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Psychological Mechanisms Underlying the Biased Interpretation of Numerical Scientific Evidence

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Do people use their statistical expertise selectively to reach preferred conclusions when evaluating scientific evidence, with those more expert showing more preferential bias? We investigated this motivated numeracy account of evidence evaluation but came to a different account for biased evaluation. Across three studies ($N = 2{,}799$), participants interpreted numerical data from gun control intervention studies. In Studies 1 and 2, participants reached accurate conclusions more frequently from scientific data when those data aligned with their political preferences than when they did not, an attitude congeniality effect. This bias was unrelated to numerical ability (i.e., numeracy) and cognitive effort, although each variable predicted correct reasoning independently. Probing further, we found that attitude congeniality did not prompt people to discover valid statistical rationales for their more frequent correct conclusions. Rather, people came to right conclusions more often but for wrong reasons, suggesting why numerical ability need not be related to the congeniality effect. In Study 2, we showed this pattern was not due to forced guessing. In Study 3, we showed that the rationales, whether right or wrong, carried some weight over multiple scenarios, indicating that participants were not just expressive responding—that is, simply stating preferred conclusion regardless of the data. Statistical training did not reduce attitude congeniality biases. We suggest that people engage in "expressive rationalization" rather than "rationality" to reach preferred conclusions, finding convenient rationales for preferred conclusions that need not be valid, even though they can lead to conclusions that are.

Public Significance Statement

Why do people interpret numerical evidence to favor their political preferences? Does numerical intelligence prevent or exacerbate this bias? We examine psychological mechanisms underlying biased interpretation of scientific data on contentious political issues. We find that partisans more often reach correct conclusions from data when it aligns with their political preferences than when it goes against them, but frequently do so via invalid rationales that support those conclusions. In short, they are right but often for the wrong reasons, a phenomenon we term expressive rationalization. This pattern fails to support other accounts of political bias, such as expressive rationality (in which people use valid cognitive ability to interpret scientific data accurately when it reaches friendly conclusions) and expressive responding (in which people simply disregard what the data say). Anyone can rationalize, so numerical skill neither produces nor prevents bias.

Keywords: motivated reasoning, statistical reasoning, numeracy, attitude congeniality effect, covariation detection

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In the age of the Internet, people are increasingly awash in information at the call of their fingertips. Nowhere is this truer than in scientific information. Citizens and policymakers can directly access journal articles and technical reports on important scientific issues of the day—and often exhorted to do their own research on making sense of available scientific data (Ballantyne et al., 2024). A 2022 Pew Research Center survey found that 48% of Americans have viewed scientific content on social media within the last few weeks, with 26% following an account focused on science. Such media addressed health and medicine, information about the ongoing pandemic, energy, and the environment (Saks & Tyson, 2022).

Thus, there is no surprise that science literacy has been called a crucial 21st century skill (Turiman et al., 2012). People require knowledge to sort through scientific information that can be valuable but can also be muddled, contradictory, changing, low quality, or downright misleading (Cook, 2019; Farrell, 2019; Treen et al., 2020; Zhang et al., 2022). One would think with greater access to scientific information, and more scientific literacy with which to assess it, citizens would be well-equipped to draw closer to the truth, as they researched scientific data. A folk assumption is that people use their intelligence to understand useful truths and overcome potential biases as they swim through a sea of information. However, this march to the truth is not straightforward; at times, it is unclear whether the truth is the destination citizens wish to march to. Scientifically literate people tend to be the most polarized in the conclusions they draw about scientific issues relative to the less literate (Drummond & Fischhoff, 2017; Fischer et al., 2022; P. S. Hart et al., 2015).

In particular, people often reach conclusions that support their political preferences, social identities, and preconceived beliefs (P. S. Hart et al., 2015; Hornsey, 2020). In one area of research in particular, Kahan et al. (2017) argue that people engage in *motivated numeracy*, selectively applying their numerical competence only when prompted by data that are misaligned with their political beliefs. In such instances, they reach smarter and more accurate conclusions that better align with their political preferences and preconceptions. Hence, people engage in *expressive rationality*, using their intelligence not to seek impartial truth but instead to ratify conclusions affirming their identity and worldview (Kahan, 2017).

In this article, we examine the expressive rationality account for biased interpretations of scientific data. We test whether people reach attitude-friendly conclusions, because they train their intelligence (and their cognitive effort) on that task, as suggested by Kahan et al. (2017), but also whether people may reach such congenial conclusions via other psychological mechanisms. There are many alternative accounts for why people tend to reach conclusions consistent with their political identities or ideological worldviews to be enumerated below.

The Expressive Rationality Account

Opposing partisan groups tend to interpret information differently, including scientific information, with this discrepancy often attributed to motivated reasoning, or the processing of information with the goal of reaching a desirable conclusion (Baumeister & Newman, 1994; Kunda, 1990). Kunda (1990) suggests that individuals engage in biased information or memory searches when faced with an open question to construct coherent arguments that support favored conclusions, but which might also convince a dispassionate observer. Psychological research suggests that motivated reasoning is endemic in processing information about politics (Ditto et al., 2019; Finkel et al., 2020; Taber & Lodge, 2006), the self (Beauregard & Dunning, 1998; Dunning et al., 1995; Klein & Kunda, 1993), visual perception (Balcetis & Dunning, 2006, 2010), science comprehension (Washburn & Skitka, 2018), social and health attitudes (Albarracín & Mitchell, 2004; Earl & Hall, 2018; W. Hart et al., 2009), legal evidence (Lord et al., 1979; D. Simon, 2004), and more.

Within research on motivated reasoning, the motivated numeracy account asks a more specific but important question: What role does the application of expertise, intelligence, or knowledge play in motivated reasoning? Does it forestall motivated reasoning processes, amplify them, or have no effect at all? To study this question, Kahan et al. (2017) investigated how partisans interpret numerical data, focusing on a classic covariance detection task taken from the judgment and decision-making literature. Political partisans were asked to decide whether some intervention had a positive or negative impact on social welfare. In a neutral condition, participants judged whether a new skin cream (the intervention) reduced skin rashes (an adverse event) by looking at a census of studies on the issue.

Data from the studies were arranged in a 2 × 2 table, tallying the number of studies that introduced skin cream versus those that did not, crossed with whether rashes increased or decreased, and asked whether the numerical evidence pointed to the skin cream increasing or decreasing the rate of rashes. In the politically charged version of the scenario, the intervention was a ban on handguns, and the adverse event was the crime rate. Respondents were asked to judge whether gun bans, based on the evidence, led to an increase or decrease in crime. To answer the question correctly, Kahan et al. (2017) asked participants look at the frequency outcomes fell into the four cells of data in the 2 × 2 table, in which the presence of the intervention (yes or no) and the occurrence of the outcome (decrease or increase) were displayed. Figure 1 displays example 2 × 2 tables that participants might view.

Classic literature suggests that many people will make a mistake viewing the 2 × 2 table, focusing just on one cell of the four—the one depicting the number of successes when the intervention is applied, typically referred to as Cell A (see the subscript applied to each cell of the tables). If that number is large, people declare the intervention a success even when considering the numbers in all the cells suggest the opposite. That is, people neglect how often the intervention turns out to be a failure, as well as how often success arises when no intervention is applied (Jenkins & Ward, 1965; Kao & Wasserman, 1993; Mata, Garcia-Marques, et al., 2015; Mata, Sherman, et al., 2015; Smedslund, 1963; Wasserman et al., 1990).

In the 2 × 2 tables in Figure 1, an exclusive attention to Cell A would lead to judgmental error. The intervention may worsen the outcome rather than improve it, or vice versa, but people miss that fact if they concentrate only on the size of the number in that particular cell. Looking at the table in the top left-hand corner of Figure 1, gun bans look to be a failure. A full 223 cities that instituted gun bans (Cell A, see subscript in Figure 1) experienced increases in crime, an outsized number of disappointments. However, that conclusion is incorrect. Instead, the correct analysis is to compare the odds that gun bans led to a decrease versus an increase in crime versus the same odds when gun bans were absent. That is, in the table presented in the top left-hand corner of Figure 1, people should compare the ratio of successes with bans (i.e., decreases in crime; Cell B) to failures of gun bans (Cell A) to the same ratio in cities than do not have gun bans (Cells D–C, see Figure 1). Comparing gun ban successes to failures initially (75 successes, 223 failures) does not look promising; bans

Figure 1

Example Displays of Scientific Data for Hypothetical Gun Control and Skin Cream Scenarios

Crime Decreases

	Increases in Crime	Decreases in Crime
Cities that *did* ban carrying concealed handguns in public	223 A	75 B
Cities that did *not* ban carrying concealed handguns in public	107 C	21 D

Crime Increases

	Decreases in Crime	Increases in Crime
Cities that *did* ban carrying concealed handguns in public	223 A	75 B
Cities that did *not* ban carrying concealed handguns in public	107 C	21 D

Rash Decreases

	Rash Got Worse	Rash Got Better
Patients who *did* use the new skin cream	223 A	75 B
Patients who did *not* use the new skin cream	107 C	21 D

Rash Increases

	Rash Got Better	Rash Got Worse
Patients who *did* use the new skin cream	223 A	75 B
Patients who did *not* use the new skin cream	107 C	21 D

Note. Numbers refer to the number of cities experiencing crime increase or decrease after gun bans versus control (top) or patients experience skin rashes or not after the use of skin cream versus control (bottom). Effectiveness of these hypothetical interventions can be flipped by swapping the column labels (e.g., increase in crime vs. decrease in crime). The italics in row labels emphasize different intervention outcomes to participants. Adapted from "Motivated Numeracy and Enlightened Self-Government," by D. M. Kahan, E. Peters, E. C. Dawson, and P. Slovic, 2017, *Behavioural Public Policy*, *1*(1), p. 63 (https://doi.org/10.1017/bpp.2016.2). Copyright 2017 by Cambridge University Press. Adapted with permission.

achieve roughly only a 1:3 success ratio. But in the cities without gun bans, the same ratio is even worse (21 successes to 107 failures; a paltry rough 1–5 success rate). Thus, cities with bans achieved a better ratio of decreasing crime than cities without them—an overall success.

Kahan et al. (2017), however, found that political preferences influence the rate at which people make Cell A errors, or, instead, discerned the correct answer. When a large number in Cell A suggested a politically preferred conclusion, partisans commit more Cell A errors: Liberals conclude that a gun ban reduces crime in the data, whereas conservatives conclude that it increases it. However, when threatened by the conclusion supported by a large Cell A number, partisans more frequently arrive at the correct answer. This overall pattern of attitude-consistent accuracy or error has been replicated many times (Washburn & Skitka, 2018), even among professional politicians (Christensen & Moynihan, 2024) and economists at the World Bank (Banuri et al., 2019). Kahan and colleagues took this as initial evidence that people selectively apply their numerical literacy to reach conclusions they wish to reach, rather than on finding the right answer. The implicit assumption, not tested directly, is that people use or discover the correct answer through appropriate reasoning when politically convenient, performing the analysis in which the two key ratios (Cell A:Cell B) and (Cell C:Cell D) are compared.

Key to the Kahan et al. (2017) argument is that this pattern is even more pronounced among numerate individuals—those demonstrating high levels of mathematical skill in general. Highly numerate individuals more successfully recruit their expertise to interpret the data toward a preferred conclusion. That is, only those with numerical expertise and can construct the correct numerical analysis have the cognitive wherewithal to engage in expressive rationality. Although the original Kahan study did find a moderating role for numeracy in line with their analysis, many attempts at replicating this specific pattern among the numerate, at best, have been mixed. A few successfully replicate the role played by numeracy (Guay & Johnston, 2022; Kahan & Peters, 2017; Nurse & Grant, 2020), but many return negative results: Numeracy fails to amplify the partisan bias in finding the right answer, although the overall bias remains (Baker et al., 2020; Chung et al., 2023; Connor et al., 2024; Hutmacher et al., 2024; Lind et al., 2022; Persson et al., 2021; Strömbäck et al., 2024).

Possible Alternative Explanations

In sum, the emerging data suggest that people interpret scientific data not necessarily to inform their beliefs but with a bias toward buttressing ones they already have. The question is open, however, as to whether this favoritism is due to expressive rationality, that is, the selective application of intelligence to the interpretation of scientific data.

In the work contained herein, we addressed this open question by taking a new approach. Instead of specifically looking only for expressive rationality, especially among the numerate, we asked what other mechanisms could produce the biased pattern of data interpretation so sturdily demonstrated in the psychological literature. Thus, we tested not only expressive rationality as a potential mechanism but variants of it, along with other possible alternative mechanisms that can lead people to get to the right answer when that answer is preferred.

Variants of Expressive Rationality

The expressive rationality account suggests that smarter cognitive processing occurs when an initial cue, such as the size of the number in Cell A, leads to an uncongenial conclusion. In essence, people play the cognitive miser and base their answers on shallow cues unless this approach leads to threatening outcomes. Faced with unpleasant outcomes, they more carefully and accurately analyze the data in front of them (Dawson et al., 2002; Ditto et al., 1998; Ditto & Lopez, 1992; Schaller, 1992). Further, given that higher knowledge can be associated with polarized responding about political beliefs (Bolsen et al., 2015; Malka et al., 2009), it is possible that the energizing of more careful analysis occurs mostly among those who can do it, namely, highly numerate individuals. We term this the “getting smart” variant of expressive rationality. People do not apply expertise they have within them until they must do so to avoid threat.

