an "Executional" stage, individuals implement the action selected in the second stage [35]. For instance, an individual might consider purchasing a new car ("whether-to-buy"). Once they have decided to purchase, they will proceed to compare options ("which-to-buy") and finally, once they identify an option, they will execute the plan by deciding "how-to-buy" (e.g., a cash purchase). Similarly, individuals contemplating getting vaccinated against COVID-19 are likely to follow this three-step process: deliberating whether to get vaccinated, comparing among options to select one, and executing the plan by determining how to get vaccinated (e.g., picking a date and location).

Because the three steps occur in sequence, the first step ("*deliberating-whether-to-choose*") must yield an affirmative outcome before a later step ("*comparing-which-to-choose*") can be contemplated. Therefore, when the first step is side-stepped and individuals are induced to contemplate the second, which-to-choose step, they likely assume that the first, *deliberating-whether-to-choose* step has yielded an affirmative outcome, and that the *comparing-which-to-choose* is the decision with which they are confronted. So, in the vaccination context, when induced to bypass the *deliberating-whether-to-choose* step and focus on the *comparing-which-to-choose* step, individuals would assume that the decision to be vaccinated has been affirmed and will move on to compare the available vaccine options to take.

An individual's likelihood of choosing to take a vaccine should increase when they are asked which vaccine they wish to take versus when they are asked whether they wish to get vaccinated. This occurs because, at the deliberative stage, the opportunity for counter-argumentation against vaccination exists (individuals might develop arguments for and against taking the vaccine), while in the comparative stage, the opportunity for counter-argumentation against vaccination effectively disappears (individuals might develop arguments for and against a particular brand, as opposed to arguments for and against taking the vaccine). Therefore, bypassing the deliberative mindset and inducing a comparative mindset by simply changing how the vaccination question is posed, could be especially useful at increasing vaccination rates because the ready availability of vaccination during ongoing door-knocking activities and clinic visits makes transitioning from the comparative mindset to an executional mindset seamless.

Finally, vaccine hesitancy is not uniformly distributed across the political spectrum. Polls indicate that, while only 5 % of Democrats are reportedly vaccine hesitant, 43 % of Republicans are vaccine hesitant [8], imoplying that 57% of Republicans are not. This data suggests that a vaccine hesitancy divide exists among Republicans [4]. This divide is likely a reflection of Republicans' differing views of Donald Trump and his early rhetroic about the virus [11]. Therefore, the variability due to political partisanship and the divide amongst Republicans need to be considered.

3. Methodology, analysis and results

3.1. Procedure

Participants were randomly assigned to one of two question frame (QF) conditions. In the *deliberative probe* condition, respondents were prompted to deliberate about their willingness to take the vaccine ("whether" question frame (QF)) on a 7-point scale (see Supplementary Appendix, Question Frame Measures for details). In the *comparative probe* condition, respondents indicated which of the three available COVID-19 vaccines (i.e., Pfizer, Moderna, Johnson & Johnson) they would take. They were also provided an "I don't want a vaccine" option so that they could freely reject all three options even in the *comparative probe* condition, allowing us to measure vaccine hesitancy in the *comparative probe* condition as well. Subsequently, participants responded to items that captured their political partisanship (PPart) (See Supplementary Appendix, Political Partisanship Measures) as well as several demographic markers.

Our decision to employ a scalar measure rather than providing participants with a binary choice (e.g., "I would like to take the vaccine" versus "I would not like to take a vaccine") in the deliberative condition, was designed to prevent participants from engaging in a comparative process while responding to the dependent variable. In other words, the 7-point scale was *the* manipulation to induce deliberative processing; offering two options as choices in the response could have yielded comparative processing, something we did not want to induce.

3.2. Study participants

U.S. citizens over 18 years of age who did not require parental consent to be vaccinated and who were paid workers on Amazon's

Mechanical Turk (MTurk, minimum HIT approval rate of 95 %) and Prolific Academic, participated in the study. Online platforms, such as MTurk, reach a diverse population and are deemed representative of the general population [9], and Prolific has been found to be a high-quality data source as well [18].

A total of 1736 usable responses were collected, with 867 in the deliberative condition and 869 in the comparative condition. Due to the lack of prior studies that have employed our methodology, we were unable to perform a power analysis. However, prior literature indicates that at least 500 responses are required for logistic regression [14]. Therefore, the sample size is deemed appropriate.

The mean age of participants was 39 years. 52.5 % of the participants were women, 71.7 % of the participants were White, and 73.5 % of the participants had a college degree. Rural residents accounted for 24.5 % of the total participants, and 51.2 % of participants had a household income that was greater than $50,000.

This study was approved by the University Institutional Review Board (IRB). Participants read the consent form that was approved by the IRB before responding to the survey.

3.3. Data collection

Our data were collected in seven waves, beginning on April 9, 2021, and ending on May 18, 2021. At this time, the Pfizer-BioNTech, Moderna and Johnson & Johnson (J&J) vaccines had been authorized for Emergency Use Authorization (EUA). Also, the Pfizer-BioNTech vaccine was authorized for adolescents aged 12–15 years [27]. One wave occurred during the April 13–23 period, during which administering of the J&J vaccine had been paused by the Centers for Disease Control and Prevention, and data from that wave was therefore excluded from analyses. Waves differed for reasons that are not germane to this research, though we made minor adjustments to the measurement of variables in different waves (described below). (Details regarding the seven waves of data collection are provided in the Supplementary Appendix, Data Collection).

Our initial waves of data collection did not screen out those who had been vaccinated, employing an approach consistent with the Department of Health and Human Services, who state "Our sample includes individuals who responded "yes" or "no" to having received the COVID-19 vaccine. . ." ([3], p. 4). However, as the number of U.S. citizens who had been vaccinated increased [30], we included a vaccination status measure. Vaccinated individuals were excluded in the last two waves (as well as in wave 3 with a small (n = 50) sample; details are available in the Supplementary Appendix, Data Collection).

