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# Partisan mathematical processing of political polling statistics: It's the expectations that count

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A B S T R A C T

In this research, we investigated voters' mathematical processing of election-related information before and after the 2012 and 2016 U.S. Presidential Elections. We presented voters with mental math problems based on fictional polling results, and asked participants who they intended to vote for and who they expected to win. We found that committed voters (in both 2012 and 2016) demonstrated wishful thinking, with inflated expectations that their preferred candidate would win. When performing mathematical operations on polling information, voters in 2012 and 2016 deflated support for the opponent. Underestimation of the opponent was found to be absent among the participants who did not expect their preferred candidate to win. Identical experiments conducted after the elections revealed that partisan mathematical biases largely disappeared in favor of estimates in alignment with reality. Results indicate that mathematical processing of political polling data is biased by people's voting intentions and wishful thinking, and, crucially, by their expectations about the likely or actual state of the world.

## 1. Introduction

In the days following the 2012 United States Presidential Election, a leading story in the news was the triumph of big data and statistics and the failure of various pundits to predict President Obama's re-election (e.g., Mirkinson, 2012). Even as statisticians called key states for Democratic re-election candidate Barack Obama and it became clear that the election was decided, commentators discussed possible ways the numbers could still work out in favor of Mitt Romney, the Republican challenger. News anchor Megyn Kelly questioned an incredulous political consultant (Karl Rove): "Is this just math that you do as a Republican to make yourself feel better?" (America's Election Headquarters, Nov. 6, 2012). The research reported in this paper, conducted just before and following the 2012 and 2016 U.S. presidential elections, asks a similar question – but across party lines. Does backing a particular political candidate lead to the disruption of basic mathematical cognition?

Media coverage of political campaigns involves an onslaught of exposure to polling results. Processing these results challenges people to objectively assess data while they manage their expectations and preferences (Berger & Berry, 1988; Van Dooren, 2014). Previous research has shown that voters are likely to demonstrate "wishful thinking," such as a "false consensus bias" where they believe that a majority of the electorate shares their political views (Morwitz & Pluzinski, 1996; Babad & Yacobos, 1993; Babad, 1997; Granberg & Nanneman, 1986; Koudenburg, Postmes, & Gordijn, 2011; Krizan, Miller, & Johar, 2010; Mullen et al., 1985; Ross, Greene, & House, 1977).

Political preferences increase voters' expectations for the preferred outcome, but this wishful thinking is not invulnerable. Polling data and monetary incentives can push back against voters' inflated preferences and expectations (Babad, 1997; Ceci & Kain, 1982). Other research suggests that expectations themselves can modulate the strength of people's candidate preferences and bias how they process polling information (Granberg & Nanneman, 1986; Morwitz & Pluzinski, 1996). The present research investigates how voters' preferences and expectations compete as they process information about the electorate's support for the candidates, and the extent to which these factors lead to error when performing mental math based on polling data.

The work we build upon (e.g., Babad & Yacobos, 1993; Babad, 1997; Granberg & Nanneman, 1986; Kahan, Peters, Dawson, & Slovic, 2017; Koudenburg et al., 2011; Krizan et al., 2010; Krizan & Sweeny, 2013; Morwitz & Pluzinski, 1996) investigated participants' answers to speculative questions, such as: Who would undecided voters vote for? What were the results of the last poll they saw? Here we investigated participants' ability to provide objectively correct answers to basic mathematical word problems presented in a political context. The use of math problems with verifiable answers is a strong test of the role of preferences and expectations in processing of polling data, as people may be especially inclined to resist bias since math problems are understood to have objectively correct answers.

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Bias in the current study was verifiable by observing the extent to which voters' answers to these simple math problems favored or undermined a candidate's support relative to an objective amount.

We used two case studies: the 2012 and 2016 U.S. Presidential Elections. In our experiments, we gave participants fictitious polling information about the percentage of people that supported Barack Obama and Mitt Romney (2012), or Hillary Clinton and Donald Trump (2016), in an anonymous county. We then asked them to mentally calculate the number of people that would be expected to support the leading candidate in a sample taken from that county—that is, they estimated the value equivalent to a percentage of a number for the leading candidate. We varied between-subjects which candidate held the advantage in the polls by alternating which had one of two possible leads in the poll: 22 points or 4 points. This design meant we could assess mental math by voters who, for example, intended to vote for Trump in 2016 and encountered either (a) Clinton or (b) Trump with the large lead. Since, in this example, (a) Clinton having a large lead but not (b) Trump having a large lead is dissonant with Trump voters' preferences, we expected Trump voters to downplay the front-runner's 22-point lead only in (a), but not (b). We expected the inverse pattern for Clinton voters; and likewise, a similar pattern of results in 2012 for Obama and Romney voters. In 2012, a rally size estimation task was included to assess whether candidate biases would extend to rough visual numerical estimates (Crollen, Castronovo, & Seron, 2011).

To assess the role of considerations about the likely or actual state of the world on participants' mathematical processing of polling information, we asked participants to report their expectations about who would win the election. We also ran the experiments again, after the 2012 and 2016 Elections. These post-Election experiments were important in order to investigate whether mathematical operations were still biased in favor of people's preferred candidates even when participants could see, from observing reality, the outcome of the election. We expected partisan mental models to challenge fact-based reasoning in the processing of political polling statistics before the election in particular. To verify the robustness of our findings, we used the same measures in Experiments 3 and 4 conducted before and after the 2016 Election.

## 2. Experiment 1 – Before the 2012 election

### 2.1. Method

#### 2.1.1. Participants

Participants completed the study online via Amazon.com's Mechanical Turk (Mturk.com) for a small payment within the eight-week period before the 2012 U.S. Presidential Election. The data of the participants (n = 437, 64% retained[1] after exclusions) who reported an intention to vote for Barack Obama ($n$ = 337; $M(SD)_{\text{age}}$ = 30.99(10.12); 128 female; 208 male; 1 selected other) or Mitt Romney ($n$ = 100; $M(SD)_{\text{age}}$ = 36.15(12.17); 44 female; 56 male) were analyzed. For all experiments, the data can be accessed via links in the Supplementary Material (see Appendix A).

#### 2.1.2. Voter intentions, expectations, mental calculations before the election

Participants were first asked which candidate they planned to vote for in the election (Obama/Romney/Other/Not Voting), which candidate they expected would win, and what proportion of the popular vote they estimated each of the two major candidates would win.

Then, all participants were presented with two math problems based on fictional polling results. Participants were instructed: "For the following questions, you will be asked to estimate your answers. Please give your best guess. We are not looking for complete accuracy, but rather for an estimation. Do not use a calculator. Please respond as quickly as possible."[2] In the first item, one candidate (Obama or Romney) was ahead of the other 57% to 35% (the "22-point lead" item), e.g., "A recent poll of residents of one U.S. county shows that residents favor Obama over Romney 57%-35%. In a random sample of 523 residents of this county, how many do you estimate will vote for Obama?" (correct answer = 298). In the second item, the other candidate was ahead 47% to 43% (the "4-point lead" item), e.g., "A recent poll of residents in a different U.S. county shows that residents favor Romney over Obama 47%-43%. In a random sample of 549 residents of this county, how many do you estimate will vote for Romney?" (correct answer = 258).

Participants were assigned to one of two conditions: the "OBAMA-ADVANTAGE" condition in which Obama held the 22-point lead and Romney held the 4-point lead, or, the "ROMNEY-ADVANTAGE" condition in which Romney held the 22-point lead and Obama held the 4-point lead.

We predicted the following patterns indicating a role for preferences in mental math involving political information: If participants first encountered the opponent holding the large lead – for example, if Obama voters read that Romney had the 22-point lead – we expected defensive underestimation. When they encountered their preferred candidate with the small 4-point lead next, we expected either that this cognitively-consistent information would be unlikely to spur biased estimation, or that participants would overestimate their preferred candidate's lead in order to compensate for the large lead of the opponent which they initially encountered. By contrast, participants first encountering their preferred candidate holding the large lead were not expected to show biased estimates of their preferred candidates' support, because their advantaged position aligned with participants' preferences. When they next encountered the comparatively small 4-point lead of the opponent, defensive underestimation would be unlikely, as participants had just encountered their preferred candidate with a comparatively much larger lead. If expectations drive candidate-favoring processing of political information, such patterns of bias should be found specifically in participants who expected the candidate they intended to vote for to win.

As practice before the test items, participants were asked to estimate the number of voters for Obama in a random sample of 673 American citizens based on the popular vote estimate they had provided. A crowd size estimation task followed these questions. This task was included in order to ascertain whether politically-motivated quantitative biases—expected for the math task which required a multi-step operation—would be absent for a task requiring just a rough visual

[1] Recruited random sample included 685 participants. We aimed to recruit a sufficient number of Romney voters (approximately 50–100) per condition) taking into account typical online repeat participation; failure to complete study, follow directions, or pass attention checks; and greater representation of politically liberal people in the subject pool. Exclusion criteria were (1) repeat participation (n = 46) or failure to provide ID (n = 13), (2) failure of catch question decided a priori (n = 48; participants were asked whether they agreed that the United States was geographically north of Central America and those who provided responses at or below the midpoint on a 7-point scale were excluded), and (3) failure to follow directions (n = 29; participants who provided nonsense values, values greater than the value they were asked to operate on, or who provided percentages such as "65%" or values under one hundred that could have been percentages for test items, see EXCLUSION_NOTES text file). Of the 549 remaining participants, 112 did not intend to vote for Obama or Romney. These participants, who selected "Other" and "Not Voting", significantly favored Obama versus Romney, making them unsuitable to serve as a comparison group to intended Obama and Romney voters ("Other": $M(SD)_{OBAMALIKE}$ = 3.50(1.53); $M(SD)_{ROMNEYLIKE}$ = 2.19(1.25); $t(51)$ = 5.21, $p < .001$; $M(SD)_{OBAMAAGREE}$ = 3.42(1.33); $M(SD)_{ROMNEYAGREE}$ = 2.44(1.36); $t(51)$ = 3.71, $p < .001$. "Not Voting": $M(SD)_{OBAMALIKE}$ = 3.62(1.74); $M(SD)_{ROMNEYLIKE}$ = 2.20(1.40); $t(59)$ = 4.74, $p < .001$; $M(SD)_{OBAMAAGREE}$ = 3.55(1.37); $M(SD)_{ROMNEYAGREE}$ = 2.33(1.20); $t(59)$ = 4.95, $p < .001$).