The alternative variant is the opposite. People typically apply their cognitive expertise to solve problems, but “turn off” that expertise just as soon as initial signs point to a congenial answer. Thus, threat does not energize analysis; rather, tentative signs toward a preferred conclusion quells the skill and effort a person would typically apply to a problem. We call this the “playing dumb” variant of expressive rationality.

Each variant suggests a different pattern of responses to politically charged questions relative to more neutral ones. First, the getting smart variant suggests that people overall interpret scientific data more accurately about politically charged events than they will neutral ones, because they are energized at times to avoid threatening outcomes to reach correct answers. This pattern should be particularly pronounced among those most numerically skilled, leading to an interaction between the type of scenario judged (politically charged vs. neutral) and numeracy.

In contrast, the playing dumb variant would suggest that people are less accurate overall on politically charged questions than they are neutral ones. The appearance of preferred outcomes causes people to switch off their typical level of analysis on political questions, leading to more erroneous conclusions. Once again, this pattern should be more evident among numerate individuals who have skill to turn off, again suggesting a Scenario × Numeracy interaction, with highly numerate individuals showing more deficit in performance in politically charged versus neutral scenarios than their less skilled peers.

In addition, we examined each variant by also assessing the amount of cognitive effort participants applied before reaching their conclusions. Recent research has shown that people respond to information more accurately on judgments they deliberate over (Bago et al., 2020; Pennycook & Rand, 2019). Thus, we could see the extent to which naturally occurring deliberation waxes and wanes when faced with politically charged versus neutral data. Under the getting smart variant, participants should show more effort overall when faced with data on politically charged issues rather than neutral ones, and particularly when faced with initial conclusions that are threatening. Under the playing dumb interpretation, one should see less effort for data on politically charged issues rather than neutral ones. In each case, differences in effort should be most evident among the more numerically skilled.

Expressive Rationalization

However, getting to the right answer when it is politically favored may not necessarily mean approaching a problem with the right analytical tools. People may get to the right answer through faulty rather than correct reasoning. Consequently, authentic numerical skill—either as a stable individual difference or as an inspired moment—may not play a role in producing the correct conclusions from scientific data when it is congenial to one’s political preferences.

That is, in politically charged settings people may stumble on the right answer for the wrong reasons. Such situations may be more common than typically realized. People make accurate observations about scientific phenomena but endorse underlying mechanisms that are not correct (Kelemen & Rosset, 2009). For example, people accurately state that biological evolution prompts species to adapt to their environment better over generations, but commonly attribute that pattern to needs-based intentional change rather than to random variation plus natural selection (Bishop & Anderson, 1990). In one study of fifth-grade students taking a science test, students answered a full 37% of test items correctly, without guessing, even though they showed no understanding of the underlying concepts the items were specifically designed to test (Noble et al., 2012).

Nowhere is this pattern of wrong rationales leading to the right conclusion more apparent than to judgments of covariation, much like those presented by Kahan et al. (2017). Shaklee and Wasserman (1986) showed participants 2 × 2 tables less contaminated by the Cell A bias, in which participants’ judgments proved to be quite sensitive to true covariations in the data but found that only 3% of participants were actually following the correct rule in reaching their valid conclusions. In a phrase, they experienced “epistemic luck,” as termed by philosophers (Pritchard, 2005), in that they made correct judgments through faulty reasoning.

How might epistemic luck be present when interpreting the numerical table in Figure 1? Consider the “Crime Decreases” condition (top right-hand corner of Figure 1). A participant who knows to use all the data presented, but is mistaken on *how*, might erroneously compare the “increase in crime” column to the “decrease in crime” column by comparing the ratios of 223:107 (Cells A:C) to 75:21 (Cells B:D). In this instance, they see that among cities that experienced decreases in crime, a roughly 3.5:1 ratio had a gun ban but among those with an increase in crime only a 2:1 ratio had a ban, and therefore conclude that the ban was effective. This is a correct conclusion, even though the numerical comparison they make is incorrect. Or look at the number of cities in Cell A, compare it to the numbers in the other cells, and dismiss the Cell A number, because it is less than 50% of the total number of cities in the entire study. Thus, the participant can arrive at the correct conclusion, but not because they have followed the correct data analytic strategy, leading to a case of epistemic luck.

Thus, in the Kahan et al.'s (2017) motivated reasoning paradigm, participants may show signs of attitude congeniality bias not because they genuinely interpret the data in the right way, but rather because they arrive at a correct conclusion through incorrect reasoning. We term this the *expressive rationalization* account for attitude congeniality effect. In contrast to expressive rationality, in which people arrive at the right reasoning for why the correct answer is right, this rationalization account suggests that people may often reach right answers when they are preferred, because they find some agreeable rationalization that need not be correct.

Thus, in the paradigm we have described above, according to the expressive rationalization account, we may find that political relevance produces an increase in the proportion who arrive at the right answer but cite an incorrect rationale for it, rather than an increase in those describing both the right answer and the correct rationale for why it is right. To be precise, we must add that correct reasoning can also serve as a rationalization for a conclusion people wish to reach. Thus, to distinguish the expressive rationalization from the rationality account, one must specifically look at whether people articulate invalid rationales for valid conclusions. According to the rationality account, there is only one avenue to the right answer and that is finding the right rationale for that answer. The rationalization account suggests that, beyond that, people may also construct fallacious rationales for that right answer.

Expressive Responding

Two other psychological mechanisms might produce greater accuracy for politically favored conclusions, each requiring little to no numerical skill, or even thinking at all. The first mechanism involves *expressive responding*, in which people give the answer that favors their partisan side with no supportive reasoning behind it (Berinsky, 2018; Bullock et al., 2015; Prior et al., 2015; Schaffner & Luks, 2018). In expressive responding, people do not attempt to report a true answer but instead just "cheerlead" their side regardless of what the data in front of them say. They simply give the answer that allows them to express their values, ideology, and group attachments. In one recent example following the 2016 American presidential election, Donald Trump and Hilary Clinton voters were shown photographs depicting the crowds attending the inauguration of Barack Obama's in 2009 and Trump in 2017. Although the 2009 crowd was clearly the bigger of the two between the two photographs, 15% of Trump versus 2% of Clinton voters (and 3% of nonvoters) reported the 2017 crowd was bigger (Schaffner & Luks, 2018), despite the obvious visual evidence to the contrary.

In terms of the Kahan et al.'s (2017) paradigm, people claiming conclusions consistent with their politics may represent this type of responding. Respondents may know the right answer, or not know but also not care, but merely indicate the response that favors their side. If there is a correct answer that respondents are aware of, it could be the case that they do not engage with the task but rather express the desired response without doing any additional information processing whatsoever.

Expressive Acquiescence

Alternatively, participants may provide congenial answers because they feel they cannot refuse to give any response at all. Confronted with the data, they may wish to refuse to give any answer. However, in the original Kahan et al.'s (2017) paradigm, participants are not allowed to say "I don't know" and are instead forced to give a response (i.e., increase or decrease) to the question posed. There is no obvious way to opt out from giving an answer, and they must acquiesce to the experimenter's wishes that they provide a judgment. Given this dilemma, participants may feel forced to guess and do so by choosing the least noxious option available to them. Thus, participants may not feel comfortable giving an answer but feel compelled to do so. They display a classic response set that merely concedes to researcher demands but that does not truly reflect their preferred course of action (Orne, 1962; Rosenthal, 1976). Thus, their answer may not reflect any belief or analysis about what they see in the data provided but rather acquiescent responding in an illusory attitude-consistent direction.

Note how this explanation differs from the expressive responding account. Under expressive responding, participants disregard any information from the data and choose from their own volition the option friendly to their political preferences, because they want to express their values or cheerlead for their side. In acquiescence, respondents instead would rather avoid making any choice but do not have that option. Thus constrained, they choose the lesser of two evils between the options they have available but would not if they could refuse to choose at all.

Overview of Studies

Herein, we report three studies that investigated the psychological processes underlying attitude congeniality effects in the interpretation of numerical scientific evidence. In Study 1, we presented participants with a task closely modeled on the Kahan et al.'s (2017) procedures. Participants are given information on the possible impacts of gun bans on crime or skin cream on rashes, displayed in a 2×2 table similar to Figure 1. As in the Kahan et al.'s (2017) study, we also assessed numeracy among our participants to see if numerical competence exacerbated the emergence of congenial responding.

However, we also included additional measures to examine whether people arrive not only at the correct answer but also the correct rationale for it, to test also for epistemic luck. Did an increase in accurate responding mean that people also identified the correct way to analyze the data, or did they stumble onto incorrect rationales that just happened to support the right conclusion? We also assessed cognitive effort by counting the number of mouse cursor transitions participants made as they switched their attention from cell to cell in the 2×2 table (i.e., a process tracing measure). This provided insight into the quantity of information processing each participant pursued.

With these measures, we could test many of the accounts for the motivated interpretation of scientific data: expressive rationality (both the getting smart and playing dumb variants), expressive rationalization, and expressive responding. Study 2 was identical to Study 1, but then also included an option where a participant could say "I don't know" and thus remain uncommitted to a response. This change allowed us to gauge also how often a participant gave a politically friendly response simply, because a response was required, thus testing for acquiescent responding.

Study 3 asked participants to look over not one but multiple 2×2 tables displaying scientific data relevant to gun control policy. In this way, we could see how much participants' judgments were tied to their political preferences setting aside any consistency in their cognitive strategy, versus consistent with the same cognitive strategy regardless of its political consequences. In doing so, we could test whether item-to-item responses revealed evidence of expressive responding—that is, people remaining loyal to their political preferences despite what the data say—or whether people remained consistent with the cognitive rationale (leading to correct or Cell-A responses) they had established in their decisions early on for interpreting the data. If participants were consistent with their political preferences across trials and not their strategy, that would be evidence of expressive responding. If they stayed consistent with the strategy seen early on in their series of decisions, that would suggest that the rationales they used did carry weight, suggesting evidence for expressive rationalization.

Study 3 also contained a training condition which exposed participants to the right way to solve these data analysis problems. We wished to see if training constrained (or, instead, exacerbated) the degree to which people engaged in attitude-consistent choice. The literature so far has examined the role played by numerical skill in the attitude congeniality effect by measuring individual differences in skill. We wondered what would happen if we instead manipulated people's skill by training some participants about how to approach covariation judgment tasks. Would creating a sharp contrast in people's skill as they approached numerical data provide a clearer answer as to whether numerical ability influences motivated numeracy in a way that increases or diminishes it?

Across these three studies, we tested many theoretical accounts and their associated hypotheses. Thus, as a handy guide, we provide Table 1, which lists the theoretical concepts we tested, the hypotheses and statistical tests drawn from them, and whether they were supported by the data.

Studies 1 and 2

Taken together, Studies 1 and 2 sought to replicate the attitude congeniality effect, assessing several different mechanisms that might underlie it: expressive rationality, rationalization, responding, and acquiescence. Following closely the procedure of Kahan et al. (2017), participants reported their gun control attitudes, and then subsequently evaluated data from studies evaluating either the effectiveness of gun control on crime rates or skin cream on rashes. Data from the studies either supported the conclusion that banning guns reduced crime (skin cream reduced rashes) or that bans instead increased crime (increased rashes). Across participants, the data contained in an outsized Cell A supported the opposite, and wrong, conclusion. The main question was whether participants would look past the misleading data in Cell A to reach the correct conclusion and would do so more frequently when that conclusion aligned with their gun control preferences, that is, the attitude congeniality effect. Thus, the base hypothesis:

> *Hypothesis 1:* Participants will reach the correct conclusion in the gun control study data more when it aligns with their gun control policy preferences than when it contradicts them but will not do so in the skin cream condition with structurally similar scenarios, leading to a Scenario × Attitude Congeniality interaction on judgment accuracy.

Does expressive rationality underlie this phenomenon? We measured participants' numerical ability (i.e., numeracy). According to the rationality account (Kahan et al., 2017), highly numerate participants should display the attitude congeniality effect more than their less skilled participants, leading to a Numeracy × Attitude Congeniality × Scenario interaction (Hypothesis 2A) or Numeracy × Attitude Congeniality interaction in the gun control condition alone (Hypothesis 2B).

We could also look at two variations of the expressive rationality account. According to the "smarten up" version, participants apply the numerical ability when the "obvious" initial answer—the one suggested by Cell A—suggests one that threatens their political preferences (and, thus, the right answer is consistent with those preferences). This would suggest, beyond the involvement of numeracy in the attitude congeniality effect, that participants would be more accurate on the gun control scenario overall than the skin cream one (Hypothesis 2C). In contrast, the "dumbing down" alternative suggests that the congeniality effect arises for the opposite reason. When the obvious and wrong initial answer (suggested by Cell A) is consistent with participant preferences, they will shut down their ability and go with that incorrect answer. This would produce less overall accuracy on the gun control scenario than the skin cream one (Hypothesis 2D).

We also looked at cognitive effort (i.e., shifts between looking at numbers on the computer screen) as participants reached their conclusions looking to see if the political relevance of gun control led to more effort, as indirectly suggested by the rationality account, leading to a main effect of scenario (Hypothesis 3A), and whether effort itself led to the congeniality effect, or a Cognitive Effort × Attitude Congeniality × Scenario interaction (Hypothesis 3B).