3.4. Measures

Our outcome measure is a binary vaccine hesitancy measure (VaxHest). Specifically, respondents who did not express a willingness to take a vaccine in the *deliberative probe* condition (i.e., a willingness rating of ≤ 4 on the 7-point scale), and those who opted for the "I don't want a vaccine" option in the *comparative probe* condition, were classified as vaccine hesitant (VaxHest = 0). The remaining respondents were classified as not vaccine hesitant (VaxHest = 1) (see Supplementary Appendix, Question Frame Measures). Since the primary dependent variable of interest, vaccine hesitancy, is a binary variable, logistic regressions were conducted.

In additional analyses we employed an alternate approach to account for respondents with extreme attitudes towards COVID-19 vaccination. We reasoned that those who provided a rating of "1″ in response to the deliberative probe ought to be classified as vaccine *resistant*, not merely hesitant. Similarly, those who provided a rating of "7" in response to the deliberative probe ought to be classified as vaccine *favoring*, not hesitant. Therefore, given our interest in vaccine hesitant individuals whose attitudes were likely more labile and therefore were more "nudgeable", we examined respondents who provided a rating between 2 and 6, inclusive, in the deliberative probe condition. That is, we excluded respondents who were either adamantly opposed to vaccines or were adamantly in favor of vaccines, as such individuals' attitudes were unlikely to be responsive to a nudge. (Finally, as a robustness check of our original approach, we conducted two additional analyses by reclassifying respondents who provided a rating of a) ≤ 3, and b) ≤ 2, on the 7-point scale in the deliberative condition as vaccine hesitant; these analyses do not change our substantive findings, as discussed in the Supplementary Appendix, Robustness Checks.).

To account for the heightened vaccine hesitancy expressed by Republicans and the variability due to the affinity for Donald Trump within the Republican party [11], respondents who self-identified as a Republican, and non-partisans who leaned towards the Republican party, were classified as Republicans (n = 1065); these respondents were further classified as either Pro-Trump Republicans (n = 750) or not (n = 315) according to their self-identified Trump affinity. The remaining respondents were classified as Democrat/Independent (n = 671).

3.5. Statistical analyses and results

3.5.1. Democrats/independents vs republicans

Examining differences in vaccine hesitancy due to sample characteristics yielded several preliminary insights. First, consistent with national polling, Republicans were over 38 % more vaccine hesitant than Democrats/Independents. More important, vaccine hesitancy was lower by over 6 % under the *comparative probe*, relative to the *deliberative* probe. Additionally, examining the interaction between Question Frame and Political Partisanship, we observe a roughly 6 % decrease in vaccine hesitancy among both Democrats and Republicans, under the comparative versus deliberative probe. (See Figs. 1-3 for details).

Before describing our formal statistical analyses, as noted above, in the initial phases of data collection, we did not ask respondents if they had been vaccinated, but did so in later phases. Therefore, in our statistical model, we include a dummy variable (Screen) to account for whether the data set comprised a vaccination screen or not. As described in the Supplementary Appendix, Robustness Checks, the Screen dummy did not interact with any of the main and interaction effects, so our results do not vary as a function of Screen. (Additional descriptive analyses correlating and regressing demographic and attitudinal markers on Vaccine Hesitancy are provided in the Supplementary Appendix, Examining the role of Demographic and Attitudinal Markers.).

We estimated a LOGIT model as follows, for all respondents:

$$VaxHest = \beta_0 + \beta_1 Screen + \beta_2 QF + \beta_3 PPart + \beta_4 QF * PPart + \varepsilon$$

where Screen compares the influence of having a vaccination status screen (compared with not having such a screen),

QF compares the influence of the comparative probe with the deliberative probe,

PPart compares the influence of being Democrat/Independent with being Republican.

The results of this estimation procedure are available in Table 1, including estimated coefficients, standard errors, Wald statistics, degrees of freedom, *p*-values, Exp (β) (the odds ratio), and confidence intervals associated with the odds ratio. The effect of the Question Frame (Exp (QF) = 0.613, p =.031) on reducing vaccine hesitancy is significant, and compared with the deliberative probe, the comparative probe lowered the odds of individuals being vaccine hesitancy by a factor of 0.613 (i.e., higher compliance as reflected in the selection of one of the three available

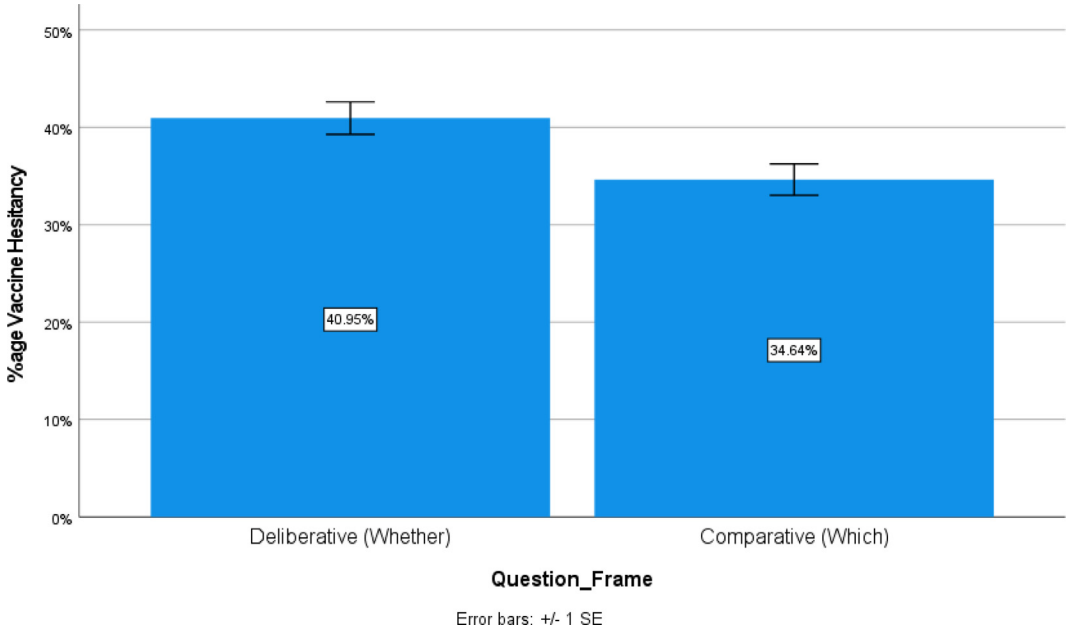

Fig. 1. Overall data based results of Question Frame.

