Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Computers in Human Behavior 131 (2022) 107218

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Preliminary evidence that brief exposure to vaccination-related internet memes may influence intentions to vaccinate against COVID-19

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ARTICLE INFO

Keywords:
COVID-19
Persuasion
Vaccine
Hesitancy
Nudge
Attitudes
Antivaxxer

ABSTRACT

Despite global efforts to rapidly distribute COVID-19 vaccines, early estimates suggested that 29–35% of the population were hesitant/unwilling to receive them. Countering such vaccine hesitancy is thus an important priority. Across two sets of online studies (total $n = 1584$) conducted in the UK before (August–October 2020) and immediately after the first effective vaccine was publicly announced (November 10–19, 2020), brief exposure (<1 min) to vaccination memes boosted the potentially life-saving intention to vaccinate against COVID-19. These intention-boosting effects, however, weakened once a COVID-19 vaccine became a reality (i.e., after the announcement of a safe/effective vaccine), suggesting meme-based persuasion may be context-dependent. These findings thus represent preliminary evidence that naturally circulating memes may—under certain circumstances—influence public intentions to vaccinate, although more research regarding this context-specificity, as well as the potential psychological mechanisms through which memes act, is needed.

1. Introduction

1.1. COVID-19 vaccination development and distribution

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected more than 250 million people worldwide, with its resulting Coronavirus disease of 2019 (COVID-19) taking more than five million individuals and counting (as of November 12th, 2021; Center for Systems Science and Engineering at Johns Hopkins University, 2021). Rebounding from the pandemic, while avoiding the lethality and economic costs of repeated waves of infection, requires vaccine development and distribution (Graham, 2020). Although this need has been largely met regarding development (and to some extent, distribution), the ultimate utility of any vaccine depends critically on the public's willingness to receive it (Ball, 2020; Chevallier et al., 2021). Early polls, however, suggested that more than 35% of the world's largest countries were hesitant or unwilling to receive a COVID-19 vaccination (Robinson et al., 2021), which was concerning given some estimates that 75–90% of the population would require vaccination to reach COVID-19 herd immunity (Anderson et al., 2020).

1.2. Vaccine hesitancy

Such vaccine hesitancy—refusal or reluctance to receive readily-available vaccinations (MacDonald, 2015)—can have lethal consequences (e.g., consider the re-emergence of measles, Phadke et al., 2016), and has been designated a top 10 threat to global health (World Health Organization, 2019). Countering hesitancy and boosting vaccination intentions is thus critical. Public outreach and information/educational campaigns by experts and authoritative sources have traditionally been used. Nevertheless, vaccine-hesitant individuals are often higher in conspiratorial thinking (Hornsey et al., 2018) and thus distrustful of such sources (Salmon et al., 2005), considering them to be motivated by malicious intentions (Kata, 2010). Further, such campaigns can result in negligible and—in some cases—backfiring effects (Hornsey et al., 2018; Kata, 2010), whereby they reduce intentions to vaccinate among those with initial, negative views about vaccinating (e.g., Nyhan et al., 2014). Another complication is that although many

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https://doi.org/10.1016/j.chb.2022.107218
Received 28 March 2021; Received in revised form 27 January 2022; Accepted 29 January 2022
Available online 1 February 2022

have recommended leveraging social media to expand outreach (e.g., Schaffer Deroo et al., 2020; Yammine, 2020), pro-vaccination information may not be designed with virality-enhancing qualities in mind, and it is often outpaced by anti-vaccination narratives on social media (Blankenship et al., 2018; Guidry et al., 2015; Harvey et al., 2019; Johnson et al., 2020). Unfortunately, even brief exposure (5–10 min) to such anti-vaccine content can decrease intentions to vaccinate (Betsch et al., 2010; Jolley & Douglas, 2014) (for results specific to COVID-19 vaccination intentions, see Loomba et al., 2021). Indeed, regions with greater (vs lesser) online anti-vaccination sentiment have lower vaccination coverage (Salathé & Khandelwal, 2011).

Other methods to counter vaccine hesitancy have had mixed success. One recent large-scale flu vaccine study showed that certain nudges—two text messages indicating, for example, that the vaccine was waiting/reserved for them—boosted appointment attendance and vaccine uptake relative to a single text message or the usual care control group (Milkman et al., 2021). Among experimental studies examining COVID-19 vaccination intentions specifically, one study found that interactions with a "chat box" (i.e., a computer program that provided pre-recorded answers after participants selected a question from a fixed list of options) increased positive attitudes towards, and intentions to receive, a COVID-19 vaccine (Altay et al., 2021). Separate studies found that providing the vaccine-hesitant with messages of physician or scientist vaccine endorsement, of how the vaccine can reduce the likelihood of harm to self or others, or about descriptive norms regarding vaccine acceptance, increased intentions to recieve a COVID-19 vaccine (Green et al., 2021; Moehring et al., 2021). Other findings, however, demonstrated that neither showing participants messages about the risks of the virus or safety of the vaccination (Duquette, 2020), nor providing monetary incentives (Sprengholz et al., 2021), were sufficient to increase vaccination intentions. Green et al. (2021) further found that vaccine intentions were largely unaffected by endorsement from one's favourite athlete, celebrity, or politician, and that backfiring effects (i.e., increased hesitancy) were found when partisan endorsement was from a political out-group.

1.3. Can internet memes affect intentions to vaccinate against COVID-19?

In short, there remains need for novel and effective interventions that (1) appear to originate from less typical sources that could be dismissed as being 'in on the conspiracy,' (2) are highly shareable on social media, possessing characteristics that promote virality, such as imagery combined with text (vs text-alone) (Chen & Dredze, 2018), and (3) are scalable—rapidly interpretable (<1 min) to allow for quick engagement, transmission, and thus widespread influence. Internet memes—often in the form of images with humorous text overlays (see additional definition details in Harvey et al., 2019; Shifman, 2014)—may possess some of these characteristics (e.g., Harvey et al., 2019; Ross & Rivers, 2019; Shifman, 2014). Although there are numerous vaccination-related memes in circulation (Harvey et al., 2019), their effects on intentions to vaccinate against COVID-19 is unknown. A sample of naturally circulating vaccination memes was thus collected and characterized on whether they appeared supportive of vaccination (and/or unsupportive of antivaxxers) and on additional features associated with and presumed to drive their virality. Participants were then exposed to a sampling of the memes (vs control) images before reporting on their intentions to vaccinate against COVID-19.

