Article

Historical narratives about the COVID-19 pandemic are motivationally biased

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How people recall the SARS-CoV-2 pandemic is likely to prove crucial in future societal debates on pandemic preparedness and appropriate political action. Beyond simple forgetting, previous research suggests that recall may be distorted by strong motivations and anchoring perceptions on the current situation[1–6]. Here, using 4 studies across 11 countries (total n = 10,776), we show that recall of perceived risk, trust in institutions and protective behaviours depended strongly on current evaluations. Although both vaccinated and unvaccinated individuals were affected by this bias, people who identified strongly with their vaccination status—whether vaccinated or unvaccinated—tended to exhibit greater and, notably, opposite distortions of recall. Biased recall was not reduced by providing information about common recall errors or small monetary incentives for accurate recall, but was partially reduced by high incentives. Thus, it seems that motivation and identity influence the direction in which the recall of the past is distorted. Biased recall was further related to the evaluation of past political action and future behavioural intent, including adhering to regulations during a future pandemic or punishing politicians and scientists. Together, the findings indicate that historical narratives about the COVID-19 pandemic are motivationally biased, sustain societal polarization and affect preparation for future pandemics. Consequently, future measures must look beyond immediate public-health implications to the longer-term consequences for societal cohesion and trust.

Since most pandemic restrictions were lifted in early 2023, many societies have been transitioning to a post-pandemic phase[7]. This includes an evaluation of the appropriateness of the measures taken and the efforts made to enhance future pandemic preparedness. Any such evaluation necessarily depends on accurate recall of factual data and subjective interpretations at the time (for example, infection rates and associated risk perceptions). Although this information is available from large-scale surveillance and survey data gathered during the pandemic[8], such evaluations are also influenced by public and media discourses, which are often tinted by personal perceptions and memories. Because memory formation is a constructive process, retrospective narratives about historical events such as the pandemic are at risk of significant distortion[1]. Beyond simple forgetting, recall and ex-post evaluation are prone to various forms of bias, reflecting differences in motivation and purpose (for example, a wish to conform with one's own or the prevailing opinion)[1–3,6]. For instance, people are more likely to remember true or false information from the past depending on pre-existing beliefs or previous behaviours in the context of vaccination, political campaigns or political riots[4,5,9].

We argue here that recall and retrospective evaluations of the COVID-19 pandemic are affected by ubiquitous bias[10–12]. Regardless of whether one complied with governments' recommendations to get vaccinated or chose to remain unvaccinated, the pandemic incurred high costs for everyone. When recalling past events or feelings, both vaccinated and unvaccinated individuals may be subject to bias, motivated by self-affirmation and consistency with today's beliefs, perhaps reinforcing the existing polarization based on vaccination status and discrimination against those who differed in this regard[13–15].

Here we report four empirical studies examining the nature and extent of bias in individual historical narratives of the COVID-19 pandemic. Study 1 mapped the extent and direction of recall bias within opinion-based groups and assessed the relationship with evaluations of political action that took place during the pandemic. Studies 2 and 3 investigated the robustness of the bias in recall and evaluation vis-a-vis different mitigation measures. Finally, study 4 assessed the potential societal implications of this bias and the generalizability of the findings across different countries.

Assessing bias in recall and evaluation

To assess the extent and direction of biased recall and evaluation, one must be able to reliably compare current and past perceptions[16]. For the purposes of study 1, we surveyed a sample of German adults (n = 1,644)

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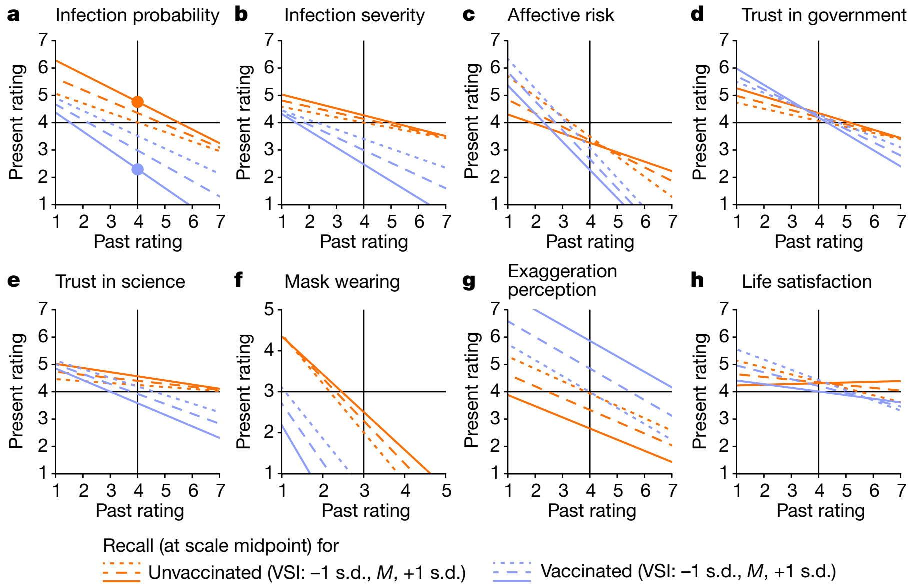

Fig. 1 | Biased recall of pandemic perceptions and behaviours in study 1. Results of a linear regression predicting the individual recall of past perceptions on the basis of actual past ratings (x axis) in 2020–2021 and present ratings (y axis) in late 2022, as well as interactions with vaccination status (colours) and vaccination status identification (VSI; dashed and dotted lines) of $n = 1,644$ participants (if not indicated otherwise) for infection probability (**a**), infection severity (**b**), affective risk (**c**), trust in government (**d**; $n = 1,600$), trust in science (**e**; $n = 1,489$), mask wearing (**f**; $n = 1,600$), exaggeration perception (**g**) and life satisfaction (**h**; $n = 1,539$). Each line indicates the recall at the scale midpoint (for example, recall = 3 for mask wearing and recall = 4 for all other variables) as predicted by past and present ratings. The direction and strength of the bias are indicated by the line's position relative to the midpoint of the scale; the angle indicates how much recall is influenced by past and present perceptions (the more tilted towards horizontality, the more influenced by present ratings; the more tilted towards verticality, the more influenced by past ratings). Example: the lines in **a** represent the predicted recall of infection probability = 4 given different past and present ratings, so the dots mark this recall given the actual past rating of 4 for highly identified vaccinated and unvaccinated people. The respective lines are tilted below (vaccinated) and above (unvaccinated) the midpoint. This indicates that people's recall of the probability of infection is influenced by their present rating of the probability, and that this influence goes in different directions for vaccinated and unvaccinated individuals (having higher and lower recalled infection probability than actually perceived in the past). See 'Study 1: Analyses' in the Methods for more information; regression tables are provided in Extended Data Table 1.

in late 2022 (see 'Study 1: Participants' in the Methods for details). Of these, 74% had received at least one dose of a COVID-19 vaccine. All respondents had previously been surveyed in summer 2020 or winter 2020–2021 (ref. 8). At both time points, they were asked about their current perceptions of risk (that is, infection probability and severity, and affective risk), trust in government and science, frequency of wearing masks and perceived exaggeration of the pandemic measures, as well as current life satisfaction (see 'Study 1: Measures' in the Methods). In the 2022 survey, respondents were asked to recall their responses to the same items as in the previous survey. On the basis of their past and current perceptions and recall of the past, we estimated the extent to which recall tended towards one end of the respective scale (directional bias) and the extent to which recall was influenced by past or current perceptions[16]. Vaccination status and vaccination status identification[14] were added as potential moderators in linear regressions (see 'Study 1: Analyses' in the Methods). Figure 1 shows how recall was influenced by past and present ratings of the variable in question. Across a range of variables related to perceived risk, trust and behaviour, the findings indicate that recall was strongly linked to current perceptions and that the direction of bias differed according to vaccination status and identification with vaccination status (for regression tables, see Extended Data Table 1). For example, for infection probability (measured on a seven-point scale), recall related to present perceptions (main effect: $b = 0.74$, s.e.m. = 0.20, $P < 0.001$) but not past perceptions (main effect: $b = 0.16$, s.e.m. = 0.21, $P = 0.447$). Vaccinated individuals tended to recall the probability of infection (mean (M) = 4.30, s.d. = 1.63) as higher than it had actually been perceived in the past ($M = 3.68$, s.d. = 1.39, $d = 0.41$) and this tendency increased the more they identified with being vaccinated (as indicated by an interaction effect in the linear regression: $b = 0.30$, s.e.m. = 0.07, $P < 0.001$). The opposite effect could be observed for unvaccinated individuals; although their average past ($M = 2.85$, s.d. = 1.50) and recalled infection probability ($M = 2.87$, s.d. = 1.64, $d = 0.01$) did not differ significantly, stronger identification was related to lower recalled infection probability (main effect of vaccination status identification: $b = -0.14$, s.e.m. = 0.06, $P = 0.028$).

As a further indicator for the motivational basis of recall, individual evaluations differed strongly in terms of whether political measures were perceived as appropriate (that is, justified, effective and based on an honest desire to protect citizens; measured on a seven-point scale, see 'Study 1: Measures' in the Methods). On average, vaccinated individuals perceived political measures as more appropriate ($M = 4.74$, s.d. = 1.35) than did unvaccinated participants ($M = 2.52$, s.d. = 1.35, $d = 1.68$). A regression analysis revealed that perceived overall appropriateness did not only vary by vaccination status ($b = -2.20$, s.e.m. = 0.25, $P < 0.001$) but also by vaccination status identification ($b = -0.53$, s.e.m. = 0.04, $P < 0.001$) and their interaction ($b = 0.96$, s.e.m. = 0.05, $P < 0.001$). So, for both vaccinated and unvaccinated individuals, appropriateness was rated as medium when identification was low. However, evaluations were increasingly positive among the vaccinated and increasingly negative among the unvaccinated as vaccination status identification increased (for visualization, see Extended Data Fig. 1). These results mirror the results for biased recall. In fact, individual appropriateness ratings were related to the extent of directional recall bias ($r = 0.24$, $P < 0.001$; individual directional recall bias could be estimated for $n = 1,574$ participants on the basis of multiple outcome variables; see 'Study 1: Analyses' in the Methods for details). This indicates that greater bias when recalling the past was associated with a more extreme evaluation of political action—in either direction.

Attempts to reduce recall bias

Assuming that recall and evaluation of the pandemic affect each other[3], it seems important to consider possible techniques for reducing memory distortion. To that end, study 2 investigated whether recall bias is reduced (i) when monetary incentives are introduced to encourage accurate recall; or (ii) when metacognitive information about widespread recall bias is provided. Both incentives[17,18] and information[19,20] are known to instigate the correction of one's own judgements in other domains.

Because these techniques might have differing effects on vaccinated and unvaccinated individuals, our sample included a disproportionally high percentage of unvaccinated individuals[14] and reassessed 3,105 participants from Germany and Austria in January 2023 (71% of whom had received at least one dose of a COVID-19 vaccine, see 'Study 2: Participants' in the Methods for details). Before asking respondents to recall their perceptions and behaviours from December 2021, they were randomly assigned to one of two intervention conditions or a control group (no intervention; see 'Study 2: Experimental manipulation' in the Methods).