We also examined one last hypothesis related to expressive rationality, and alongside it a test of expressive rationalization and responding. Participants reported the specific rationale that led to the conclusion they had reached, and we looked to see if attitude congeniality effect extended not only to reaching the right answer when it fit a person's political preferences but also articulating the right rationale for that answer (Hypothesis 4). In the gun control condition, this meant that attitude congeniality would be correlated with people who choose both the right answer and the right rationale for it.

We also presented participants with plausible but false rationales, to see if attitude congeniality was associated with selecting a faulty basis for choosing the right answer. The expressive rationalization account would predict a correlation in the gun control condition between attitude congeniality and choosing the right answer but also a flawed rationale (Hypothesis 5). Finally, in Study 1, one rationale choice we presented to participants allowed them to say that the "numbers don't matter." If expressive responding is present and blatant, attitude congeniality should correlate with the choice of this rationale in the gun control scenario (Hypothesis 6).

Finally, Study 2 allowed a test of expressive acquiescence. Participants were given the option of saying "I don't know." If participants produce attitude congeniality because they are required to give an answer they would rather avoid, the effect should diminish when given a chance to demur (Hypothesis 7).

Thus, in sum, Studies 1 and 2 contained several tests of expressive rationality along with other alternative accounts (rationalization, responding, acquiescence) for the attitude congeniality effect.

Table 1
Summary of Theoretical Concepts, Hypotheses, Statistical Tests, and Results Examined Across All Studies

Theoretical concept	Description	Hypothesis	Statistical test	Supported
Attitude congeniality affect	People are more likely to interpret statistical information correctly, if it aligns with their attitudinal preferences.	Participants are more likely to reach correct conclusion looking over gun control data, when the data align with their gun control policy attitudes than when it contradict them but will not do so in the skin cream data with structurally similar properties (Hypothesis 1, Studies 1 and 2).	Attitude Congeniality × Scenario Content (guns vs. skin cream) interaction	Yes
Expressive rationality account	Individuals recruit their expertise and cognitive ability to interpret data toward a preferred conclusion.	Highly numerate participants display the attitude congeniality effect more than less skilled participants (Hypothesis 2A, Studies 1 and 2).	Numeracy × Attitude Congeniality × Scenario Content interaction	No
		For the gun control scenario only, highly numerate participants display the attitude congeniality effect more than less skilled participants (Hypothesis 2B, Studies 1 and 2).	In gun control conditions: Attitude Congeniality × Scenario Content interaction	No
	"Getting Smarter" variant: Because they recruit their expertise on a politically charged issue, participants will be more accurate overall on the gun control scenario than the skin cream one.	Participants will be more accurate on the gun control overall (Hypothesis 2C, Studies 1 and 2).	Main effect of scenario content	No
	"Playing Dumb" variant: To protect favored conclusions, participants will avoid expertise and achieve less accuracy on a politically charged issue; participants will be more accurate overall on the skin cream scenario when compared to the gun control one.	Participants will be less accurate on the gun control scenario overall (Hypothesis 2D, Studies 1 and 2).	Main effect of scenario content	No
	Individuals expend more cognitive effort to interpret data toward preferred conclusion.	Participants will show more cognitive effort in the gun control condition (Hypothesis 3A, Studies 1 and 2).	Main effect of Scenario content on cognitive effort	No
		Cognitive effort will moderate the interaction of Scenario × Attitude Congeniality predicting accuracy (Hypothesis 3B, Studies 1 and 2).	Cognitive Effort × Attitude Congeniality × Scenario interaction	No
		In the gun control condition, congeniality will predict having both a correct response plus a correct rationale (Hypothesis 4, Studies 1 and 2).	Main effect of Attitude Congeniality on likelihood participants express both right answer and correct statistical rationale	No
		Statistical training will increase the attitude congeniality effect (Hypothesis 12, Study 3).	Training × Attitude Congeniality interaction	No
Expressive rationalization	People find a rationalization for preferred answers, and thus can reach the right answer through faulty rather than correct reasoning.	In the gun control condition, attitude congeniality will predict having a correct response but an incorrect rationale for it (Hypothesis 5, Studies 1 and 2).	Main effect of attitude congeniality on likelihood of citing right answer but incorrect rationale	Yes
		Across multiple trials, attitude congeniality effect will initially affect judgment, but that effect will disappear in subsequent cases where the same rationale supports different conclusions (Hypothesis 9, Study 3).	Evaluation of permanence (or lack thereof) of attitude congeniality effect across multiple trials with different underlying circumstances	Yes
		Across multiple trials, respondent choices will exhibit consistency with the strategy (e.g., correct response, Cell A response) shown in first trial (Hypothesis 10, Study 3).	Evaluation of stability of responses (correct responses, Cell A responses) across multiple trials with different underlying circumstances	Yes

(*table continues*)

Table 1 *(continued)*

Theoretical concept	Description	Hypothesis	Statistical test	Supported
Expressive responding	People give the answer that favors their preferences without reference to any data or reasoning.	Attitude congeniality will be correlated with choosing the "numbers don't matter" rationale (Hypothesis 6, Studies 1 and 2).	Correlation of "don't matter" rationale with choosing the right answer in gun control scenario	No
		Attitude congeniality effect will be stably predictive of accuracy across multiple scenarios despite shifting statistics across them (Hypothesis 8, Study 3).	Evaluation of permanence (or lack thereof) of attitude congeniality effect across multiple trials with different underlying circumstances	No
Expressive acquiescence	Respondents feel forced to respond and do so by choosing the least noxious option available to them.	The attitude congeniality effect will decrease when participants are allowed to say "I don't know" (Hypothesis 7, Study 2).	Examination of participant responses when given a "don't know" option	No
Training effects		Training will reduce the attitude congeniality effect (Hypothesis 11, Study 3).	Training × Attitude Congeniality interaction	No

Method

Participants

Study 1. We recruited 500 self-identified Republicans and 500 self-identified Democrats from Amazon's Mechanical Turk service using TurkPrime (Litman et al., 2017). Our target sample size was predetermined to be comparable to similar studies in the literature. Adopting a conservative stance and assuming effect sizes of OR = 1.20 (equivalent to $\phi = .05$) as the smallest effect size of interest for any main effect, simple effect, or interaction observed led to a sample size calculation of roughly 950 total participants with $\alpha = .05$ and $\beta = .20$, which was rounded up to 1,000 to allow exclusions. The effects we were centrally concerned with testing included the attitude congeniality effect (Hypothesis 1) and its interaction with numeracy (Hypothesis 2A) when predicting accuracy, although we believed the sample size would also give us sufficient power to capture more subtle effects within the entire sample (see above) or within the gun control condition only ($OR = 0.166$, equivalent to $\phi = .12$, using the same parameters described above). This benchmark was adopted for all studies. Participants were paid $1.00 for their participation. From the initial sample of 1,000, 9% of participants were removed: 20 did not respond affirmatively to our data quality question, 48 self-reported or logged errors with the experimental task, and 22 submitted incomplete data. Our final sample size was 910 participants ($M_{\text{age}} = 39.93$, $SD_{\text{age}} = 12.94$). Participants were mostly female (54.4% female, 44.5% male, .3% other, and .8% nonresponse) and White (76.5% White, 6.4% Black, 5.9% Asian, 5.6% multiracial, 4.1% Latino, .5% Native American, .5% nonresponse, and .4% other). Specific demographic item and data quality language used in all studies can be seen in the Supplemental Materials.

Study 2. As with Study 1, we recruited 500 self-identified Republicans and 500 self-identified Democrats from Amazon Mechanical Turk using TurkPrime (Litman et al., 2017), providing $1.00 for compensation. From the initial sample of 1,000, 5.6% were removed: 10 did not respond affirmatively to our data quality question, 22 self-reported or logged errors with the experimental task, and 24 submitted incomplete data. The final sample size was 944 participants ($M_{\text{age}} = 39.4$, $SD_{\text{age}} = 12.81$). Participants were mostly female (53.3% female, 46% male, .7% nonresponse) and White (76.4% White, 6.6% Black, 5.9% Asian, 5.4% multiracial, 4.1% Latino, .9% Native American, .3% other, .3% nonresponse, and .1% preferred not to respond).

Design and Procedure

Study 1. In the informed consent page, participants were initially told that they would be evaluating hypothetical data about a scientific study. Participants were randomly assigned to either a gun control or skin cream condition (ns = 460 and 450, respectively). Each condition described an intervention with cities implementing a concealed carry ban on handguns or medical teams testing a skin rash treatment. After reading about the intervention, participants were presented with a 2 × 2 contingency table of results, as seen in Figure 1. All numbers in the table cells were the same but column headers, that determined if the intervention led to an increase or decrease in crime, were counterbalanced between subjects.

To assess cognitive effort, participants interacted with the page to gain information. We adapted a procedure similar to bulletin board experiments (Payne, 1976) or more recent web-based mouse tracking applications (Willemsen & Johnson, 2019). To display each number in the contingency table, participants needed to hover over each cell with their mouse cursor. If the cursor was positioned anywhere outside a table cell, they would not see its number. Consequently, if they wanted to compare multiple numbers, they might dart back-and-forth between cells with their mouse, as only one could be visible at a time. We calculated a fixation as when a participant was hovering within the bounds of each table cell for any amount of time. As a simple metric of effort, we summed the number of oscillations between cell fixations in the table with a participant's mouse cursor. A high volume of cell transitions might indicate that an individual is not only engaging with the task more but exercising their numeracy skills to arrive at a satisfactory response.

After engaging with the table, participants reported their interpretation of the data, strategy used, numeracy, and congeniality toward the gun control outcome. Our primary outcome measure is directly adapted from Kahan et al.'s (2017). Participants chose one of the following conclusions: "Cities that enacted a ban on carrying concealed handguns were more likely to have a *decrease* in crime than cities without bans" or "Cities that enacted a ban on carrying concealed handguns were more likely to have an *increase* in crime than cities without bans." In the rash condition, participants chose between "People who used the skin cream were more likely to get *better* than those who didn't" or "People who used the skin cream were more likely to get *worse* than those who didn't." In all cases, responses were coded as 1 (correct) or 0 (incorrect), based on if the mathematical interpretation was correct or not.

After choosing a conclusion, participants were next asked about the statistical rationale leading to the conclusion they choose. Specifically, they were asked: "For the following, which one of the numbers or comparisons below was the decisive one that led you to your answer (please choose the one best answer)." Several possible responses were presented; for example: "How the 223 compared to all the other numbers," "How the 107 figure compared to the 21," and "I knew the answer already; the numbers don't matter." The correct response, "How the ratio 223/75 compared to the ratio 107/21," was coded as 1 if selected, and 0 if any other response was selected. A complete list of the rationales offered to participants to endorse is provided in Supplemental Tables S2 and S3. As a measure of trait numeracy, participants then completed the Berlin Numeracy Test (Cokely et al., 2012). The Berlin Numeracy Test consists of four items with a possible additive score of 0–4.

We next collected demographic data, including gender, race, education level, age, political ideology on a 7-point scale ranging from *very liberal* to *very conservative*, and party identification (i.e., Democratic, Republican, independent/other). We collected self-reported attitudes toward gun control at the end of the online session to precisely measure prior beliefs when compared to partisan affiliation or ideology (Tappin et al., 2020). Eight items were adapted from the Pew Research American Trends Panel (Pew Research Center, 2017) and included items like "I think gun violence is a big problem in the United States" and "Overall, I think gun laws should be a lot more strict than they are today." These items were rated by participants on a 5-point scale (*strongly disagree* to *strongly agree*). An exploratory factor analysis confirmed that these items all loaded onto a single factor ($\alpha = .92$). All eight items were appropriately coded and averaged for a composite score. This composite correlated strongly with ideological conservativism ($r = -.68$) and party identification as a Republican ($r = -.68$).

Study 2. The procedure was identical to Study 1 with one exception ($ns = 450$ and 494 in gun control and skin cream conditions, respectively): When participants reported their interpretation for the data, they were given an additional response of "I don't know." If participants selected this response, the page expanded with an additional question: "If you were forced to choose, which response would you lean toward?" and presented with the options again (e.g., "Cities with the ban were more likely to have a *decrease* in crime than cities without bans" or "Cities with the ban were more likely to have an *increase* in crime than cities without bans" for the gun control condition). Acquiescence rates are reported separately, but we initially group these "leaners" along with initial responders to analyze the interpretation outcome below. Gun control attitudes again correlated strongly with ideological conservativism ($r = -.64$) and party identification as a Republican ($r = -.64$).

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Data and analysis scripts are available on Open Science Framework (https://osf.io/b6z53/; McKenna & Dunning, 2024). All studies were programmed in oTree, a research platform for online behavioral experiments (Chen et al., 2016). All data preparation and analyses were performed using R Version 4.0.2 (R Core Team, 2022). We used the following R packages: *tidyverse* for data manipulation and plotting (Wickham et al., 2019), *jtools* for extracting model results (Long, 2020), *interactions* for simple slopes estimation (Long, 2021), *AER* for overdispersion testing (Kleiber & Zeileis, 2008), *MASS* for negative binomial regression (Venables & Ripley, 2002), *lmerTest* for mixed-effects models (Kuznetsova et al., 2017), and *psych* for item reliability and factor analysis (Revelle, 2019). No studies were preregistered.