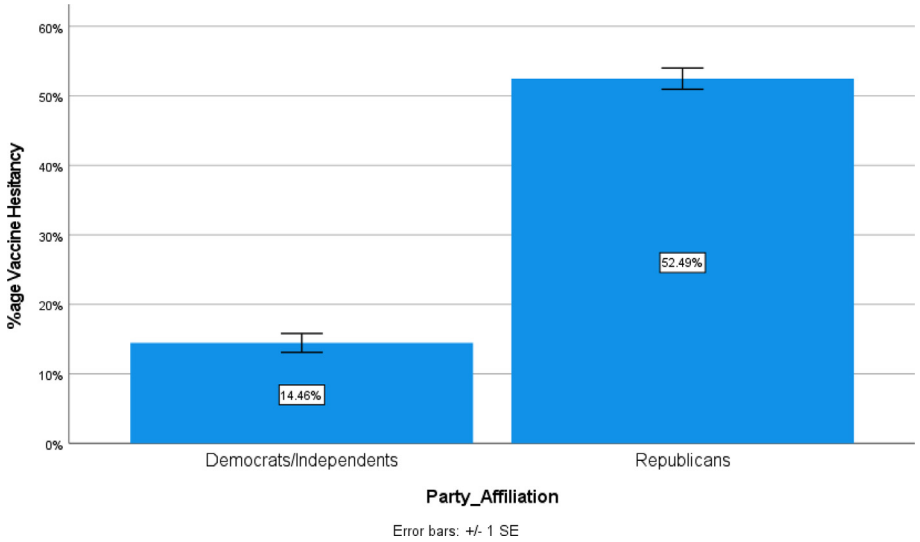

Fig. 2. Overall data based results comparing Democrats/Independents and Republicans.

options). Further, the significant coefficient for Political Partisanship (PPart) confirms that the odds of Republicans being vaccine hesitant were 4.739 (p <.001) times higher than the odds of Democrats being vaccine hesitant (Simple effects are available in Table 2). The absence of a significant interaction (p =.382) indicates that the treatment was equally effective for both Republicans and Democrats.

Additionally, we believe that individuals who hold extreme attitudes, such as those who are vaccine *resistant,* are unlikely to be persuaded. Vaccine resistant individuals will likely decline the vaccine regardless of the question frame. We conducted analyses to test this nuance.

Performing the same analyses after excluding those deemed vaccine resistant/favoring, we find similar results (Table 3). Compared with the deliberative probe, the comparative probe significantly reduced the odds of respondents being vaccine hesitant by a factor of 0.192 (or 80.8 %, Exp (QF) = 0.613, p <.001) (higher compliance as reflected in the selection of one of the three available options). Further, the significant coefficient for Political Partisanship (PPart) confirms that the odds of Republicans being vaccine hesitant were 1.649 (p =.030) times higher than the odds of Democrats being vaccine hesitant. Finally, a significant interaction emerges (p <.001), such that the effect of QF is stronger among Democrats/Independents, relative to Republicans. (Simple effects are available in Table 4).

A graphical representation of the results is available in Figs. 4-6. The comparative probe elicits roughly 18 % lower vaccine hesitancy than the deliberative probe, Republicans are roughly 30 % more vaccine hesitant than Democrats/Independents, and Democrats/Independents are roughly 32 % less vaccine hesitant under

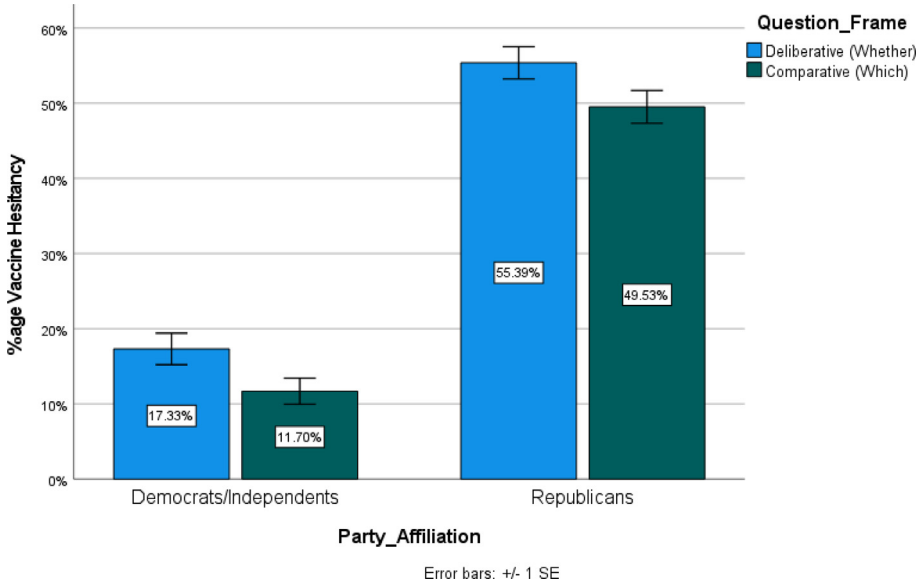

Fig. 3. Interaction Effect of Question Frame and Political Partisanship (Overall data).

Table 1
LOGIT estimation results (overall data).

Variable	β[a]	S.E.	Wald	df	Sig.	Exp(β)	95 % C.I. for Exp (β)	
							Lower	Upper
Constant	−1.796	0.151	140.633	1	0.000	0.166		
QF	−0.489	0.227	4.640	1	0.031	0.613	0.393	0.957
PPart	1.556	0.175	79.284	1	0.000	4.739	3.365	6.675
QF*PPart	0.228	0.261	0.765	1	0.382	1.256	0.753	2.095
Screen	1.278	0.120	112.959	1	0.000	3.588	2.835	4.541

Note. df = degrees of freedom, S.E. = standard errors, Exp(β) = the odds ratio.
[a] The β coefficient should be interpreted as log-odds.

Table 2
Simple effects (overall data).

	Effect[a]	SE	Wald	p	Exp (B)	LL 95 % CI for Exp (B)	UL 95 % CI for Exp (B)
Democrats/Independents	−0.49	0.23	4.69	0.030	0.61	0.39	0.95
Republicans	−0.26	0.13	4.09	0.043	0.77	0.60	0.99

[a] The Effect values should be interpreted as log-odds.