To test the effect of incentives, participants were told that more accurate recall would increase their chances of winning a cash prize: 100 euros were raffled among all participants, and more accurate recall resulted in participating more often in the lottery. To test the effect of metacognitive information on the existence of recall bias, participants were told about the extent of this bias in others. Following these interventions, we tested participants' recall and assessed their perceptions of the appropriateness of political action as in study 1 (for details, see 'Study 2: Measures' in the Methods). Inspection of response times indicates that participants read the interventions; in the information (incentive, control) condition, participants took a median time of 94 (61, 45) seconds to read the instructions and recall their answers.

The analysis used the same linear regression as in study 1; the only difference was that the experimental condition replaced vaccination status identification as a moderating variable (details are provided in 'Study 2: Analyses' in the Methods; see Extended Data Fig. 2 for visual presentation; regression results are provided in Extended Data Table 3; all regressions are based on the full sample of $n = 3{,}105$ participants). Across all variables, recall bias again differed by vaccination status, as indicated by a significant effect of being vaccinated on recall of infection probability ($b = 0.54$, s.e.m. = 0.12, $P < 0.001$) and severity ($b = 0.42$, s.e.m. = 0.11, $P < 0.001$), avoiding contacts ($b = 0.39$, s.e.m. = 0.17, $P = 0.022$), trust in government ($b = 0.62$, s.e.m. = 0.12, $P < 0.001$) and trust in science ($b = 0.53$, s.e.m. = 0.12, $P < 0.001$). Only for mask wearing were no significant differences found between vaccinated and unvaccinated individuals ($b = 0.25$, s.e.m. = 0.16, $P = 0.122$). Notably, recall accuracy was not significantly improved by incentivizing accurate recall (indicated by insignificant main effects of incentives in all regressions, $0.146 < P < 0.853$, as well as insignificant interaction effects of incentives and vaccination status, $0.221 < P < 0.864$) or by providing information about widespread bias (indicated by insignificant main effects of information in all regressions, $0.075 < P < 0.731$, as well as insignificant interaction effects of information and vaccination status, $0.161 < P < 0.435$). Although the effects of both interventions and their interaction with a participant's vaccination status were negligible, equivalence tests indicated that they were not equal to zero, because confidence intervals overlapped but also exceeded regions of practical equivalence (ROPE) for infection probability (ROPE = [−0.18, 0.18]; overlap for information, incentive, information × vaccination status or incentive × vaccination status = 54%, 75%, 34%, and 65%, respectively; equivalence test result: $P = 0.449, 0.245, 0.708, 0.293$), infection severity (ROPE = [−0.17, 0.17]; overlap = 61%, 75%, 54%, 64%; $P = 0.368, 0.223, 0.454, 0.357$), trust in government (ROPE = [−0.19, 0.19]; overlap = 44%, 45%, 43%, 54%; $P = 0.583, 0.577, 0.594, 0.473$), trust in science (ROPE = [−0.20, 0.20]; overlap = 86%, 68%, 69%, 69%; $P = 0.150, 0.300, 0.286, 0.300$), mask wearing (ROPE = [−0.17, 0.17]; overlap = 28%, 51%, 35%, 46%; $P = 0.772, 0.414, 0.706, 0.460$) and contact avoidance (ROPE = [−0.20, 0.20]; overlap = 29%, 34%, 42%, 38%; $P = 0.762, 0.712, 0.617, 0.647$).

Because stronger interventions might be more successful in correcting recall bias[17], study 3 investigated the effects of considerably higher incentives. In July 2023, 906 vaccinated German participants were asked to recall their perceptions and behaviours from summer and autumn 2021 (see 'Study 3: Participants' in the Methods for details). Half of the participants were told that a more accurate recall would increase their chances of winning a cash prize. Participants learned that one of their recall values would be randomly selected and compared with their past answer. When both were equal, they received a bonus of 25 euros. The chance of winning the bonus decreased the more the recalled and the true answer diverged (binarized scoring rule[21], see 'Study 3: Experimental manipulation' in the Methods).

The analysis used similar linear regressions to those in the previous studies; the recall of six variables was predicted by past and present answers, condition and their interactions with condition (see 'Study 3: Measures' and 'Study 3: Analyses' in the Methods). In some cases, past answers were missing, resulting in slightly reduced samples for the analysis of some variables ($n = 902$ for mask wearing, $n = 859$ for contact avoidance, $n = 881$ for trust in government and $n = 906$ for all other variables). Figure 2 shows that although participants again overestimated past risk perceptions (directional bias reflected by the regression intercepts; infection probability: $b = 1.60$, s.e.m. = 0.07, $P < 0.001$; severity: $b = 0.66$, s.e.m. = 0.07, $P < 0.001$), protective behaviours (mask wearing: $b = 0.29$, s.e.m. = 0.16, $P = 0.071$; contact avoidance: $b = 0.52$, s.e.m. = 0.08, $P < 0.001$) and trust in the government ($b = 0.37$, s.e.m. = 0.06, $P < 0.001$), recall of some variables improved when incentives were offered (for regression details, see Extended Data Table 4). For example, the incentive improved the recall of mask wearing and trust in government, as it reduced the influence of present perceptions (interaction effects of present ratings and being offered an incentive; mask wearing: $b = -0.16$, s.e.m. = 0.07, $P = 0.021$; trust: $b = -0.12$, s.e.m. = 0.05, $P = 0.025$) and increased the influence of past perceptions (interaction effect of past trust rating and being offered an incentive: $b = 0.20$, s.e.m. = 0.06, $P < 0.001$). For infection probability, even a main effect was found; directional bias was reduced when an incentive was offered ($b = -0.38$, s.e.m. = 0.10, $P < 0.001$). Notably, the incentive also reduced recalled exaggeration perceptions (main effect: $b = -0.42$, s.e.m. = 0.10, $P < 0.001$). Combining all six variables in a mixed-effects regression (controlling for multiple answers from the same individual, including $n = 5{,}360$ answers, see Extended Data Table 5) revealed that offering an incentive decreased directional bias (main effect: $b = -0.35$, s.e.m. = 0.10, $P = 0.001$) and increased the influence of past ratings (interaction effect of incentive and past ratings: $b = 0.08$, s.e.m. = 0.02, $P = 0.002$), indicating a reduction of recall bias. When vaccination status identification was added as an additional moderator to the regressions for each variable (see Extended Data Table 4), it was found to increase recalled risk perceptions (main effect for infection probability: $b = 0.21$, s.e.m. = 0.05, $P < 0.001$; infection severity: $b = 0.22$, s.e.m. = 0.05, $P < 0.001$) and recalled trust in government ($b = 0.17$, s.e.m. = 0.05, $P < 0.001$), but to decrease recalled exaggeration perceptions ($b = -0.30$, s.e.m. = 0.05, $P < 0.001$), confirming the result of study 1 that greater identification with vaccination status is associated with more biased recall.

As a neutral control item, all participants were asked to recall the time of day when they had participated in the survey in 2021. We assumed that there was no motivational basis for distorting one's recall of this item. Indeed, although recall was positively related to the actual time in 2021 ($b = 0.18$, s.e.m. = 0.04, $P < 0.001$) as well as to the present time ($b = 0.22$, s.e.m. = 0.04, $P < 0.001$), we found no significant effect of the incentive on recall; the main effect of incentive ($b = -0.12$, s.e.m. = 0.08, $P = 0.105$) was 50% in the ROPE of [−0.12, 0.12] (equivalence test: $P = 0.507$), the

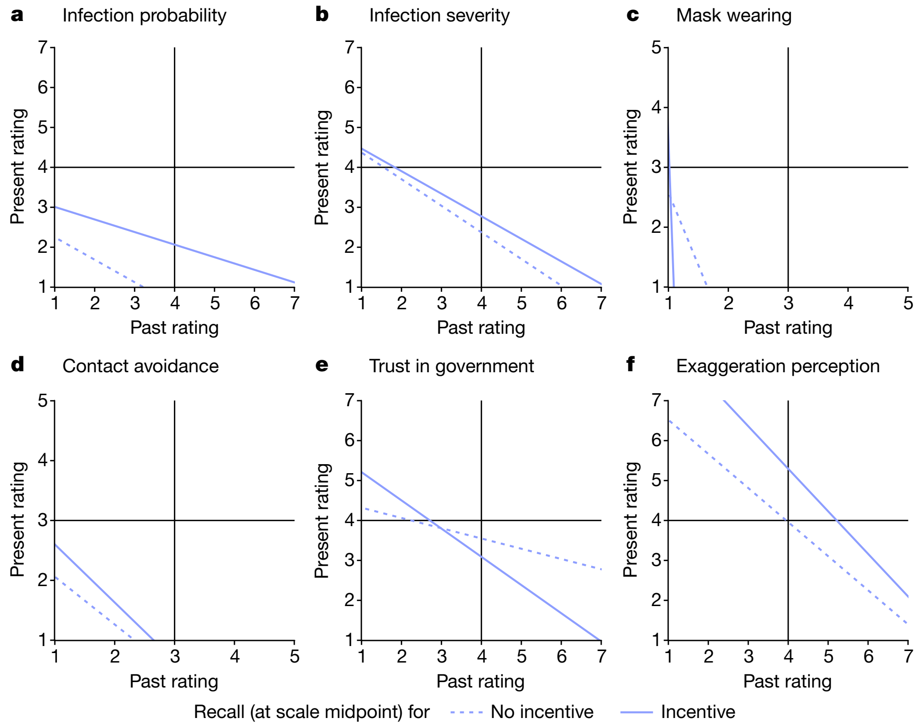

Fig. 2 | Effects of monetary incentives on reducing recall bias in study 3. Results of a linear regression predicting the individual recall of vaccinated individuals ($n = 906$, if not indicated otherwise) on the basis of past (summer and autumn 2021) and present (July 2023) ratings and their interactions with the experimental condition for infection probability (**a**), infection severity (**b**), mask wearing (**c**; $n = 902$), contact avoidance (**d**; $n = 859$), trust in government (**e**; $n = 881$) and exaggeration perception (**f**). Each line visualizes directional bias and how past and present perceptions affect recall at a fixed value (scale midpoint; that is, recall = 3 for mask wearing and contact avoidance as these were measured on a five-point scale, and recall = 4 for all other variables as these were assessed on a seven-point scale) when recall was or was not incentivized in the experiment. Regression tables are provided in Extended Data Table 4.

interaction effect with past completion time ($b = 0.09$, s.e.m. = 0.05, $P = 0.076$) was 66% in the ROPE (equivalence test: $P = 0.297$) and the interaction effect with current time ($b = 0.01$, s.e.m. = 0.05, $P = 0.888$) was 100% in the ROPE (equivalence test: $P = 0.025$). Adding vaccination status identification as an additional moderator revealed no main effect of identification or its interactions with the other model variables on the recall of time ($0.115 < P < 0.902$), further supporting the claim that it was not motivationally biased (for regression details, see Extended Data Table 6).