Results

Congeniality Effect on Study Interpretation

Study 1. Our first outcome examined correctly interpreting the data as a function of our predictors using a logistic regression. Correct study interpretation (coded 0 or 1) to the contingency table was regressed on different predictor variables in separate models: congeniality score, scenario condition (gun control vs. skin rash), numeracy, and cognitive effort. Models are reported with predictor variables unless otherwise stated, as with interaction results. Participants were mostly inaccurate across both conditions, with only 35.5% responding correctly. There was no main effect of scenario content: Participants in the skin rash and gun control conditions responded accurately at about the same rate (34.4% and 36.5%, respectively), $b = .091$, $p = .513$, $SE_b = .139$, $OR = 1.095$, OR 95% CI [0.834, 1.437]. See Supplemental Table S4 for full main effect and interaction regression results.

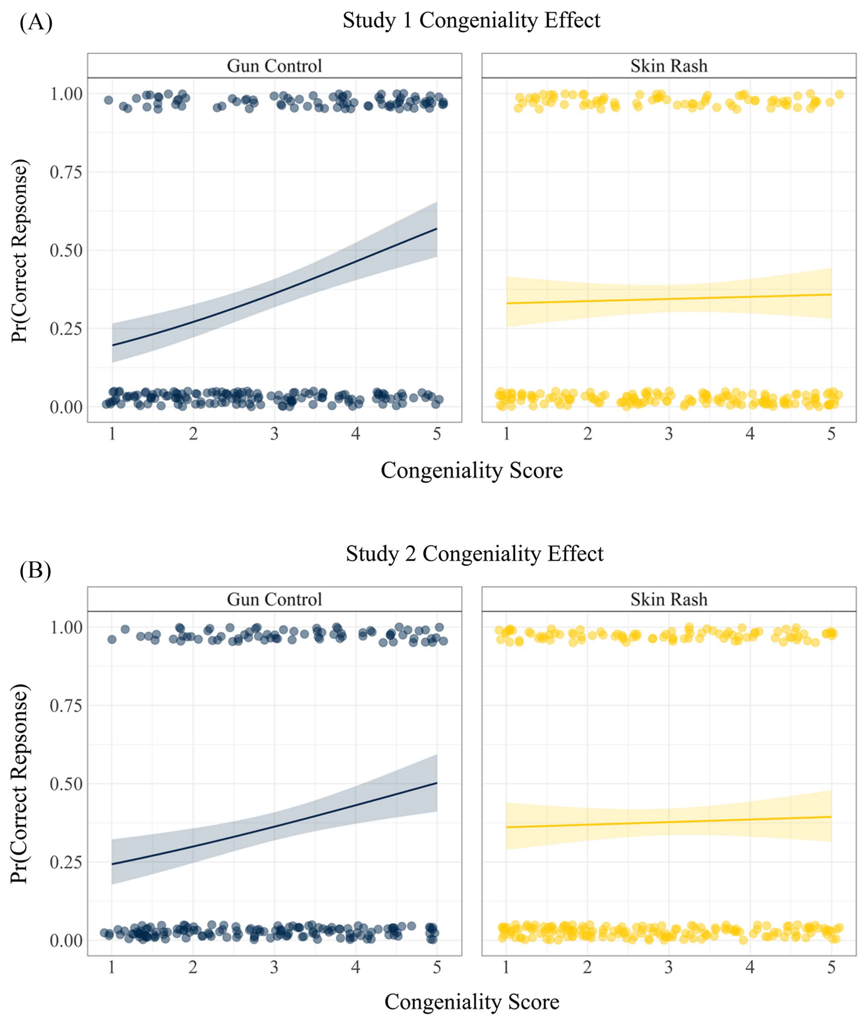
To assess the relation of attitudes to correct responding, we recoded gun control attitudes into an attitude congeniality measure, that is, how preference-consistent the outcome was to their prior attitudes. Thus, when the correct answer was that gun bans decreased crime, attitudes were scored such that higher numbers meant more procontrol attitudes. A participant who was progun control would have a high congeniality score, if they correctly interpreted data suggesting crime decreased and a low congeniality score, if they interpreted data suggesting crime increased. When the correct answer in the scenario suggested that gun bans increased crime, attitudes were scored such that anti-gun control attitudes received higher numbers. The same recoding scheme was mirrored for participants in the skin rash condition, based on the outcome (e.g., the rash decrease scenario was treated the same way as the crime decrease one).

Congeniality was predictive of correct interpretation, suggesting that participants who arrived at the correct data interpretation also happened to be favorable to the interpretation. As expected, this was qualified by a scenario Content × Congeniality interaction, $b = .391$, $p = .001$, $SE_b = .114$, $OR = 1.479$, OR 95% CI [1.183, 1.848], as it only occurred in the gun control condition (simple slopes $b = .422$, $p < .001$) but not the rash condition (simple slopes $b = .031$, $p = .694$). This interaction is depicted in Figure 2A, which can be seen to be symmetric around the midpoint of attitude congeniality.

Study 2. Participants were again mostly inaccurate, with only 37.1% reporting a correct interpretation of the data. Using a logistic regression with condition predicting accuracy, there was no main effect of scenario content (i.e., gun control vs. skin cream; 35.8% and 37.9%, respectively), $b = -.052$, $p = .701$, $SE_b = .135$, $OR = 0.95$, OR 95% CI [0.729, 1.237]. Congeniality was again predictive of

Figure 2

Probability of Reaching Correct Conclusion in Studies 1 and 2 as a Function of Political Congeniality and Scenario Content



Note. Panels depict Study 1 (A) and Study 2 (B) accuracy probability (Pr) as predicted by congeniality. Points represent a single participant's response. Fitted lines estimate a simple logistic regression. Facets divide participants from the gun control versus skin rash condition. This figure depicts the scenario Condition × Congeniality score interaction. For both studies, participants who were favorable to the gun control intervention result were also more likely to arrive at the correct interpretation but only for the relevant topic. See the online article for the color version of this figure.

correct responses and qualified by a scenario Content × Congeniality interaction, $b = .251$, $p = .024$, $SE_b = .111$, $OR = 1.286$, OR 95% CI [1.034, 1.599]. Congenial participants were more accurate in the gun control condition (simple slopes $b = .287$, $p < .001$) but not in the rash condition (simple slopes $b = .035$, $p = .629$). Full regression results are available in Supplemental Table S5. This interaction is shown in Figure 2B, which shows again that the interaction was symmetric around the midpoint of the congeniality scale.

Numeracy and Effort

Study 1. Both numeracy and effort are reported using simple logistic regression models, unless examining interactions. Overall, we found a consistent effect of numeracy in all models, suggesting that more numerate participants correctly interpreted the data at a higher rate, $b = .358$, $p < .001$, $SE_b = .065$, $OR = 1.431$, OR 95% CI [1.26, 1.625]. We also found a two-way interaction of scenario Content × Numeracy, although this did not persist when including other interaction terms: Participants who were in the rash condition (simple slopes $b = .513$, $p < .001$) showed a stronger relation between numeracy and accuracy when compared to the gun control condition (simple slopes $b = .235$, $p = .007$), $b = -.278$, $p = .036$, $SE_b = .132$, $OR = .757$, OR 95% CI [0.584, 0.982]. Numeracy did not interact, however, with the attitude congeniality effect. No three-way interaction of Condition × Congeniality × Numeracy emerged, suggesting that the relation between gun control condition and congeniality did not rely on numeracy, $b = -.066$, $p = .529$, $SE_b = .105$, $OR = 0.936$, OR 95% CI [0.761, 1.15]. A full regression table can be seen in Supplemental Table S6. If we look at the gun control condition specifically, we see no attitude Congeniality × Numeracy interaction, $b = -.033$, $p = .647$.

Effort, as quantified by total mouse transitions, was assessed once again using a simple logistic regression when not examining interactions. Full results are available in Supplemental Table S7. Like numeracy, effort was also predictive overall of accuracy, $b = .027$, $p < .001$, $SE_b = .004$, $OR = 1.027$, OR 95% CI [1.019, 1.036]. There was also a scenario Content × Effort interaction: The relation between effort and accurate responding was more evident in the skin cream condition (simple slopes $b = .041$, $p < .001$) relative to the gun control condition (simple slopes $b = .017$, $p = .002$), both showing a positive association, $b = -.024$, $p = .008$, $SE_b = .009$, $OR = 0.976$, OR 95% CI [0.959, 0.994]. This scenario Content × Effort interaction did not vary as a function of either congeniality or numeracy. Figure 3A shows the main effects of both numeracy and effort for Study 1.

Did prior gun control beliefs affect effort? We investigated the rate of effort as an outcome predicted by congeniality, condition, and numeracy in a separate model. Individual predictors were modeled as simple regressions. Specifically, we modeled mouse transitions in a negative binomial regression predicted by these predictors, using natural log of time on page as an offset. Full regression results are available in Supplemental Table S8. Overall, congeniality and numeracy did not predict effort, but there was a slightly lower rate of effort in the gun control condition when compared to the skin rash condition, $b = -.141$, $SE = .04$, $p < .001$. These predictors did not interact to predict differential rates of effort, suggesting that the participants reading about gun control generally processed the data at lower extent compared to those reading about a skin rash.

Study 2. Accuracy was predicted with a simple logistic regression with single predictors, except in the case of interactions. Full regression results can be seen in Supplemental Table S9. As with Study 1, numeracy overall was predictive of a correct interpretation such that more numerate participants were more accurate, $b = .365$, $p < .001$, $SE_b = .064$, $OR = 1.441$, OR 95% CI [1.271, 1.634]. Unlike Study 1, we did not find a scenario Content × Numeracy interaction. There was also once again no three-way interaction of Condition × Attitude Congeniality × Numeracy, $b = -.017$, $p = .867$, $SE_b = .103$, $OR = 0.983$, OR 95% CI [0.803, 1.203]. In the gun control scenario specifically, we observed no attitude Congeniality × Numeracy interaction, $b = -.065$, $p = .407$.

Patterns of effort closely resembled Study 1. Increased effort was predictive of accuracy, $b = .029$, $p < .001$, $SE_b = .004$, $OR = 1.029$, OR 95% CI [1.022, 1.037]. There was once again an interaction with scenario content: Effort was more predictive of accuracy in the rash condition (simple slopes $b = .051$, $p < .001$) relative to the gun control condition (simple slopes $b = .016$, $p < .001$), $b = -.035$, $p < .001$, $SE_b = .008$, $OR = 0.965$, OR 95% CI [0.95, 0.981]. This Condition × Effort interaction did not vary significantly by congeniality or numeracy. Full regression results are displayed in Supplemental Table S10. The main effects of numeracy and effort are depicted in Figure 3B.

Looking at effort as an outcome, we generated similar models to those described in Study 1. Similarly, we found that there was a slight decrease in effort rates among the gun control condition when compared to the rash condition, $b = -.246$, $SE = .042$, $p < .001$. As with Study 1, neither congeniality nor numeracy interacted with scenario content to produce differential effects on effort rates.

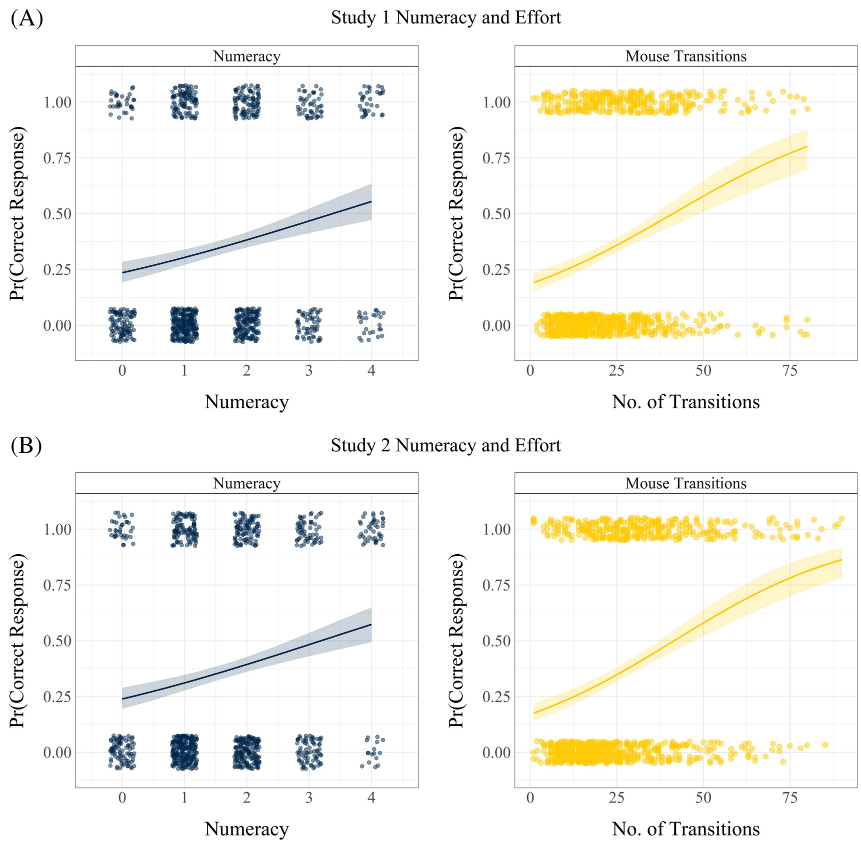
In sum, although participants overall displayed attitude congeniality biases, endorsing correct answers more often when those answers were attitude-consistent (Hypothesis 1). The phenomenon, however, did not appear to be a product of expressive rationality, in that the many hypotheses driven by the account failed to find support. The attitude congeniality effect in both studies was not stronger among high numerate participants (i.e., Hypothesis 2A and Hypothesis 2B failed in both studies) nor by the amount of effort participants applied to their decisions (i.e., Hypothesis 3B). Numeracy and effort, however, did predict correct responding, and effort unexpectedly predicted accuracy more in the skin cream scenario than in the gun control one, but these effects were independent of attitude preferences and did not account for the attitude congeniality effect. Further, our models found no overall increase or decrease in accuracy that would suggest support for the "smartening up" or "dumbing down" variants of the expressive rationality account, in that performance across gun control and skin cream scenarios was rather equivalent, and performance differences did not appear to be "lopsided" as suggested by either variant of the account (Hypothesis 2C–2D).