Table 3
LOGIT estimation results (excluding vaccine resistant/favoring).

Variable	β[a]	S.E.	Wald	df	Sig.	Exp(β)	95 % C.I. for Exp (β)	
							Lower	Upper
Constant	−0.545	0.196	7.713	1	0.005	0.580		
QF	−1.651	0.257	41.148	1	0.000	0.192	0.116	0.318
PPart	0.500	0.230	4.711	1	0.030	1.649	1.050	2.591
QF*PPart	1.323	0.300	19.479	1	0.000	3.753	2.086	6.753
Screen	0.930	0.135	47.389	1	0.000	2.535	1.945	3.304

Note. df = degrees of freedom, S.E. = standard errors, Exp(β) = the odds ratio.
[a] The β coefficient should be interpreted as log-odds.

Table 4
Simple effects (excluding vaccine resistant/favoring).

	Effect[a]	SE	Wald	p	Exp (B)	LL 95 % CI for Exp (B)	UL 95 % CI for Exp (B)
Democrats/Independents	−1.65	0.26	41.05	0.001	0.19	0.12	0.32
Republicans	−0.33	0.15	4.56	0.033	0.72	0.53	0.97

[a] The Effect values should be interpreted as log-odds.

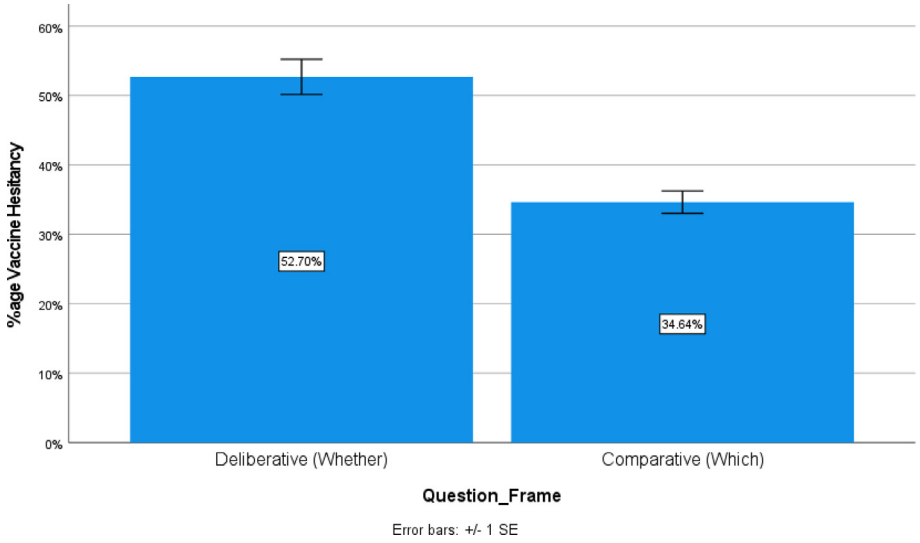

Fig. 4. Results of Question Frame on Vaccine Hesitancy after excluding vaccine resistant/favoring respondents.

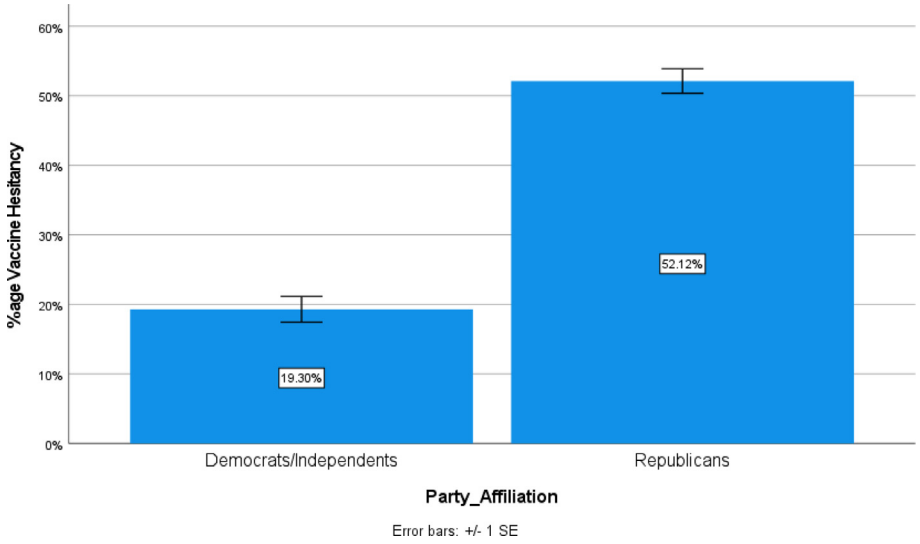

Fig. 5. Results of Party Affiliation on Vaccine Hesitancy after excluding vaccine resistant/favoring respondents.

the comparative probe condition relative to the deliberative probe condition, while Republicans are roughly 6 % less vaccine hesitant under the comparative probe condition relative to the deliberative probe condition.

3.5.2. Democrats/independents versus Pro-Trump Republicans versus Other Republicans

We now turn to a more nuanced analysis that incorporates subtle differences in the Political Partisanship variable. Specifically, we incorporate a potential schism among Republicans that might account for differences in vaccine hesitancy.

In this analysis, we estimated a LOGIT regression on our data employing Helmert coding. Helmert coding compares one level of a factor with the mean of the levels that follow allowing for a comparison between different levels of an independent variable. Applying this coding to PPart yields two categorical variables: PPart1 [comparing Democrats/Independents (coded as 0.667), with Other Republicans (coded as −0.333) and Pro-Trump Republicans (coded as −0.333)] and PPart2 [comparing Other Republicans (coded as 0.500) with Pro-Trump Republicans (coded as −0.500)]. The estimation model is:

$$\begin{aligned} VaxHest = {} & \beta_0 + \beta_1 Screen + \beta_2 QF + \beta_3 PPart1 + \beta_4 PPart2 + \beta_5 QF \\ & * PPart1 + \beta_6 QF * PPart2 + \beta_7 Screen * QF + \beta_8 Screen \\ & * PPart1 + \beta_9 Screen * PPart2 + \beta_{10} QF * Screen * PPart1 \\ & + \beta_{11} QF * Screen * PPart2 + \varepsilon \end{aligned}$$

where Screen compares the influence of having a vaccination status screen with not having such a screen,

QF compares the influence of the comparative probe to the deliberative probe,

PPart1 compares the influence of being Democrat/Independent with being Republican, and.