1.4. Hypotheses and current studies

In line with evidence reviewed above—specifically, that certain forms of vaccine supportive content via electronic communication (e.g., text message "nudges", interactions with a "chat box") boosted intentions to vaccinate—it was predicted that exposure to COVID-19 memes supportive of vaccination or unsupportive of antivaxxers would similarly boost intentions to vaccinate against COVID-19. Further, this prediction was partly based on Social Identity Theory (Tajfel & Turner, 1986), which posits that we define ourselves, in part, by our perceived memberships in or identification with certain groups (e.g., pro- or anti-vaxxers). Given the importance of these groups for our identity and self-concept, the theory further proposes that we strive to view these groups as superior to, or more favourably than, other groups. Having this favourable own- or in-group view, for example, helps boost or maintain our social identity and self-esteem. Memes supportive of vaccination or unsupportive/critical of antivaxxers, however, often employ sarcasm and disparage antivaxxers and the vaccine-hesitant (Harvey et al., 2019). Exposure to such memes may thus cause some to distance themselves from these groups, and/or express beliefs or behaviours less consistent with them, minimizing social identity threat (for more on disparaging humour and social identity theory, see review in Ferguson & Ford, 2008; for more recent work, see Abrams & Bippus, 2011; Ford et al., 2019; Lee et al., 2015).

Others have pointed out that disparaging humour (often employed in memes, Harvey et al., 2019) may further signal that the beliefs and behaviours of the targeted group (antivaxxers or the vaccine-hesitant) are non-normative and undesirable/disliked (e.g., Lee et al., 2015; Zekavat, 2021). At the same time, such humour appears to serve a social-corrective function, hypothetically increasing conformity to the alternative, implied norm (for example, see review by Janes & Olson, 2010). Along these lines, memes supportive of vaccination and/or unsupportive of antivaxxers may make antivaxxers' intentions to not vaccinate seem non-normative and undesirable/disliked and, at the same time, increase conformity to the implied alternative norm that most people intend to vaccinate. Similarly, the Theory of Planned Behaviour (Ajzen, 1991) posits that such norms and attitudes (e.g., that most people intend to vaccinate, and that vaccination is desirable/likeable)—in addition to one's sense of control—directly influence intentions to engage in a target behaviour (e.g., vaccinating). Indeed, recent studies have demonstrated links between norms, attitudes, perceptions of control, and intentions to vaccinate against COVID-19 (e.g., Hossain et al., 2021; Sherman et al., 2021). In short, memes supportive of vaccination or unsupportive of antivaxxers may both signal and promote conformity (and positive attitudes) towards vaccination/pro-vaccination norms.

Therefore, because of these hypothesized identity-distancing, norm-signalling, and conformity- and attitude-promoting effects, it was predicted that brief exposure (<1-min) to the memes (vs control images) would increase participants' intentions to vaccinate against COVID-19. Although these predictions were based, in part, on hypotheses derived from Social Identity Theory and the Theory of Planned Behaviour (and thus certain measures relevant to these theories are included across some studies such as identification with and attitudes towards antivaxxers), it is important to note that the studies reported here were not necessarily designed to test these specific theories. Rather, much of the work was aimed at more generally establishing—and replicating—the effects of memes on intentions to vaccinate.

To this aim, an initial set of studies (Studies 1–3) was conducted between August and October 2020, before the first safe/effective vaccine was publicly announced (on November 9th, 2020). In the wake of this important update, however, several additional studies were conducted (Studies 4–6) to determine if the meme effects established in the initial set of studies would persist after a COVID-19 vaccine shifted from being hypothetical (i.e., pre-announcement) to a reality (i.e., post-announcement). Note that final analyses and results thus deviated from the individual preregistrations to provide greater focus on this main research question (Do memes increase intentions to vaccinate against COVID-19?) and the more general finding(s) that emerged across the studies when they were combined for analysis. This combined analysis also allowed for greater precision when estimating the effects of the memes on intentions to vaccinate. Nevertheless, datasets and materials from these 6 studies are provided for those interested in testing additional or secondary research questions.

2. Material and methods

2.1. Participants

Residents of the United Kingdom were recruited through Prolific, an online labour market, and paid according to the site's minimum wage (£5.00/hour) (Palan & Schitter, 2018). Sample sizes varied across studies but were initially preregistered to ensure more than 80% power to detect an effect of *Cohen's d* = 0.339 (an estimate obtained from a preliminary study, $n = 92$). When combining data from this preliminary study (Study 1) and all subsequent studies (6 studies total), the total sample size was 1584 participants (67.6% women; $M_{age} = 34.91$ years, $SD = 12.43$) [after exclusions based on failed attention checks, missing vaccination intention responses, and/or inconsistent/discrepant responses, *n excluded* = 100 (6%)]. See Table 1 for dates and sample sizes associated with each of the studies. All participants consented to the procedures of the studies, which were approved by the Human Research Ethics Board of the corresponding author's University.

2.2. Materials

2.2.1. Primary measures

Across Studies 1–6, participants reported their gender, birth year (which was transformed to age), political orientation ["Please indicate on the scale how liberal or conservative (in terms of your general outlook) you are" (7-point Likert scale: 1 = *very liberal,* 7 = *very conservative*)], intentions to be vaccinated against COVID-19 ("When COVID-19 vaccinations are available, do you intend to get vaccinated?" 7-point Likert scale: 1 = *definitely will not*, 7 = *definitely will*), and their identification as either pro- or anti-'vaxxer'. Note that this identification question was asked after the measurement of vaccination intentions to avoid any potential biases that the identification questions may have had on the main dependent variable of interest (intentions to vaccinate). Nevertheless, it was anticipated that participants' responses on this identification question could have been affected by the preceding meme manipulation. In Studies 1 and 2, in an attempt to minimize this potential influence, participants were asked to indicate their 'pre-study' (and thus pre-meme-manipulation) identification ("*Before taking this survey*, how would you identify yourself in relation to vaccination?" 7-point Likert scale: 1 = *Anti-vaxxer*, 4 = *neither Pro- nor Anti-vaxxer*, 7 = *Pro-vaxxer*). Afterwards, however, it was reasoned that shifts in identification may be an additional (potentially informative) effect of the memes and so, in subsequent studies, participants were simply asked how they would identify, without specifying "*before taking this survey*". [2]

Table 1
Dates and sample sizes associated with each study.