[2] Five participants reported guesses that matched both accurate values. The results were unchanged when we re-ran analyses with these participants excluded.

assessment of numeric magnitude (Crollen et al., 2011). Participants briefly viewed a series of four images of crowds, purportedly showing attendees at political rallies for Obama (first and third images) and Romney (second and fourth images). They were instructed to estimate the number of people in the photos[3]; images were presented for 3 s to prevent counting. Participants entered their estimates into text boxes.

#### 2.1.3. Affinity for the candidates and investment before the election

In all experiments, in order to verify that participants reporting an intention to vote for a candidate indeed supported the candidate, participants were asked how much they liked the candidates and agreed with their political positions. To gauge the intensity of participants' investment in the election, we asked how important the election was to them, how upset they would be if their preferred candidate did not win the election, and how concerned they were about the possibility that their preferred party would not be in power after the election. Finally, we also measured how closely participants followed politics to gauge general political investment. Participants rated their responses to these items on 7-point Likert-scales anchored at 1 (Not at all), 4 (Somewhat), and 7 (Very much).

### 2.2. Results and discussion

#### 2.2.1. Voter intentions and expectations, affinity for the candidates, investment before the election

Consistent with "wishful thinking", voters overwhelmingly expected their preferred candidate to win the election (e.g., Babad & Yacobos, 1993; Koudenburg et al., 2011; Krizan et al., 2010; Krizan & Sweeny, 2013; Morwitz & Pluzinski, 1996). The great majority (98.2%) of intended Obama voters reported expecting that Obama would win; 72% of intended Romney voters expected that Romney would win. Estimates of the popular vote each candidate was predicted to receive also reflected participants' voting intentions (see Fig. 1). Obama voters inflated popular vote predictions for Obama ($M = 57\%$) compared to Romney voters ($M = 47\%$; $t(434) = 11.87$, $p < .000$). Likewise, Romney voters inflated popular vote predictions for Romney ($M = 51\%$) compared to Obama voters ($M = 41\%$; $t(434) = -11.05$, $p < .000$).[4] While the majority of voters expected their preferred candidate to win, the percentage of intended Obama voters who expected an Obama win was significantly higher than the percentage of intended Romney voters who expected a Romney win ($Z = 8.6$, $p < .001$), consistent with national polls at the time (Pew Research Center, 2012).

Participants indeed liked and agreed with their chosen candidate significantly more than the opponent (*p's* $< .001$; see Table 1). There were no significant differences between Obama and Romney voters in most measures of investment in the election (Table 1) including how closely they followed politics, how important the outcome of the election was for them, or how concerned they were about the possibility that their party would not be in power after the election. Obama voters' ratings of how upset they would be if the other candidate won the election were higher than Romney voters' ($p < .007$), however.

#### 2.2.2. Mental calculations before the election

We created an index of math bias in participants' estimates for the mental calculation items, for which we computed two difference scores: (1) between the participant's response to the 22-point lead question and the correct answer (298), and between the participant's response to the 4-point lead question and the correct answer (258). Because the 22-point lead question and the 4-point lead question always presented the opponent in the lead, we then computed a math bias score as the difference of these difference scores, and standardized the result by reducing by 40 (the difference in the two correct answers: 298–258). Thus, perfect accuracy is indicated by a math bias score of zero, and the extent of bias (underestimation of the opponent or overestimation of the preferred candidate) is indicated by the magnitude of deviation from zero, with a negative score indicating a bias away from the 22-point lead candidate and/or toward the 4-point lead candidate. The math bias score served as the dependent variable in an ANOVA with the between-subjects factors: VOTE (who the participant planned to vote for: OBAMA, ROMNEY) × CONDITION (OBAMA-ADVANTAGE, ROMNEY-ADVANTAGE). While the main effects were not significant ($p > .6$), we did find a significant interaction ($F(1,433) = 17.09$, $p < .0001$; $\eta^2_{partial} = 0.04$; see top left panel of Fig. 2), revealing a significantly greater math bias for voters in conditions in which their preferred candidate was not favored (i.e., Obama voters in the ROMNEY-ADVANTAGE condition and Romney voters in the OBAMA-ADVANTAGE condition) compared to when voters encountered their preferred candidate in the lead.

Follow-up one-sample *t*-tests on participants' raw estimates indicated that math biases were largely driven by voters underestimating the opponent's 22-point lead (see bottom left panel of Fig. 2). Intended Obama voters' estimates of Romney's 22-point lead were significantly lower than the accurate value of 298 ($t(162) = -3.6$, $p < .001$) – on the other hand, estimates of their own candidate's 22-point lead were accurate ($t(173) = 1.0$, $p > .3$). Likewise, intended Romney voters' estimates of Obama's 22-point lead were significantly lower than the accurate value of 298 ($t(49) = -2.3$, $p = .024$), while again, estimates of their own candidate's 22-point lead were accurate ($t(49) = 0.92$, $p > .3$).

There was some evidence of overestimating the preferred candidate by intended Obama voters for the 4-point lead item ($M = 270(4.4)$; $t(162) = 2.72$, $p = .007$). Intended Obama voters' estimates of Romney's 4-point lead were not significantly different from the accurate value ($M = 255(3.3)$; $t(173) = -1.01$, $p = .32$). For intended Romney voters, estimates for the 4-point lead items were marginally higher than the accurate value for Romney's 4-point lead ($M = 273(7.8)$; $t(49) = 1.86$, $p = .068$), but generally accurate for Obama's 4-point lead ($M = 268(7.4)$, $t(49) = 1.3$, $p = .192$). Taken together, the follow-up tests indicate that math bias was driven by Obama and Romney voters symmetrically underestimating the opponent's large lead.

To ensure that differences in the difficulty of these items did not contribute to this pattern, we compared standardized differences scores (comprised of the absolute value of the Z-score of their responses subtracted from the accurate value) for the 4-point item ($M = 6.48$) and the 22-point lead item ($M = 6.44$). These values were not significantly different: $t(548) = -0.02$, $p = .987$, suggesting a lack of difference in calculation difficulty.

To summarize, before the 2012 Election, both committed Obama and Romney voters produced math estimates that were biased against the opponent when he was presented as holding the large lead. If participants first encountered the opponent holding a large 22-point lead, they defensively underestimated. By contrast, if they first encountered the preferred candidate holding the large lead, they did not defensively underestimate, rather they produced generally accurate estimates. Thus, motivated mathematical processing stemming from commitment to vote for a particular candidate played out in a logical manner within the experiment.

#### 2.2.3. Expectations

The role of expectations in mathematical bias was examined in an

[3] Instructions: "For the next part of this survey, you will see photographs of crowds of people. Please try your best to estimate (but do not count) the number of people you see in each picture. Each picture will only be presented for a short period of time, so pay close attention or you may miss the pictures."

[4] We note that popular vote estimates for the two candidates did not add up to 100%. This may be partially explained by general impreciseness, and partially by participants assuming that a proportion of the popular vote might go to a candidate other than the two leading candidates or to error.

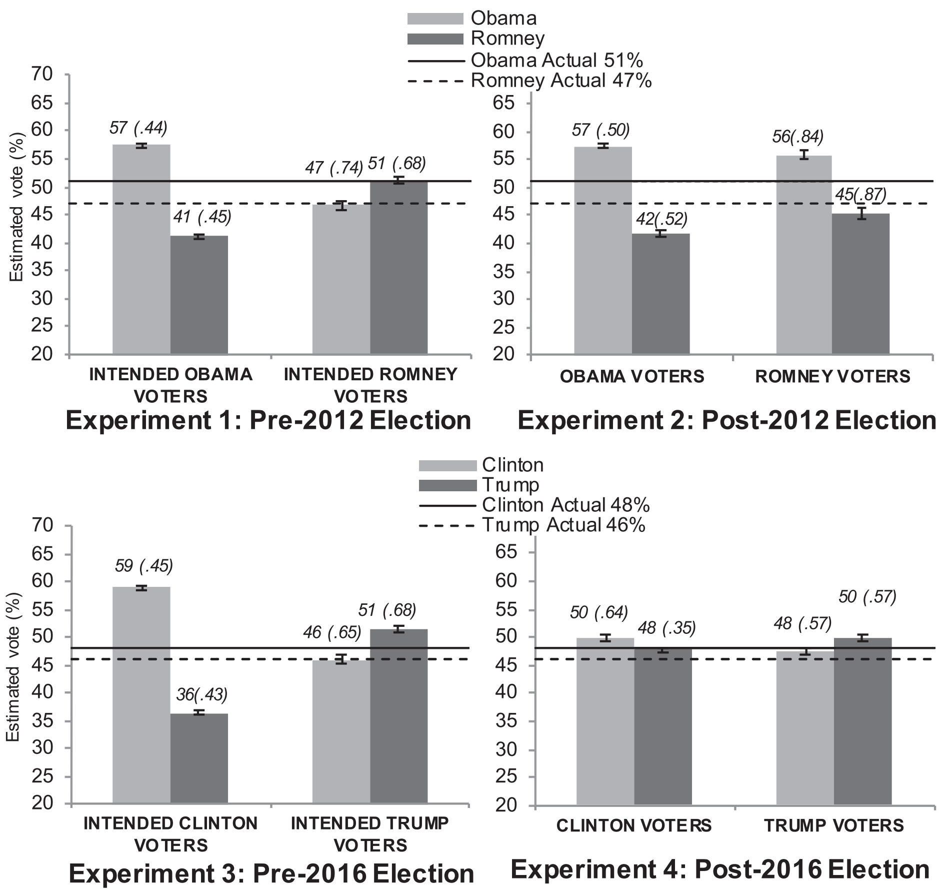


**Fig. 1.** Pre-election predictions and post-election estimates of proportions of the popular vote by candidate. Popular vote predictions were collected in Experiments 1 and 3 before the 2012 and 2016 U.S. Presidential elections (left). Popular vote estimates were collected in Experiments 2 and 4 after the elections (right). Actual popular vote proportions received by the candidates are indicated with solid and dashed lines. Error bars indicate standard error of the mean.