PPart2 compares the influence of being Other Republican with being Pro-Trump Republican.

The results of the logit model using Helmert coding are displayed in Table 5, including estimated coefficients, standard errors,

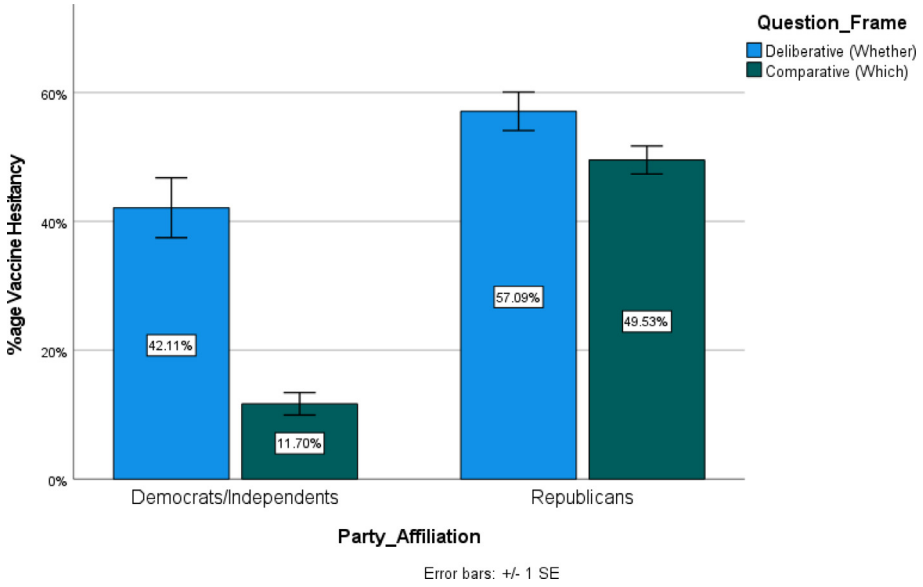

Fig. 6. Interaction of Party Affiliation and Question Frame on Vaccine Hesitancy after excluding vaccine resistant/favoring respondents..

Table 5
LOGIT estimation results.

Variable	β[a]	S.E.	Wald	df	Sig.	Exp(β)	95 % C.I. for Exp (β)	
							Lower	Upper
Constant	−0.976	0.095	105.702	1	0.000	0.377		
QF	−0.256	0.124	4.264	1	0.039	0.774	0.607	0.987
PPart1	−1.253	0.183	46.638	1	0.000	0.286	0.199	0.409
PPart2	−1.428	0.212	45.509	1	0.000	0.240	0.158	0.363
QF*PPart1	−0.355	0.271	1.711	1	0.191	0.702	0.412	1.193
QF*PPart2	0.595	0.294	4.09	1	0.043	1.813	1.019	3.228
Screen	1.344	0.124	117.293	1	0.000	3.834	3.006	4.889

Note. df = degrees of freedom, S.E. = standard errors, Exp(β) = the odds ratio.
[a] The β coefficient should be interpreted as log-odds.

Table 6
Simple effects of political partisanship.

	Effect[a]	SE	Wald	p	Exp (B)	LL 95 % CI for Exp (B)	UL 95 % CI for Exp (B)
Democrats/Independents	−0.49	0.23	4.69	0.030	0.61	0.39	0.95
Other Republicans	0.16	0.25	0.41	0.522	1.17	0.72	1.90
Pro-Trump Republicans	−0.44	0.16	7.75	0.005	0.65	0.47	0.88

[a] The Effect values should be interpreted as log-odds.

Wald statistics, degrees of freedom, *p*-values, Exp (β) (the odds ratio) and confidence intervals associated with the odds ratio. (Simple effects are available in Table 6.).

The significant coefficient for PPart1 indicates that Republicans are significantly more vaccine hesitant than Democrats/Independents. Employing STATA's margin command procedure, we estimate that Republicans are 26.76 % (estimated probability, 95 % CI = [22.39 %, 31.13 %]) more vaccine hesitant than Democrats/Independents. Similarly, the significant coefficient for PPart2 indicates that there is a divide among Republicans regarding their vaccine hesitancy; Pro-Trump Republicans display higher vaccine hesitancy than Other Republicans by 24.90 % (estimated probability, 95 % CI = [18.96 %, 30.85 %]) (see Fig. 7). This effect occurs perhaps because Other Republicans display psychological reactance to the anti-vaccine stance of Pro-Trump Republicans and are therefore more willing to get vaccinated. The overall interaction between question frame and political partisanship is displayed in Fig. 8.

After controlling for the variability due to partisanship and Trump affinity, the model suggests that the *comparative probe* (vs *deliberative probe*) seems to be effective at countering vaccine hesitancy in general. First, when controlling for participants' political partisanship, the significant effect of QF indicates that participants who responded to the *comparative probe* and chose which vaccine to take, as opposed to the *deliberative probe* and contemplate their willingness to take any of the available vaccines, is an effective way to reduce vaccine hesitancy; the *comparative probe* reduces vaccine hesitancy by 5.75 % (estimated probability, 95 % CI = [1.79 %, 9.70 %]). Second, the non-significant QF*PPart1 interaction indicates that the probing effect is equally effective for both Republicans and Democrats/Independents, as observed in the earlier analysis.