Study	Date(s) of data collection	*n*, after exclusions
Pre-Announcement Studies		
Study 1	July 24th, 2020	92
Study 2	August 4th, 2020	247
Study 3	October 15/16th, 2020	352
First safe/effective vaccine announced on November 9th, 2020		
Post-Announcement Studies		
Study 4	November 10th, 2020	321
Study 5	November 13th, 2020	278
Study 6	November 19th, 2020	294
Combined *n*:		1584

[2] See Supplemental Material, point 1 for discussion of scale usage and comparability across studies. See point 2 regarding additional questions asked about a) when participants intended on being vaccinated against COVID-19, and b) intentions to receive the seasonal influenza vaccine.

2.2.2. Additional measures

In two studies (Studies 3 and 4), participants also reported their ethnicity (white vs other/non-white), religiosity (religious vs non-religious), and whether they had received a vaccination in the last two years (received vs not received). As (potentially informative) additional outcome variables, participants also reported—after the meme manipulation and the vaccination intention question—the extent to which they believed antivaxxers were cognitively and behaviourally similar (modified from Swart et al., 2011: "All antivaxxers think the same and have similar views and opinions on things"; "I think all antivaxxers behave in the same way"; *1* = not at all; *7* = very much so; responses were standardized and averaged to form a perceived homogeneity composite, *Cronbach's* $\alpha = 0.907$), their feelings towards antivaxxers (modified from Converse et al., 1986: "Indicate on this scale how you feel about antivaxxers, with lower scores indicative of cold/unfavourable feelings and higher scores indicative of warm/favourable feelings; 100-point analog scale), and their perceptions about how they would be treated if they told others that they were an antivaxxer (modified from Ford et al., 2019: "If I told others I was an antivaxxer, they would…": "treat me less fairly"; "think negatively of me"; "make environments we share less comfortable for me"; *1* = not at all, *7* = very much so; responses were standardized and averaged to form a perceived negative treatment scale, *Cronbach's* $\alpha = 0.823$).

2.2.3. Meme Stimuli

The initial set of memes was identified through Google Image Search using the terms "COVID-19 vaccinate meme", "COVID-19 vaccinate meme funny", "COVID-19 vaccinate meme scary", "COVID-19 antivax meme", "COVID-19 antivax meme funny", "COVID-19 antivax meme scary" (searches conducted between May 29 and June 15, 2020). From these searches, a set of 29 memes was collected, the majority of which appeared to be supportive of vaccination and/or sarcastic and critical of "antivaxxers" ($n = 17$). A smaller subset appeared either unsupportive/critical of vaccination or neutral ($n = 12$). An independent set of undergraduate participants ($n = 26$) viewed the memes in randomized order and rated them—using 7-point Likert scales—on perceived funniness ("How funny is this meme?"; 1 = *not at all*, 7 = *very much so*), scariness ("How scary is this meme?"), persuasiveness regarding vaccination intentions ("To what extent does this meme increase your intention to vaccinate against COVID-19?"), accuracy ("To what extent is this meme accurate/truthful?"; note that this measure was included to answer research questions unrelated to those investigated here and will not be mentioned further), and virality ("Would you share/post/retweet this meme?"). The order of ratings was fixed, except for the first two, which were randomized across participants. Ratings of funniness and scariness were prioritized given work suggesting that these features may be central to and thus differentiate pro- and anti-vaccination memes, respectively (Harvey et al., 2019).

Consistent with the initial categorization, the 17 memes identified as supportive of vaccination and/or sarcastic and critical of antivaxxers (vs those identified as anti-vaccination or neutral) were indeed rated as more persuasive in increasing intentions to vaccinate ($t_{27} = 2.945$, $p = .007$, *Cohen's d* = 1.11). From this subset of 17 memes, two were excluded from final selection: one because it was text-only (i.e., did not include an underlying image), unlike the other memes, and another because it appeared to have an error in its text that may have interfered with its interpretation. Among the remaining 15 memes, the eight funniest were selected as final stimuli. Meme funniness, rather than scariness, guided selection because it appears more essential to pro-vaccination memes (Harvey et al., 2019) and because it predicted the meme's shareability in the meme rating study mentioned above, whereas scariness did not (funniness-shareability $r = 0.720$, $p = .002$; scariness-shareability $r = 0.222$, $p = .427$), indicating higher potential for widespread impact/influence outside of the lab. The choice of eight memes was based on the desire to balance scalability (i.e., having a manipulation that would be brief, requiring less than 1-min of

participant time) and generalizability to other (humorous) pro-vaccination memes (see Supplementary Materials, point 3 for additional rationale based on a small pilot study examining meme funniness and vaccination intentions).

After conducting the first preregistered study (Study 2), the goal was to replicate and extend the effects, not only with new participants, but also with new memes. Another aim was to identify more general vaccination memes that did not specifically mention COVID-19 (reducing potential demand characteristics and allowing for effects that could potentially generalize to other vaccines). A second set of more general vaccination memes was thus identified through Google Image Search using the terms "vaccine memes", "vax memes", "antivaccine memes", and "antivax memes" between September 14th and September 19th, 2020. From these searches, members of the laboratory identified memes that were ostensibly designed by the meme creators to (1) be funny and (2) make fun of antivaxxers, but that did not (3) strongly target other groups/ideas (e.g., those related to religion) or (4) highlight the effects of (not) vaccinating children (to avoid effects specific to parents versus more general audiences). Several (albeit overlapping) combinations of these new stimuli were tested in which—as mentioned above—they were kept in their original form and were not COVID-specific (Study 3), were modified to be COVID-specific (Study 4 and 5), and/or selected to directly target antivaccine logic/beliefs/stereotypes specifically (Study 5) rather than, for example, emphasizing the lethal consequences of not vaccinating against COVID-19. In the final two studies (Study 5 and 6), the initial set of memes (those collected between May 29 and June 15, 2020) was also included to allow for greater comparison of meme effects pre- and post-vaccine-announcement, and comparison of the two stimuli sets (see Supplementary Materials, point 4 for more details; in short, the two meme sets did not differ and were thus combined for analysis here). In summary, across the studies, four unique, but overlapping, combinations of memes were used. Stimuli for each of the 6 studies are provided in Supplementary Materials.