**Table 1**
Average ratings of candidate support and political investment.

| | Experiment 1 | | Experiment 2 | |
|---|---|---|---|---|
| | Obama voters | Romney voters | Obama voters | Romney voters |
| Like Obama | 5.6(0.06) | 2.1(0.12) | 4.9(0.08) | 1.9(0.12) |
| Agree w/ Obama | 5.4(0.06) | 2.0(0.10) | 4.7(0.08) | 1.8(0.11) |
| Like Romney | 1.7(0.05) | 5.0(0.12) | 1.8(0.06) | 4.3(0.15) |
| Agree w/ Romney | 1.7(0.05) | 5.1(0.12) | 1.8(0.06) | 4.6(0.14) |
| Closely follow politics | 4.9(0.08) | 4.7(0.15) | 4.4(0.09) | 4.5(0.16) |
| Importance | 5.7(0.07) | 5.6(0.17) | 5.3(0.09) | 5.4(0.16) |
| Upset | 5.7(0.08) | 5.2(0.17) | 5.4(0.10) | 5.3(0.19) |
| Concern | 4.3(0.09) | 4.6(0.17) | 4.1(0.11) | 4.8(0.18) |
| | **Experiment 3** | | **Experiment 4** | |
| | Clinton voters | Trump voters | Clinton voters | Trump voters |
| Like Clinton | 4.6(0.07) | 1.4(0.05) | 4.8(0.08) | 1.4(0.06) |
| Agree w/ Clinton | 5.2(0.06) | 1.6(0.06) | 5.3(0.07) | 1.6(0.07) |
| Like Trump | 1.3(0.03) | 4.8(0.10) | 1.4(0.04) | 5.3(0.09) |
| Agree w/ Trump | 1.5(0.04) | 5.3(0.08) | 1.6(0.05) | 5.4(0.08) |
| Closely follow politics | 5.2(0.06) | 5.2(0.08) | 5.3(0.07) | 5.2(0.09) |
| Importance | 6.2(0.05) | 5.9(0.08) | 6.2(0.06) | 6.0(0.08) |
| Upset | 6.1(0.06) | 5.5(0.10) | 6.2(0.07) | 1.3(0.05) |
| Concern | 4.6(0.09) | 5.0(0.12) | 5.4(0.09) | 4.9(0.13) |

*Note.* Mean and standard error of the mean shown. All items used 7-point scales.

ANOVA with math bias scores as the dependent variable and between-subjects factors EXPECTATION (who the voter expected to win the election: OBAMA, ROMNEY) × CONDITION (OBAMA-ADVANTAGE, ROMNEY-ADVANTAGE). This was only possible for committed Romney voters (72% expected a Romney win whereas 98.2% of committed Obama voters expected Obama to win). We observed a significant interaction of EXPECTATION × CONDITION ($F(1,96) = 5.64$, $p = .02$, $\eta^2_{partial} = 0.06$; see Fig. 3). Main effects were not significant ($p > .5$).

Follow-up one-sample $t$-tests on participants' raw estimates for the 22-point lead items indicated that Romney voters who expected Romney to win underestimated Obama's lead ($t(37) = -3.4, p = .002$), whereas Romney voters who expected Obama to win did not ($t(11) = 1.37$, $p = .2$). Romney voters' expectations were not significantly associated with estimates of Romney's 22-point lead; there was a trend of underestimation when they expected Obama to win ($t(15) = -1.9$, $p = .08$), estimates trended in the other direction when they expected Romney to win ($t(33) = 1.9$, $p = .07$). Romney voters' expectations were not significantly associated with estimates of Romney or Obama's 4-point lead ($p$'s $> 0.14$).

In sum, these results indicate that expectations together with preferences drove the math biases we observed: Romney voters who expected Romney to win underestimated Obama's advantage.

### 2.2.4. Crowd size estimation task

Estimates of the two Obama rally estimates were averaged for analyses, as were estimates of the two Romney rally estimates. Compared to committed Obama voters ($M(SEM) = 59.26$ (1.19)), committed Romney voters (67.79 (2.7)) provided significantly higher estimates for the Romney rallies ($t(435) = 3.25$, $p = .001$). There was no significant difference between Obama voters (86.47 (3.37)) and Romney voters (93.97 (4.5)) in estimates for the Obama rallies ($p > .26$). Thus, although Romney voters overestimated Romney rallies compared to Obama voters, we did not observe a similar Obama-favoring pattern of bias for Obama voters, see Fig. 4.

To determine whether voters' estimates of Romney and Obama rallies differed relative to the number of people in the images, we conducted one-sample $t$-tests. We took the mean of the counts produced

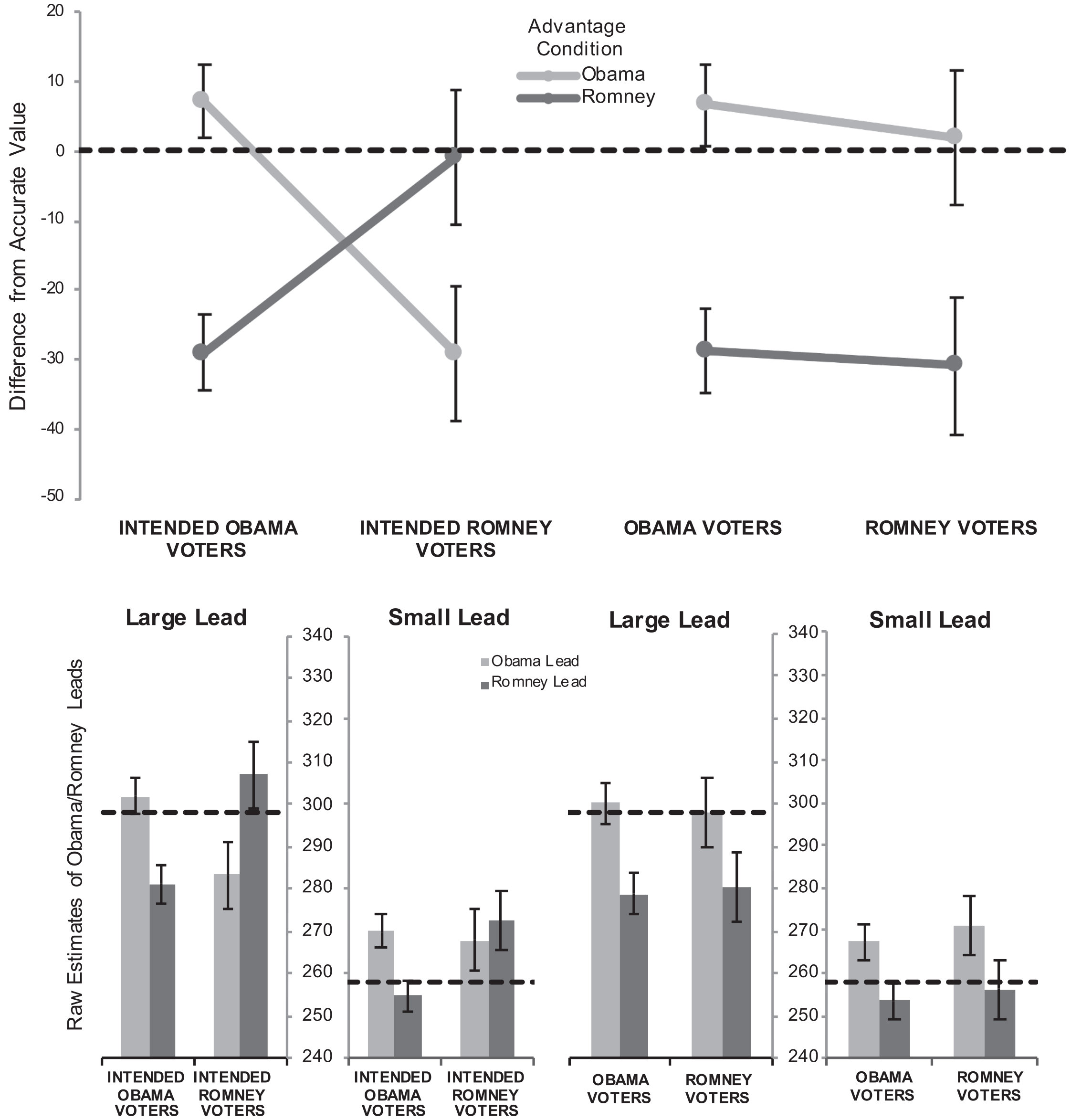


**Fig. 2.** Difference in estimates by candidate support and candidate advantage (top), and raw estimates by candidate support (bottom). Before the 2012 Election (top left panel, bottom left panels), intended Obama and Romney voters demonstrated a pattern of biased processing in which they were more likely to underestimate the opponent's lead. After the Election (top right panel, and bottom right panels), both Obama and Romney voters' responses were more likely to favor the winning candidate (Obama). Accurate values indicated with dashed line. Error bars indicate standard error of the mean.

by twelve research assistants blind to the purpose of the task to establish neutral values for each rally. The crowds did not display candidate signage or other politically themed material (Obama rallies $M = 93$ (SEM = 8.1); Romney rallies $M = 62$ (SEM = 3.8).