Rationales

We then explored the question of whether attitude congeniality predicted arriving at the correct rationale for their answers. Only 30.2% and 35.4% of participants in Studies 1 and 2, respectively, identified the correct rationale for choosing the right conclusion to the scientific data they were presented. These figures stand in contrast to the prevalence of participants who cited comparing Cell A to

Figure 3

Probability of Reaching Correct Conclusion in Studies 1 and 2 as a Function of Numeracy and Cognitive Effort



Note. Panels depict Study 1 (A) and Study 2 (B) accuracy probability (Pr) with trait numeracy and mouse cursor transitions as predictors. Points represent a single participant's response (in each study, one point for both predictors). Fitted lines estimate a simple logistic regression. Facets divide participants from the numeracy and effort predictors. For both studies, participants who were either numerate or displayed increased effort were more likely to arrive at the correct interpretation. See the online article for the color version of this figure.

all or one of the other cells (46.3% and 42.7% in Studies 1 and 2, respectively).[1] Considering only those who chose the right conclusion, only 53.6% and 57.8% in Studies 1 and 2, respectively, also selected the right rationale for it (as opposed to 17.4% and 22.4% who chose the wrong conclusion for Studies 1 and 2, respectively). Thus, reaching the right judgment did not imply people had used valid reasoning to get there.

Study 1. In our analysis of endorsing the right rationale, we first examined numeracy and effort as predictors of choosing the correct rationale. Models were computed using single predictors predicting correct rationale. Both numeracy (b = .556, p < .001, SE_b = .07, OR = 1.744, OR 95% CI [1.521, 2]) and effort (b = .033, p < .001, SE_b = .005, OR = 1.034, OR 95% CI [1.025, 1.043]) predicted more correct rationales, even controlling for other variables. Figure 4A shows these main effects for Study 1.

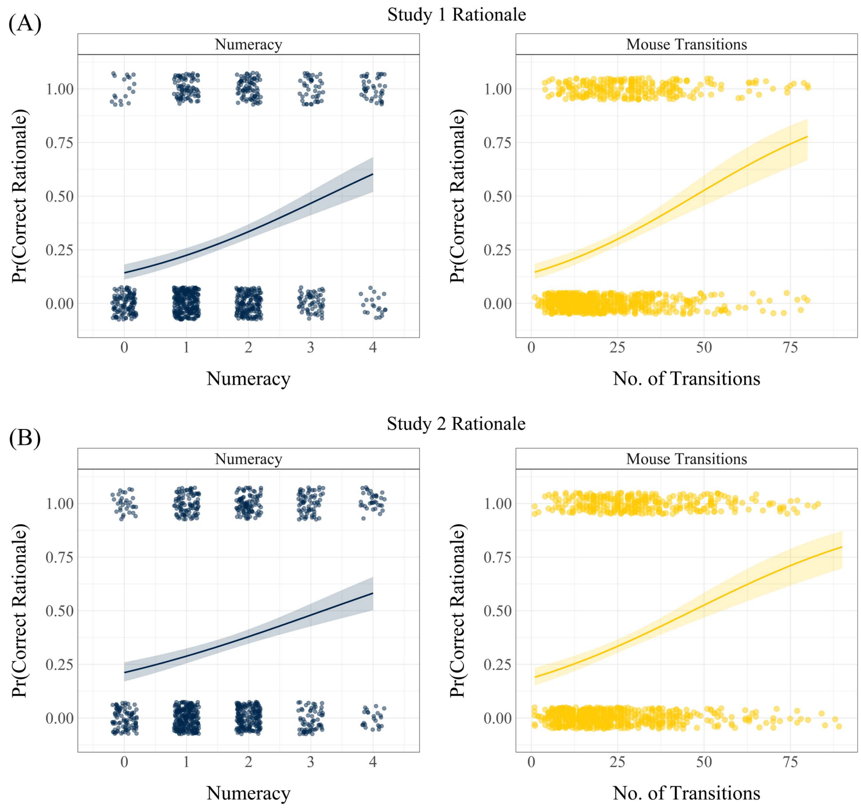
Attitude congeniality, however, did not predict reporting the correct rationale in the gun control scenario (b = −.065, p = .446, SE_b = .085, OR = .937, OR 95% CI [.792, 1.108]), suggesting that the attitude congeniality effect did not reflect participants discovering more correct reasoning. Then what produced attitude congeniality? To explore this question further, we looked at the subset of participants within the gun control condition who provided both the correct interpretation of the data and the right rationale (N = 69), compared to everyone else (N = 391). When regressing this variable on congeniality in a simple logistic regression, congeniality was only marginally predictive of membership in this correct answer/correct rationale group, b = .186, p = .08, SE_b = .106, OR = 1.205, OR 95% CI [0.978, 1.484].

However, a different picture emerged when we compared those who provided a correct interpretation accompanied by an erroneous rationale (N = 99) compared to everyone else in the condition (N = 361). In this case, congeniality was positively predictive of membership in this correct interpretation/incorrect rationale group,

[1] The reporting rate for valid and specific invalid rationales for the first two studies can be found in Supplemental Tables S2 and S3.

Figure 4

Probability of Citing the Correct Rationale Supporting the Correct Conclusion in Studies 1 and 2 as a Function of Numeracy and Cognitive Effort



Note. Panels depict Study 1 (A) and Study 2 (B) correct rationale probability (Pr) with trait numeracy and mouse cursor transitions as predictors. Points represent a single participant's response (in each study, one point for both predictors). Fitted lines estimate a simple logistic regression. Facets divide participants from the numeracy and effort predictors. For both studies, as with interpreting the study correctly, participants who were either numerate or displayed increased effort were more likely to report using a mathematically correct rationale. See the online article for the color version of this figure.

$b = .434$, $p < .001$, $SE_b = .097$, $OR = 1.543$, OR 95% CI [1.276, 1.866]. Full regression results can be viewed in Supplemental Table S13. In sum, the attitude congeniality effect appears to be due to participants who arrived at the right answer through inappropriate statistical reasoning. These analyses are shown in Figure 5A.[2]

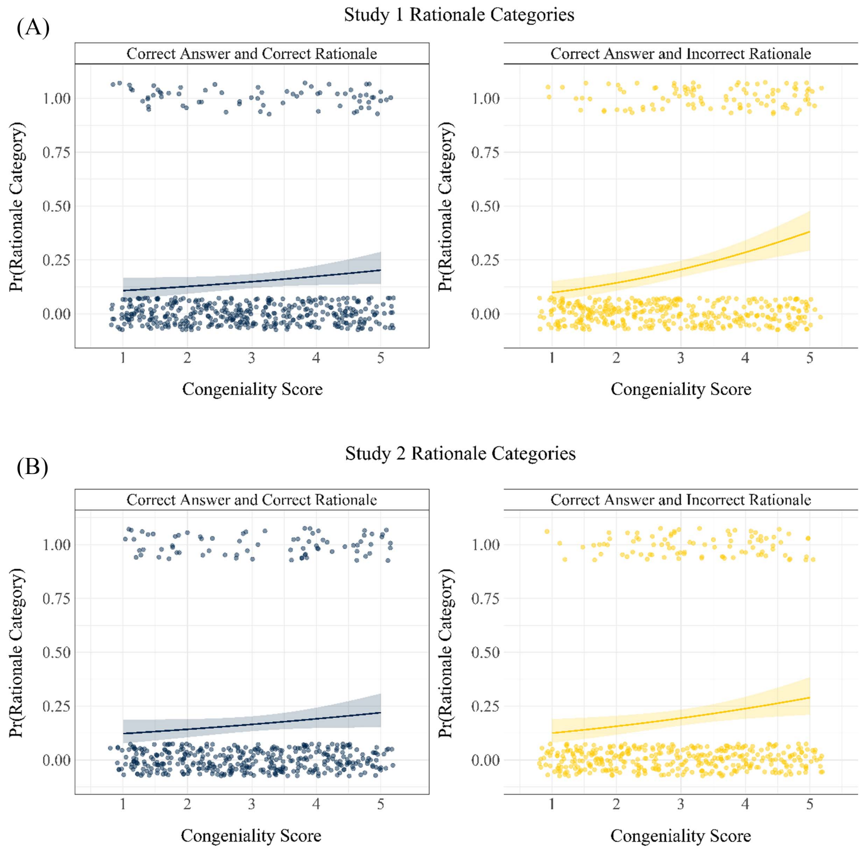
In supplemental analyses, scenario content predicted more accurate responding: participants in the rash condition were more likely to report the correct rationale than those in the gun control condition (33.8% vs. 26.7%, respectively), $b = -.335$, $p = .021$, $SE_b = .145$, $OR = 0.716$, OR 95% CI [0.539, 0.951]. As with the correct interpretation data, effort was more predictive of choosing the correct rationale for participants in the rash condition (simple slopes $b = .056$, $p < .001$) than those in the gun control condition (simple slopes $b = .021$, $p < .001$), $b = -.036$, $p < .001$, $SE_b = .01$, $OR = 0.965$, OR 95% CI [0.947, 0.984]. Full model results can be viewed in Supplemental Table S14. Finally, we should note that only five participants stated that the numbers did not matter in determining their answer, providing weak explicit support for expressive responding; and only eight stated that they just guessed.

Study 2. In Study 2, we took the same analysis approach as with Study 1. Specifically, all predictors other than interactions can be assumed to be a simple logistic regression with no other control variables. Numeracy ($b = .407$, $p < .001$, $SE_b = .065$, $OR = 1.502$, OR 95% CI [1.322, 1.706]) and effort ($b = .023$, $p < .001$, $SE_b = .004$, $OR = 1.023$, OR 95% CI [1.016, 1.031]) both significantly predicted participants choosing the correct rationale. The full regression table can be seen in Supplemental Table S15. Figure 4B shows the effects of numeracy and effort as predicting a correct rationale. Importantly, attitude congeniality was again not predictive of choosing the correct rationale in the gun control condition, $b = .036$, $p = .675$, $SE_b = .086$, $OR = 1.037$, OR 95% CI [0.876, 1.227].

[2] The expressive rationality account does not provide predictions about which specific invalid rationales in the Kahan paradigm would be associated with attitude congeniality effects, only that people will reach for more flawed reasoning that results in valid conclusions. When we examine specific rationales, we do not find any specific rationales that are endorsed more over others when valid conclusions are congenial. Rather, we just see a general rise in the endorsement of valid rationales overall.

Figure 5

Probability of Citing the Correct Versus Incorrect Rationale Supporting the Correct Conclusion in Studies 1 and 2



Note. Panels depict Study 1 (A) and Study 2 (B) rationale categorie choice probability (Pr) predicted by attitude congeniality in the gun control condition. Points represent a single participant's response (in each study, one point for both predictors). Fitted lines estimate a simple logistic regression. Facets divide participants from the rationale categories. For both studies, congeniality predicted giving a correct response with the wrong rationale but did not predict giving a correct response with the right rationale. See the online article for the color version of this figure.

As in Study 1, we next examined whether attitude congeniality predicted participants responding both accurately with the correct rationale ($N = 75$) as opposed to other cases in the study ($N = 375$) in the gun control conditions. Gun control congeniality was not predictive of participants providing correct interpretations with correct rationales, $b = .176$, $p = .098$, $SE_b = .106$, $OR = 1.193$, OR 95% CI [0.968, 1.469].

However, when we compared participants in the gun control condition who provided the correct interpretation but wrong rationales ($N = 89$) to everyone else ($N = 361$) we found that attitude congeniality predicted a greater likelihood of belonging to the correct conclusion/wrong rationale group, $b = .262$, $p = .009$, $SE_b = .101$, $OR = 1.3$, OR 95% CI [1.067, 1.583]. Thus, replicating Study 1, the attitude congeniality effect appears related to participants choosing the correct option more often via inappropriate reasoning. These results are depicted in Supplemental Table S16 and Figure 5B.

In supplemental analyses, participants in the skin cream condition again reported greater rationale accuracy (40.7% vs. 29.6%, respectively), $b = -.492$, $p < .001$, $SE_b = .138$, $OR = 0.612$, OR 95% CI [0.467, 0.802]. As in Study 1, there was a scenario Content × Effort interaction: participants in the skin cream condition (simple slopes $b = .04$, $p < .001$) reported a stronger association between effort and correct rationale when compared to those in the gun control condition (simple slopes $b = .016$, $p < .001$), $b = -.024$, $p = .001$, $SE_b = .008$, $OR = 0.976$, OR 95% CI [0.962, 0.991]. These model results are displayed in Supplemental Table S17.