To better characterize, more generally, the complete set of memes used across each of the studies reported here, two of the authors independently rated each of them on the extent to which they appealed to logos (i.e., rationality) and pathos (i.e., emotionality), as well as fear specifically. The memes were also rated on the extent to which they employed sarcasm and, finally, coded for whether they referred (explicitly or implicitly) to antivaxxers. Ratings of logos, pathos, fear, and sarcasm were completed using the descriptions of these characteristics provided in Harvey et al. (2019), and 7-point Likert scales (1 = *not at all*, 7 = *very much so*). Note that in cases where more than one version of the meme was used (e.g., updated to match infection rates; to be more general vs specific to COVID-19), only the updated and COVID-specific version was rated. Overall, the memes appealed very little to logos ($M_{rationality} = 2.4$), pathos ($M_{emotionality} = 2.6$), and fear specifically ($M_{fear} = 2.0$). They were, however, rated above the scale midpoint on sarcasm ($M_{sarcasm} = 4.5$), with the majority (70%) referring (implicitly or explicitly) to antivaxxers (inter-rater reliabilities across ratings: *r*s > 0.67).

2.3. Procedure

The exact procedure (e.g., the ordering of questionnaire items/tasks) differed slightly across studies but, generally, participants consented to the details of the study then indicated their year of birth, political orientation, gender, and—in Study 3 and 4—ethnicity and religiosity. Afterwards, they were randomly assigned to view eight memes or eight control images (presented in randomized order) and then indicate their intentions to be vaccinated against COVID-19. Participants were shown the following prompt before the memes/images were displayed, to promote greater processing/attention: "Please view and read carefully the following memes. Later in the study you will be asked a series of questions regarding the memes and your thoughts about them" (in the image condition, "memes" was replaced with "images" and "and read" was removed from this prompt). Next, participants indicated the extent to which they identified as either pro- or anti-'vaxxer' and, depending on the study, completed some of the additional measures mentioned above. These identity and other additional questions were asked after the measurement of vaccination intentions to avoid any potential biasing of responses on the main dependent variable of interest (intentions to vaccinate). Nevertheless, the exact ordering of the questions/tasks for each of the 6 studies are provided in Supplementary Materials.

2.4. Statistical analyses

Robust regressions, using the robustbase package (with setting = "KS2014", Maechler et al., 2016) in R (R Core Team, 2017), were conducted for the main analyses predicting vaccination intentions across the 6 studies (for review of the advantages of robust models, see Field & Wilcox, 2017). Variables were centered (e.g., meme vs control images, gender, pre-vs post-announcement) or standardized (e.g., age, political orientation) in the regression models such that estimates from the models reflect differences in, for example, vaccination intentions (in terms of number of points on the 100-point visual analog scale) between the two condition (memes vs control images) or groups (men vs women), or changes in intentions associated with 1-*SD* increases in the predictor variable (e.g., age, political orientation). Follow-up analyses on interactions were conducted by transforming moderating variables—such that 0 represented the level (e.g., 1 *SD* above or below mean) at which the effect of the other, focal predictor was tested—and re-running the models. The package *emmeans* (Lenth, 2020) was used for follow-ups when robust models did not converge and non-robust variants were used instead (e.g., on provaxxer identification). Note that participants were able to skip any questions with which they felt uncomfortable and thus sample size varied across measures within each study. Several participants reported 'other' for gender identification (e.g., non-binary) and were excluded from analyses involving gender in which men and women were compared. *Cohen's d* [$d = 2t/\text{sqrt}(df)$] is provided as a measure of effect size for the predictors given that the main variable of interest, memes (vs control images), was categorical.

3. Results

3.1. Do memes (vs control images) influence intentions to vaccinate against COVID-19?

In the combined analysis (including Studies 1–6), exposure to vaccination memes (vs control images) increased intentions to vaccinate against COVID-19 (*estimate* = 3.251, *se* = 1.318, $t_{1582} = 2.467$, $p = .014$, *Cohen's d* = 0.124). This effect was robust to and not dependent on the (most consistently measured) individual difference covariates—gender, age, and political orientation. In other words, meme exposure did not interact with these covariates (*p*s > .550) and remained a significant predictor (*estimate* = 3.330, *se* = 1.309, $t_{1497} = 2.545$, $p = .011$, *Cohen's d* = 0.132) when they—and their interaction terms with meme-exposure—were added to the model.[3] For comparison or benchmarking, this effect of the memes—which increased intentions to vaccinate by more than 3.30 points on the 100-point vaccination intention scale—was equivalent to a one-unit decrease in conservativism on the 7-point political orientation scale. Also note that re-running this model (including covariates and their interactions with meme-exposure) with non-robust

[3] Additional variables were collected and examined in Study 3 and 4 (ethnicity: 91.2% white, 8.8% other/non-white; religiosity: 66.2% non-religious, 33.8% religious; receiving a vaccination in the last two years: 63.5% not vaccinated, 36.5% vaccinated), but they did not moderate the meme effects reported here. Results from these models are reported in Supplemental Materials, point 5.

regression produced the same meme effect on intentions to vaccinate (*estimate* = 4.076, *se* = 1.481, t_{1497} = 2.752, p = .006, *Cohen's d* = 0.142).

These meme effects were context-dependent, however, such that meme exposure interacted with the announcement of a safe/effective COVID-19 vaccine (p = .013, see Fig. 1). Specifically, memes (vs control images) produced much weaker (and non-significant) intention-boosting effects after the announcement (*estimate* = 0.396, *se* = 1.778, t_{1489} = 0.223, p = .824, *Cohen's d* = 0.012) compared to before the announcement (*estimate* = 7.029, *se* = 1.987, t_{1489} = 3.538, p < .001, *Cohen's d* = 0.183) (for full model results, see Table 2).[4] Note that these weakened meme effects could not be attributed to any general shifts in vaccination intentions—in other words, there were no changes in intentions to vaccinate from pre-to post-announcement within the control group (t_{1489} = 0.313, p = .754).[5]

3.2. Do memes (vs control images) produce similar announcement-dependent effects on identification with and perceptions of antivaxxers?