Third, and perhaps most important, the significant QF*PPart2 interaction indicates that QF yields a stronger response among Pro-Trump Republicans than Other Republicans. Subsequent simple effect analysis suggests that compared to the *deliberative probe,*

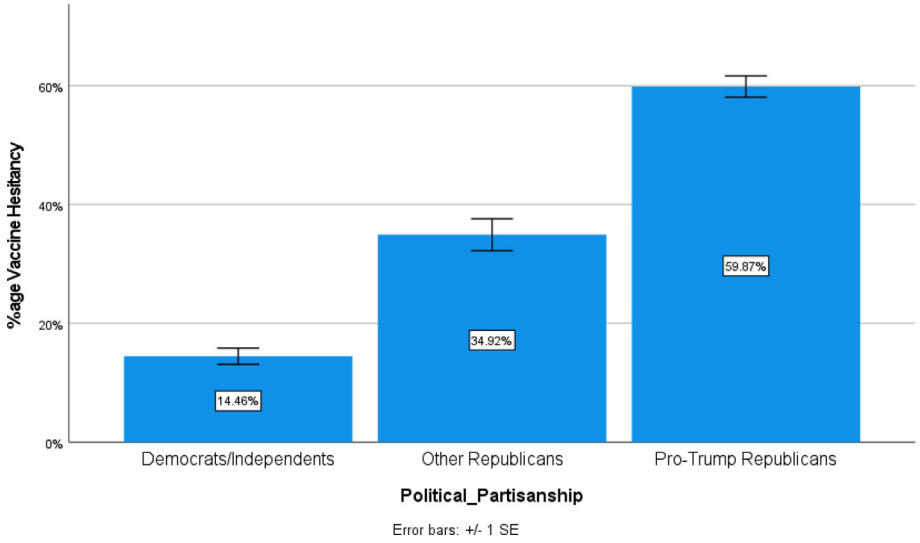

Fig. 7. Overall data based results comparing Democrats, Other Republicans, and Pro-Trump Republicans.

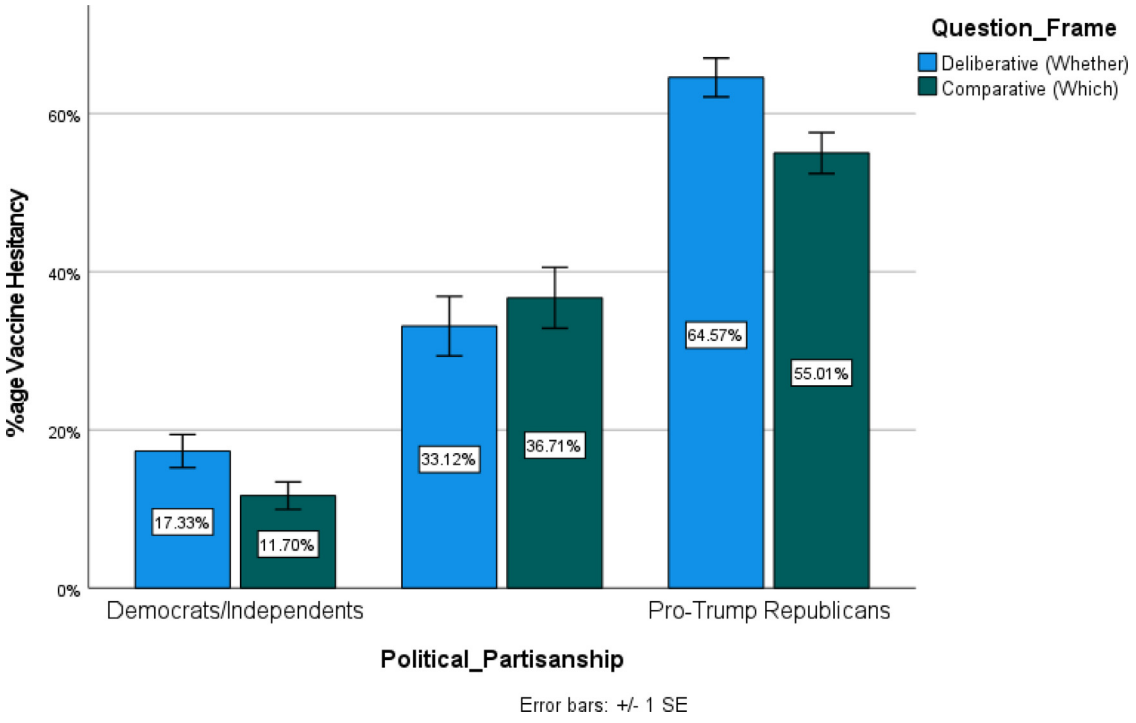

Fig. 8. Interaction Effect of Question Frame and Political Partisanship.

the *comparative probe* significantly lowered vaccine hesitancy among Democrats/Independents by 6.65 % (estimated probability, 95 % CI = [0.68 %, 12.63 %]). Crucially, the *comparative probe* was even more effective at lowering vaccine hesitancy among the most vaccine-hesitant Pro-Trump Republicans by 9.85 % (estimated probability, 95 % CI = [2.95 %, 16.75 %]). In sum, vaccine hesitancy declines among Pro-Trump Republicans and Democrats/Independents due to the comparative probe when compared with Other Republicans (see Table 6).

We then estimated the same model while excluding those deemed vaccine resistant/favoring (see Table 7 and see Table 8 for simple effects). The results are largely similar to the results reported for the entire data set in terms of signs of coefficients and statistical significance, except for one difference. The interaction effect between QF*PPart2 is no longer significant. That is, when considering only those respondents who are not adamantly opposed to or in favor of vaccination, the direction of the efficacy of the nudge at reducing vaccine hesitancy appears to be similar for individuals with differing political views. However, an examination of the simple effects continues to indicate that the nudge is most effective among Pro-Trump Republicans and Democrats/Independents.

Baseline vaccine hesitancy follows political partisanship (see Fig. 9) with Democrats/Independents displaying relatively low vaccine hesitancy at 19.3 %, Other Republicans displaying moderate levels of vaccine hesitancy at 39.59 %, and Pro-Trump Republicans displaying relatively high levels of vaccine hesitancy at 57.6 %. However, as Fig. 10 indicates, the nudge reduces vaccine hesitancy

Table 7
LOGIT estimation results (selected data).