Obama voters underestimated both Obama and Romney rallies relative to the neutral values (Obama rallies: $M(SEM) = 86.5(3.4)$, $t(336) = -2.06$, $p = .04$; Romney rallies: $M(SEM) = 59.27(1.2)$, $t(336) = -2.19$, $p = .03$). Romney voters' estimates did not differ from the neutral mean for Obama rallies ($p = .99$); and overestimated Romney rallies ($M(SEM) = 67.79(2.66)$, $t(99) = 2.22$, $p = .03$). In addition, demonstrating that estimation difficulty did not differ between the Obama and Romney rally images and was unlikely to explain Romney voters' overestimation of Romney rallies, on average, voters' estimates of Obama and Romney rallies did not significantly differ from the neutral mean value (p's $> 0.06$).

### 2.3. Summary

In sum, Experiment 1 demonstrated that Obama and Romney voters showed biased math estimates that underestimated the opponent's lead. Further analysis revealed that biases favoring the preferred candidate depended on expectations: intended Romney voters underestimated Obama's lead when they also expected him to win. Despite the symmetrical biases found in the context of mathematical processing, no

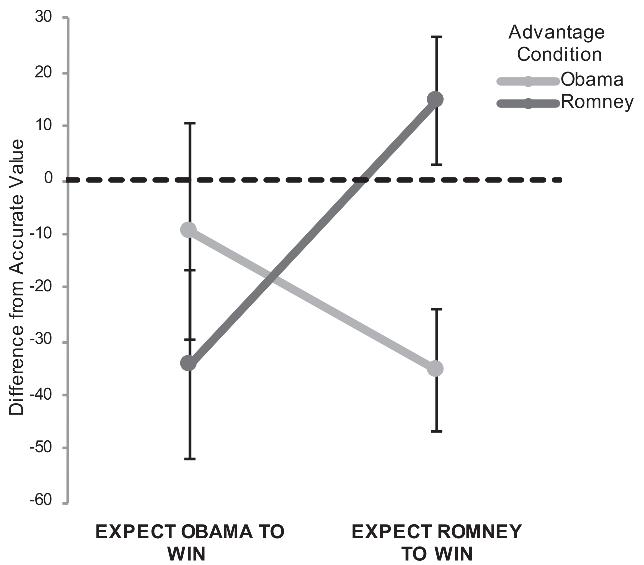


**Fig. 3.** Difference in Romney voters' estimates by expectations and candidate advantage. Experiment 1 showed that before the 2012 Election, only Romney voters who expected Romney, not Obama, to win demonstrated a candidate-favoring bias in estimates. Error bars indicate standard error of the mean.

symmetrical pattern of bias was observed when voters were asked to estimate the size of crowds at rallies. The source of the differences in rally estimates is not clear, as only Romney voters produced candidate-favoring estimates.

## 3. Experiment 2 – After the 2012 election

In Experiment 1, we found a symmetrical bias in estimates of the opponent's lead, and evidence that bias was driven by expectations regarding who would win the election. To determine whether voters would produce similar biased estimates in the absence of an impending election and associated expectations, in Experiment 2 we re-ran the experiment with new group of participants approximately ten months after the 2012 U.S. Presidential Election in which President Obama was re-elected.

### 3.1. Method

#### 3.1.1. Participants and tasks

Participants completed the study online via Amazon.com's Mechanical Turk (Mturk.com) for a small payment. The data of only participants (n = 378, 65% retained[5] after exclusions) who reported voting for Obama ($n = 278$; $M(SD)_{\text{age}} = 33$ (11.3); 129 female; 148 male; 1 selected other) or Romney ($n = 100$; $M_{\text{age}} = 37$ (11.9); 48 female; 52 male) were analyzed. The tasks were identical to those used in Experiment 1 with wording changed to reflect the occurrence of the 2012 Presidential Election in the past where appropriate.

### 3.2. Results and discussion

#### 3.2.1. Popular vote estimates, affinity for the candidates, investment after the election

Obama voters inflated popular vote estimates for Obama ($M = 58\%$) compared to Romney voters ($M = 56\%$), this time not significantly ($t(376) = 1.76, p < .08$). Symmetrically, Romney voters inflated popular vote estimates for Romney ($M = 45\%$) compared to Obama voters ($M = 42\%$; $t(376) = -3.57, p < .000$). While much less dramatic than in Experiment 1, this biasing of the popular vote represents another demonstration of candidate-favoring estimates, even after the election (see Fig. 2).[6]

Again, voters liked and agreed with their chosen candidate significantly more than the opponent, as in Experiment 1 (see Table 1, $p$'s $< .001$). There were no significant differences between Obama and Romney voters in most measures of investment in the election (Table 1), including how important the outcome was, how closely they followed politics, or how upset Obama voters reported they would have been if Romney had won, and how upset Romney voters reported they were by Obama's win (Table S1). Romney voters reported that they had been more concerned that their candidate would lose than Obama voters (Table 1, $t(376) = -3.4, p < .001, d = -0.35$).

#### 3.2.2. Mental calculations after the election

As in Experiment 1, we computed a math bias score based upon their responses to the mental calculation questions. The math bias score served as the dependent variable in an ANOVA with the between-subjects factors: VOTE (who the participant voted for: OBAMA, ROMNEY) × CONDITION (OBAMA-ADVANTAGE, ROMNEY-ADVANTAGE). This time, only the main effect of CONDITION was significant ($F(1,374) = 17.67$, $p < .0001$, $\eta^2_{partial} = 0.05$; see top right panel of Fig. 2). The interaction of VOTE × CONDITION and main effect of VOTE were not significant ($p$'s = .67).

Follow-up one-sample $t$-tests on participants' raw estimates indicated that both Obama and Romney voters significantly underestimated Romney 22-point lead (see bottom right panel of Fig. 2). Obama voters' estimates of Romney's 22-point lead were significantly lower than the accurate value of 298 ($t(134) = -3.3$, $p < .001$), as were Romney voters' ($t(48) = -1.99, p = .05$). For the second, 4-point lead item, an identical pattern of estimates favoring Obama over Romney for all voters was observed (see bottom right panel of Fig. 2). Both Obama voters' ($t(134) = 2.2$, $p < .03$) and Romney voters' (not significantly: $t(48) = 1.6$, $p < .12$) estimates of Obama's 4-point lead were higher than the accurate value. Their estimates of Romney's 4-point lead were not significantly different from the accurate value ($p$'s $> 0.3$).

#### 3.2.3. Crowd size estimation task

There was no difference between Obama voters (M(SEM) = 101.35 (9.88)), versus Romney (104.21 (16.48)) voters in estimates of the Obama rallies ($p > .88$); or for Obama voters (65.24 (4.22)) versus Romney voters (69.77 (7.04)) in estimates of the Romney rallies ($p > .58$); see Fig. 4. In terms of comparison with the neutral participants' counts, Romney voters were again different from the neutral count of the people in Romney rallies; they estimated significantly higher than the neutral value of 62 ($M(SEM) = 69.8(3.4)$, $t(99) = 2.28$,

[5] Recruited random sample included 741 participants–this number reflected our aim to repeat Experiment 1 and again obtain sufficient Romney voters, taking into account typical online repeat participation; failure to complete study, follow directions, or pass attention checks; greater representation of politically liberal people in the subject pool; and the relatively smaller number of committed Romney voters compared to Obama voters found in Experiment 1. Exclusion criteria were, as in Expt 1, (1) repeat participation (n = 45) or failure to provide ID (n = 43), (2) failure of catch question (n = 65), and (3) failure to follow directions (n = 39). Of the 549 remaining participants, 171 participants who did not vote for Obama or Romney were then excluded.

[6] A lack of knowledge about reasonable percentages of the popular vote received by Obama and Romney, or a biasing of memory for the results favoring the outcome, likely produced the exaggerated spread between the candidates for both Obama and Romney voters (in fact, Obama won 51% and Romney won 47%); therefore both Obama and Romney voters significantly overestimated Obama's, and Obama voters significantly underestimated Romney's percentages; $p$'s < .001). However, a general lack of knowledge cannot account for the significant interaction indicating that both groups produced candidate-favoring estimates (see Fig. 2).