When the same analysis was repeated but on participants' identification as provaxxer, meme exposure interacted with announcement again (p = .006, see Fig. 1) such that memes increased provaxxer identification before the announcement (*estimate* = 3.610, *se* = 1.750, t_{1473} = 2.056, p = .040, *Cohen's d* = 0.107)—much like it increased intentions—but slightly (and non-significantly) decreased such identification after the announcement (*estimate* = −2.470, *se* = 1.620, t_{1473} = −1.528, p = .127, *Cohen's d* = −0.080) (for full model results, see Table 3).[6] In Study 3 and 4, participants also reported their feelings towards, perceptions of, and perceived social consequences associated with, identifying as antivaxxer(s). When the same analysis was conducted but on each of these three outcomes, a similar two-way meme by announcement interaction emerged selectively for feelings (p < .001, see Fig. 1), with memes (vs control images) reducing cold/negative feelings towards antivaxxers after (*estimate* = −11.616, *se* = 2.263, t_{702} = −5.132, p < .001, *Cohen's d* = −0.387) but not before (*estimate* = −0.745, *se* = 2.223, t_{702} = −0.335, p = .737, *Cohen's d* = -0.025) the announcement (note that this feelings scale was reversed for these in-text results and for plotting but the full model results, including original scoring, are displayed in Table 4, for interested readers).

4. Discussion

Across the studies reported here, exposure to vaccination memes influenced intentions to vaccinate against COVID-19, but these effects were context-dependent. Specifically, memes (vs control images) boosted intentions to vaccinate against COVID-19 before the first safe/effective vaccine was announced, but effects weakened and became non-significant after this announcement. Given that the observed pre-announcement effects were evident across age, gender, and political orientation, memes may hold potential for reducing vaccine hesitancy in the public, but more work is needed regarding the specificity of such effects to certain contexts or particular stages of vaccine development and/or roll-out. Further, future work will be needed to identify potential mechanisms through which memes may act to influence vaccination intentions.

Vaccination memes may have boosted (pre-announcement) vaccination intentions because they did not appear to originate from authorities or scientific sources, the information from which could be dismissed by antivaxxers or vaccine-hesitant as biased/conspiratorial (reviewed in Hornsey et al., 2018). Further, rather than emphasizing accurate details and correcting misinformation—a sometimes ineffective or counterproductive approach (Hornsey et al., 2018; Nyhan et al., 2014)—they often employed sarcasm and satirized anti-vaccination concerns/beliefs (e.g., see the meme sarcasm ratings under Meme Stimuli in the Methods Section). This alternative approach may bypass more typical lines of defence or processes (e.g., motivated reasoning, Hornsey et al., 2018; Hornsey & Fielding, 2017; confirmation bias, Brewer et al., 2017) that can make vaccination intentions resistant to persuasion. According to Psychological Reactance Theory (Brehm & Brehm, 1981), perceived threats to one's freedoms—such as those that likely arise when encountering more explicit attempts to persuade—motivate one to act in ways or express attitudes that serve to assert or re-establish their freedom (e.g., attitudes and behaviours opposite to those encouraged by the persuasion attempt). In short, by appearing more like entertainment than persuasion, memes may be processed less defensively than more explicit, pro-vaccination messages (for similar arguments regarding humour, more generally, see Moyer-Gusé et al., 2018). Such a humour-based mechanism would be consistent with previous work in which satirical (vs non-satirical/humorous) pro-vaccination video segments reduced vaccine hesitancy by, in part, reducing psychological reactance (Moyer-Gusé et al., 2018).

The sarcasm and satire in the memes used here may have also increased (pre-announcement) intentions to vaccinate by delegitimizing antivaxxers and their associated beliefs and movement, making social identification as—and behaviours consistent with—antivaxxers less appealing (e.g., see Ford et al., 2019; Hodson & MacInnis, 2016). Indeed, before the first safe/effective vaccine was announced, exposure to the memes (vs control images) slightly shifted participants' social identification, causing them to identify more with provaxxers and less with antivaxxers. Thus, unlike other pro-vaccination messages or interventions that target (mis)information and beliefs about vaccines, the memes may have been effective, in part, because they instead targeted the social groups that endorse such beliefs[7] (for additional reviews of satire and its persuasive potential, see Kaltenbacher & Drews, 2020; Zekavat, 2021; for more on social identity threat and humour, see Abrams & Bippus, 2011; Ferguson & Ford, 2008; Ford et al., 2019; Lee et al., 2015).

According to the Elaboration Likelihood Model of Persuasion (Petty & Cacioppo, 1986), one's attitudes and intentions can be changed through a central or peripheral route. The central route involves

[4] We also repeated this model using a composite dependent variable, representing the average of standardized scores on vaccine intentions and timing (or speed), and results revealed the same meme × announcement interaction (p = .001).

[5] Among those higher (vs lower) in conservativism, however, there was a decrease in intentions to vaccinate after the first safe/effective vaccine was announced. Specifically, there was a political orientation × announcement interaction (p = .001, see full model results in Table 1) with intentions decreasing from pre-to post-announcement among those who reported a more conservative (i.e., less liberal) political orientation (*estimate* = −8.810, *se* = 1.923, t_{1489} = −4.581, p < .001, *Cohen's d* = −0.237), but not changing among those who reported a less conservative (i.e., more liberal) orientation (*estimate* = 0.669, *se* = 1.908, t_{1489} = 0.351, p = .726, *Cohen's d* = 0.018).

[6] Note that non-robust regression analyses were conducted on provaxxer identification given robust regression models did not converge.

[7] To further test the idea that sarcasm or satirizing humour directed at antivaxxers accounts, in part, for the efficacy of the memes, an exploratory analysis was conducted on the initial meme selection and ratings data. Specifically, the larger pool of memes supportive of vaccinating or critical of antivaxxers (n = 15) was re-categorized specifically as either 'making fun' of antivaxxers or not (note that this coding was done independent of the other meme ratings/coding mentioned in the Meme Stimuli subsection of the Methods). As would be predicted based on the idea that memes work by targeting and delegitimizing antivaxxers as a social group, memes that made fun of antivaxxers (n = 10) were rated as more persuasive in increasing participants' intentions to vaccinate than were memes that did not make fun of antivaxxers (n = 5) (t_{13} = 2.694, p = .018, *Cohen's d* = 1.494). Although involving a small sample of memes, this exploratory analysis suggests that the satirizing component of vaccination memes may be an important feature accounting for the memes' efficacy.