Acquiescence

In Study 2 responses, we allowed participants to opt out of (initially) interpreting the data with an "I don't know" option to account for the possibility that participants are acquiescing to expectations demanded by the experiment. We found only 5.3% of participants chose this option. Among these 50 participants, skin cream participants ($N = 10$) were less likely to initially choose this option when compared to gun control participants ($N = 40$). In the gun control condition, using a simple logistic regression, those in the "I don't know" group demonstrated attitude congeniality only to a marginal degree when pressed to give an answer, $b = .533$, $p = .064$, $SE_b = .288$, $OR = 1.704$, OR 95% CI [0.968, 2.997], which suggests that these participants contributed to but were ultimately not responsible for the overall congeniality effect across all participants. Thus, it appears that expressive acquiescence fails as an explanation for attitude congeniality effects.[3]

Studies 1 and 2 Discussion

In sum, in both Studies 1 and 2, we explored for but no evidence of the expressive rationality account for attitude congeniality effects, as noted above in our review of several hypotheses, Hypothesis 2A through Hypothesis 3B. As attitude congeniality of the correct response in the gun control scenario increased, participants did indeed select it more often, replicating past work. However, this relation did not vary as a function of participant numeracy or cognitive effort, even though numeracy and effort independently predicted accurate responding and stating the correct rationale for that response.

What do the results of our first two studies suggest are the mechanisms underlying the attitude congeniality effect? Our first two studies are consistent more with the expressive rationalization account than the expressive rationality one. Although participants did endorse the correct conclusion from the scientific data they were shown when it agreed with their gun control attitudes, they were not necessarily more likely to happen upon the correct rationale for why they should endorse that conclusion in either study (i.e., Hypothesis 4 failed). If they find a supportive rationale, it was likely to be wrong even though it reinforced the right answer. In both studies, the rise in participants arriving at the correct interpretation of the scientific data when it was congenial to their political preferences was accompanied by a rise in incorrect rationales for that interpretation (supporting Hypothesis 5). Attitude congeniality effects were accompanied with beliefs that were epistemically lucky, in that they were faulty but consistent with the right answer—and also with the expressive rationalization account.[4]

Finally, in Study 2 we find no evidence that the attitude congeniality effect was due to acquiescence, in that very few participants opted to say "I don't know" when the option was available, failing to support Hypothesis 7. This suggests that participants were generally providing answers they believed to be correct. Very few participants in Study 1 explicitly stated that the "number's don't matter," giving little evidence for an expressive responding account (Hypothesis 6), although we thought this evidence is intriguing but hardly decisive.

Study 3

An uncertainty, thus, remains. The previous two studies found no support for many potential explanations for the attitude congeniality effect but left two standing. Under one, based on expressive rationalization, attitude preferences guide people to find convenient rationales, many incorrect, that justify a result from scientific data that is pleasing. However, data from the first two studies are also consistent with expressive responding, in which no rationale is required. That is, people do not reason their way to preferred answers, they just express them. Any rationale they articulate for that selection is merely an epiphenomenon, inconsequential, and easily discarded, if it would lead to an uncongenial conclusion in the future.

Study 3, thus, was designed with two aims in mind. First, we sought to determine how well each of these accounts, rationalization versus responding, characterizes the mechanism underlying the attitude congeniality effect. We presented participants with not one but 10 gun control scenarios in which the same underlying statistical reasoning would at times lead to a progun control conclusion and at other times to the opposite. We then asked whether the congeniality effect persisted as people worked through these multiple scenarios. Under the expressive responding account, it should. Rationales are ephemeral and people should change their reasoning, if they reason at all, to get to answers that are congenial to their attitudes as they progress through the scenarios. This leads to a formal hypothesis that attitude congeniality should predict judgment accuracy on all 10 scenarios without dissipating (Hypothesis 8).

A different pattern should arise if the expressive rationalization account is more operative. Attitudes may initially sway the strategy people initially adopt for the statistical reasoning task, but once they arrive at that strategy, they will rely on it as they turn to additional scenarios, whether those rationales suggest pleasing or threatening outcomes. Because of this, the impact of attitudes wanes or disappears. This account predicts that the attitude congeniality effect may arise at the start but then should disappate on subsequent trials (Hypothesis 9), as participants stick to the rationale they formed for early decisions (Hypothesis 10): If the strategy they adopt initially correlates with correct decisions, they should continue to give right answers; if that strategy initially aligns with Cell A bias, they should continue to show that tendency.

Thus, we assessed the weight given to attitudes and rationales by varying the answers suggested by attitudinal preferences independent of the right answer and Cell A bias. Regarding attitudes, over the 10 scenarios, we counterbalanced whether pro- or anti-gun control attitudes aligned with the correct answer and the one suggested by

[3] Although not explicitly designed to test for the acquiescence account, we note that Study 1 participants could report that they had "just guessed" their answer. Only eight participants reported this as the rationale for their conclusion.

[4] Some readers may adopt a more stringent criterion for concluding that the data from Studies 1 and 2 favor the expressive rationalization over the expressive rationality account, requiring that the relation between attitude congeniality and right answer/wrong rationale responses be significantly stronger than for right answer/right rational ones. Across the studies, we can test for such a difference by coding right answer/wrong rational cases as −1, right answer/right rationale cases as +1, and everyone else as 0, and then see if we see a significant attitude congeniality trend toward right answer/wrong rationale cases in an ordinal logistic regression analysis. In such analyses, we see a significant trend in Study 1, estimate = .18, $p = .021$, but not Study 2, estimate = .07, $p = .023$—evidence can be seen as indicative of a difference but not conclusive. However, we would argue against making the comparison. First, we do not construe the first two studies as a competition between the two theoretical positions, and both could have received affirmative evidence. Therefore, we did not construct our analysis as a comparison in which only one account could win. Second, as noted in the introduction, providing a correct rationale is arguably consistent with the expressive rationalization account, so the presence or absence of correct rationales would not necessarily discriminate between the two theoretical positions. Epistemically lucky beliefs, however, do. The expressive rationality account takes the strong position that people do reach the right rationale, and so false but lucky beliefs should not arise. Under the rationalization account, though, lucky beliefs are allowed, so the key test is whether they independently emerge as the right conclusion becomes more congenial to one's preferences.

Cell A. At the same time, we also counterbalanced whether Cell A was consistent or inconsistent with the right answer; Cell A bias aligned with the correct answer half the time and away from it in the other half. The scenarios were also arranged such that whether the correct answer was pro- or anti-gun control was independent of whether that correct answer was supported by Cell A bias.

In this way, we could assess the degree to which participants gave weight to their attitudinal preferences, the correct answer, and Cell A bias across the scenarios. The key question centered on behavior after participants answered the first scenario. Would they jettison their rationales to opt for preferred answers (suggesting their rationales were ephemeral), or would they stick to their rationales even in the face of unpleasant answers (suggesting they gave weight to reasoning they formed on the initial scenario)? If the relationship between attitudes and their conclusions remained constant and significant across all 10 scenarios, and the relationship of their responses to the right answer and Cell A bias diminished, this would provide evidence of expressive responding. If they instead stuck to their rationale, with the relationship of their responses to the right answer or Cell A bias remaining evident but the association of those responses to their gun control attitudes diminishing, this would suggest that people give weight to their statistical reasoning, and thus favor the expressive rationalization account.

The second aim of Study 3 was to look at numerical skill in a different way. In the first two studies, we assessed numeracy as an individual difference variable. We simply measured the level of numeracy people brought with them to the study. In Study 3, roughly half of participants were given a brief but explicit training on to approach covariation judgment tasks. Hence, we asked whether training people to approach the Kahan statistical reasoning task more accurately would reduce the congeniality phenomenon (producing a negative Training × Attitude congeniality interaction, Hypothesis 11), or perhaps exacerbate it (producing an opposite, positive interaction, Hypothesis 12), creating a sharper and more direct test of the relationship between numerical skill and the attitude congeniality effect. As in previous studies, we also collected measures of numeracy and cognitive effort, so that we could again assess their relationship to this phenomenon, testing hypotheses similar to the family of Hypothesis 2 and Hypothesis 3 hypotheses from the previous studies.

Method

Participants

We recruited 500 self-identified Republicans and 500 self-identified Democrats from Prolific Academic. Participants were paid \$2.35 for their participation. From the initial sample of 1,000, 5.5% of participants were removed: 29 did not respond affirmatively to our data quality question and 26 submitted incomplete data. Our final sample size was 945 participants ($M_{\text{age}} = 33.42$, $SD_{\text{age}} = 12.37$) who were mostly female (50.9% female, 47.4% male, 1.7% other/nonresponse) and White (67.7% White, 11.1% Asian American, 8.8% Black, 6% multiracial, 3.5% Latino, 1.8% other/nonresponse, and 1.1% Native American).

Design and Procedure

Participants were randomly assigned to training and control conditions (ns = 448 and 497, respectively). We began by presenting participants with a description of the skin rash intervention and with two practice trials that resembled the contingency table problems from Studies 1 and 2, where participants used their mouse cursor to reveal relevant data.

Control participants were presented with the practice data and gave their responses. Training participants were given the same data but forced to go through several steps to proceed: They needed to copy the numbers from Cells A and B into separate boxes, calculate the ratio, do the same for Cells C and D, compare the two ratios, and arrive at the correct response. If at any point, the training participants inputted the wrong data or interpretation, they were prompted by the experiment to correct themselves and given an explanation at each step. Doing two practice trials (one where the skin cream worked and one where it did not) demonstrated that all data in the table must be used appropriately for the main experiment.

After the practice rounds, participants in both conditions completed 10 trials of similar problems about gun control interventions. They were shown 10 different descriptions of gun control studies modeled closely after the ones used in Studies 1 and 2, in which participants examined 2 × 2 tables of data providing counts of cities that had or had not instituted gun bans, crossed with whether they had subsequently experienced an increase or a decrease in crime. Presentation order for the individual 10 scenarios was randomized individually for each participant.

Across the 10 scenarios, we counterbalanced whether the data supported gun control and whether the data in Cell A were consistent with the correct response. Thus, for each participant, the overall data in the scenario and the large number in Cell A both indicated the correct answer in five of the 10 scenarios; for the remaining half they diverged, as in the previous two studies. For half of participants, the scenarios in which Cell A indicated the right answer also indicated that gun bans decreased crime with the remaining scenarios indicating the opposite. For the other half, this pairing between Cell A and correct answer was reversed. The key feature, of course, was that the order of specific scenarios was randomized for each participant across the 10 rounds. Thus, unlike the previous two studies, the first trial could start with either a correct response consistent with Cell A or not. It could also start with one where the correct response favored or opposed gun control. In all trials, participants were required to judge whether the data suggested that gun bans tended to increase or decrease crime rates, as in Study 1.

After providing judgments for all 10 scenarios, participants provided demographic data about education, age, gender, race, political and ideological identification, and gun control attitudes, using the same measures used in the previous studies. Gun control attitudes once again correlated strongly with ideological conservatism ($r = -.60$) and party identification as a Republican ($r = -.57$).

Results

In contrast to previous studies, overall accuracy was quite high ($M = 73.8\%$). This high accuracy was, in part, aided by Cell A bias, in that the right answer aligned with Cell A bias for half of the scenarios. We ran a simple mixed-effects logistic model with Cell A bias status as the sole predictor. Full results can be found in Supplemental Table S18. Participants achieved much higher accuracy rates when the right answer aligned with Cell A bias than when it did not (Ms = 82.7% vs. 65.4%, respectively), $b = 1.766$, $p < .001$, $SE_b = .193$, $OR = 5.85$, OR 95% CI [4.008, 8.539], according to a multilevel model that included participant as a random variable (random intercept and slope).

Importantly, unlike the first two studies, the attitude congeniality effect failed to appear across all 10 scenarios. We used simple multilevel regression with congeniality predicting accuracy (including random intercept and slope for subjects). These results can also be viewed in Supplemental Table S18. Our regression showed that whether the correct answer aligned with participants' attitudes failed to reach statistical significance, $b = .142$, $p = .099$, $SE_b = .086$, $OR =$ 1.152, OR 95% CI [0.974, 1.364].

Why is this so? The answer becomes clear when looking at answers for each of the 10 scenarios separately, according to their order. For each individual scenario from the first to the tenth participants saw, we conducted separate logistic regression analyses in which we predicted their accuracy from attitude congeniality and whether Cell A supported the correct answer. As Figure 6 and Supplemental Table S19 shows, the attitude congeniality effect was clearly present for the first scenario participants encountered, $b = .189$, $p = .003$, $SE_b = .063$, $OR = 1.208$, OR 95% CI [1.067, 1.367], a result that holds even if one adopts a Bonferroni correction ($p < .005$) for multiple comparisons. This effect, however, never arose again in any of the following scenarios, all ORs < 1.11, ps > .10, in Scenarios 2 through 10. The impact of Cell A bias, however, stayed strong across all 10 scenarios, all ORs > 2.061, all ps < .001.