Overall, the results of studies 2 and 3 indicate that biased recall is relatively stable. Metacognitive information about common biases and minor incentives was not sufficient to significantly increase recall accuracy. Yet, stronger incentives could reduce but not eliminate bias. Of note, incentives seem to only increase recall accuracy when people can be assumed to have some motivation for distortion in pandemic-related variables but not for a neutral control variable. These results thus provide evidence for the motivational nature of biased recall. Finally, individual directional bias (estimable for $n = 2{,}946$ participants in study 2 and $n = 868$ participants in study 3) was again related to the evaluation of the appropriateness of past political action in study 2 ($r = 0.31$, $P < 0.001$) and study 3 ($r = 0.36$, $P < 0.001$).

Generalizability across countries

As polarization can be observed in many countries[13,22], study 4 investigated the relation between biased estimates of the pandemic and post-pandemic evaluations on a more global scale. We also wanted to investigate correlates that might indicate societal tension. A study[23] conducted in March–April 2020 served as a benchmark, providing data on pandemic perceptions in ten countries (Australia, Germany, Italy, Japan, Mexico, South Korea, Spain, Sweden, the UK and the USA) that differ in terms of culture, pandemic impact and government response. We collected data from new samples in these countries ($n = 5{,}121$; country sample sizes ranging from $n = 498$ to 563; see 'Study 4: Participants' in the Methods for details; below analyses refer to the complete samples). Most participants (88%) had received at least one dose of a COVID-19 vaccine (ranging from 72% in Japan to 96% in Spain). Respondents were asked to estimate how many people perceived a high probability and severity of infection and high government effectiveness at the beginning of the pandemic (see 'Study 4: Measures' in the Methods). A pretest with additional data from study 1 showed that such population-level estimates relate to individual-level recall as used in studies 1–3 (for details, see 'Study 1: Analyses' in the Methods and Extended Data Table 2). Although population estimates are likely to be influenced by other factors (for example, media exposure and education) and can only be seen as a noisy proxy for individual-level recall, they were considered a viable replacement given that no individual data were available from the past.

Comparing estimates with the benchmark values[23], we found that the majority of participants in all countries overestimated the perceived probability of infection (ranging from 65% in the UK to 92% in Italy), whereas most participants in all countries except Japan (24%) and Mexico (42%) underestimated the perceived severity of the illness in 2020 (ranging from 74% in Spain to 97% in the UK; see also Fig. 3a and Extended Data Table 7). Bias with regard to government effectiveness varied by country (the share of participants overestimating this variable ranged from 31% in Italy to 81% in Japan). As in the previous studies, we identified associations between bias and post-pandemic evaluation, but this varied by country (for details, see Extended Data Table 7). For instance, in some countries, estimating COVID-19 as more severe than

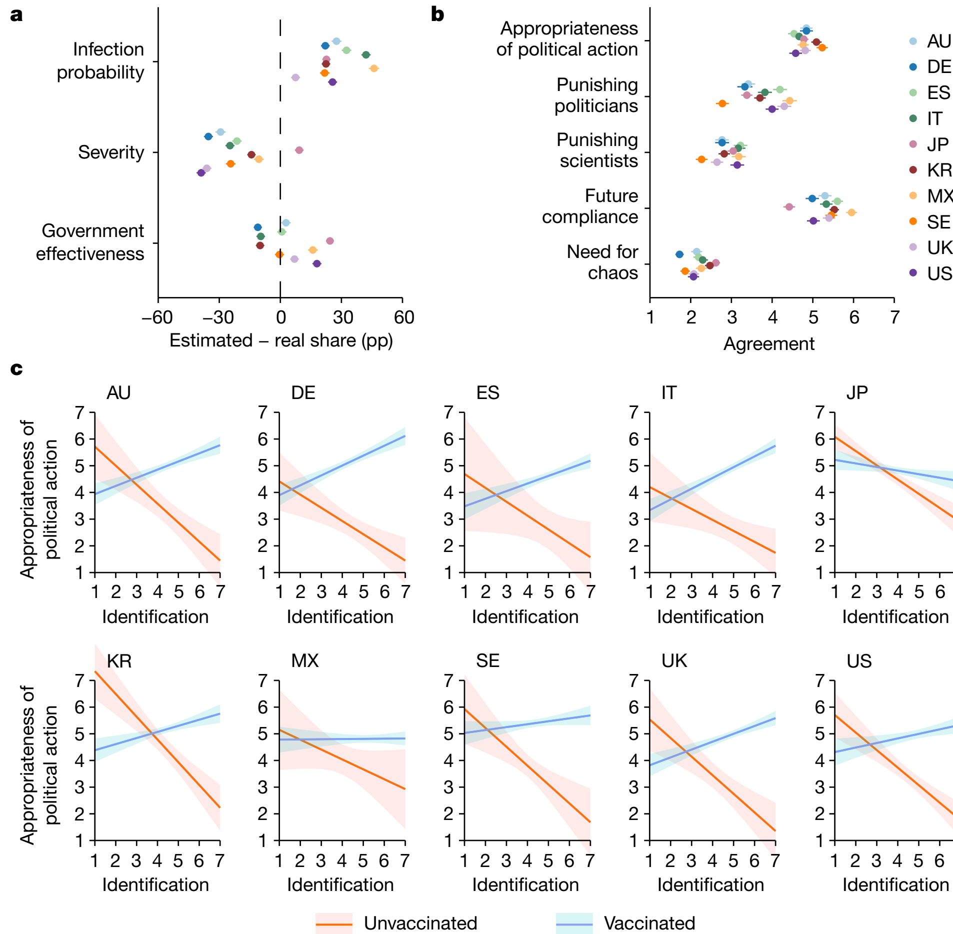

Fig. 3 | Pandemic perceptions and behavioural intentions across countries in study 4. Results from Australia (AU, $n = 502$), Germany (DE, $n = 499$), Spain (ES, $n = 498$), Italy (IT, $n = 498$), Japan (JP, $n = 511$), South Korea (KR, $n = 510$), Mexico (MX, $n = 510$), Sweden (SE, $n = 506$), the UK ($n = 524$) and the USA (US, $n = 563$). **a**, Participants' estimates of the share of perceived high levels of infection probability, severity and government effectiveness as reported in a 2020 survey[23]. Dots depict average differences between these estimates and observed values (in percentage points (pp)); error bars indicate 95% confidence intervals (CIs; significant differences between two countries can be inferred from non-overlapping CIs). **b**, Evaluation of appropriateness of political action, desire to punish politicians and scientists for their handling of the pandemic and intended compliance with regulations and recommendations in any future pandemic, ranging from 1 (very much disagree) to 7 (very much agree); dots depict means, and error bars indicate 95% CIs (significant differences between countries can be inferred from non-overlapping CIs). **c**, Linear regression analyses of vaccination status, vaccination status identification and their interaction, predicting the mean evaluation of the appropriateness of political action. Lines represent linear fit, with ribbons visualizing 95% CIs. See Extended Data Table 9 for regression details.

it had actually been perceived in the past by a representative country sample was associated with the evaluation of political action as more appropriate ($r = 0.11$ in Australia, 0.13 in Spain, 0.19 in South Korea and 0.21 in Sweden).

Evaluations of the appropriateness of political action during the pandemic were broadly similar across the included countries, with the largest difference between Spain ($M = 4.54$, s.d. = 1.69) and Sweden ($M = 5.23$, s.d. = 1.58, $d = 0.42$; see Fig. 3b and Extended Data Table 8). Notably, in all countries other than Japan and Mexico, evaluations of political measures were more positive among vaccinated individuals (across all countries: $M = 4.96$, s.d. = 1.59) than among unvaccinated individuals ($M = 3.72$, s.d. = 1.76, $d = 0.74$), and evaluations increased for the vaccinated and decreased for the unvaccinated as vaccination status identification increased (Fig. 3c; see Extended Data Table 9 for regression details), echoing the results of the previous studies. With regard to post-pandemic societal tension (measurement details are provided in 'Study 4: Measures' in the Methods), we found that between 19% (Sweden) and 49% (Mexico) of participants had a strong desire to punish politicians (above the scale midpoint) and between 12% (Sweden) and 27% (Italy) had a strong desire to punish scientists for their handling of the pandemic. When participants evaluated past political action as less appropriate, these desires were stronger ($r = -0.32$ in Mexico to −0.70 in Germany for punishing politicians; $r = -0.47$ in Mexico to −0.77 in the USA for punishing scientists). Those who evaluated political actions more negatively were also less inclined to vote ($r = 0.09$ in South Korea to 0.20 in Germany; non-significant exceptions: $r = 0.05$ in the USA and 0.07 in Mexico) and had a greater desire to dismantle the entire political order (need for chaos[24]: $r = -0.35$ in Germany to −0.58 in Sweden). The groups seeking chaos (above the scale midpoint) were small but considerable (ranging from 6% in Germany to 15% in Italy). Finally, post-pandemic evaluations were positively related to intended compliance in a future pandemic in all countries ($r = 0.18$ in Mexico to 0.56 in Germany) except Japan ($r = 0.03$). Overall, between 49% (in Japan) and 84% (in Mexico) indicated high (above the scale midpoint) intentions to comply with future pandemic regulations. For all percentages and correlations, see Extended Data Table 8.

The results suggest that although a vaccinated majority has a more positive view of the measures taken during the pandemic, as warranted by respective perceptions of the past, a small segment of society has a strong desire to take revenge on those who spoke out or took responsibility during the pandemic. In summary, we observed polarized evaluations of the pandemic and indicators of social tension in many countries and across continents.

Discussion

The COVID-19 pandemic has had a profound effect on global society. Around the world, governments and individuals have experienced considerable upheaval, and tough decisions were made to mitigate the spread of the virus. The four studies presented here reveal how past behaviour and today's perceptions influence how individuals recall their attitudes, perceptions and behaviours during the pandemic and how their biased memories continue to affect everyday life and influence future public-health responses. In line with previous research on recall bias in the context of IQ-test performance and fertility preferences[17,25], the bias was found to be strong, as it could not be reduced by bias-awareness information or minor monetary incentives; only large incentives partially increased accurate recall.

On a societal level, the observed recall bias is problematic because it could lead to systematically different ideas of how effective and appropriate pandemic interventions were. Furthermore, the desire to punish those responsible for past pandemic measures might make it difficult to build on 'lessons learnt'. The strong directional character of this bias and the influence of identity in this regard have major implications that warrant further exploration. For instance, memory distortions can be functional in coping with major life events[26]. Therefore, future research could investigate whether people with a larger (versus a smaller) tendency for biased recall of the COVID-19 pandemic might have had some advantages on other psychological dimensions, including psychological functioning during or after the pandemic. Yet, catastrophic events typically require a rapid response, and this works best when people can agree on a way forward. It follows that diverging representations of the past might impede effective future action, and it would be useful to investigate this problem in other crisis contexts, such as climate change.