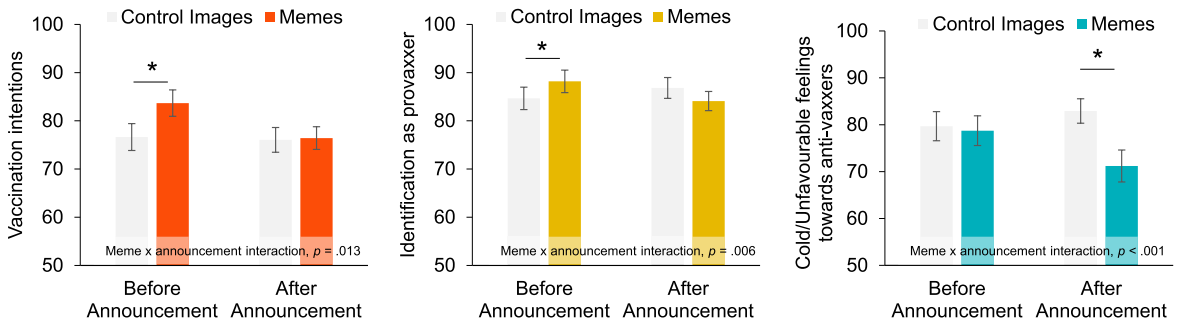

Fig. 1. Effects of memes (vs control images) before and after the first safe/effective vaccine was announced. Model estimated meme effects—both before and after the first safe/effective vaccine was announced—on intentions to vaccinate (left panel, $n = 1505$), identification as provaxxer (middle panel, $n = 1489$), and cold/unfavourable feelings towards antivaxxers (right panel, $n = 718$). Note that the scale score for this right panel plot was reversed (to show reductions in cold/unfavourable rather than increases in warm/favourable feelings). Error bars represent 95% confidence intervals. *$p < .05$.

Table 2
Robust regression model ($n = 1505$) examining the effect of meme (vs control image) exposure on intentions to vaccinate in combination with gender, political orientation, and age. Announcement was entered as an additional predictor/moderator to examine how the intention-boosting effects of memes (both alone, and in combination with gender, political orientation, and age) may have changed once the first safe/effective vaccine was announced (i.e., comparing effects from pre-to post-announcement).

Predictors	*estimate*	*se*	*t*	*df*	*p*	*d*
Intercept	77.968	0.661	117.887	1489	<.001	
Meme	3.310	1.325	2.498	1489	0.013	0.129
Gender	6.878	1.413	4.868	1489	0.000	0.252
POL	−5.274	0.683	−7.725	1489	0.000	−0.400
Age	1.697	0.674	2.518	1489	0.012	0.131
Announcement	−4.070	1.332	−3.055	1489	0.002	−0.158
Meme x Gender	−0.594	2.828	−0.210	1489	0.834	−0.011
Meme x POL	−1.043	1.366	−0.764	1489	0.445	−0.040
Meme x Age	−0.707	1.348	−0.524	1489	0.600	−0.027
Meme x Announcement	−6.633	2.668	−2.487	1489	0.013	−0.129
Gender x Announcement	−1.312	2.830	−0.464	1489	0.643	−0.024
POL x Announcement	−4.739	1.376	−3.444	1489	0.001	−0.179
Age x Announcement	−0.629	1.347	−0.467	1489	0.640	−0.024
Meme x Gender x Announcement	2.404	5.661	0.425	1489	0.671	0.022
Meme x POL x Announcement	1.347	2.753	0.489	1489	0.625	0.025
Meme x Age x Announcement	−1.960	2.694	−0.727	1489	0.467	−0.038

Note. Meme (0 = control images; 1 = memes), Gender (0 = woman; 1 = man), and Announcement (0 = pre-announcement, 1 = post-vaccine announcement) were centered and scored such that *estimates* represent the difference in intentions to vaccinate (100-point scale, higher values indicate greater intentions) between the two groups or between each level of the variable. POL (Political Orientation: 1 = *very Liberal*, 7 = *very Conservative*) and Age were standardized such that their corresponding *estimates* represent unit changes in vaccination intentions associated with a 1 *SD* change in the predictor.

Table 3
Regression model ($n = 1489$) examining the effect of meme (vs control image) exposure on identification with provaxxers, in combination with gender, political orientation, and age. Announcement was entered as an additional predictor/moderator to examine how the intention-boosting effects of memes (both alone, and in combination with gender, political orientation, and age) may have changed once the first safe/effective vaccine was announced (i.e., comparing effects from pre-to post-announcement).

Predictors	*estimate*	*se*	*t*	*df*	*p*	*d*
Intercept	85.927	0.558	153.936	1473	<.001	
Meme	0.040	1.117	0.036	1473	0.971	0.002
Gender	2.021	1.195	1.691	1473	0.091	0.088
POL	−4.909	0.573	−8.570	1473	<.001	−0.447
Age	−1.647	0.567	−2.905	1473	0.004	−0.151
Announcement	−1.116	1.125	−0.992	1473	0.321	−0.052
Meme x Gender	1.024	2.390	0.428	1473	0.669	0.022
Meme x POL	−1.666	1.146	−1.454	1473	0.146	−0.076
Meme x Age	−1.401	1.135	−1.235	1473	0.217	−0.064
Meme x Announcement	−6.223	2.250	−2.765	1473	0.006	−0.144
Gender x Announcement	−0.470	2.397	−0.196	1473	0.844	−0.010
POL x Announcement	−3.502	1.156	−3.030	1473	0.002	−0.158
Age x Announcement	−0.209	1.134	−0.184	1473	0.854	−0.010
Meme x Gender x Announcement	1.004	4.792	0.210	1473	0.834	0.011
Meme x POL x Announcement	3.441	2.311	1.489	1473	0.137	0.078
Meme x Age x Announcement	−1.535	2.269	−0.677	1473	0.499	−0.035

Note. Meme (0 = control images; 1 = memes), Gender (0 = woman; 1 = man), and Announcement (0 = pre-announcement, 1 = post-vaccine announcement) were centered and scored such that *estimates* represent the difference in identification as provaxxer (100-point scale with higher values indicating greater identification) between the two groups or between each level of the variable. POL (Political Orientation: 1 = *very Liberal*, 7 = *very Conservative*) and Age were standardized such that their corresponding *estimates* represent unit changes in identification with a 1 *SD* change in the predictor.

thoughtful consideration of a message's argument(s) whereas the peripheral route involves a shallower, simplistic processing of cues or heuristics related to the message or messenger(s) (e.g., their perceived credibility or attractiveness). Whereas deeper, central route processing promotes more meaningful and enduring change (particularly when arguments are strong and convincing), humour-based persuasion is thought to operate more through peripheral routes (review in Martin & Ford, 2018). For example, the detection and resolution of some form of incongruity is thought to be necessary to perceive humour (as posited by incongruity-resolution theories of humour, e.g., Shultz, 1972; Suls, 1972), but such humour processing can distract one from the message's core arguments (e.g., see Jones, 2005; Moyer-Gusé et al., 2011; Young, 2008), increasing reliance on simplistic heuristics/cues. Notably, such a reduction of central—and enhancement of peripheral—route processing would be consistent with the meme mechanisms proposed above (defence/reaction-reduction and antivax delegitimization).