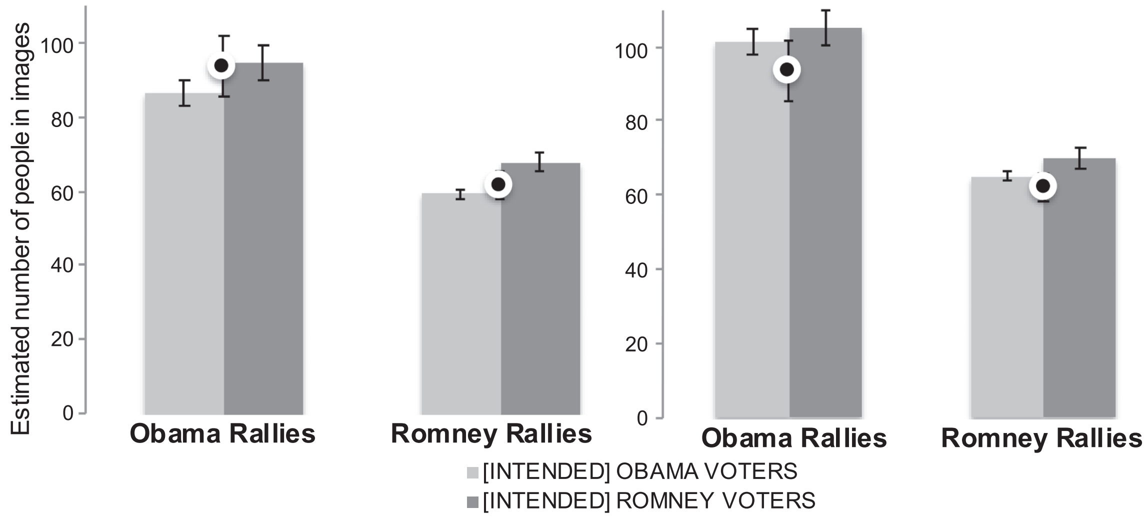


**Fig. 4.** Crowd size estimates by candidate support. Some partisan effects were observed with Romeny voters. In Experiment 1 (left panel), before the 2012 Election: Romney voters (darker bars) overestimated Romney rallies relative to Obama voters. In addition, relative to the neutral counts (indicated with black marker), Romney voters overestimated Romney rallies both before and after the Election (left and right panels). Obama voters generally underestimated both Obama and Romney rallies before the election. Error bars indicate standard error of the mean.

$p$ = .025). Obama voters' estimates were not different from the neutral value. Merging voters, estimates were again not statistically different from neutral participants' for Obama and Romney rallies ($p$'s > .21)

### 3.3. Summary

In Experiment 2, Obama and Romney voters demonstrated biased mathematical processing that favored the candidate who actually won (Obama) – with stronger effects for the 22-point lead item compared to the 4-point lead item. Participants "corrected" statistics incongruous with reality, whereas in Experiment 1, they "corrected" statistics incongruous with their views of expected reality.

## 4. Experiment 3 – Before the 2016 election

In Experiments 1–2, we found that participants underestimated the opponent's lead before the election (Experiment 1), and that candidate-favoring biases disappeared after the election (Experiment 2). Here in Experiment 3, we re-ran the pre-election experiment just before the 2016 U.S. Presidential Election involving Donald Trump and Hillary Clinton to investigate whether these patterns replicated when the paradigm was extended to new candidates.

### 4.1. Method

#### 4.1.1. Participants and tasks

Participants completed the study online via Amazon.com's Mechanical Turk (Mturk.com) for a small payment within the five-week period before the 2016 U.S. Presidential Election. The data of the participants (n = 725, 56% retained[7] after exclusions) who reported an intention to vote for Donald Trump ($n$ = 257; $M(SD)_{age}$ = 39.97(12.4); 144 female; 113 male) or Hillary Clinton ($n$ = 468; $M(SD)_{age}$ = 36.05(17.9); 277 female; 189 male; 2 selected other) were analyzed.

The experiment used the mental calculations items from Experiment 1 except questions were reworded to refer to the two candidates in the 2016 election (Hillary Clinton and Donald Trump). No crowd estimation task was given. Because popular vote estimates were higher for the candidate participants supported in Experiments 1–2, participants in Experiment 3 were asked to estimate what proportion of the popular vote they estimated each of the two major candidates would win prior to measurement of their political affiliations to determine whether this would affect the relationship between candidate support and popular vote estimates. It did not (see next section).

### 4.2. Results and discussion

#### 4.2.1. Voter intentions and expectations, affinity for the candidates, investment before the election

As in Experiment 1, committed Clinton voters overwhelmingly (98.3%) reported expecting that Clinton would win; and the majority of Trump voters expected Trump would win (60%). That a full 40% of committed Trump voters expected a Hillary Clinton win is notable. As in Experiment 1, estimates of the proportion of the popular vote each candidate was expected to receive reflected participants' voting intentions (see Fig. 2). Clinton voters inflated popular vote estimates for Clinton ($M$ = 59%) compared to Trump voters ($M$ = 46%; $t(723) = -16.65$, $p < .000$). Likewise, Trump voters inflated popular vote estimates for Trump ($M$ = 51%) compared to Clinton voters ($M$ = 36%; $t(723) = 19.64$, $p < .000$). As Fig. 2 illustrates, Clinton supporters were more confident in their candidate than Trump supporters, in terms of more biased popular vote predictions and a greater majority believing their preferred candidate would win.[8]

As in all prior experiments, participants liked and agreed with their chosen candidate significantly more than the opponent (p's < .001; see

[7] Recruited random sample included 1281 participants. We aimed for approximately 100 Trump voters per condition. We were unsure of our ability to recruit Trump supporters from the Amazon Turk pool, taking into account failure to complete the study, follow directions, or pass attention checks; and greater representation of politically liberal people in the subject pool. We excluded participants: for (1) failure of catch question (n = 159), and (2) failure to follow directions (n = 62; participants who provided nonsense values, values greater than the value they were asked to operate on, or who provided percentages such as "65%" or values under one hundred that could have been percentages for test items. Of the remaining participants, 335 did not intend to vote for Trump or Clinton and were excluded from analysis).

[8] This is reminiscent of the pattern shown by Obama supporters relative to Romney supporters in Experiment 1, but is not necessarily a reflection of liberal voters being more likely to engage in wishful thinking in general (though it could be). More likely, it reflects the fact that both liberal candidates (in 2012 and 2016) were considered the favorites according to the majority of public polls.

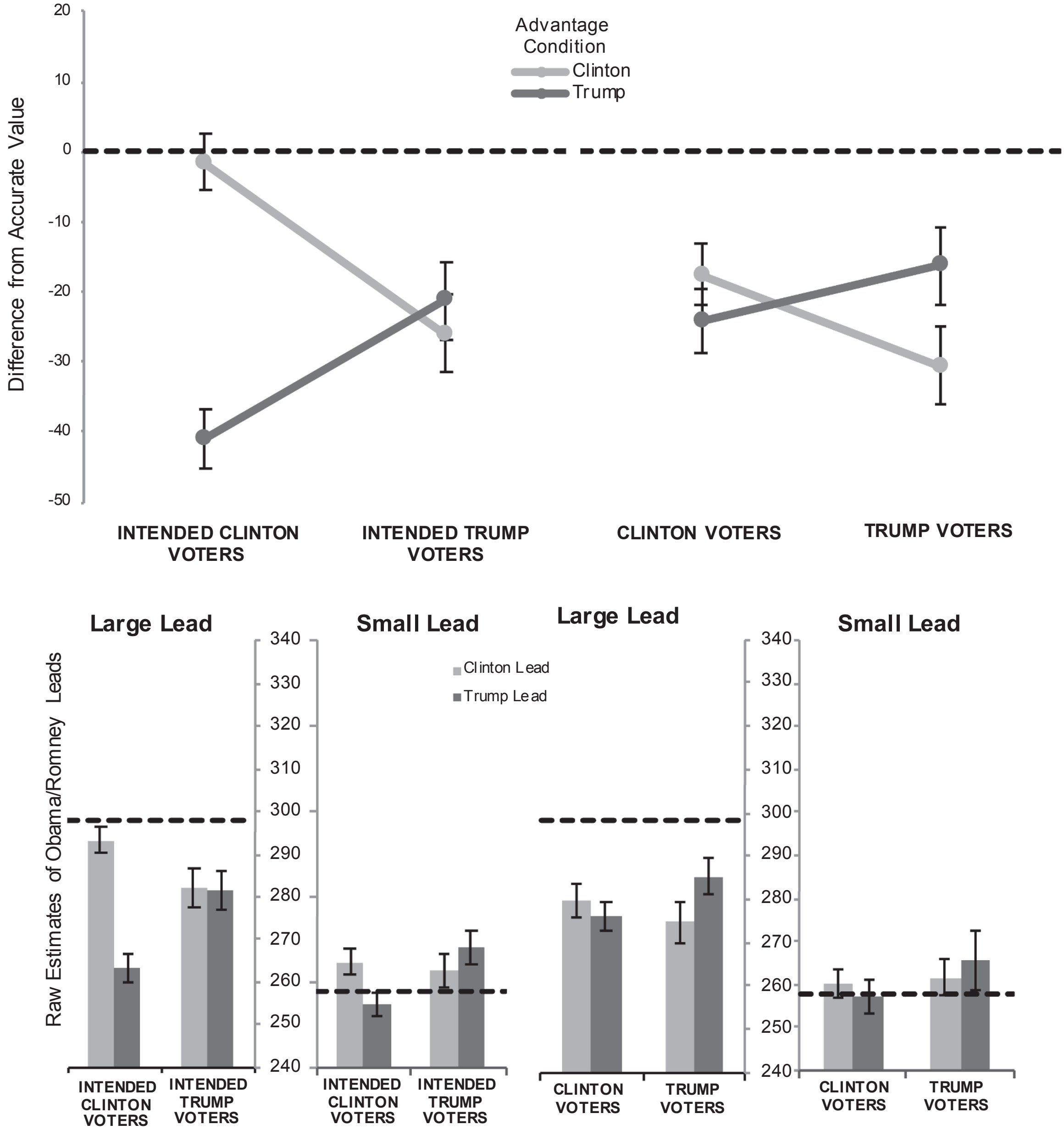


**Fig. 5.** Difference in estimates by candidate support and candidate advantage (top), and raw estimates by candidate support (bottom). Before the 2016 Election (top left panel, bottom left panels), intended Clinton and Trump voters demonstrated a pattern of biased processing in which they were more likely to underestimate the opponent's lead. After the Election (top right panel, bottom right panels), estimates were generally not indicative of candidate-favoring processing. Accurate values indicated with dashed lines. Error bars indicate standard error of the mean.