The studies reported here have some limitations. First, although the tested interventions addressed metacognitive processes, our findings suggest that it might prove more useful to target motivational issues such as identity. Second, the estimate of others' past ratings used in study 4 can be considered a proxy for individual recall. However, the two concepts might differ, as estimates for the general population could also depend on other factors, such as feelings and thoughts about this population. Third, in study 4, the observed single effects could further reflect country-specific factors beyond the scope of the present study, and these invite further investigation. Finally, previous research suggests that there is a bidirectional link between identity and (biased) recall of the past[3]. Although our results support the motivational nature of recall bias, it is beyond the scope of the present research to tease the causal directions apart.

In conclusion, the four studies reported here highlight the complex nexus of attitudes, memories and behaviours surrounding the COVID-19 pandemic. Motivational factors related to identity and behaviour in extreme situations seem pivotal in this context, linking the past to biased memories and future behaviours. Researchers and policymakers must pursue a better understanding of these connections to develop more fruitful ways of learning from the past to improve crisis preparedness and response.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41586-023-06674-5.

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Methods

Study 1

Participants. Participants were surveyed for the first time in summer 2020 or winter 2020–2021 (within the COVID-19 Snapshot Monitoring project, COSMO) and for the second time in late 2022. In total, 1,644 individuals took part. They were aged 18–74 years during the first survey (M = 52.68, s.d. = 12.75); 49% were male and 51% were female. Unvaccinated participants were oversampled compared to the general population to assess the interaction of vaccine status and vaccination status identification.

Measures. Vaccination status and vaccination status identification. Participants were asked how many vaccines they had received against COVID-19 (recoded to vaccinated if they received at least one vaccine, or unvaccinated if they received no vaccine). Identification with vaccination status was assessed using a previously described five-item scale[14] (sample item: 'I am proud (not) to be vaccinated against COVID-19', measured on a seven-point scale from 'do not agree at all' to 'very much agree').

Pandemic perceptions and behaviours. At both time points, participants were asked how likely it was that they would get infected (infection probability, measured on a seven-point scale from 'very unlikely' to 'very likely') and how severe the infection would be (severity, measured on a seven-point scale from 'completely harmless' to 'very severe'). Affective risk was assessed by mean-averaging answers to three seven-point items: how often participants thought about the coronavirus, how much they worried about it and how scary they found it (Cronbach's α = 0.84 at the first and 0.91 at the second time point).

Participants also indicated how often they had worn a face mask in the previous week (measured on a five-point scale ranging from 'never' to 'always'; participants could choose to not answer at the first time point, resulting in n = 44 missing answers); how much they trusted the federal government and science to manage the pandemic (measured on a seven-point scale ranging from 'no trust at all' to 'very much trust'; participants could choose to not answer at the first time point, resulting in n = 44 missing answers for trust in government and n = 155 missing answers for trust in science); and to what extent they agreed with the statement 'I think the measures that are currently being taken are greatly exaggerated' (measured on a seven-point scale ranging from 'do not agree at all' to 'agree very much'). Finally, participants were asked to assess their overall life satisfaction (on a seven-point scale ranging from 'not at all satisfied' to 'very satisfied'; some surveys of the first time point did not include the item, resulting in n = 105 missing answers).

At the second time point, participants were asked to estimate the share of people who perceived high infection severity, high exaggeration of pandemic measures, high life satisfaction (values 5–7 on the respective seven-point scale presented above) and low trust in government (values 1–3 on the seven-point scale presented above) in a survey in the summer of 2020. This served to validate the usability of population estimates as individual recall proxies (see 'Analyses' below).

Pandemic recall. At the second time point, participants were asked to recall the time of the first survey. To help them recall the period in question, they were provided with some details of the pandemic situation and a visual showing COVID-19 cases over time. They were asked to recall their perceptions of risk, their trust in government and science, their mask-wearing behaviour, how exaggerated they had perceived the policies to be and their life satisfaction during that period (using the same five- or seven-point scales as before).

Appropriateness of political action. Participants were asked to respond to nine items evaluating how the pandemic was handled, measured on a seven-point scale ranging from 'do not agree at all' to 'agree very much' (example items: 'It has been proved that most corona measures have not worked' and 'The corona measures were a pretext to restrict civil liberties'; Cronbach's α = 0.92). The items were inspired by a newspaper report[10].

Analyses. Population models. To assess the effects of past and present ratings on recall for each variable, eight truth and bias (T&B) models[16] were estimated. In each model, recall of one variable (for example, infection probability) was regressed on past and present ratings, along with all their possible interactions with vaccination status and vaccination status identification. For visualization purposes (Fig. 1), we plotted all intersections of present and past values that resulted in a predicted recall at the scale midpoint of the respective variable (separately for vaccinated and unvaccinated individuals with different levels of identification). Modelling showed the effects of vaccination status and vaccination status identification on directional bias (the extent to which responses tended towards scale end-points, model intercept) and the force of past ('truth force') and present ('bias force') ratings. To be able to interpret directional bias as an over- or underestimation of recall compared to the past, all models were estimated for a second time, with recall, past and present ratings being centred by the grand mean of past ratings (for regression tables, see Extended Data Table 1).

Individual models. Assuming that recall at the individual level is similarly biased for all variables, we estimated directional bias and the biasing force of past and present ratings for each participant. In calculating each participant's T&B model, only seven variables were included; life satisfaction was excluded, as this hardly differed between participants, and recall of life satisfaction was based almost entirely on current life satisfaction at the population level (see Fig. 1). Perceptions of exaggeration were inverted (as they correlated negatively with the other variables). All variables were rescaled to range from 0 to 1 before model estimation. Please note that for n = 70 participants, no individual model could be estimated. For all analyses, the necessary preconditions were met.

Population estimates as proxies of individual recall. To show that individual recall bias is linked to biased population estimates, participants' estimated shares of people who perceived high infection severity, low trust in government, high exaggeration of pandemic measures and high life satisfaction were predicted by their individual recall, past and present evaluations of these variables in three multiple linear regressions (see Extended Data Table 2).

Study 2

Participants. Participants were surveyed at two time points: December 2021 and early 2023. In total, 3,105 individuals aged 18–97 years (M = 49.90, s.d. = 16.02) participated, of whom 50% were male and 50% were female. Participants were recruited from a panel containing Austrian and German participants who had already taken part several times in surveys around vaccination[14]. The panel included more unvaccinated participants than the general population to reliably observe potential changes in vaccination-related perceptions, intentions and behaviours over time.

Experimental manipulation. At the second time point, participants were randomly assigned to one of three groups. Those in the 'incentive' group were told that accurate recall increased their chances of winning a 100-euro prize. For a given variable, correct recall was awarded five points; if recall varied by one scale unit, four points were awarded, and so on. Each respondent's total points determined how often they would participate in the prize lottery. This intervention aimed at incentivizing correct recall (that is, giving people the chance to overrule motivated thinking by valuing a financial win as higher than confirming with one's current opinions). Participants assigned to the 'information' group were provided with some written details of another study, in which a selected group of 100 people were asked to recall their perceptions of infection severity, their trust in government and their mask-wearing behaviour during December 2021. The information group participants were then asked to guess what proportion of that other group underestimated those three variables. Each of our participants was then given an answer ranging from 10% to 90% (in 10% increments) based on randomly selected individuals from the other study. Thus, some participants were told that 10% of people underestimated perceived infection severity, trust in government and mask-wearing behaviours; others were told that 20% had underestimated these variables, and so on. This procedure generated random variation in the information received. The control group received no such information or incentive. The intervention aimed to raise people's awareness of bias, triggering accuracy concerns.

Measures. As in study 1, vaccination status and vaccination status identification (Cronbach's $\alpha = 0.75$) were assessed at the second time point. Present and past risk perceptions, trust and protective behaviours, as well as their recall, were assessed. Items queried infection probability, severity, trust in government and science and mask wearing again, plus the frequency of avoiding close contact (on a seven-point scale ranging from 'never' to 'always'). Appropriateness of political action was assessed as in study 1 (Cronbach's $\alpha = 0.92$).

Analyses. Again, as in study 1, population T&B models[10] were estimated for each of the six variables. On this occasion, however, recall was regressed on past and present values for each variable, along with potential interactions with vaccination status and experimental manipulation. As in study 1, recall, past and present ratings were again centred by the grand mean of past ratings. Regression details are provided in Extended Data Table 3. For all analyses, the necessary preconditions were met.

Study 3

Participants. Participants were surveyed for the first time between May and October 2021 (within COSMO) and for the second time in July 2023. As the panel provider was not able to reach enough unvaccinated individuals for group comparisons, only vaccinated individuals were invited to participate in the second survey. In total, 906 individuals participated. They were aged 18–74 years during the first survey ($M = 50.67$, s.d. = 14.11); 45% were male and 55% were female.

Experimental manipulation. At the second time point, participants were randomly assigned to one of two groups. Those in the 'incentive' group were told that accurate recall increased their chances of winning a 25-euro prize. For payment, for each participant in this group, one recall variable was randomly selected and compared to the original answer they provided in 2021. The probability of winning the prize was then calculated by applying a binarized scoring rule[21] using the following formula: $P = 100 - 100 \times \left(\left|\frac{\text{Original answer}}{y} - \frac{\text{Recalled answer}}{y}\right|\right)$, with $y = 6$ for seven-point-scale items and $y = 4$ for five-point-scale items. That is, when recall met the original answer, participants received the prize with certainty, and the larger the deviation, the lower the probability of winning the prize. In total, 64% of participants in the incentive group received the prize. Recall in the control group was not incentivized.

Measures. As in studies 1 and 2, present and past perceptions and behaviours, as well as their recall, were assessed. Items queried infection probability, severity, trust in government, exaggeration perception (seven-point scales), mask wearing and contact avoidance (five-point scales). As participants could choose to not answer some items at the first time point, there are missing answers for past mask wearing ($n = 4$), contact avoidance ($n = 47$) and trust in government ($n = 25$). Participants were further asked to recall the time they completed the 2021 survey (choosing one of seven time intervals). Appropriateness of political action was assessed as in study 1 (Cronbach's $\alpha = 0.89$).

Analyses. Again, population T&B models[16] were estimated for each of the six pandemic-related variables and the survey completion time. On this occasion, however, recall was regressed on past and present values for each variable, along with interactions with the experimental manipulation. Except for visualization (Fig. 2), recall, past and present ratings were again centred by the grand mean of past ratings. Extended models, including vaccination status identification as an additional moderator, were also explored (see Extended Data Table 4). As in study 1, individual T&B models were calculated to estimate individual directional bias (note that for $n = 38$ participants, no individual model could be estimated). For all analyses, the necessary preconditions were met.