Importantly, though, peripheral (vs central) route persuasion is posited to be most effective for issues or topics that are of low (vs high) personal relevance and that have received little thought (reviewed in Petty & Cacioppo, 1986). Conversely, when issues become more personally relevant, discussed, and/or contemplated, motivation to process and scrutinize issue-related arguments increases, reducing the

Table 4
Robust regression model ($n = 718$) examining the effect of meme (vs control image) exposure on warm/favourable feelings towards antivaxxers in combination with gender, political orientation, and age. Announcement was entered as an additional predictor/moderator to examine how the intention-boosting effects of memes (both alone, and in combination with gender, political orientation, and age) may have changed once the first safe/effective vaccine was announced (i.e., comparing effects from pre-to post-announcement).

Predictors	*estimate*	*se*	*t*	*df*	*p*	*d*
Intercept	21.823	0.805	27.094	702	<.001	
Meme	6.589	1.592	4.138	702	<.001	0.312
Gender	−4.810	1.731	−2.779	702	0.006	−0.210
POL	4.136	0.842	4.913	702	<.001	0.371
Age	2.819	0.813	3.466	702	<.001	0.262
Announcement	2.446	1.602	1.526	702	0.127	0.115
Meme x Gender	4.024	3.420	1.177	702	0.240	0.089
Meme x POL	−0.766	1.661	−0.461	702	0.645	−0.035
Meme x Age	4.048	1.611	2.512	702	0.012	0.190
Meme x Announcement	10.871	3.173	3.426	702	<.001	0.259
Gender x Announcement	−0.047	3.432	−0.014	702	0.989	−0.001
POL x Announcement	1.668	1.680	0.993	702	0.321	0.075
Age x Announcement	−0.157	1.622	−0.097	702	0.923	−0.007
Meme x Gender x Announcement	−9.275	6.787	−1.367	702	0.172	−0.103
Meme x POL x Announcement	2.002	3.318	0.603	702	0.546	0.046
Meme x Age x Announcement	−1.606	3.217	−0.499	702	0.618	−0.038

Note. Meme (0 = control images; 1 = memes), Gender (0 = woman; 1 = man), and Announcement (0 = pre-announcement, 1 = post-vaccine announcement) were centered and scored such that *estimates* represent the difference in warm/favourable feelings (100-point scale with higher values indicating warmer and more favourable feelings) between the two groups or between each level of the variable. POL (Political Orientation: 1 = *very Liberal*, 7 = *very Conservative*) and Age were standardized such that their corresponding *estimates* represent unit changes in identification/feelings with a 1 *SD* change in the predictor. Note that this outcome feeling score is in its original units for this output but was reversed for in-text reporting and plotting (with higher values indicating colder/unfavourable feelings).

influence of these peripheral heuristics/cues. According to this model, then, humorous memes—to the extent that they operate through more peripheral (vs central) routes—should more strongly affect behavioural intentions that are perceived as being less personally relevant and that have generated little contemplation. This idea may explain the finding that memes boosted intentions to vaccinate before the announcement (when vaccines were not yet publicly available and thus considered more hypothetical or of little personal relevance) but not after the announcement, which likely prompted much discussion and reflection about whether one would receive it (i.e., increased personal relevance and contemplation).[8] In future meme studies, it will thus be critical to measure and/or manipulate personal relevance and prior thoughts about the target health behaviour/intention.

Relatedly, the vaccine announcement may have prompted the sharing of vaccination concerns and increased the online prominence of groups identifying as antivax or vaccine-hesitant.[9] Similarly, many people—regardless of their own intentions to vaccinate—likely discovered that certain close friends/family were antivaxxers or vaccine-hesitant after the announcement. In this context, some of the memes—especially those that satirized antivaxxers—could have been perceived as more insensitive and as less humorous after the announcement (e.g., see Disposition Theory of Humour and Mirth, Zillmann & Cantor, 1996). Perceiving the memes to be insensitive and less humorous may ultimately have caused some to distance themselves from extreme provaxxers or appear more moderate regarding their social identification with and feelings towards this group (an interpretation consistent with the post-announcement findings shown in Fig. 1). Although satire involves this blend of positive (e.g., humour/amusement) and more provoking negative emotions (e.g., indignation, hostility, contempt), future work may benefit from disentangling these components (e.g., see Skurka et al., 2019) in the memes. Doing so might allow for the identification of potential thresholds at which memes may shift from being effective/humorous to ineffective/insensitive, and the extent to which such thresholds depend on one's social ties with members of groups targeted by the memes.

Although this discussion has largely focused on humour—given that the memes were selected primarily for this feature (and were rated rather low on fear, overall; see meme ratings in the Meme Stimuli section in Methods)—it is important to note that some memes nonetheless contained certain threatening or fearful elements, which may have triggered thoughts about COVID-19 susceptibility and severity. The Terror Management Health Model (Arndt & Goldenberg, 2017) suggests that such mortality cues—when they promote conscious processing of potential or eventual death—boost intentions to engage in behaviours that are perceived to effectively protect health. Protection Motivation Theory (Rogers, 1975, 1983) similarly posits that threats to health (e.g., COVID-19) drive health-protective coping responses (e.g., vaccination) to the extent that the threats are perceived as severe and personally relevant (i.e., the individual feels susceptible) and the coping responses are perceived as possible (e.g., affordable/obtainable) and effective. Consistent with these models, such beliefs related to seasonal influenza and the flu shot accounted for 66% of the variability in intentions to vaccinate, with perceived susceptibility representing one of the strongest predictors (Ling et al., 2019) (for additional review, see Bish et al., 2011). Therefore, it is possible that the memes used here affected pre-announcement intentions to vaccinate by, in part, boosting perceived susceptibility to (and/or severity of) the disease. It is unclear, however, why such severity/susceptibility effects would no longer be relevant after a safe/effective vaccine was announced, an important follow-up question for future studies. Potentially, fears not about the virus but about the vaccine (e.g., side effects, general safety, and unestablished efficacy, Dodd et al., 2021) became more salient after the announcement (e.g., see Rosenthal & Cummings, 2021) and these fears were instead triggered in response to the memes.