Table 1). Trump voters reported that they were more concerned that their candidate would lose than Clinton voters (Table 1, $t(723) = -2.3$, $p < .001$, $d = -0.17$). The outcome of the election was rated as more important to Clinton voters than Trump voters ($t(723) = -3.1$, $p < .001$, $d = -0.23$), and Clinton voters said they would be more upset than Trump voters if the other candidate won ($t(723) = -5.4$, $p < .001$, $d = -0.40$). There was no difference in how closely they followed politics ($p > .91$).

#### 4.2.2. Mental calculations before the election

As in the previous experiments, the math bias score served as the dependent variable in an ANOVA with the between-subjects factors: VOTE (who the participant planned to vote for: TRUMP, CLINTON) × CONDITION (TRUMP-ADVANTAGE, CLINTON-ADVANTAGE). We found a significant main effect of CONDITION ($F(1,721) = 12.77$, $p < .0001$, $\eta^2_{partial} = 0.02$) and a significant interaction ($F(1,721) = 20.52$, $p < .0001$, $\eta^2_{partial} = 0.03$) of VOTE × CONDITION (see top left panel of Fig. 5). The main effect of VOTE was not significant ($p > .6$).

Follow-up one-sample $t$-tests on participants' raw estimates indicated that once again, voters underestimated the opponent's big lead (see bottom left panel of Fig. 5). Intended Trump voters' estimates of Clinton's 22-point lead were significantly lower than the accurate value of 298 ($t(126) = -3.05$, $p = .003$), as were Clinton voters' estimates of Trump's 22-point lead ($t(222) = -9.1$, $p < .0001$). This time, voters also underestimated their own preferred candidates' large leads as well: Trump voters underestimated Trump's lead ($t(129) = -3.9$, $p > .0001$), and Clinton voters underestimated Clinton's lead ($t(244) = -1.9$, $p = .05$).

There was overestimation of the preferred candidate's 4-point lead by both intended Trump voters ($t(126) = 2.2$, $p = .03$) and Clinton voters ($t(222) = 2.0$, $p = .05$; see bottom left panel of Fig. 5). Estimates of the opponent's 4-point lead were not significantly different from the

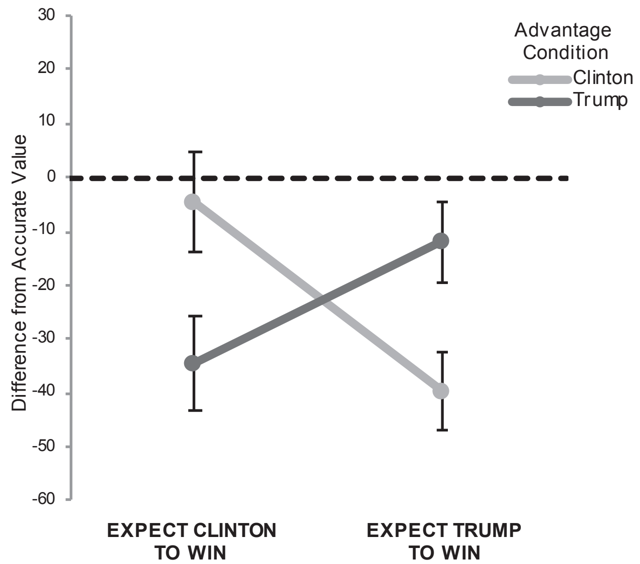


**Fig. 6.** Difference in Trump voters' estimates by expectations and candidate advantage condition. As in Experiment 1, in Experiment 3 before the 2016 Election, only Trump voters who expected Trump, not Clinton, to win demonstrated a candidate-favoring bias in estimates. Error bars indicate standard error of the mean.

accurate value (Trump voters: $t(129) = 1.2$, $p = .22$; Clinton voters: $t(244) = -1.2$, $p = .21$). Taken together, results indicate that math bias in Experiment 3 was driven by Trump and Clinton voters symmetrically underestimating the opponent's large lead (as in Experiment 1), and overestimating their preferred candidates' small lead.

#### *4.2.3. Expectations*

As in Experiment 1, we examined the role of expectations in mathematical bias with an ANOVA on math bias scores with the between-subjects factors: EXPECTATION (who the participant expected to win the election: TRUMP, CLINTON) × CONDITION (TRUMP-ADVANTAGE, CLINTON-ADVANTAGE). Again, this was only possible for intended Trump voters since 98% of Clinton voters expected her to win, whereas 60% of Trump voters expected him to win. We observed a significant interaction of EXPECTATION × CONDITION ($F(1,252) = 12.2$, $p = .001$, $\eta^2_{partial} = 0.05$; see Fig. 6). Main effects were not significant ($p > .45$).

Follow-up one-sample *t*-tests on participants' raw estimates for the 22-point lead items indicated that Trump voters who expected Trump to win underestimated Clinton's lead ($t(76) = -3.9$, $p = .0002$), whereas Trump voters who expected Clinton to win did not ($t(48) = 0.42$, $p = .7$). Moreover, Trump voters underestimated Trump's 22-point lead when they expected Clinton to win ($t(53) = -4.6$, $p < .0001$); but not when they expected Trump to win ($p = .23$). Tests for the 4-point lead items indicated that Trump voters who expected Trump to win overestimated Trump's lead ($t(76) = 2.12$, $p = .04$), whereas Trump voters who expected Clinton to win provided generally accurate estimates of Trump's 4-point lead ($t(48) = 0.95$, $p = .35$). Trump voters expectations were not significantly associated with estimates of Clinton's 4-point lead ($p$'s $> .23$).

Taken together, these results replicate Experiment 1 and indicate that preferences combined with expectations drove Trump voters' biased estimates: they underestimated Clinton's advantage and overestimated Trump's advantage when they expected Trump to win (Fig. 6).

### *4.3. Summary*

Experiment 3, conducted just prior to the 2016 U.S. Presidential election, replicated findings of Experiment 1, conducted just prior to the 2012 U.S. Presidential election. The majority of both Clinton voters and Trump voters demonstrated wishful thinking in their predictions for the outcome of the presidential election. Biases in their answers to a math problem with political framing aligned more closely with Trump voters' expectations for the outcome than with their commitments their candidate.

## 5. Experiment 4

Expectations become irrelevant, and so biases should be as well, when we have hindsight to show exactly what happened. Experiment 2, conducted 10 months after the 2012 election supported this prediction. We aimed to replicate and bolster the results of Experiment 2 with Experiment 4, this time testing the same voters from Experiment 3 approximately a month later. In addition, by testing the same voters as in Experiment 3, we were able to examine the extent to which estimation biases before the election related to reported voting behavior on election day.

### *5.1. Method*

We re-ran Experiment 3 in days 4–10 after the 2016 U.S. Presidential Election in which Donald Trump was elected.

#### *5.1.1. Participants and tasks*

We invited the participants[9] who completed Experiment 3 to complete Experiment 4 via Amazon.com's Mechanical Turk (Mturk.com) for a small payment. The data of only participants (74% retained after exclusions) who reported voting for Trump ($n = 245$; $M(SD)_{age} = 39.56(12.1)$; 128 female; 117 male) or Clinton ($n = 372$; $M(SD)_{age} = 36.64(11.8)$; 217 female; 155 male) in the election were analyzed. Wording was changed to reflect the occurrence of the 2016 Presidential Election in the past where appropriate.

### *5.2. Results and discussion*

#### *5.2.1. Popular vote estimates, affinity for the candidates, and investment after the election*

First, as in Experiment 2 (conducted just after the 2012 election), a small but systematic bias was found in mean estimates of the percentage of the popular vote each candidate received based on who participants had voted for. Clinton voters still inflated popular vote estimates for Clinton ($M = 50\%$) compared to Trump voters ($M = 48\%$; $t(615) = -3.63$, $p < .000$); symmetrically, Trump voters still inflated popular vote estimates for Trump ($M = 50\%$) compared to Clinton voters ($M = 48\%$; $t(615) = 3.6$, $p < .000$). While certainly less dramatic than that of pre-election Experiments 1 and 3, these estimates of the popular vote represent another demonstration of candidate-favoring bias even after the election, and are consistent with the findings of Experiment 2. Although Trump voters estimated that a higher proportion of the popular vote went to Trump than to Clinton, it should be noted that Clinton did actually win a majority of the popular vote, despite losing the election based upon the electoral college.