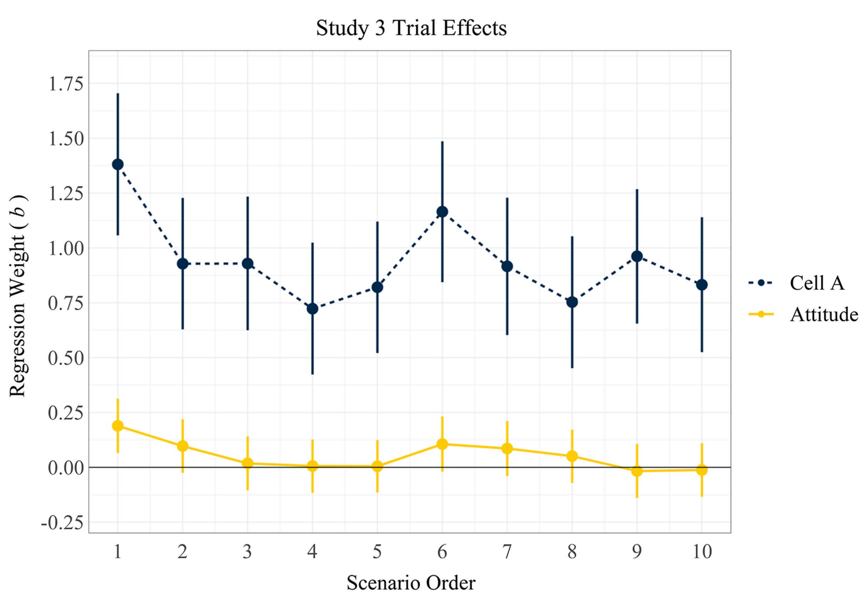
This analysis suggests that attitudes had an impact on the first judgment that participants made but that this influence did not carry over to subsequent scenarios, indicating that the reasoning participants arrived at in the first scenario mattered. This conclusion is also supported by the fact that Cell A bias and being correct, in contrast, did carry over—indicating that the reasoning participants used for the first scenario did carry over to subsequent judgments. Making a correct judgment on the first scenario carried over to the likelihood of making correct judgments afterward, controlling for whether the Cell A bias also indicated a right answer on the first scenario, $\beta = .235$, $SE = .019$, $p < .001$, $R^2 = .138$, 95% CI [0.198, 0.273]. The likelihood of making Cell A biased responses on Scenarios 2 through 10 was also related to making a biased response on Scenario 1, controlling for whether the biased response was also correct, $\beta = .134$, $SE = .016$, $p < .001$, $R^2 = .075$, 95% CI [0.103, 0.165], and failed to weaken across rounds ($p = .115$). This overall Cell A bias, however, held only in the no training condition (simple slopes $\beta = .214$, $p < .001$) but not in the training condition (simple slopes $\beta = .034$, $p = .089$), $\beta = -.18$, $SE = .027$, $p < .001$, $R^2 = .153$, 95% CI [−0.232, −0.127]. These full regression results are displayed in Supplemental Table S20.

Thus, the reasoning implicated on the first scenario persisted over the entire run of the session. As a further check on whether attitude preferences also mattered, we conducted an analysis on whether pro- or anti-gun control attitudes predicted pro- or anti-gun control conclusions across scenarios. Again, we examined each scenario separately according to their ordinal position, predicting whether participants reached a progun control conclusion based on their gun control attitudes, as well as whether the liberal answer was correct or aligned with Cell A bias. As seen in Figure 7, gun control attitudes predicted a liberal response on the first scenario participants confronted, according to a logistic analysis, $b = .236$, $p = .001$, $SE_b = .073$, $OR = 1.266$, OR 95% CI [1.097, 1.461].

We conducted additional post hoc analyses to affirm that attitudes mattered for the first scenario participants confronted, but not afterward, looking at whether liberal versus conservative attitudes

Figure 6

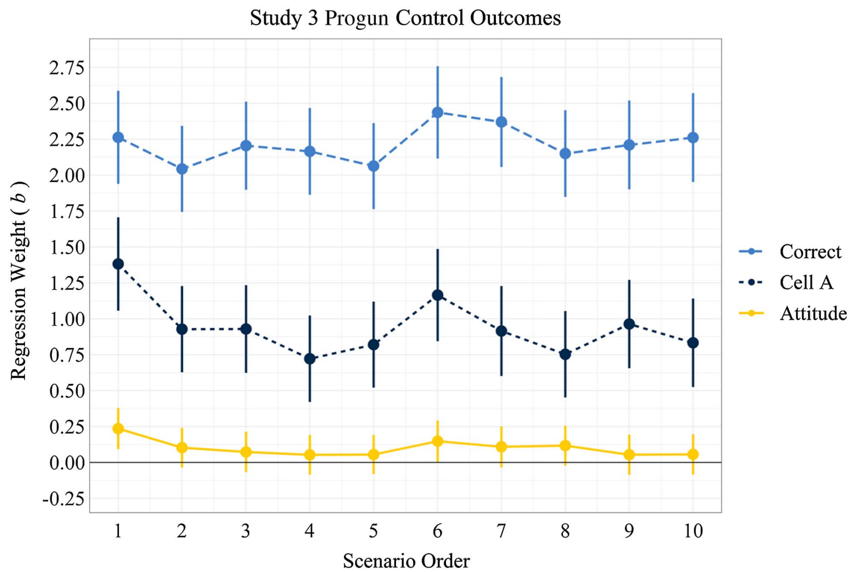
Weight Given to Cell A and Attitude Congeniality in Predicting Correct Responding by Scenario Order



Note. Regression weight (b) of attitude congeniality and Cell A bias on correct responding as a function of scenario order. Error bars reflect 95% confidence intervals for that scenario. See the online article for the color version of this figure.

Figure 7

Weights Given to the Right Answer, Cell A, and Political Attitude (Liberal vs. Conservative) in Predicting Correct Responding by Scenario Order



Note. Regression weight (*b*) of correct answer, gun control attitudes (liberal vs. conservative), and Cell A bias on progun control responding as a function of scenario order. Error bars reflect 95% confidence intervals for that scenario. See the online article for the color version of this figure.

predicted pro- versus anti-gun control conclusions. We coded whether participants reached a pro- or anti-gun control conclusion in the first scenario (coded as 1 and 0, respectively). Attitudes predicted liberal responses again only for Round 6, $b = .148$, $p = .045$, $SE_b = .074$, $OR = 1.159$, OR 95% CI [1.003, 1.339]. However, if one adopts a Bonferroni correction to adjust for the 10 multiple comparisons across the scenarios, only the first scenario achieves significance. The impact of the liberal response being correct, *OR*s > 7.711, or aligning with Cell A, *OR*s > 2.058, is strongly predictive across all scenarios, all *p*s < .001. All regression reports from all rounds are displayed in Supplemental Table S21. For remaining scenarios, we calculated the average likelihood, from 0 to 1, that participants reached progun control conclusions. Gun-control attitudes (liberal vs. conservative) predicted progun control responses on the first scenario, $b = .229$, $p < .001$, $SE_b = .062$, $OR = 1.257$, OR 95% CI [1.113, 1.42], but predicted responses to the remaining scenarios only to a marginal degree, $r(943) = .059$, $p = .068$, 95% CI [−0.004, 0.123].

To test further whether the first scenario was different, we created a difference score subtracting the likelihood measure from Scenarios 2 through 10 from the coded response on Scenario 1. Higher scores meant that the participants first scenario response was more progun control than their responses on any subsequent scenario. This difference score was correlated positively with gun control attitudes in the first scenario, $r(943) = .094$, $p = .004$, 95% CI [0.031, 0.157], meaning that attitudes predicted responding on the initial scenario more than they did any succeeding scenario on average. Or, put differently, the relation of attitudes to responding significantly collapsed after the first scenario. Because this analysis was post hoc, we adopted a Bonferroni correction ($p < .005$) and tested all 10 scenarios to see if any were significantly different from the average of the others. Only the first scenario was shown to be different from all the other scenarios in this analysis. These correlation results can be viewed in Supplemental Table S22. A similar analysis comparing the first scenario to the rest on right and Cell A bias answers failed to reveal any significant differences to the same specification.

Impact of Numeracy, Effort, and Training

We tested outcomes of accuracy and Cell A bias as a function of numeracy, cognitive effort, and training effects. Both accuracy (0 = incorrect response, 1 = correct response) and Cell A bias (0 = response that Cell A does not point toward, 1 = response that Cell A points toward) were measured as binary outcomes. Following, we report mixed-effects logistic regression model predictors with participant as a random intercept and slope where possible, with interactions where appropriate.

To test numeracy, we fitted a mixed-effects model, with participant as a random intercept (but not slope) to converge the model. These results are displayed in Supplemental Table S23. Numeracy once again predicted accuracy, $b = .404$, $p < .001$, $SE_b = .058$, $OR = 1.498$, OR 95% CI [1.338, 1.678], and reduced Cell A bias, $b = −.061$, $p = .022$, $SE_b = .027$, $OR = 0.941$, OR 95% CI [0.893, 0.991]. Training moderated neither effect. Numeracy also did not interact with the attitude congeniality effect, as evidence by a nonsignificant Numeracy × Attitude congeniality interaction, $b = −.039$, $p = .079$, $SE_b = .022$, $OR = 0.961$, OR 95% CI [0.92, 1.005].

Cognitive effort was not related to correct responding, $b = −.002$, $p = .282$, but was related to Cell A bias, with more effort associated with fewer biased responses, $b = −.202$, $p < .001$, $SE_b = .033$, $OR = 0.817$, OR 95% CI [0.766, 0.871], a trend that interacted with training condition with effort (standardized for model convergence), $b = .256$, $p < .001$, $SE_b = .065$, $OR = 1.292$, OR 95% CI [1.138, 1.466]. These model details are in Supplemental Table S25. This interaction revealed that cognitive effort reduced Cell A responding significantly when no training was present (simple slopes $b = -.326$, $p < .001$); with training, Cell A was so suppressed that cognitive effort could not reduce it further (simple slopes $b = -.07$, $p = .132$). As in previous studies, cognitive effort did not moderate the attitude congeniality effect, as evidenced by a nonsignificant Attitude × Effort (standardized) interaction, $b = -.039$, $p = .091$, $SE_b = .023$, $OR = 0.962$, OR 95% CI [0.919, 1.006].

Did injecting participants with numerical skill via training matter? Training did influence participant accuracy, albeit only modestly, *M*s = 76.1% versus 72.1% for training versus no training conditions, respectively, $b = .565$, $p < .001$, $SE_b = .144$, $OR = 1.76$, OR 95% CI [1.327, 2.335]. It did, however, have a stronger impact on reducing Cell A bias, *M*s = 53.5% versus 63.1% for training versus no training conditions, respectively, $b = -.517$, $p < .001$, $SE_b = .064$, $OR = 0.597$, OR 95% CI [0.526, 0.677]. These regression results are viewable in Supplemental Table S24. Training also predicted whether participants reported the correct rationale for judging the scenarios, *M*s = 79.9% versus 57.3%, for training and no training conditions, respectively, $b = 1.085$, $p < .001$, $SE_b = .149$, $OR = 2.959$, OR 95% CI [2.211, 3.961].

However, despite influencing correct responding overall, training failed to moderate the relationship between attitude congeniality and correct responding, as evidenced by a nonsignificant Congeniality × Training interaction when adding congeniality as a random slope, $b = .268$, $SE_b = .151$, $p = .076$, $OR = 1.307$, OR 95% CI [0.972, 1.757].

Summary

In sum, although participants initially displayed an attitude congeniality bias in their first judgment, that bias quickly evaporated although a tendency to respond in a way consistent with the correct answer or a Cell A bias remained prominent throughout subsequent scenarios, supporting Hypothesis 9. This pattern is indicative of an expressive rationalization interpretation of the attitude congeniality effect, supporting Hypothesis 10, in which people show some commitment to a statistical strategy adopted or evident in the initial scenario the encountered, but not one based on expressive responding, in which people give attitude-consistent responses regardless of what the data show (i.e., Hypothesis 8 fails). We can conclude that attitude preferences are connected to thinking of convenient rationales, but it does not undo them. These rationales carry weight throughout responding and are not ephemeral.

Training significantly raised accuracy but only to a small degree. The biggest impact of the brief training regimen was to prompt participants away from Cell A bias. However, training did not influence the attitude congeniality effect overall. Like the first two studies, numeracy and cognitive effort again predicted accuracy but did not moderate the congeniality effect. In short, the sharp test of expressive rationality we designed in Study 3 failed to find any relationship between cognitive skill and the magnitude of the attitude congeniality effect. We should note once again that responding correctly did not necessary mean that participants adopted the correct rationale, only that their responses were consistent. In fact, 42.7% and 20.1% of participants in the no training condition and training groups, respectively, endorsed wrong rationales.

General Discussion

In a world increasingly connected electronically, information is everywhere, sometimes in a raw form that requires interpretation. This is also true for numerical information, which people often receive in the context of health (Reyna et al., 2009), finance (Lusardi & Mitchell, 2011), and science (van der Bles et al., 2019). The question of how well people interpret numerical information is an important one, particularly when it comes to science, because such evidence increasingly comments on contentious social issues.

In the current research, we examined how motivated biases and prior attitudes may influence how people interpret numerical evidence from science. Recent work has shown that people across many settings interpret such data to come to conclusions that best fit their political preferences (e.g., Kahan et al., 2017; Persson et al., 2021). That phenomenon is widely replicated and inspires no dispute. What does inspire dispute, however, is the specific psychology behind the phenomenon. Do people reach attitude congenial conclusions through expressive rationality, engaging their cognitive resources to discover the right interpretation of data when it fits attitude preferences, with those with the most resources showing the most bias?