Study 4

Participants. Participants from ten countries were assessed once between March and April 2023 ($n = 5{,}121$). The included countries were Australia ($n = 502$), Germany ($n = 499$), Italy ($n = 498$), Japan ($n = 511$), Mexico ($n = 510$), South Korea ($n = 510$), Spain ($n = 498$), Sweden ($n = 506$), the UK ($n = 524$) and the USA ($n = 564$). Participants were aged 18–89 years ($M = 46.05$, s.d. = 15.87); of these, 50% were male and 50% were female. The selection of countries and the criteria for representativeness matched those in a previous 2020 study[23].

Measures. Vaccination status and vaccination status identification (Cronbach's $\alpha = 0.72$) were assessed as in study 1.

Pandemic recall. Participants were asked to guess responses (0–100%) to the following items in a survey conducted previously[23] between mid-March and mid-April 2020: the seriousness of COVID-19 ('What percentage of respondents (do you think) said in March/April 2020 that getting sick with COVID-19 can be serious?'); the probability of getting sick with COVID-19 ('What percentage of respondents (do you think) said in March/April 2020 that they would probably get sick with COVID-19?'); and the effectiveness of the government's response to the pandemic ('What percentage of respondents (do you think) said in March/April 2020 that the official response in their country was an effective way of dealing with the pandemic up to that point in time?'). Participants were told that we defined 'agreement' in the original study as a rating of 4 or 5 for infection severity and probability (originally measured on a five-point scale) and a rating of 6 or 7 for government effectiveness (originally measured on a seven-point scale). For each of the items, we compared our participants' guesses with the actual percentage of people, as found before[23].

Appropriateness of political action. This issue was examined using two items from study 1: 'The corona measures were a pretext to restrict civil liberties' and 'Evidence shows that most corona measures have not worked' (measured on a seven-point scale ranging from 'do not agree at all' to 'agree very much').

Punishment intention. To measure punishment intention, we asked participants to respond to two statements: 'Politicians should be punished for how they handled the corona pandemic' and 'Scientists who gave advice to the government should be punished for how they handled the corona pandemic' (measured on a seven-point scale ranging from 'strongly disagree' to 'strongly agree').

Voting intentions. Future voting intentions were assessed using the following yes/no question: 'If there was an election next week, would you vote?'

Compliance in a future pandemic. Compliance in a future pandemic was assessed in terms of the following statement: 'If there was a similar but new pandemic coming up, I would comply with measures and regulations.' (This was measured on a seven-point scale ranging from 'strongly disagree' to 'strongly agree').

Need for chaos. Participants were asked about their agreement with three items developed in a previous study[24]: 'Sometimes I just feel like destroying beautiful things'; 'I think society should be burned to the ground'; and 'I fantasize about a natural disaster wiping out most of humanity such that a small group of people can start all over' (measured on a seven-point scale from 'strongly disagree' to 'strongly agree', Cronbach's $\alpha = 0.83$).

Ethical approval

The study was conducted in accordance with German Psychological Association guidelines. Ethical clearance was obtained from the University of Erfurt's institutional review board (20200302/20200501/20211215) and the University of Bamberg's institutional review board (2023-07/31). All participants provided informed consent to use and share their data for scientific purposes without disclosing their identities. Participants were compensated for their participation by the panel providers.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

Data are available at https://doi.org/10.17605/OSF.IO/BXG7V. Study 2 (https://aspredicted.org/uw47f.pdf) and study 3 (https://aspredicted.org/kk33k.pdf) were preregistered.

Code availability

Data analysis scripts are available at https://doi.org/10.17605/OSF.IO/BXG7V.

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Author contributions All authors designed and performed the research. P.S. and L.H. performed the data analyses. All authors wrote and revised the manuscript.

Competing interests The authors declare no competing interests.

Additional information

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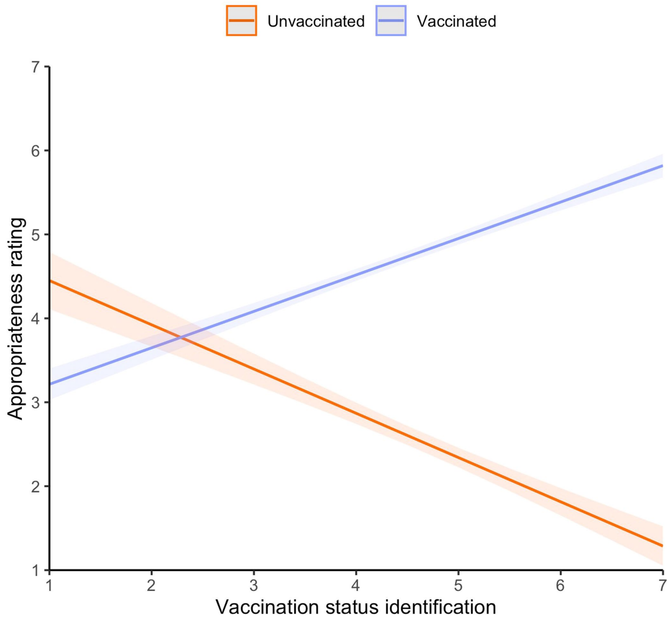
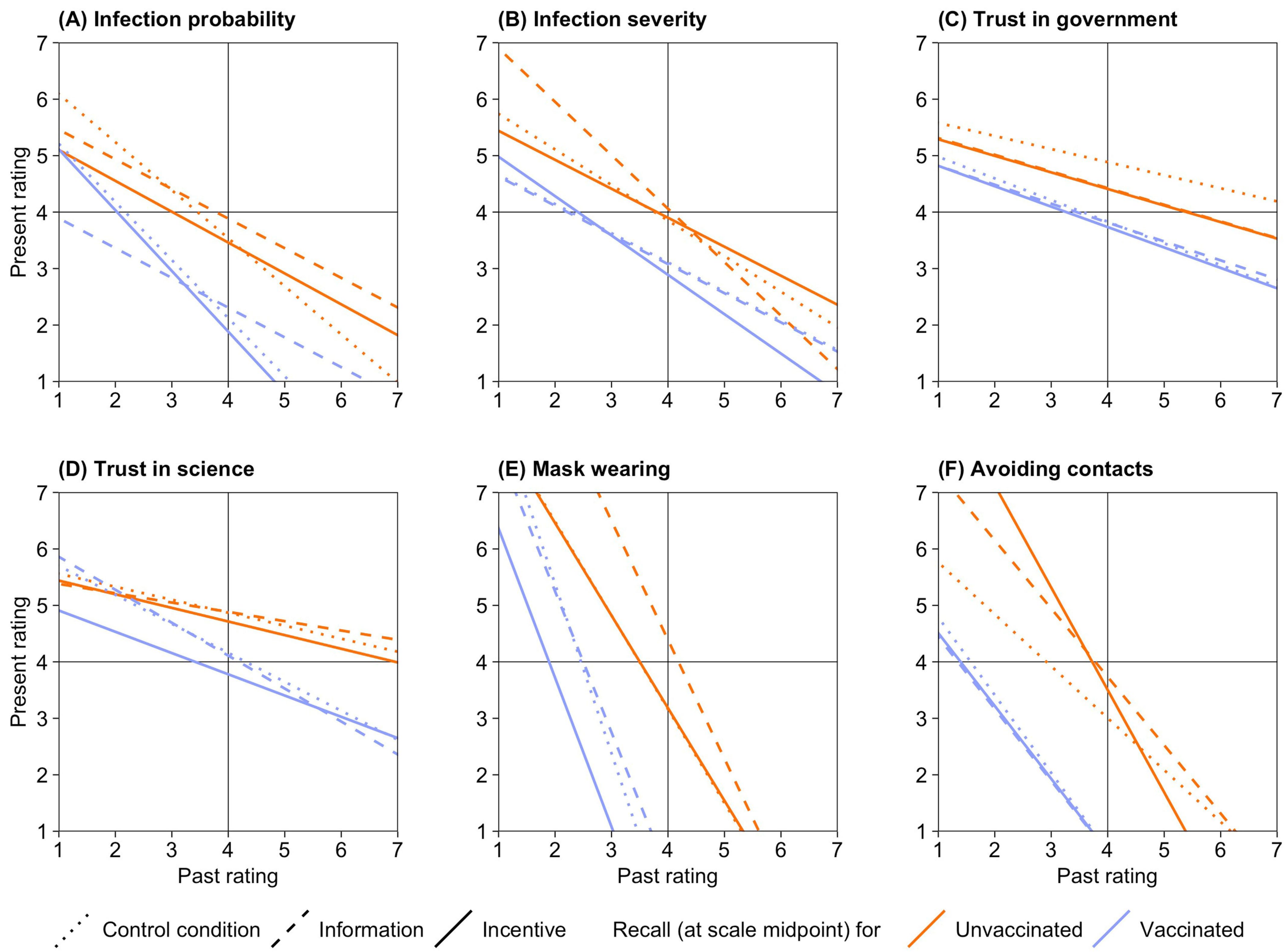


Extended Data Fig. 1 | Predictors of appropriateness of political action in study 1. Results of a multiple linear regression with vaccination status and vaccination status identification predicting perceived appropriateness of political measures to contain the COVID-19 pandemic. Ribbons visualize 95% confidence intervals; $R^2 = 0.482$.



Extended Data Fig. 2 | Effects of interventions to reduce recall bias in study 2. **a**–**f**, Linear regression predicting individual recall on the basis of past (December 2021) and present (January 2023) ratings and their interactions with vaccination status and experimental condition for infection probability (**a**), infection severity (**b**), trust in government (**c**), trust in science (**d**), mask wearing (**e**) and avoiding contacts (**f**) (n = 3,105). Each line visualizes directional bias and how past and present perceptions affect recall (at recall = 4) for a given vaccination status and experimental condition (see the Fig. 1 legend for details on how to read the figure).