Clinton and Trump voters liked and agreed with their chosen candidate significantly more than the opponent, as in all the previous experiments (Table 1). There was no difference in how closely they followed politics ($p > .22$). Clinton voters' ratings of "concern that their

[9] 109 additional people did not provide an ID and were unable to be checked as repeat participants so were not included. N = 72 were excluded because they failed the catch question or (n = 36) failed to follow directions by providing nonsense values. Participants in Experiment 3 and 4 also completed additional tasks (Implicit Causality Task and a survey about how appreciated they felt at home and work) at the end of the task, not discussed here; all materials available at the corresponding authors repository.

party would not be in power after the election" exceeded Trump voters' ($t(615) = -3.1$, $p = .002$, $d = -0.25$); they rated the election as more important to them than Trump voters ($t(615) = -2.13$, $p = .033$, $d = -0.17$); and, unsurprisingly, given Clinton's win of the majority of the popular vote, Clinton voters were vastly more upset by Trump's win than Trump voters ($t(615) = -49.7$, $p < .001$, $d = -4.01$).

#### 5.2.2. Mental calculations after the election

As in Experiments 1–3, the math bias score served as the dependent variable in an ANOVA with the between-subjects factors: VOTE (who the participant voted for: TRUMP, CLINTON) × CONDITION (TRUMP-ADVANTAGE, CLINTON-ADVANTAGE). We found a significant interaction ($F(1,613) = 4.3$, $p = .04$, $\eta^2_{partial} = 0.01$) of VOTE × CONDITION (see top right panel of Fig. 5). Main effects were not significant ($p > .4$).

Follow-up one-sample *t*-tests on participants' raw estimates indicated broad underestimation for the 22-point lead item (see Fig. 5): both Trump voters ($t(123) = -2.4$, $p = .02$) and Clinton voters ($t(180) = -6.0$, $p < .0001$) underestimated Trump's lead; likewise, Trump voters ($t(120) = -4.7$, $p < .0001$) and Clinton voters ($t(190) = -5.1$, $p < .0001$) underestimated Clinton's 22-point lead. Estimates of 4-point leads for the preferred candidate and opponent were not significantly different from the accurate value (*p*'s > .14). The significant interaction was driven by Trump voters slightly favoring Trump in their estimates: they demonstrated slightly less mathematical bias in the TRUMP-ADVANTAGE condition ($M = -16.3$, $SEM = 4.77$) compared to the CLINTON-ADVANTAGE condition ($M = -30.6$, $SEM = 6.122$; $t(243) = 1.85$, $p = .065$). Clinton voters also directionally favored Clinton, but the difference in math bias between the TRUMP-ADVANTAGE condition ($M = -24.2$, $SEM = 5.02$) and the CLINTON-ADVANTAGE condition ($M = -17.6$, $SEM = 4.06$) was not significant ($t(370) = -1.03$, $p = .31$).

In sum, as in post-Election Experiment 2, here in Experiment 4, we found that large symmetrical candidate-favoring biases were gone after the election. Voters generally deflated estimates across both candidates. These results are consistent with upset and confusion that occurred in the days after the election as a result of Clinton's loss despite winning (48.2–46.1%) the popular vote (e.g., large-scale protests broke out nationally). We note as well that estimates were generally lower across all participants, on average, in 2016 (Experiments 3 and 4), compared to 2012 (Experiments 1 and 2). One possibility is that the psychological resources that supported participants' inflated estimates (strong preferences and high expectations) were both challenged more in 2016 with candidates Trump and Clinton, compared to 2012 with candidates Romney and Obama.

#### 5.2.3. Exploratory analyses: Examining pre-election math bias (Experiment 3) and voting reported in Experiment 4

We re-contacted participants from Experiment 3; therefore, we were able to explore connections between biased estimations in Experiment 3 and voting behavior reported in Experiment 4 in 217 Trump voters, 329 Clinton voters, and 57 respondents who did not vote.[10]

*Math bias pre-election and voting behavior.* We were first interested in the mathematical biases of participants who planned to vote for Clinton or Trump, but ultimately did not vote or voted for the opponent. Of Clinton supporters (in Experiment 3 who took Experiment 4), only 19/322 did not vote or voted for another candidate. Of Trump supporters in Experiment 3 who took Experiment 4, only 8/191 did not vote or voted for another candidate in Experiment 4. These proportions indicate that people overwhelmingly did not deviate from their voting intentions. Because there was insufficient variability to allow for analyses of biases in those who did and did not carry out their voting intentions, we next compared participants who did not vote in the election to those who did.

Of the participants who did not vote, 77% (n = 44) reported in Experiment 3 that they expected Clinton to win; 12% (n = 7) expected Trump to win; 6 declined to make a prediction. Thus, the majority of those who did not vote had expected Hillary Clinton to win. We examined math biases in those who did not vote and those who did. People who did not vote (n = 28; *M(SEM)* = −62.07 (12.41)) had more extreme math biases pre-election in the TRUMP-ADVANTAGE condition compared to those who voted for Trump (n = 109; $M = -15.76$ (6.29)), Clinton (n = 168; $M = -36.76$ (5.07)), or Other (n = 47; $M = -32.55$ (9.56); $F(3,348) = 4.47$, $p < .004$; $\eta^2_{partial} = 0.04$; see Fig. 7 top panel). As shown in Fig. 7 (bottom panel), the non-voters gave substantially reduced pre-election estimates of Trump's large lead, and increased pre-election estimates of Clinton's small lead. In the CLINTON-ADVANTAGE condition, math bias did not significantly differ between groups ($p > .09$). Post-election in Experiment 4, math bias also did not significantly differ between groups ($p > .2$). In sum, people who did not vote – who by and large expected Clinton to win – showed math biases before the election when Trump was presented as having the advantage: they underestimated Trump and overestimated Clinton.

## 6. General discussion

Novel evidence of motivated cognition in the political domain was obtained across four experiments. First, in Experiments 1 and 3, committed voters demonstrated "wishful thinking" (e.g., Babad & Yacobos, 1993; Koudenburg et al., 2011; Krizan et al., 2010; Krizan & Sweeny, 2013; Morwitz & Pluzinski, 1996). Three-quarters of committed Romney voters, sixty-percent of Trump voters, and nearly all committed Obama and Clinton voters reported expecting the candidate they had committed to voting for to win. Committed voters also inflated the proportion of the popular vote their preferred candidate would receive before the election. Moreover, voters showed a tendency to downplay the opposition by producing mental math solutions that put the opponent at a distinct disadvantage. In Experiments 1 and 3 held before the elections, when participants performed mental math based on fictional polling statistics indicating the opponent held a large 22-point lead, they systematically underestimated support for the opponent relative to the preferred candidate.

Importantly, however, when expectations were taken into account, it became clear that our results principally demonstrated "expectant thinking" rather than "wishful thinking". In particular, we found that committed voters who expected the opponent to win (Romney voters expecting an Obama win in Experiment 1; Trump voters expecting a Clinton win in Experiment 3) produced estimates of the opponent's 22-point lead that resembled those of voters who preferred the opponent (i.e., Obama and Clinton voters). Crucially, we found that rather than reflecting candidate-favoring preferences, these math biases reflected participants' expectations of who would actually win the elections. This finding demonstrates an important role for expectations in processing biases in the political domain: a necessary condition for biases in favor of one's preferred candidate may be not only a wish, but an expectation, that they will actually win.

The results of these experiments align with and extend previous findings of differing effects on processing of politically related information based on cognitive consistency (Granberg & Nanneman, 1986; Krizan & Sweeny, 2013; Morwitz & Pluzinski, 1996). Specifically, in prior work, when voters entered experiments in a state of cognitive consistency—intending to vote for a particular candidate and expecting a win—and then encountered dissonant polling information, they defensively resisted the information by maintaining their expectations and preferences (Experiment 3 in Morwitz & Pluzinski, 1996). Underestimation of the opponent's large 22-point lead by voters who expected their favored candidate to win suggests that this lead was sufficiently dissonant to trigger reactive deployment of motivated mathematical processing. By contrast, in the case of the large 22-point lead by their

[10] Exclusions from Experiments 3 and 4 were applied.

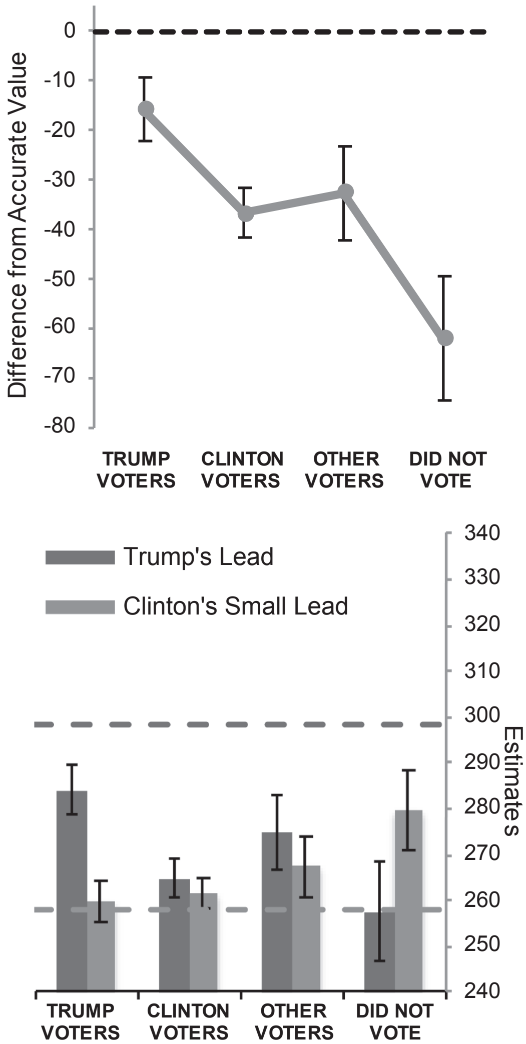


**Fig. 7.** Pre-Election math bias (top) and raw estimates (bottom) in the Trump-advantage condition in Experiment 3 in participants who reported voting activity in Experiment 4. The math bias of participants who did not vote was larger than those who voted for Trump, Clinton, and Other (top panel). They underestimated Trump's lead (bottom panel, darker dotted line indicates accurate value for Trump's lead), and overestimated Clinton's small lead (bottom panel, lighter dotted line indicates accurate value for Clinton's small lead). Error bars indicate standard error of the mean.

preferred candidate or the candidate they expect to win, voters produced accurate solutions. Here, voters' preferences and expectations were unchallenged and motivated mathematical processing was not triggered.