Across three studies, we explored this expressive rationality account for attitude congeniality effects, along with several alternative explanations. Although we found, like others, a robust attitude congeniality effect, we found no evidence for expressive rationality underlying it. Attitude congeniality effects for finding the right answer were not greater for those with higher levels of numeracy nor for those who exerted more cognitive effort in reaching their conclusion. Participants overall showed no evidence of "getting smart" to get to preferred conclusions or "playing dumb" to avoid threatening conclusions. Moreover, attitude congeniality, while increasing endorsements of the right answer, did not similarly increase endorsement of appropriate statistical reasoning or rationale supporting that answer.

Finally, in Study 3, a training session designed to enhance numeracy skills failed to significantly diminish or to exacerbate attitude congeniality effects. To be sure, the training intervention was helpful in reducing reliance on Cell A, and slightly improved accurate responding overall, but it did not reduce attitude effects when they appeared. In sum, our results are consistent with recent efforts that fail to replicate a motivated numeracy account for attitude congeniality biases (e.g., Hutmacher et al., 2024; Persson et al., 2021; Stagnaro et al., 2023).

Thus, the attitude congeniality effect appears to be supported by a psychological mechanism different from expressive rationality. Across the three studies, the data instead fit best an expressive rationalization account in which people construct rationalizations for their preferred, and sometimes correct, conclusions. Those rationalizations need not be valid even when they lead to valid conclusions. They can be epistemically lucky: flawed reasoning that leads to accurate judgment. In the first two studies, the attitude congeniality effect was associated with people getting the right answer, when it aligned with their political attitudes but then citing mistaken rationales for that right answer.

Other data tended to rule out other alternative explanations for the attitude congeniality effect. In Study 3, we looked at responses across multiple trials. We found that in the first trial, participants were likely to display an attitude congeniality bias, but this bias evaporated in subsequent trials. However, consistency in cognitive strategy endured, suggesting that people gave weight to the statistical rationales they had alighted on initially. Cell A bias—responding to an answer consistent with the cue from the top-left cell in a table—was consistent throughout trials, as was coming to the right answer. Those who came up with the right answer initially tended to continue to do so throughout the experimental session.

We additionally tested a training manipulation to train up numeracy skills for half of the participants. Taken together, these data suggest that people do give weight to the rationalizations they construct once they possess them. The data are inconsistent with an expressive responding account in which people just give the answers that best fit their preferences with no underlying reasoning. If that were the case, the attitude congeniality effect should have remained strong across all scenarios. Further, Study 2 argued against an expressive acquiescence account in which people give attitude-consistent responses only because they are forced to give a response. Allowing people to say "I don't know" did not reduce the effect, and roughly only 5% of participants took that option when provided.

We note, however, that the evaporation of the attitude congeniality effect in Study 3 can potentially be explained by something akin to motivational satisficing (H. A. Simon, 1959). Participants may not persist in interpreting information to be consistent with their attitude preferences after Round 1, because that one response sufficiently satisfies some threshold to fulfill a quota of partisan responding. Specifically, participants may enter the experiment with a strong motive to affirm their political beliefs. After the first round, this need is satisfied, and the responses that follow can be informed by data and less constrained by partisan motivations. Consider the case of moral licensing as a comparison to these results (Monin & Miller, 2001). Research on cognitive consistency would predict that people are generally consistent in their behavior, but in moral licensing, people permit themselves to engage in morally undesirable behavior after having first engaged in a moral action.

Beyond this issue, the work leaves four topics that deserve comment.

Individual Variation

Future work can move to more nuanced questions than we addressed here. In this research, we focused on general trends in responses to numerical information. However, could people be split up into meaningful subgroups according to divergent responses? Do some people exhibit more attitude congeniality effects than others? Are others more likely to engage in expressive rationalization or responding than others?

Our data were not amenable to such analyses, although we did conduct one speculative analysis, looking at whether there were respondents in Study 3 who always chose the liberal ($n = 41$, 4%) or conservative response ($n = 70$, 7%) on all 10 trials, showing evidence of expressive responding, although surprisingly the two groups did not differ significantly in their gun control attitudes ($t = 1.37$, $p = .174$). This frequency is compared to the 41% ($n = 392$) who showed no attitudinal favoritism, 32% ($n = 299$) who always answered correctly, and 11% ($n = 100$) who always followed Cell A. In this, our data echoed Schaffner and Luks (2018), who found a similar small bias in partisans' judgments of the crowd sizes at President Trump's and President Obama's inaugurations despite clear photographic evidence. Thus, although expressive responding may not provide an overall explanation for attitude congeniality biases, it may exist in certain small cadres of individuals (although, again, we see no significant attitude difference in our consistent responders). That said, we hasten to add that our analysis is post hoc and should be viewed with appropriate caution, but grist for further empirical investigation.

Motivated Reasoning Versus Prior Belief

Herein, we have adopted the theoretical framework characteristic of work on attitude congeniality effects that emphasizes motivated reasoning, validation of personal identity, and preference as its presumed causal driver (see Kahan et al., 2017). At least in the case of gun control attitudes, there are good reasons for doing so, in that they are tied more closely to cultural and ideological values than to utilitarian calculations (Braman et al., 2005; Kahan & Braman, 2003). Such attitudes are typically formed early in life, based on personal experience, seen as personally important, and correlate tightly with political ideology and fear of other social groups (Smith, 2000). They are resistant to change, even in the face of national tragedies of gun fatalities such as Littleton, Orlando, or El Paso (Smith, 2000; Stroebe et al., 2022).

That said, the assignment of any judgmental bias to motivated reasoning can be contentious. One can instead assert that people bias their judgment to align with their attitudes because those attitudes come with compatible expectations and prior beliefs. People are not under motivated pressure to validate their attitudes. Rather, they just hold honest beliefs that make attitude-consistent conclusions seem more likely to be true. In the case of gun control attitudes, gun control proponents and opponents differ, for example, in their prior beliefs about whether guns make an environment safer or more dangerous (Smith, 2000; Stroebe et al., 2022).

This contention between motivation and prior belief is as old as classic work on motivated reasoning in social psychology (Bem, 1967; Miller & Ross, 1975; Wetzel, 1982) and now runs red hot among scholars in adjacent fields (e.g., Ditto et al., 2024; Druckman & McGrath, 2019; Tappin et al., 2021; Thaler, 2024). Thus, one can argue that the attitude congeniality effect arises because consistent conclusions just seem more plausible given a person's prior beliefs, not because of any preferences or motives they harbor.

We do not adjudicate this contention here. It comprises a longstanding debate, and we believe it will remain one for a long time. We do make two notes. First, if the attitude congeniality effect is driven by prior beliefs rather than motivation and identity concerns, as originally asserted by Kahan and colleagues (Kahan et al., 2017), the analysis and conclusions we present in this article remain the same. No matter what instigator jumpstarts the bias toward preferred conclusions, the question of whether people reach that conclusion as their destination by traveling via expressive rationality, rationalization, responding, or acquiescence remains—and it is this specific question where our focus was placed. Second, the separate question of whether the attitude congeniality effect is instigated by motivated desire or by prior beliefs remains on the theoretical agenda, to be addressed by future scholars if they so desire, and whatever their prior beliefs might be. It would make a sizable and ambitious research program to tackle on its own, and perhaps a good candidate for adversarial collaboration (see Ceci et al., 2024), namely between theorists who differ on the question.

Cognitive Ability and Motivated Reasoning

The second issue our results present is why there is little to no link between numerical ability and motivated reasoning (Dunning, in press). According to the expressive rationality account, high cognitive ability allows individuals to discover the proper rationale needed to justify the conclusion that they prefer. Those with low ability do not have the cognitive resources to construct such justifications and so cannot get to the right answer. In contrast, our work reveals that all people, regardless of their numerical ability, can come to some sort of justification for their answers. High ability is not necessary. That is, high-ability individuals may discover the correct rationale for their choice, but low-ability individuals have sufficient cognitive resources to construct alternative justifications for the choices they favor. They may not have the resources to identify the right rationale, but they can find an incorrect but plausible-sounding rationale that serves their motivated purposes adequately. Thus, although lack of cognitive ability may be a constraint on finding the correct rationale for a preferred conclusion, it is not a constraint for constructing other seemingly reasonable rationales that support judgments people wish to achieve.

We also believe we need to address an apparent paradox. We, like others, find that numerical ability leads people to reach right answers more frequently, yet it does nothing to reduce the impact of attitudinal preferences. Other work in motivated reasoning has similarly found that cognitive ability fails to reduce motivated biases or affect their magnitude at all. For example, myside bias, in which people generate and prefer arguments pointing to favored conclusions over threatening ones, is found just as much among the cognitively able as those who are less so (Stanovich, 2021). Fans betting on professional football games become more skilled at picking winners over the course of a season, but the undue optimism they show toward their favorite team remains undiminished (Massey et al., 2011).

How can cognitive ability lead to more accurate performance yet fail to reduce bias inspired by motivated preferences? Psychological research, stretching back to classic work on signal detection, has long provided an answer to this question. Judgmental performance rests on two different and often independent parameters. One is sensitivity (in signal detection terms, d'), marking the ability to distinguish between truth from falsity. It is a responsiveness to the truth of an answer. The second is bias (in signal detection terms, c) which indicated a tendency to favor one conclusion over the other independent of its accuracy, like a lean toward concluding something is "true" rather than "false." Signal detection theory (McNicol, 2004) as well as more recent treatments of human judgment (West & Kenny, 2011) show how sensitivity and bias can wax and wane independently of each other. They are not hydraulically related: An increase in sensitivity does not imply a reduction in bias, and an increase in the bias does not necessitate a lowering in sensitivity. Both parameters, however, have their own impact on performance.

Our work suggests that numerical ability influences sensitivity, making people more responsive to the truth, but motivated reasoning instead influences bias, making people more responsive to what they prefer. Thus, numerical ability and motivated reasoning have their impact on separate and independent parameters of performance. Highly numerate respondents in our studies were more likely to reach the true answer overall in their judgments of the data we showed them, but those judgments are still just as contaminated by a lean toward the conclusion they preferred. Consequently, having greater numerical ability is beneficial, in that the highly able make more accurate judgments, but the motivated biases they harbor still operate, in effect preventing them from achieving the even higher rates of performance they could have achieved, if they had no bias at all.

On Intervention

Finally, our research contributes to the broader discussion of the role of expertise in an informed citizenry. One could argue that making the public resistant to misinformation and fraud would focus first and foremost on making them more skilled and knowledgeable, both in terms of content and in how to handle information. We do not disagree; we find that increased expertise was generally helpful for accuracy rates. However, should expertise be seen as the only needed remedy for combatting misinformation? What about factors relevant instead to judgmental bias? Attitudes toward the issue can produce bias in judgment, and so can attitudes toward information sources (Cialdini et al., 1981). Thus, bolstering familiarity, trust, or liking of information sources might be more useful if the issue is removing bias rather than ignorance in considering data or information on an issue, and possibly easier to scale up to a wider population.

For example, research examining intentions toward COVID-19 safety behavior suggest that attitudes toward scientists may be more important than measures of politics or expertise (Sanchez & Dunning, 2021). Positive attitudes might in turn activate coherent traits related to honest, unbiased deliberation of political topics. For instance, ideological opponents can also be viewed as lacking good reasons, lower intellectual capabilities, and lower moral character when compared to ideological allies (Stanley et al., 2020). It may be more fruitful to facilitate exposure to individuals who hold different beliefs to create positive evaluations and more trust of them rather than more information about the issues that divide. After all, information seeking under liking and familiarity (or their opposite) may be activated more in everyday life (i.e., in the lunchroom of one's workplace) rather than a cold evaluation of hypothetical information in a survey.

Constraints on Generality

The research reported herein is not without limitations. It specifically targeted motivated reasoning and numeracy in a political context within the United States. Our samples should generalize best to politically conscious U.S. adults of various gender and racial identifications. Further research should be needed to fully understand the nuances of other social subgroups and issues not explicitly explored here, such as participants from other countries or nonnative English speakers. To be sure, work on motivated numeracy has been conducted with non-American samples (e.g., Dutch politicians, e.g., Christensen & Moynihan, 2024), but even then samples have been highly educated and Western.

Future research could address other limitations of our studies. Consistent with prior research, we looked at gun control as a focal issue. As the political and legal landscape is rapidly changing, other social issues could be investigated to elicit motivated information evaluation. For instance, many are looking to experts in law and medicine on the topic of abortion now that federal protections have changed. Might this topic elicit different cognitive processes, or could expertise about biology or law distort one's ability to rationally evaluate evidence? Cognitive load may also be an important design characteristic in the task we presented to participants, as it may interfere with the ability to properly refute received information (Gilbert et al., 1990, 1993). As the task was already difficult for the typical layperson, researchers should investigate possible other process tracing methods that allow more externally valid experience for participants (although one could also adjust the difficulty of the problems as we did in Study 3).

Conclusion

In sum, we examined the psychological mechanisms underlying the attitude congeniality effect in the interpretation of scientific evidence numerically presented. We replicate the effect that people are more likely to set aside common biases and interpret the evidence correctly when the correct conclusion is the one they favor. However, we found no evidence for many plausible explanations for the effect, including the one (expressive rationality) most associated with it. We do find evidence that attitude preferences lead people to reasoning supporting their favored conclusions, with that reasoning not necessarily needing to be valid. This is a fact that should inspire more thought and research, given in the world that there are many more rationales that are plausible—and pleasing—than are true.

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