Variable	β[a]	S.E.	Wald	df	Sig.	Exp(β)	95 % C.I. for Exp (β) Lower	Upper
Constant	−0.340	0.120	7.999	1	0.005	0.712		
QF	−0.769	0.141	29.595	1	0.000	0.463	0.351	0.611
PPart1	−0.330	0.237	1.941	1	0.164	0.719	0.451	1.144
PPart2	−0.914	0.272	11.265	1	0.001	0.401	0.235	0.684
QF*PPart1	−1.322	0.308	18.410	1	0.000	0.267	0.146	0.488
QF*PPart2	0.121	0.338	0.127	1	0.721	1.128	0.582	2.186
Screen	0.991	0.138	51.577	1	0.000	2.694	2.056	3.531

Note. df = degrees of freedom, S.E. = standard errors, Exp(β) = the odds ratio.
[a] The β coefficient should be interpreted as log-odds.

Table 8
Simple effects (selected data).

	Effect[a]	SE	Wald	p	Exp (B)	LL 95 % CI for Exp (B)	UL 95 % CI for Exp (B)
Democrats/Independents	−1.65	0.26	41.05	0.001	0.19	0.12	0.32
Other Republicans	−0.28	0.28	1.02	0.313	0.76	0.44	1.30
Pro-Trump Republicans	−0.40	0.19	4.41	0.036	0.67	0.46	0.97

[a] The Effect values should be interpreted as log-odds.

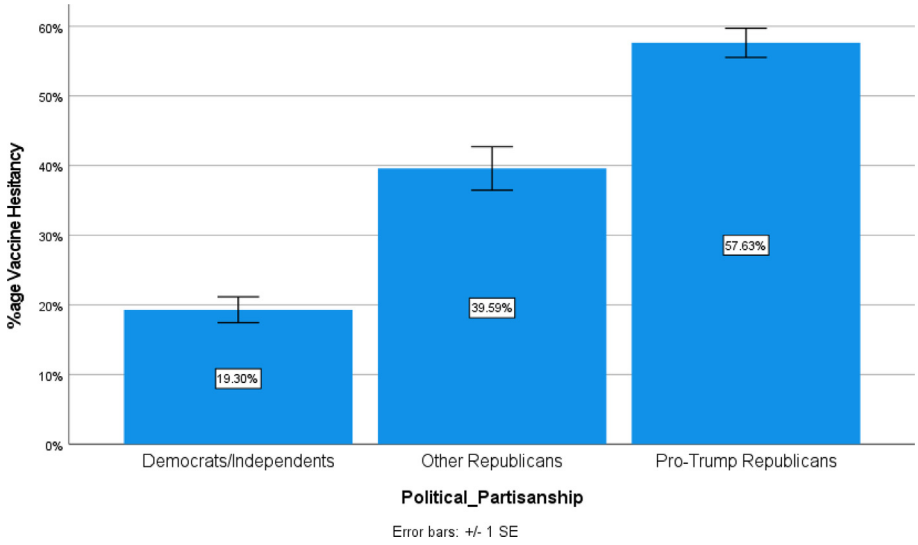

Fig. 9. Results due to Party Affiliation while excluding vaccine resistant/favoring.

among Democrats/Independents by about 31 %, among Other Republicans by a non-significant 8 % and among Pro-Trump Republicans by a significant 7 %. In sum, and consistent with our earlier analysis, vaccine hesitancy declines among Pro-Trump Republicans and Democrats/Independents due to the comparative probe, when compared with Other Republicans.

4. Discussion

For the health and well-being of the general population, vaccine hesitancy will need to be addressed. While other, costly attempts at persuasion such as monetary incentives and credible spokespeople are currently being employed, we identify an alternative approach to increase vaccination outcomes simply by changing the way the vaccination option is posed. Our results indicate that using *a comparative probe* to ask an individual to choose which vaccine they would like to take versus *a deliberative probe* to ask whether they would like to take a vaccine at all, significantly reduces hesitancy. Aggregating our findings to the U.S. population has the potential for significant positive public health outcomes. For instance, if 32 % of the U.S. adult population of 255 million has yet to be vaccinated despite the ready availability of vaccines (and is therefore deemed to be vaccine hesitant), then roughly 82 million U.S. adults require a nudge. If employing a *comparative probe* could reduce vaccine hesitancy among that 82 million by 6 %, 4.92 million people will be protected from COVID-19. Particularly in populations that are deemed to be hesitant *a priori*, such as Trump supporters, our approach could have a major impact on COVID prevention and protection.

4.1. Study strengths and implications

Our approach has advantages over approaches that feature economic and other incentives. First, our approach does not require costly outlays in the form of cash or products. Second, some recent programs such as lotteries likely do not work [29], perhaps because of a backlash effect [2]. Third, our approach is simple to implement. Our results suggest a communication protocol to increase vaccina-