Altering of mathematical processing in the service of cognitive consistency can likewise explain the results of Experiments 2 and 4. In Experiment 2, *both* Obama and Romney voters produced lower estimates of Romney's versus Obama's support. After the election, all participants could reflect on the historical record, resulting in a shared reality in which Obama won and Romney lost. For all voters, Obama holding the advantage was consistent with reality, whereas Romney holding the advantage was not. The observed underestimation of Romney's large lead by both Obama and Romney voters demonstrates that people "corrected" statistics to line up with reality. This converges with other findings of constraints on motivated cognitive biases for real versus hypothetical events (Armor & Sackett, 2006). Similarly, in Experiment 4, voters produced generally low estimates. Remaining bias was present only as a slight hint by Trump voters. Voters' broad underestimation for both Trump and Clinton could be explained by the unusual election outcome in 2016 in which Trump lost the popular vote, Clinton lost the election, and a period of widespread public unrest ensued.

We did not find symmetrical candidate-favoring biases for the crowd estimation task (Experiments 1 and 2), although in Experiment 1, Romney voters produced higher estimates of Romney rallies than Obama voters, and estimates that were significantly higher than the accurate value. A lack of symmetrical biases in crowd estimates compared to mental math solutions may stem from differences in the numerical processing demands of these tasks (Crollen et al., 2011). The crowd size estimation task required rudimentary numerical representation: participants assessed numeric magnitude from a quick look at a picture and reported that value. The mental math involved a multi-step operation with each numerical representation vulnerable to bias: the number of people in the given county sample, the given percentage that supported their candidate versus the opponent, the value they settled on as the solution. Although people are aware that a math problem has an objectively correct answer and this may have worked against bias, quantifications involving more steps are also reasonably presumed to be more error-prone than those with fewer steps. Restraints on biases may be relaxed when claiming clumsy math could allow one to evade characterization as biased.

It is also possible that that biases in crowd size estimates were only observed in Romney voters and not in Obama voters due to an order effect that functioned as a manipulation of motivation for Romney voters. All participants estimated a purported Obama rally first, followed by a Romney rally, another Obama rally, and finally another Romney rally. Encountering an Obama rally first may have led Romney voters to overestimate the subsequent Romney rallies. Although order of rally presentation might have influenced the pattern of results, it seems unlikely that this accounts for the overall overestimation by the Romney voters relative to the Obama voters for Romney rallies, specifically. Indeed, research on basic magnitude estimation would predict underestimation in general, and thus, that we'd see voters underestimate the number of voters in each rally (Crollen et al., 2011). However, Romney voters provided estimates that were significantly greater than the actual number of individuals within the rally pictures for Romney rallies, suggesting a tendency to estimate more individuals in rallies for their preferred candidate. The numerical estimation of crowds, and how public figures and the media report these estimates, is certainly a potentially important influence on political behavior. These findings suggest future studies should follow-up by more carefully counterbalancing the stimuli in order to fully address the question of whether crowd estimates differ as a function of political commitment.

Biased math was reliably observed in participants' solutions for the first math problem they encountered, which showed underestimation of the large, 22-point lead of the opponent. Biased math was less reliably observed in their solutions for the second math problem, which trended toward overestimation of the preferred candidate's 4-point lead. Differences in the difficulty of these items was unlikely to have contributed to this pattern, as supported by no difference in the magnitude of deviation between the 4-point and 22-point lead items. Even if there was a difference in difficulty between the 22-point and 4-point lead items, would this pose an issue for our primary findings? Item difficulty, rather than candidate-favoring processing biases playing out within the design of the experiment, cannot explain our pattern of results which show targeted underestimation of the opponent, and only before the elections.

We did observe mostly null findings – or a lack of political bias – in a task considered simple: estimating numerical magnitude of rally crowd sizes. This contrasts with the main findings showing comparatively strong bias in a math problem involving estimating a value equivalent to the proportion of another value. It is possible that future research that systematically investigates how political bias affects mathematical processing might uncover wide-ranging vulnerabilities to math from bias, based on difficulty. This endeavor might be approached with matched tasks varying in complexity. Furthermore, such tasks will enable researchers to address another open issue regarding at which point in cognitive processing political bias occurs. That is, does mathematical processing become biased in a particular way, or at multiple steps; or, is the final answer altered to conform to expectations? When one of these, or both occur, or whether people make us of different strategies in different situations are questions for targeted future research.

Finally, these results are also representative of the common error in which people infer that a particular sample from a population (voters in an anonymous county) must be representative of that population (Tversky & Kahneman, 1971). Yet purely cognitive sources of bias, such as a general problem with statistical representativeness, do not explain patterns of estimates aligning with voters' commitments and expectations. Before the 2012 election, mental models of the United States voting population were apparently Obama-favoring for committed Obama voters, and Romney-favoring for Romney voters—and people's biased mathematics on the samples they were given resulted in estimates more representative of these candidate-favoring models. After the election, participants didn't need to speculate: the population was one that ultimately elected President Obama. This time, people's biased mathematics on the samples resulted in estimates more representative of the now shared reality between Obama and Romney voters. In 2016, after the election, the tested sample went from being split into factions: (i) voters with a Clinton-favoring mental model of the population, or (ii) voters with a Trump-favoring mental model of the population, to a sample that generally underestimated *both* candidates, possibly reflecting the confusing election outcome in which Trump lost the popular vote and Clinton lost the election. Voters' commitments and expectations most often aligned (almost 100% of the time for Obama and Clinton voters). The cases in which they did not (for a portion of Romney and Trump voters) allowed us to observe that expectations affected calculations in a surprising way – shifting biases in calculations toward the dis-preferred candidate. Taken together, these results spotlight how people's beliefs about the way things did or will actually turn out importantly affect their calculations involving political polling statistics.

To what extent people are able to report that they hold particular expectations independent of their preferences, and how differences in accessibility might factor into the effects of expectations is a question for future research. For example, it might be that despite being aware that one's mathematical solutions deflated the opponent, these solutions still reinforce one's support of a candidate. Or, like other manifestations of the "psychological immune system" involving defenses like dissonance reduction, when one's biases are brought to light, they might lose their impact on associated behaviors and beliefs (Gilbert, Pinel, Wilson, Blumberg, & Wheatley, 1998). We also note that we have been discussing the findings as biased mathematical processing, yet another interpretation is that the partisan estimates are evidence of adaptive cognition, rather than irrational biases. The estimation shifts were found across party lines. To the extent that one views political ideology as resulting from rational self-interest, one might interpret the cognition that brings people's estimates in line with their political interests to be rational as well. Moreover, we found expectations, in addition to preferences, to be a strong contributor to participants' biases. When participants did not expect their preferred candidate to win, their mathematical biases were not present, indicating participants' preferences and models of likelihood did not completely overlap.

### 6.1. Conclusions and implications

It is remarkable that given the differences in the political climates and the particular candidates, symmetrical candidate-favoring biases were observed across both election year 2012 and 2016. In both years, committed voters demonstrated biased mathematical processing that underestimated the opponent when confronted with polling information that was dissonant with their expectations and preferences. In both years, voters who admitted they did not expect their preferred candidate to win failed to show candidate-favoring mathematical biases. After the Election, (in 2012) voters ceased to show symmetrical candidate-favoring biases and instead produced solutions in alignment with the actual election result; (in 2016) voters showed a flattened-out pattern of generally low estimates. These findings indicate that a motivation to maintain mental models consistent with expectations affects mathematical processing in the political domain. Before the elections, commitment to a candidate involved maintaining mental models infused with hopeful expectations along with strong affinity for their candidate and inflation of the likelihood that others shared their view. Presented with dissonant polling information, cognitive consistency was maintained by opponent-deflating mathematics, if participants also expected the preferred candidate would win.

It has been suggested that biased cognition in the political context may contribute to voter turn-out and post-election disappointment (Krizan & Sweeny, 2013). The present results suggest the extent of intended voters' candidate-favoring math bias could signal whether they actually expect the candidate they intend to vote for to win. The capacity for erroneous math in politics to affect other political behavior, and the effects of altering such biases are areas ripe for investigation. Other recent work has found that greater skill in numeracy was related to *increased* numerically-based political polarization effects. This suggests that identity preservation will be pursued to the extent that it can be and with the means available – and that quantitative skill will not necessarily bring with it alleviation of bias (Kahan et al., 2017).

Finally, our exploratory analyses showed that most of the people in our sample who did not vote in 2016 expected Clinton to win. These non-voters showed substantial mathematical biases before the election, downplaying Trump's large lead and overestimating Clinton's small lead. Future work should continue to examine the repercussions of biased mathematical processing on political behavior, for example, inclinations to contribute to a candidates' campaigns, and motivations to publically endorse a candidate's campaigns. Given the role of expectations in partisan processing of polling statistics, it will be important to determine the extent to which intervening on biases alters people's expectations about their candidate's ability to be successful, and, downstream, their own willingness to get to the polls on election day.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2019.02.002.

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