Extended Data Table 1 | Recall in study 1

Predictor	Infection probability (n = 1,644; R^2 = 0.40)			Infection severity (n = 1,644; R^2 = 0.59)		
	b	SE	p	b	SE	p
(Intercept)	0.53	0.29	0.066	0.17	0.30	0.573
Vaccinated (Baseline: unvaccinated)	-0.67	0.32	**0.039**	-0.27	0.33	0.404
Vaccination status identification	-0.14	0.06	**0.028**	-0.07	0.07	0.318
Past evaluation	0.16	0.21	0.447	0.08	0.17	0.627
Present evaluation	0.74	0.20	**<0.001**	0.70	0.19	**<0.001**
Interaction: Vaccinated x Identification	0.30	0.07	**<0.001**	0.18	0.07	**0.010**
Interaction: Past evaluation x Vaccinated	0.01	0.23	0.955	0.03	0.19	0.873
Interaction: Past evaluation x Identification	0.02	0.04	0.670	0.02	0.03	0.612
Interaction: Present evaluation x Vaccinated	-0.14	0.23	0.538	0.01	0.21	0.948
Interaction: Present evaluation x Identification	-0.04	0.04	0.379	0.00	0.04	0.970
Interaction: Past evaluation x Vaccinated x Identification	-0.00	0.05	0.935	0.01	0.04	0.799
Interaction: Present evaluation x Vaccinated x Identification	-0.00	0.05	0.951	-0.05	0.04	0.243

Predictor	Affective risk (n = 1,644; R^2 = 0.60)			Trust in government (n = 1,600; R^2 = 0.60)		
	b	SE	p	b	SE	p
(Intercept)	-0.24	0.37	0.520	0.17	0.35	0.618
Vaccinated (Baseline: unvaccinated)	0.18	0.40	0.647	-0.45	0.38	0.228
Vaccination status identification	0.15	0.08	**0.071**	-0.07	0.09	0.411
Past evaluation	0.52	0.17	**0.002**	0.12	0.16	0.445
Present evaluation	0.16	0.17	0.362	0.84	0.18	**<0.001**
Interaction: Vaccinated x Identification	-0.03	0.09	0.743	0.10	0.09	0.266
Interaction: Past evaluation x Vaccinated	-0.05	0.20	0.795	0.08	0.17	0.660
Interaction: Past evaluation x Identification	-0.04	0.03	0.260	0.01	0.03	0.657
Interaction: Present evaluation x Vaccinated	0.24	0.19	0.208	-0.07	0.20	0.706
Interaction: Present evaluation x Identification	0.12	0.04	**0.002**	-0.03	0.04	0.464
Interaction: Past evaluation x Vaccinated x Identification	0.03	0.04	0.447	-0.00	0.04	0.976
Interaction: Present evaluation x Vaccinated x Identification	-0.12	0.04	**0.005**	-0.02	0.04	0.602

Predictor	Trust in science (n = 1,489; R^2 = 0.67)			Mask wearing (n = 1,600; R^2 = 0.47)		
	b	SE	p	b	SE	p
(Intercept)	-0.04	0.28	0.883	-0.06	0.26	0.813
Vaccinated (Baseline: unvaccinated)	-0.51	0.31	0.100	-0.03	0.29	0.914
Vaccination status identification	-0.09	0.07	0.190	0.01	0.06	0.809
Past evaluation	-0.01	0.12	0.932	0.40	0.12	**0.001**
Present evaluation	0.88	0.13	**<0.001**	0.21	0.11	0.063
Interaction: Vaccinated x Identification	0.19	0.07	**0.009**	0.03	0.07	0.610
Interaction: Past evaluation x Vaccinated	0.20	0.15	0.175	-0.08	0.16	0.608
Interaction: Past evaluation x Identification	0.02	0.02	0.383	0.00	0.02	0.927
Interaction: Present evaluation x Vaccinated	-0.04	0.15	0.793	0.13	0.13	0.296
Interaction: Present evaluation x Identification	-0.02	0.03	0.428	0.04	0.03	0.110
Interaction: Past evaluation x Vaccinated x Identification	-0.01	0.03	0.650	0.00	0.03	0.976
Interaction: Present evaluation x Vaccinated x Identification	-0.03	0.03	0.412	-0.07	0.03	**0.022**

Predictor	Exaggeration perception (n = 1,644; R^2 = 0.64)			Life satisfaction (n = 1,539; R^2 = 0.46)		
	b	SE	p	b	SE	p
(Intercept)	-0.72	0.33	**0.029**	-0.34	0.22	0.116
Vaccinated (Baseline: unvaccinated)	1.73	0.36	**<0.001**	-0.26	0.25	0.300
Vaccination status identification	0.28	0.08	**0.001**	-0.01	0.05	0.789
Past evaluation	0.32	0.12	**0.008**	0.39	0.17	**0.020**
Present evaluation	0.66	0.13	**<0.001**	0.47	0.16	**0.004**
Interaction: Vaccinated x Identification	-0.53	0.09	**<0.001**	0.08	0.05	0.135
Interaction: Past evaluation x Vaccinated	0.02	0.14	0.866	0.00	0.19	0.997
Interaction: Past evaluation x Identification	-0.02	0.03	0.426	-0.07	0.03	**0.043**
Interaction: Present evaluation x Vaccinated	-0.08	0.15	0.613	0.08	0.19	0.655
Interaction: Present evaluation x Identification	-0.03	0.03	0.361	0.05	0.03	0.109
Interaction: Past evaluation x Vaccinated x Identification	0.00	0.03	0.972	0.02	0.04	0.654
Interaction: Present evaluation x Vaccinated x Identification	-0.00	0.03	0.954	-0.04	0.04	0.272

Extended Data Table 2 | Prediction of population estimates in study 1

Predictor	High infection severity (n = 1,644; R^2 = 0.06)			Low trust in government (n = 1,600; R^2 = 0.02)			High exaggeration perception (n = 1,644; R^2 = 0.04)			High life satisfaction (n = 1,539; R^2 = 0.06)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	46.49	1.64	**<0.001**	47.11	1.37	**<0.001**	36.29	1.17	**<0.001**	36.78	2.20	**<0.001**
Individual Recall	4.31	0.47	**<0.001**	2.34	0.47	**<0.001**	1.61	0.41	**<0.001**	3.95	0.49	**<0.001**
Present evaluation	-2.03	0.54	**<0.001**	-0.92	0.50	0.067	-0.36	0.41	0.067	-0.91	0.55	0.097
Past valuation	0.14	0.44	0.746	0.09	0.41	0.822	0.82	0.35	0.822	-0.12	0.43	0.777

Extended Data Table 3 | Recall in study 2

Predictor	Infection probability (n = 3,105; R^2 = 0.43) b	SE	p	Infection severity (n = 3,105; R^2 = 0.60) b	SE	p
(Intercept)	0.31	0.11	**0.004**	0.11	0.10	0.261
Past evaluation	0.38	0.07	**<0.001**	0.35	0.06	**<0.001**
Experimental condition: information (Baseline: control)	-0.16	0.13	0.206	-0.13	0.12	0.291
Experimental condition: incentive (Baseline: control)	0.05	0.15	0.738	-0.03	0.14	0.853
Vaccinated (Baseline: unvaccinated)	0.54	0.12	**<0.001**	0.42	0.11	**<0.001**
Present evaluation	0.45	0.08	**<0.001**	0.56	0.06	**<0.001**
Interaction: Past evaluation x Information	-0.08	0.09	0.335	0.11	0.08	0.134
Interaction: Past evaluation x Incentive	-0.04	0.09	0.660	-0.04	0.09	0.657
Interaction: Past evaluation x Vaccinated	0.01	0.08	0.940	-0.08	0.07	0.276
Interaction: Information x Vaccinated	0.26	0.15	0.078	0.15	0.14	0.256
Interaction: Incentive x Vaccinated	0.03	0.17	0.864	0.10	0.16	0.524
Interaction: Present evaluation x Information	0.12	0.09	0.195	-0.06	0.08	0.418
Interaction: Present evaluation x Incentive	0.18	0.10	0.082	0.05	0.09	0.586
Interaction: Present evaluation x Vaccinated	-0.07	0.09	0.420	-0.03	0.08	0.712
Interaction: Past evaluation x Information x Vaccinated	-0.07	0.10	0.508	-0.11	0.09	0.240
Interaction: Past evaluation x Incentive x Vaccinated	0.06	0.11	0.616	0.12	0.10	0.261
Interaction: Present evaluation x Information x Vaccinated	-0.05	0.11	0.651	0.08	0.09	0.373
Interaction: Present evaluation x Incentive x Vaccinated	-0.18	0.12	0.143	-0.08	0.11	0.479

Predictor	Trust in government (n = 3,105; R^2 = 0.72) b	SE	p	Trust in science (n = 3,105; R^2 = 0.74) b	SE	p
(Intercept)	-0.41	0.12	**<0.001**	-0.71	0.11	**<0.001**
Past evaluation	0.15	0.08	0.070	0.16	0.06	**0.006**
Experimental condition: information (Baseline: control)	0.23	0.15	0.145	-0.05	0.13	0.731
Experimental condition: incentive (Baseline: control)	0.23	0.18	0.212	0.11	0.15	0.448
Vaccinated (Baseline: unvaccinated)	0.62	0.12	**<0.001**	0.53	0.12	**<0.001**
Present evaluation	0.65	0.08	**<0.001**	0.68	0.06	**<0.001**
Interaction: Past evaluation x Information	0.05	0.10	0.622	-0.04	0.07	0.538
Interaction: Past evaluation x Incentive	0.05	0.12	0.669	0.01	0.08	0.855
Interaction: Past evaluation x Vaccinated	0.09	0.09	0.305	0.14	0.07	**0.038**
Interaction: Information x Vaccinated	-0.23	0.17	0.161	0.11	0.14	0.435
Interaction: Incentive x Vaccinated	-0.17	0.19	0.384	0.10	0.16	0.553
Interaction: Present evaluation x Information	0.03	0.10	0.801	0.02	0.07	0.810
Interaction: Present evaluation x Incentive	0.03	0.12	0.781	0.03	0.08	0.714
Interaction: Present evaluation x Vaccinated	-0.02	0.09	0.841	-0.10	0.07	0.132
Interaction: Past evaluation x Information x Vaccinated	-0.06	0.11	0.550	0.09	0.08	0.292
Interaction: Past evaluation x Incentive x Vaccinated	-0.06	0.12	0.640	-0.08	0.09	0.409
Interaction: Present evaluation x Information x Vaccinated	0.02	0.11	0.851	-0.01	0.08	0.909
Interaction: Present evaluation x Incentive x Vaccinated	-0.02	0.13	0.873	0.01	0.09	0.874

Predictor	Mask wearing (n = 3,105; R^2 = 0.54) b	SE	p	Avoiding contacts (n = 3,105; R^2 = 0.55) b	SE	p
(Intercept)	-0.03	0.15	0.821	0.35	0.15	**0.021**
Past evaluation	0.53	0.05	**<0.001**	0.41	0.04	**<0.001**
Experimental condition: information (Baseline: control)	-0.31	0.18	0.093	-0.33	0.18	0.075
Experimental condition: incentive (Baseline: control)	-0.05	0.21	0.826	-0.31	0.21	0.146
Vaccinated (Baseline: unvaccinated)	0.25	0.16	0.122	0.39	0.17	**0.022**
Present evaluation	0.32	0.04	**<0.001**	0.45	0.05	**<0.001**
Interaction: Past evaluation x Information	0.07	0.06	0.197	0.07	0.05	0.190
Interaction: Past evaluation x Incentive	-0.01	0.06	0.825	0.13	0.07	**0.046**
Interaction: Past evaluation x Vaccinated	-0.00	0.06	0.963	-0.02	0.06	0.763
Interaction: Information x Vaccinated	0.27	0.20	0.174	0.25	0.21	0.223
Interaction: Incentive x Vaccinated	0.04	0.23	0.859	0.29	0.24	0.221
Interaction: Present evaluation x Information	-0.03	0.05	0.521	-0.05	0.07	0.445
Interaction: Present evaluation x Incentive	-0.00	0.06	0.943	-0.15	0.08	0.061
Interaction: Present evaluation x Vaccinated	-0.14	0.05	**0.004**	-0.16	0.06	**0.009**
Interaction: Past evaluation x Information x Vaccinated	-0.09	0.08	0.241	-0.12	0.07	0.091
Interaction: Past evaluation x Incentive x Vaccinated	-0.06	0.09	0.513	-0.16	0.08	0.058
Interaction: Present evaluation x Information x Vaccinated	0.06	0.06	0.319	0.04	0.08	0.636
Interaction: Present evaluation x Incentive x Vaccinated	0.00	0.07	0.988	0.15	0.09	0.107