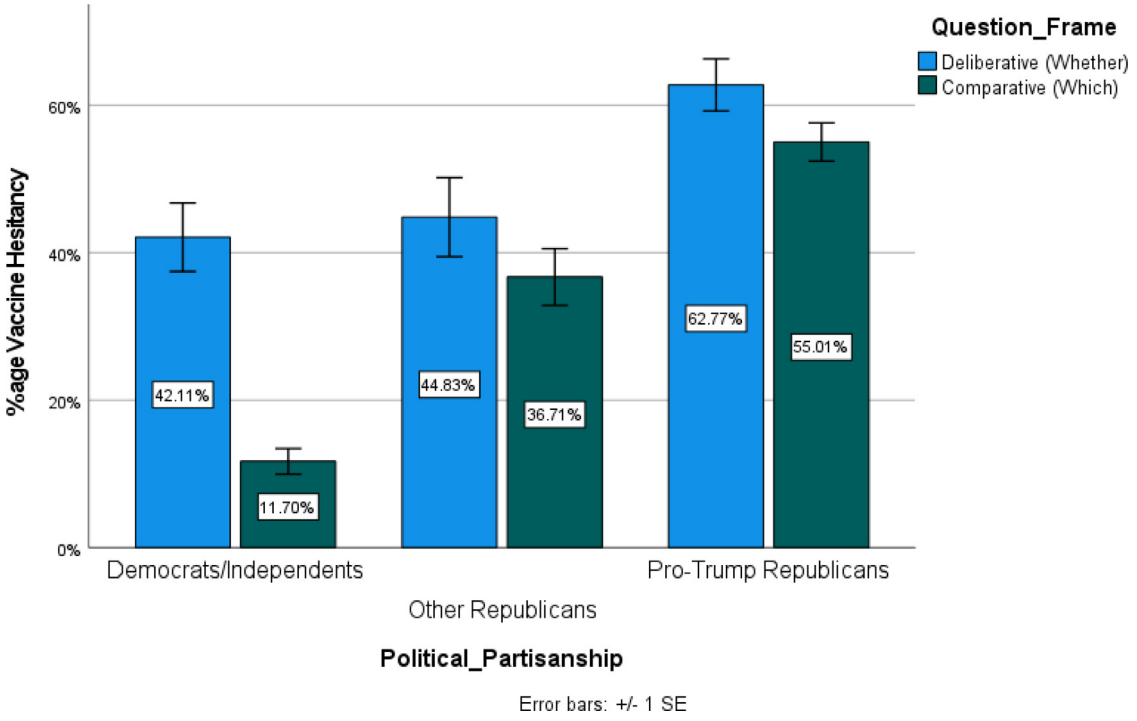

Fig. 10. Interaction of Political Ideology and Question frame while excluding vaccine resistant/favoring.

tions during the door-knocking exercises suggested in President Biden's July 6th, 2021 remarks. Doorknockers should pose vaccination questions in a *comparative* fashion and prompt respondents to decide which vaccine they would like to receive, along with the freedom to decline one. During clinic visits, physicians should ask patients which vaccine they would like (along with the freedom to decline one). Our framing approach would be especially useful during door-knocking and in a clinic setting as vaccination can take place immediately after people choose which vaccine they would like to receive.

In other situations featuring the resumption of in-person activities, such as colleges welcoming students to dormitories, vaccination campaigns should be presented as a menu of vaccines to choose from, immediately followed by an email or phone sign-up to transition into the execution stage. Mass communication efforts should emphasize the vaccination decision as a choice problem of selecting which vaccine to take, followed by a QR code for respondents to scan and sign up. Although there might be a lag between choosing which vaccine to receive and actually getting a vaccine, inducing a comparative mindset could lead to an executional mindset for COVID vaccines, particularly in settings in which executing the option is easy. Importantly, face-to-face and mass communications should emphasize the choice frame, particularly in areas that voted for Donald Trump [31].

An issue that merits contemplation is the significant effect of the nudge on Pro-Trump Republicans. Our theory suggests that bypassing the deliberative stage and engaging the comparative stage in the choice architecture reduces the likelihood of vaccine resistance because of a reduction in the tendency to counter-argue. In other words, asking Pro-trump Republicans "whether" they would like to take a vaccine results in their contemplating reasons *not* to take the vaccine. However, when asked which vaccine they would like to take, Pro-Trump Republicans engage in choice processing, thus reducing or eliminating the possibility of counter-argumentation about whether to take the vaccine and limiting counter-argumentation to the pros and cons of specific vaccine brands. Such a process would imply that, consistent with prior research, Pro-Trump Republicans engage in greater heuristic processing [26].

Finally, as in all behavioral research, not all participants respond to the manipulation. As noted above, the change occurs predominantly among those who are persuadable (i.e., the mid-range on the 7-point scale), while those at the extremes, who already have strong attitudes that are relatively inflexible, are relatively immune to nudges.

4.2. Limitations and future research

Our work suffers from several limitations. First, we measure behavioral intention as opposed to actual behavior, in an on-line, relatively sterile environment. While current evidence indicates a strong and significant effect of influenza vaccination intention and actual vaccination uptake [17], behavioral intention might not readily translate to actual behavior [23], particularly for novel vaccines such as the COVID-19 vaccines. Other scholars (e.g., [12]), however, have employed a similar approach, measuring behavioral intentions, to examine mechanisms that might reduce vaccine hesitancy. In addition, potential door-knocking campaigns and the wide availability of several COVID-19 vaccines in clinics and community centers are likely to reduce the intention-behavior lag. Future research, of course, should investigate whether the comparative framing indeed increases vaccination behavior.

Second, our sample is a U.S. sample and likely not representative of the world population. However, since one of our goals is to investigate how political partisanship impacts the effect of message framing on vaccine hesitancy, we elected to focus on the U.S. population. Our attempts to recruit participants from across the political spectrum in the U.S. did yield a remarkably wide spread of political preferences and demographic representation.

Third, the issue of vaccine hesitancy is complex, and subject to conspiracy theorizing, politicization, concerns about "purity violation" and the like, and our research provides limited insight into the underlying reasons for vaccine hesitancy and resistance (but see our data and discussion under in the Supplementary Appendix,

Examining the Reasons for Vaccine Hesitancy). Much like other similar research (e.g., Pfattheicher et al., 2021), we readily acknowledge the possible role of other interventions, such as general vaccine skepticism that might impact vaccine intentions.

Fourth, our effects are small, but, should they translate into actual behavior, potentially millions of individuals could be protected from the pandemic. As Pfattheicher et al. (2021) note, "...small effect sizes matter in the context of a pandemic." (p. 7).

In future research, these limitations can be addressed by running field experiments in clinics and other face-to-face settings to assess the efficacy of our nudge. Further, developing a nationally representative sample and conducting research that probes (perhaps employing ethnographic approaches) the core reasons underlying vaccine hesitancy would help develop interventions to increase compliance *before the next pandemic* occurs. Finally, other important interventions that emphasize promotion versus prevention goals and the like, ought to be tested.

5. Conclusion

Although vaccination can effectively enhance immune responses against variants of the COVID- 19 virus, even among people who had been infected in the past [1], vaccine hesitancy exists. Furthermore, as new mutations continue to emerge, the fear of vaccine fatigue is becoming increasingly real. Current approaches to overcome vaccine hesitancy emphasize the provision of information to counter viscerally held beliefs that include conspiracy theories. Other perspectives have discussed empathetic listening, and a recognition that science skepticism is not likely to be overcome [20]. In fact, such approaches attempt to persuade people to get vaccinated based on evidence, data and argument designed to address the "deliberative" stage in decision making. Our approach side-steps this phase and engages the "comparative" stage in decision making, thus avoiding counter-argumentation. Further, while other approaches to segment the population based on peoples' responsiveness to the welfare of the community (e.g., [13]) and to design messages that feature credible messengers might also be appropriate, our results provide an important and subtle *messaging strategy* that messengers could readily employ.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.10.077.

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