Ultimately, future work will be required to test these various possibilities and determine if additional measures can serve as buffers against such vaccine-related fears. For example, memes may be more effective during vaccine rollout if combined with infographics that dispute misinformation (Vraga & Bode, 2021), mollify anxiety from common concerns (e.g., safety), or are shared/endorsed by—or delivered in tandem with messages from—trusted leaders (Bavel et al., 2020). Such combination approaches may also better utilize the full continuum of persuasion channels (peripheral and central, Petty & Cacioppo, 1986), while benefitting from the attentional draw and potential virality of humour (e.g., see association between humour and shareability in the Meme Stimuli section of the Methods).

4.1. Limitations

Although the findings presented here suggest that meme effects are robust to and not dependent on certain individual difference variables (e.g., gender, age, political orientation, ethnicity, and religiosity), some

[8] Google Trends data is consistent with this idea, showing that searches containing the word "vaccine" rose by more than 500% in the United Kingdom—where participants in the current studies resided—after the first safe/effective vaccine was announced.

[9] Google Trends analysis of the year 2020 also indicated that in the United Kingdom—where participants in the current studies resided—the searches including the term "antivax" also quickly increased in popularity and reached its highest level for the year between November 8–21, the time window within which the vaccine announcement was made and in which our three post-announcement studies (Studies 4–6) were conducted.

of these tests were likely underpowered and—regarding ethnicity and, to some extent, religiosity—relied on quite homogenous samples. It will be important to replicate the findings in more diverse samples (Simons et al., 2017), allowing for disaggregated or stratified analyses. Most participants also identified as provaxxer across the studies (see Fig. 1); it will thus be important to test these meme effects in groups identifying more strongly as antivaxxer, although some preliminary analyses suggest that the meme effects may be stronger in such individuals (or at least in those identifying less strongly as provaxxer).[10] Finally, the best test of an intervention's efficacy will involve real-world vaccine uptake data. Here, however, like other existing COVID-19 studies (Altay et al., 2021; Duquette, 2020; Green et al., 2021; Loomba et al., 2021; Moehring et al., 2021; Sprengholz et al., 2021), self-reported vaccination intentions were the only available option given that vaccines were not yet publicly/widely available when the studies were conducted. Nevertheless, recent longitudinal studies suggest intentions account for more than 40% of the variability in actual uptake, measured months later (Fall et al., 2018; Ng et al., 2020). Therefore, intention-boosting interventions delivered in earlier stages of vaccine development may translate into actual uptake, although such data is certainly required before conclusions can be made about the effects of memes on vaccination behaviour.

5. Conclusions

Vaccine hesitancy is a top 10 threat to global health (World Health Organization, 2019), and has become particularly relevant during the ongoing COVID-19 pandemic. Although numerous approaches exist to counter such hesitancy—including recent vaccine-supportive, electronic communications (e.g., text-based "nudges" and chat box programs, Altay et al., 2021; Milkman et al., 2021)—little is known about the effects of exposure to naturally circulating internet memes. Across the studies reported here, memes supportive of vaccination and/or unsupportive of antivaxxers were found to increase intentions to vaccinate, although this effect was only evident before the first safe/effect vaccine was announced, suggesting such effects may be dependent on contextual variables such as the stage of vaccine development and its personal relevance to one's life. It will thus be critical for future studies to investigate this possibility more directly and to also establish or rule out some of the proposed psychological pathways through which memes may act to influence vaccine-related attitudes, beliefs, and behaviours. The use of disparaging humour in memes may be particularly relevant, functioning to signal that the targeted group (e.g., antivaxxers) and their associated behaviours are non-normative and undesirable/disliked, leading some to distance themselves from these groups and conform more to the alternative norms implied by the memes (e.g., that vaccinating is desirable/common). Future work applying the Theory of Planned Behaviour (Ajzen, 1991) and Social Identity Theory (Tajfel & Turner, 1986) more directly to memes and their persuasive effects via these hypothesized humour-related routes may thus be particularly fruitful, especially if such approaches also incorporate dynamic changes in vaccine development and/or its personal relevance to participants (consistent with predictions derived from the Elaboration Likelihood Model of Persuasion, Petty & Cacioppo, 1986). Finally, although the memes did not appear to strongly appeal to fear, it will also be important to explore the extent to which any intention-boosting effects are explained by changes in perceived virus severity/susceptibility (consistent with Terror Management of Health and Protection Motivation theories (Arndt & Goldenberg, 2017; Rogers, 1975, 1983).

[10] An exploratory robust regression analysis with memes, provaxxer identification, announcement, and their interactions entered as predictors of COVID-19 vaccination intentions revealed a three-way meme x announcement × identification interaction ($p = .004$). Keep in mind the memes (vs control images) were shown to increase participants' identification as provaxxer before the announcement (as described in a separate analysis reported in the results section and shown in Fig. 1). Nevertheless, this three-way interaction revealed that those who reported lower provaxxer identification (or, i.e., greater antivaxxer identification; -1*SD* or 62.84 on the 100-point identification scale) showed larger intention-boosting meme effects (*estimate* = 8.994, *se* = 2.002, $t_{1558} = 4.494$, $p < .001$) than did those who reported higher (1 *SD* above mean) provaxxer identification (*estimate* = 1.369, *se* = 1.851, $t_{1558} = 0.740$, $p = .460$). Therefore, although the studies reported here did not specifically target antivaxxers, these findings suggest that memes may especially boost vaccination intentions among those identifying as relatively less provaxxer (and relatively more antivaxxer).

Funding

This work was supported by an Accelerate Research Grant and by a Research Option Scholarly Activity Release from the Research, Engagement, and Graduate Studies, University of the Fraser Valley.

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Declarations of interest

None.

Acknowledgement

We thank Ravdeep Thind, Raneeta Sidhu, Huiyan He, Melchorita Deley, and Katarina Bell, as well as other members of the lab for their assistance with meme searching and preparation. We also thank Drs. Thomas Ford and Andrew Olah, as well as Will Rice, for helpful discussions and insightful comments regarding some of the findings presented here, which improved the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2022.107218.

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