Extended Data Table 4 | Recall in study 3

Predictor	**Infection probability** (n = 906)						**Infection severity** (n = 906)					
	Base model (R^2 = 0.24)			Plus identification (R^2 = 0.27)			Base model (R^2 = 0.40)			Plus identification (R^2 = 0.44)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	1.60	0.07	**<0.001**	0.74	0.23	**0.001**	0.66	0.07	**<0.001**	-0.28	0.23	0.230
Past evaluation	0.21	0.05	**<0.001**	0.32	0.16	**0.048**	0.29	0.04	**<0.001**	0.25	0.13	**0.049**
Incentive (Baseline: No incentive)	-0.38	0.10	**<0.001**	0.11	0.34	0.744	0.02	0.10	0.822	0.38	0.35	0.278
Present evaluation	0.38	0.05	**<0.001**	0.64	0.15	**<0.001**	0.43	0.04	**<0.001**	0.58	0.13	**<0.001**
Interaction: Past evaluation x Incentive	-0.05	0.07	0.465	-0.32	0.24	0.183	0.04	0.06	0.540	0.31	0.20	0.127
Interaction: Present evaluation x Incentive	0.13	0.07	0.061	-0.02	0.21	0.934	0.14	0.06	**0.021**	0.11	0.20	0.572
Vaccination status identification				0.21	0.05	**<0.001**				0.22	0.05	**<0.001**
Interaction: Past time x Identification				-0.03	0.04	0.455				-0.01	0.03	0.845
Interaction: Incentive x Identification				-0.12	0.07	0.094				-0.09	0.07	0.232
Interaction: Present time x Identification				-0.07	0.03	**0.043**				-0.04	0.03	0.170
Interaction: Past time x Incentive x Identification				0.06	0.05	0.230				-0.05	0.04	0.235
Interaction: Present time x Incentive x Identification				0.04	0.05	0.411				0.01	0.04	0.877

Predictor	**Mask wearing** (n = 902)						**Contact avoidance** (n = 859)					
	Base model (R^2 = 0.12)			Plus identification (R^2 = 0.20)			Base model (R^2 = 0.27)			Plus identification (R^2 = 0.33)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	0.29	0.16	0.071	-0.14	0.61	0.821	0.52	0.08	**<0.001**	-0.14	0.61	0.871
Past evaluation	0.42	0.05	**<0.001**	0.60	0.16	**<0.001**	0.25	0.04	**<0.001**	0.60	0.16	0.400
Incentive (Baseline: No incentive)	-0.35	0.21	0.099	-1.31	0.85	0.124	0.04	0.12	0.751	-1.31	0.85	0.772
Present evaluation	0.17	0.05	**0.001**	0.33	0.18	0.072	0.31	0.04	**<0.001**	0.33	0.18	**<0.001**
Interaction: Past evaluation x Incentive	-0.01	0.08	0.905	0.32	0.23	0.167	0.07	0.06	0.198	0.32	0.23	0.053
Interaction: Present evaluation x Incentive	-0.16	0.07	**0.021**	-0.57	0.26	**0.029**	0.02	0.06	0.788	-0.57	0.26	0.662
Vaccination status identification				0.06	0.11	0.584				0.06	0.11	0.052
Interaction: Past time x Identification				-0.06	0.04	0.111				-0.06	0.04	0.377
Interaction: Incentive x Identification				0.20	0.16	0.197				0.20	0.16	0.809
Interaction: Present time x Identification				-0.05	0.03	0.145				-0.05	0.03	0.060
Interaction: Past time x Incentive x Identification				-0.09	0.06	0.107				-0.09	0.06	0.165
Interaction: Present time x Incentive x Identification				0.09	0.05	0.063				0.09	0.05	0.557

Predictor	**Trust in government** (n = 881)						**Exaggeration perception** (n = 906)					
	Base model (R^2 = 0.53)			Plus identification (R^2 = 0.55)			Base model (R^2 = 0.44)			Plus identification (R^2 = 0.48)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	0.37	0.06	**<0.001**	-0.34	0.21	0.112	0.20	0.07	**0.005**	1.45	0.23	**<0.001**
Past evaluation	0.16	0.04	**<0.001**	0.35	0.13	**0.006**	0.38	0.04	**<0.001**	0.20	0.13	0.107
Incentive (Baseline: No incentive)	0.15	0.09	0.087	0.33	0.32	0.293	-0.42	0.10	**<0.001**	-0.40	0.34	0.247
Present evaluation	0.64	0.04	**<0.001**	0.53	0.12	**<0.001**	0.45	0.04	**<0.001**	0.67	0.12	**<0.001**
Interaction: Past evaluation x Incentive	0.20	0.06	**<0.001**	0.35	0.19	0.071	0.01	0.06	0.885	0.31	0.19	0.101
Interaction: Present evaluation x Incentive	-0.12	0.05	**0.025**	-0.14	0.17	0.437	-0.08	0.06	0.164	-0.33	0.18	0.062
Vaccination status identification				0.17	0.05	**<0.001**				-0.30	0.05	**<0.001**
Interaction: Past time x Identification				-0.05	0.03	0.089				0.04	0.03	0.222
Interaction: Incentive x Identification				-0.05	0.07	0.508				0.00	0.07	0.973
Interaction: Present time x Identification				0.02	0.03	0.528				-0.07	0.03	**0.019**
Interaction: Past time x Incentive x Identification				-0.02	0.04	0.584				-0.08	0.04	0.073
Interaction: Present time x Incentive x Identification				0.00	0.04	0.953				0.06	0.04	0.136

Extended Data Table 5 | Mixed-effects regression of recall in study 3

Predictor	Base model (n = 5,360; marginal/conditional R^2 = 0.35/0.38)			Plus identification (n = 5,360; marginal/conditional R^2 = 0.36/0.39)		
	b	*SE*	*p*	*b*	*SE*	*p*
(Intercept)	1.64	0.07	**<0.001**	1.24	0.22	**<0.001**
Past evaluation	0.37	0.02	**<0.001**	0.25	0.05	**<0.001**
Incentive (Baseline: No incentive)	-0.35	0.10	**0.001**	-0.01	0.33	0.982
Present evaluation	0.38	0.02	**<0.001**	0.51	0.05	**<0.001**
Interaction: Past evaluation x Incentive	0.08	0.02	**0.002**	0.15	0.08	0.062
Interaction: Present evaluation x Incentive	-0.02	0.02	0.336	-0.18	0.07	**0.016**
Vaccination status identification				0.10	0.05	**0.033**
Interaction: Past time x Identification				0.03	0.01	**0.026**
Interaction: Incentive x Identification				-0.08	0.07	0.235
Interaction: Present time x Identification				-0.03	0.01	**0.004**
Interaction: Past time x Incentive x Identification				-0.02	0.02	0.333
Interaction: Present time x Incentive x Identification				0.04	0.02	**0.022**

Results of fixed-effects regression analysis, including observations of six variables (infection probability and severity, mask wearing, contact avoidance, trust in government and exaggeration perception) and modelling participant ID as a random intercept.

Extended Data Table 6 | Recall of participation time in study 3

Predictor	Base model (n = 906; R^2 = 0.15)			Model with identification (n = 906; R^2 = 0.16)		
	b	SE	p	b	SE	p
(Intercept)	0.43	0.05	**<0.001**	0.51	0.18	**0.005**
Past participation time	0.18	0.04	**<0.001**	0.19	0.12	0.103
Incentive (Baseline: No incentive)	-0.12	0.08	0.105	-0.04	0.26	0.879
Present participation time	0.22	0.04	**<0.001**	0.18	0.13	0.145
Interaction: Past time x Incentive	0.09	0.05	0.076	0.28	0.17	0.104
Interaction: Present time x Incentive	0.01	0.05	0.888	0.30	0.19	0.114
Vaccination status identification				-0.02	0.04	0.647
Interaction: Past time x Identification				-0.00	0.03	0.902
Interaction: Incentive x Identification				-0.02	0.06	0.753
Interaction: Present time x Identification				0.01	0.03	0.769
Interaction: Past time x Incentive x Identification				-0.04	0.04	0.268
Interaction: Present time x Incentive x Identification				-0.06	0.04	0.115

Extended Data Table 7 | Biases in population estimates and their correlation with appropriateness of political action ratings in study 4

Country	Infection probability		Infection severity		Government effectiveness	
	%	*r (p)*	%	*r (p)*	%	*r (p)*
Australia (n = 502)	80	0.03 (0.497)	84	**0.11 (0.011)**	50	**0.14 (0.002)**
Germany (n = 499)	75	**-0.09 (0.048)**	97	0.03 (0.469)	40	0.09 (0.052)
Spain (n = 498)	87	0.05 (0.312)	74	**0.13 (0.004)**	60	**0.14 (0.001)**
Italy (n = 498)	92	-0.02 (0.679)	77	0.03 (0.502)	31	0.03 (0.473)
Japan (n = 511)	80	**-0.14 (0.002)**	24	0.00 (0.983)	81	0.07 (0.108)
South Korea (n = 510)	83	-0.01 (0.865)	76	**0.19 (<0.001)**	45	**0.21 (<0.001)**
Mexico (n = 510)	90	-0.02 (0.640)	42	0.04 (0.405)	71	0.01 (0.843)
Sweden (n = 506)	73	**0.14 (0.002)**	82	**0.21 (<0.001)**	42	**0.21 (<0.001)**
United Kingdom (n = 524)	65	-0.02 (0.632)	97	0.05 (0.284)	58	0.07 (0.129)
United States (n = 563)	78	**-0.18 (<0.001)**	93	**-0.15 (<0.001)**	75	**-0.12 (0.005)**

The % columns indicate the share of participants overestimating infection probability, underestimating infection severity and overestimating government effectiveness in the 2020 population compared to a survey from that time. Pearson correlations (*r* and *P* values in parentheses) indicate the relationship between individual estimates of the share of the 2020 population perceiving high infection probability, high infection severity and high government effectiveness and perceived appropriateness of political action.

Extended Data Table 8 | Correlates of appropriateness of political action ratings in study 4

Country	*M (SD)*	Correlates									
		Punishing politicians		**Punishing scientists**		**Need for chaos**		**Voting intention**		**Future compliance**	
		%	*r (p)*	%	*r (p)*	%	*r (p)*	%	*r (p)*	%	*r (p)*
Australia (n = 502)	4.84 (1.70)	28	**-0.60 (<0.001)**	18	**-0.67 (<0.001)**	14	**-0.48 (<0.001)**	88	**0.14 (0.002)**	71	**0.49 (<0.001)**
Germany (n = 499)	4.84 (1.80)	29	**-0.70 (<0.001)**	19	**-0.73 (<0.001)**	6	**-0.35 (<0.001)**	89	**0.20 (<0.001)**	64	**0.56 (<0.001)**
Spain (n = 498)	4.54 (1.69)	43	**-0.60 (<0.001)**	25	**-0.60 (<0.001)**	11	**-0.41 (<0.001)**	85	**0.17 (<0.001)**	77	**0.36 (<0.001)**
Italy (n = 498)	4.66 (1.79)	37	**-0.66 (<0.001)**	27	**-0.73 (<0.001)**	15	**-0.45 (<0.001)**	80	**0.15 (0.001)**	73	**0.52 (<0.001)**
Japan (n = 511)	4.78 (1.30)	20	**-0.63 (<0.001)**	14	**-0.53 (<0.001)**	7	**-0.57 (<0.001)**	73	**0.09 (0.033)**	49	0.03 (0.501)
South Korea (n = 510)	5.09 (1.46)	31	**-0.51 (<0.001)**	15	**-0.67 (<0.001)**	13	**-0.56 (<0.001)**	90	**0.12 (0.007)**	79	**0.43 (<0.001)**
Mexico (n = 510)	4.76 (1.58)	49	**-0.32 (<0.001)**	25	**-0.47 (<0.001)**	13	**-0.47 (<0.001)**	88	0.07 (0.118)	84	**0.18 (<0.001)**
Sweden (n = 506)	5.23 (1.58)	19	**-0.65 (<0.001)**	12	**-0.70 (<0.001)**	9	**-0.58 (<0.001)**	91	**0.16 (<0.001)**	74	**0.47 (<0.001)**
United Kingdom (n = 524)	4.81 (1.59)	48	**-0.36 (<0.001)**	15	**-0.59 (<0.001)**	12	**-0.46 (<0.001)**	85	**0.15 (<0.001)**	73	**0.47 (<0.001)**
United States (n = 563)	4.58 (1.90)	40	**-0.56 (<0.001)**	24	**-0.77 (<0.001)**	13	**-0.51 (<0.001)**	85	0.05 (0.258)	64	**0.46 (<0.001)**

Means and standard deviations of appropriateness ratings across countries plus their correlation with the desires to punish politicians and scientists for how they handled the pandemic, the desire to dismantle the entire political order (need for chaos), intention to vote in the next elections and complying with future pandemic regulations (*r* refers to Pearson correlations, *P* values in parentheses). The % columns indicate the share of participants indicating the respective desires or intentions above the respective scale midpoint (for example, the share of people with a desire to punish politicians of 5 or higher on the seven-point scale).

Extended Data Table 9 | Predictors of appropriateness of political action in study 4

Predictor	Australia (n = 502, R^2 = 0.16)			Germany (n = 499, R^2 = 0.26)		
	b	SE	p	b	SE	p
(Intercept)	6.42	0.77	**<0.001**	4.91	0.69	**<0.001**
Vaccination status identification	-0.71	0.17	**<0.001**	-0.49	0.15	**0.001**
Vaccinated (Baseline: Unvaccinated)	-2.79	0.82	**0.001**	-1.38	0.74	0.062
Interaction: Vaccinated x Identification	1.02	0.18	**<0.001**	0.86	0.16	**<0.001**
Predictor	**Spain** (n = 498, R^2 = 0.10)			**Italy** (n = 498, R^2 = 0.21)		
	b	SE	p	b	SE	p
(Intercept)	5.21	1.34	**<0.001**	4.61	0.81	**<0.001**
Vaccination status identification	-0.52	0.26	**0.050**	-0.41	0.17	**0.014**
Vaccinated (Baseline: Unvaccinated)	-2.01	1.37	0.143	-1.68	0.86	**0.050**
Interaction: Vaccinated x Identification	0.80	0.27	**0.003**	0.81	0.17	**<0.001**
Predictor	**Japan** (n = 511, R^2 = 0.09)			**South Korea** (n = 510, R^2 = 0.10)		
	b	SE	p	b	SE	p
(Intercept)	6.61	0.32	**<0.001**	8.20	0.67	**<0.001**
Vaccination status identification	-0.53	0.08	**<0.001**	-0.85	0.15	**<0.001**
Vaccinated (Baseline: Unvaccinated)	-1.26	0.40	**0.002**	-4.04	0.73	**<0.001**
Interaction: Vaccinated x Identification	0.40	0.10	**<0.001**	1.08	0.16	**<0.001**
Predictor	**Mexico** (n = 510, R^2 = 0.02)			**Sweden** (n = 506, R^2 = 0.12)		
	b	SE	p	b	SE	p
(Intercept)	5.52	0.99	**<0.001**	6.63	0.86	**<0.001**
Vaccination status identification	-0.37	0.24	0.118	-0.71	0.21	**0.001**
Vaccinated (Baseline: Unvaccinated)	-0.74	1.04	0.472	-1.71	0.91	0.060
Interaction: Vaccinated x Identification	0.38	0.24	0.122	0.82	0.22	**<0.001**
Predictor	**United Kingdom** (n = 524, R^2 = 0.15)			**United States** (n = 563, R^2 = 0.18)		
	b	SE	p	b	SE	p
(Intercept)	6.23	0.76	**<0.001**	6.36	0.54	**<0.001**
Vaccination status identification	-0.70	0.17	**<0.001**	-0.66	0.12	**<0.001**
Vaccinated (Baseline: Unvaccinated)	-2.71	0.80	**0.001**	-2.22	0.63	**<0.001**
Interaction: Vaccinated x Identification	0.99	0.18	**<0.001**	0.83	0.13	**<0.001**

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n/a	Confirmed	
☐	☒	The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	A description of all covariates tested
☐	☒	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. F, t, r) with confidence intervals, effect sizes, degrees of freedom and P value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's d, Pearson's r), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	The web platform Tivian (EFS Fall 2021) was used to collect the data.
Data analysis	We used R (v4.2.2) with packages dplyr (v1.1.0), sjPlot (v2.8.14), rstatix (v0.7.2), reshape2 (v.1.4.4), ggplot2 (v3.4.1), psych (v2.3.3), ggpubr (v0.6.0), compareGroups (v4.6.0), broom (v3.1.6), sandwich (v3.0-2), tidyr (v1.3.0), bayestestR (v0.13.0). The analysis code is permanently available at http://dx.doi.org/10.17605/OSF.IO/BXG7V

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

Original data (in RDS format) and codebooks (in PDF format) are permanently available for all studies at http://dx.doi.org/10.17605/OSF.IO/BXG7V

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	In all studies, participants' self-reported gender was assessed. As the focus of our work was not on gender differences, analyses did not differentiate between participants' gender. Additional checks confirmed that the investigated biases did not considerably differ by gender. Participants' sex was not assessed.
Reporting on race, ethnicity, or other socially relevant groupings	Participants were not grouped based on race or ethnicity. As the paper investigates pandemic-related memory biases and having or not having received a COVID-19 vaccine in the past is likely to affect these biases, we differentiate between vaccinated and unvaccinated individuals.
Population characteristics	Population characteristics are described in response to "Recruitment" below.
Recruitment	In all studies, samples (quota-representative for age and gender) were recruited online by a panel provider (Bilendi AG), people without internet access and those being from lower SES are likely to be underrepresented. Studies 1, 2 and 3 were longitudinal and dropout can affect results. We assumed that dropping out may especially differ between vaccinated and unvaccinated participants (as unvaccinated people may not want to answer a survey on pandemic-related topics again). To account for this, our analyses controlled for vaccination status.
Ethics oversight	IRBs of the University of Erfurt and the University of Bamberg

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☒ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Study 1: quantitative panel study Study 2: quantitative panel study with experimental manipulation Study 3: quantitative panel study with experimental manipulation Study 4: quantitative cross-sectional study
Research sample	Study 1: 1,644 participants from Germany age at the first panel timepoint (2020/2021): 18 to 74 years (M = 52.68, SD = 12.75); gender: 49% male, 51% female; vaccination status: 74% had received at least one dose of a COVID-19 vaccine (non-representative, oversampling unvaccinated individuals) Study 2: 3,105 participants from Germany and Austria; age at the first panel timepoint (2021): 18 to 97 years (M = 49.90, SD = 16.02); gender: 50% male, 50% female; vaccination status: 71% had received at least one dose of a COVID-19 vaccine (non-representative, oversampling unvaccinated individuals) Study 3: 906 participants from Germany; age at first panel timepoint (2021): 18 to 74 years (M = 50.67, SD = 14.11); gender: 45% male, 55% female; vaccination status: 100% had received at least one dose of a COVID-19 vaccine (non-representative, sampling only vaccinated individuals) Study 4: 5,121 participants from 10 countries (Australia, Germany, Italy, Spain, Japan, South Korea, Mexico, Sweden, United Kingdom, United States); age: 18 to 89 years (M = 46.05, SD = 15.87); gender: 50% male, 50% female; vaccination status: 88% had received at least one dose of a COVID-19 vaccine (samples quota-representative for age and gender)
Sampling strategy	Participants were invited and paid by a large panel provider (Bilendi AG). In Studies 1-3, participants of earlier surveys were re-recruited while samples for Study 4 were stratified by age and gender. Study 1: Initially, we intended to reassess data from 500 vaccinated and 500 unvaccinated individuals at the second panel timepoint. As re-recruiting unvaccinated individuals was more difficult than expected, quotas were changed to oversample vaccinated individuals, resulting in 426 unvaccinated and 1,218 vaccinated participants. Study 2: For the initial panel timepoint (2021), we intended to collect data from about 3,000 vaccinated and 3,000 unvaccinated individuals. However, as recruiting unvaccinated individuals was difficult, data collection stopped after 12 days, resulting in 3267 vaccinated and 2,038 unvaccinated participants. For the followup (2023), we reassessed as many individuals as possible within 10 days, resulting in 892 unvaccinated and 2,213 vaccinated individuals.

	Study 3: We intended to reassess 900 vaccinated participants as this was considered enough to detect small effects of incentives. The sample sizes (450 per group) was preregistered. Study 4: We intended to recruit 500 participants per country as this was considered enough to detect moderate interaction effects as shown in Figure 3C.
Data collection	Data was collected in online surveys.
Timing	Study 1: summer 2020 or winter 2020/2021 (first panel timepoint) plus December 2022 (second panel timepoint) Study 2: December 2021 (first panel timepoint) plus January 2023 (second panel timepoint) Study 3: summer and autumn 2021 (first panel timepoint) plus July 2023 (second panel timepoint) Study 4: April 2023
Data exclusions	No data were excluded
Non-participation	We did not record the number of participants who declined participation (denied consent at the beginning of the survey) or started but did not finish the survey (this resulted in not recording their answers in the dataset). Reasons for not finishing the survey were also not recorded.
Randomization	Participants were allocated to experimental groups randomly.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging