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## Belief in Fake News is Associated with Delusionality, Dogmatism, Religious Fundamentalism, and Reduced Analytic Thinking

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Delusion-prone individuals may be more likely to accept even delusion-irrelevant implausible ideas because of their tendency to engage in less analytic and less actively open-minded thinking. Consistent with this suggestion, two online studies with over 900 participants demonstrated that although delusion-prone individuals were no more likely to believe true news headlines, they displayed an increased belief in “fake news” headlines, which often feature implausible content. Mediation analyses suggest that analytic cognitive style may partially explain these individuals’ increased willingness to believe fake news. Exploratory analyses showed that dogmatic individuals and religious fundamentalists were also more likely to believe false (but not true) news, and that these relationships may be fully explained by analytic cognitive style. Our findings suggest that existing interventions that increase analytic and actively open-minded thinking might be leveraged to help reduce belief in fake news.

### *General Audience Summary*

There has been a proliferation of fabricated news stories that are presented as being from legitimate sources on social media. The present studies made progress toward answering the questions of who is most likely to believe this “fake news” and why. Two studies with over 900 participants suggested that individuals who endorse delusion-like ideas (e.g., thinking that people can communicate telepathically), as well as dogmatic individuals and religious fundamentalists, are more likely to believe fake news. These studies also suggested that two related forms of thinking may protect against belief in fake news: The first, actively open-minded thinking, involves the search for alternative explanations and the use of evidence to revise beliefs. The second, analytic

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thinking, involves the disposition to initiate deliberate thought processes in order to reflect on intuitions and gut feelings. Reduced engagement in these forms of thinking predicts increased belief in fake news, and may help to explain belief in fake news among individuals who endorse delusion-like ideas, dogmatic individuals, and religious fundamentalists. These results suggest that existing interventions designed to increase actively open-minded and analytic thinking might be leveraged to combat belief in fake news.

*Keywords:* Fake news, Dogmatism, Dual-process theory, Religious fundamentalism, Actively open-minded thinking, Delusion-proneness

The formation of accurate beliefs guides many adaptive behaviors. One contributor to inaccurate beliefs is misinformation, including “fake news,” which consists of fabricated news stories that are presented as being from legitimate sources and promoted on social media to deceive the public for ideological or financial gain (Lazer et al., 2018). Indeed, a single prior exposure encourages later belief in fake news, even when headlines are contested by fact checkers or are inconsistent with the reader’s political ideology (Pennycook, Cannon, & Rand, 2018). Given that widespread dissemination of false information can have negative consequences at both the individual and societal levels, it is imperative to determine who may be susceptible to believing fake news and why.

Delusion-prone individuals, who endorse unusual ideas considered to be on a continuum with psychotic symptoms (see Rössler et al., 2015; Van Os, Hanssen, Bijl, & Ravelli, 2000), may be especially susceptible to believing fake news. These individuals are more likely to endorse conspiracy theories (Dagnall, Drinkwater, Parker, Denovan, & Parton, 2015), believe in paranormal phenomena (Pechey & Halligan, 2011), and give higher plausibility ratings to absurd explanations for ambiguous events (Bronstein & Cannon, 2017; Zawadzki et al., 2012). These observations suggest that endorsement of delusion-like beliefs is associated with increased vulnerability to believing many types of other implausible ideas. This vulnerability may make delusion-prone individuals especially likely to believe implausible ideas conveyed through misinformation, such as fake news. The present study therefore evaluates the hypothesis that delusion-prone individuals are particularly vulnerable to fake news, and that this vulnerability is due, at least in part, to deficits in traits (e.g., analytic thinking and actively open-minded reasoning) that may reduce the likelihood that a given individual will endorse other types of implausible beliefs (e.g., belief in conspiracy theories or paranormal phenomena).

Analytic reasoning processes are typically more effortful because they rely on working memory resources (Evans & Stanovich, 2013). Analytic reasoning may sometimes override default responses suggested by intuitive processes, which are thought to emerge autonomously from simple stimulus-response pairings (Evans, 2007; Evans & Stanovich, 2013). Through this override process, engagement in analytic reasoning may reduce gullibility, and may therefore decrease endorsement of many intuitive-but-implausible beliefs, including those advanced via fake news (Krueger, Vogrincic-Haselbacher, & Evans, 2019; Pennycook & Rand, 2018a, 2018b). In the general population,

use of this override process may vary due to individual differences in general cognitive ability and in willingness to engage in analytic thinking (i.e., in the degree to which individuals have an “analytic cognitive style”; Frederick, 2005; Pennycook, Koehler, & Fugelsang, 2015; Stanovich & West, 2000). Research suggesting that a more intuitive (non-analytic) cognitive style is associated with the endorsement of implausible ideas, including belief in delusion-related ideas (Freeman, Evans, & Lister, 2012; Freeman, Lister, & Evans, 2014), conspiracy theories (Barron et al., 2018; Swami, Voracek, Stieger, Tran, & Furnham, 2014), paranormal phenomena (Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012), and pseudo-profound bullshit (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2015; Pennycook & Rand, 2018b), is therefore consistent with the notion that reduced engagement in analytic reasoning might cause individuals to believe broadly in the implausible. This effect seems likely to generalize to delusion-prone individuals given that engagement in analytic reasoning mediates the relationship between delusion-like beliefs (magical/odd beliefs on the Schizotypal Personality Questionnaire; see Raine, 1991) and conspiracy theories (Barron et al., 2018).

If an intuitive cognitive style does predispose delusion-prone individuals to believing implausible ideas in general, it may leave these individuals specifically prone to endorsing implausible beliefs advanced via fake news. This possibility is broadly consistent with the recently documented association between belief in fake news and reduced analytic thinking (Pennycook & Rand, 2018a). Given the theoretical connection between analytic thinking and working memory (Evans & Stanovich, 2013), this possibility is also consistent with research indicating that retracted misinformation (i.e., misinformation that is declared incorrect after dissemination) has a greater impact on beliefs in individuals with lower working memory capacities (Brydges, Gignac, & Ecker, 2018).

Reduced actively open-minded thinking (AOT; Baron, 1985) is a second (albeit conceptually related) trait that may increase belief in fake news by encouraging those who endorse delusion-like ideation to accept multiple other types of implausible ideas. AOT captures differences in the use of evidence (e.g., the opinions of others, information that disconfirms one’s beliefs) when forming and revising beliefs (Stanovich & West, 1997). It also captures the related tendency to actively search for alternatives (Campitelli & Gerrans, 2014). If individuals endorsing delusion-like ideation exhibit reduced AOT, they may be less likely to disconfirm implausible beliefs and replace them with

more viable alternatives. Broadly consistent with this possibility, reduced AOT is associated with belief in conspiracy theories (Swami et al., 2014) and paranormal phenomena (Svedholm & Lindeman, 2013).<sup>1</sup>

This study also examined whether dogmatic individuals and religious fundamentalists, who past research indicates may engage in less analytic and actively open-minded thinking, are more likely to fall for fake news. The possibility that more dogmatic individuals engage in less actively open-minded thinking stems from the overlapping nature of these constructs (see Stanovich & West, 1997). For example, one aspect of AOT is the disposition to search for alternative explanations (Campitelli & Gerrans, 2014). Both before and after judgments are made, dogmatic individuals generate less evidence against their judgments (Davies, 1998), which may impede this search. The evidence that dogmatic individuals engage in less analytic thinking is more empirical. Dogmatic individuals engage in less analytic reasoning during syllogism evaluation tasks that feature conflicting cues regarding syllogism validity (Martin, 2008). These individuals also produce fewer correct answers on the Cognitive Reflection Test (CRT; Frederick, 2005), which is comprised of items with intuitive-but-incorrect answers that must be overridden using analytic thinking to arrive at a correct response (Friedman & Jack, 2018).

Religious fundamentalists may also engage in less analytic and actively open-minded thinking. Categorical measures of religious belief suggest that individuals who believe in a personal God (vs. atheists) perform more poorly on the CRT (Pennycook, Ross, Koehler, & Fugelsang, 2016). Continuous measures of religious belief are also associated with poorer CRT performance (Bahçekapili & Yilmaz, 2017; Gervais & Norenzayan, 2012; Shenhav, Rand, & Greene, 2012) and with reduced AOT (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2014). Religious fundamentalism was chosen from the many aspects of religious belief as the focus of this study because religious fundamentalism is strongly correlated with dogmatism (Altemeyer, 2002). Given this strong correlation, the aforementioned evidence that dogmatism is related to both actively open-minded and analytic thinking provides additional support for the notion that religious fundamentalism is related to a reduced likelihood of exhibiting these cognitive styles.

In sum, this work was expected to identify three groups that may be particularly vulnerable to believing fake news (delusion-prone individuals, dogmatic individuals, and religious fundamentalists), and to suggest inter-related mechanisms that may contribute to this vulnerability (reduced analytic and actively open-minded thinking).

<sup>1</sup> Two additional traits (individual differences in the illusory truth and post-diction effects) were also examined in this study. However, because individual differences in these effects were not related to belief in fake news, this portion of the present study is not discussed in detail in this manuscript (but, see SI Section S14).

## Method

### Participants

Participants were recruited via Amazon's Mechanical Turk (MTurk) in two waves (Study 1:  $n=502$ , Study 2:  $n=446$ ; Demographics: SI Section S1). Only participants who were over 18 and who lived in the United States were recruited.

### Data Quality

Several steps were taken to ensure high data quality. Only MTurk workers with a history of providing good-quality responses (i.e., an acceptance ratio of >95%) were allowed to participate in this study. Studies employing MTurk workers who meet this criterion have obtained results comparable to those of studies conducted in the laboratory (Johnson & Borden, 2012). To prevent individuals from completing the same study multiple times or participating in more than one of the studies presented herein, only one response associated with a given MTurk ID (a unique identifier assigned to each MTurk worker) was accepted. Data from participants who did not complete the entire study were discarded prior to all analyses.

### Measures

Participants completed a number of different measures. A news evaluation task measured belief in fake and real news. During this task, participants encountered 12 fake and 12 real news headlines, in random order. Headlines were presented in a format often used on social media (accompanied by a photo and brief description). Example stimuli can be found in Figure 1. The fake news headlines used in this study were either taken from claims judged false by Snopes.com (a popular fact-checking website) or described widely circulated fake news stories from the 2016 US presidential election. Real news headlines were taken from credible mainstream media sources. Real and fake news stimuli included an equal number of pro-Democrat and pro-Republican news headlines. The political leaning of news headlines was evaluated via a large pretest (Pennycook & Rand, 2018b). Participants were instructed to rate the accuracy of each headline based on the degree to which they believed the headline described something that actually happened. Accuracy ratings were made on a four-point scale (1 = *Not at all accurate*, 4 = *Very accurate*). Belief in fake news was calculated using the average of these judgments across all fake stories, while belief in real news was calculated using the average across all real stories. Real news stories were selected to be contemporaneous with the fake news stories.

The Peters et al. Delusion Inventory (PDI; Peters, Joseph, Day, & Garety, 2004; example item: "Do you ever feel as if there is a conspiracy against you?") measured delusion-like ideation. Each of the 21 items in this inventory asks participants whether or not they have had one delusion-like experience. If they endorse the experience, they are asked to rate how distressing (1 = *Not distressing at all*, 5 = *Very distressing*), preoccupying (1 = *Hardly ever think about it*, 5 = *Think about it all the time*) and convincing (1 = *Don't believe it's true*, 5 = *Believe it's absolutely true*) it is on three separate five-point scales. The sum of



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Vice President-elect Mike Pence claims that a 1983 conversion therapy saved him.

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**Donald Trump Protester Speaks Out: "I Was Paid \$3,500 To Protest Trump's Rally"**

PHOENIX A.Z. (AP) — For months now, rumors have circulated the internet that individuals were being paid to protest at rallies held by presidential hopeful Donald Trump. Today a...  
ABCNEWS.COM.CO

**Figure 1.** Example fake news stimuli. Left: Pro-Democrat fake news. Right: Pro-Republican fake news.

the number of experiences endorsed and all ratings describing aspects of those experiences (the PDI Total Score) was used to quantify delusion-like ideation.

Cognitive style was measured in two ways. The first was a shortened version of the actively open-minded thinking scale (Stanovich & West, 2007; example item: "A person should always consider new possibilities"; for the shortened scale, see SI Section S2). Participants indicated their agreement with each of the eight items comprising this measure using a six-point scale (1 = *Strongly disagree*, 6 = *Strongly agree*). AOT scores were computed as the sum of these ratings (after items were reverse scored as appropriate). Higher scores on this measure reflect greater use of evidence when forming and revising beliefs (Stanovich & West, 1997), and greater consideration of alternatives (Campitelli & Gerrans, 2014).

The second was the Cognitive Reflection Test (CRT; Frederick, 2005; example item: "How many cubic feet of dirt are there in a hole that is three feet deep by three feet wide by three feet long?"). The Cognitive Reflection Test measures analytic thinking by presenting participants with several problems that have intuitive-but-incorrect responses that must be overridden to arrive at the correct answer. The version of the CRT employed here consisted of seven items: three reworded items from the original CRT (via Shenhav et al., 2012) and the four-item non-numeric CRT (Thomson & Oppenheimer, 2016). Previous research has shown that this seven-item version of the CRT has acceptable reliability (Pennycook & Rand, 2018a). Scores on the CRT represent the number of correct answers given by participants. Higher scores reflect greater cognitive ability and/or a more analytic cognitive style.

Dogmatism was measured using the DOG scale (Altemeyer, 2002; example item: "The things I believe in are so completely true, I could never doubt them"). Participants indicated their agreement with each of the 20 items comprising this measure on a nine-point scale (1 = *Strongly disagree*, 9 = *Strongly agree*). Dogmatism scores were computed as the sum of these ratings (after items were reverse scored as appropriate). Higher scores indicated greater dogmatism (relatively unchangeable,

unjustified certainty; Altemeyer, 2002). The DOG scale was selected to measure dogmatism because its validity has been demonstrated across multiple studies (Altemeyer, 2002; Crowson, DeBacker, & Davis, 2008) and because it was designed to capture dogmatism in a manner not specific to any political philosophy (Altemeyer, 2002).

Religious fundamentalism was measured using an established religious fundamentalism scale (Altemeyer & Hunsberger, 1992; example item: "The basic cause of evil in this world is Satan, who is still constantly and ferociously fighting against God"). Participants indicated their agreement with each of the 20 items comprising this measure on a nine-point scale (1 = *Strongly disagree*, 9 = *Strongly agree*). Religious fundamentalism scores were computed as the sum of these ratings (after items were reverse scored as appropriate); higher scores indicated greater fundamentalism. For details on the measurement of the illusory truth and postdiction effects, see SI Section S14.

The internal consistency of all questionnaire measures was assessed using McDonald's (1999) Omega Total. All measures had good, very good, or excellent internal consistency (see SI Section S3). Descriptive statistics for all measures can be found in Table 1. To discourage responses to any measure that were motivated by social desirability, the survey alternated between items from the measures of dogmatism, actively open-minded thinking, religious fundamentalism, and delusion-like ideation.

**Table 1**  
Descriptive Statistics: Means (SDs)

	Study 1	Study 2
Belief in fake news	1.79 (0.46)	1.85 (0.49)
Belief in real news	2.78 (0.47)	2.82 (0.46)
Actively open-minded thinking	34.09 (7.18)	34.02 (7.51)
Analytic thinking	3.65 (2.11)	4.12 (2.03)
Delusion-like ideation	51.52 (37.76)	41.39 (38.47)
Dogmatism	78.43 (27.12)	81.06 (26.45)
Religious fundamentalism	71.59 (40.17)	72.57 (41.91)

**Table 2**  
Zero-Order Correlations Between Variables

	2	3	4	5	6	7	8	9
1. Belief in fake news	.05	-.66*	.72*	-.32*	-.19*	.24*	.28*	.26*
2. Belief in real news	–	.65*	.68*	.14	.12	.06	-.15	-.07
3. News sensitivity		–	-.04	.34*	.25*	-.14*	-.32*	-.23*
4. News bias			–	-.15*	-.08	.23*	.10	.14
5. A.O. thinking				–	.33*	-.40*	-.69*	-.67*
6. Analytic thinking					–	-.31*	-.21*	-.37*
7. Delusion-like ideation						–	.25*	.46*
8. Dogmatism							–	.61*
9. Religious Fundamentalism								–

Note. Non-parametric correlations (Spearman's rho) were reported because variable distributions were non-normal. Only correlations with  $p$ -values less than .001 are reported as significant and marked by an asterisk. A.O. thinking = Actively open-minded thinking. Zero-order correlations for variables in Studies 1 and 2 can be seen in supplementary material (Tables S6/S7).

## Procedure

In Study 1, participants completed the Cognitive Reflection Test along with several additional individual difference measures (AOT scale, DOG scale, RF scale, and PDI). Half of the participants completed the Cognitive Reflection Test before these additional individual difference measures. The other half of the participants completed these additional individual difference measures first. Participants also completed the news-evaluation task, which either preceded or followed all other individual difference measures (i.e., the order of these two sets of stimuli was counterbalanced).

In Study 2, participants began by completing the first phase of the illusory truth task (in which they rated the interestingness of several facts; see SI Section S14). They then completed the CRT, news-evaluation task, postdiction task (see SI Section S14), and several additional individual difference measures (AOT scale, DOG scale, RF scale, and PDI), in random order. Finally, they completed the second phase of the illusory truth task (in which they rated the accuracy of several facts). Participants were given as much time as they needed to complete each study. For additional details regarding the order of measure administration, see SI Section S4.

## Analyses

Although we completed preregistrations (which can be found in SI Section S5) for each of the two recruitment waves, in the main text we combine the data from both waves and—based on the advice of a referee—many of our analyses deviated substantially from our preregistered plans. However, given that analyzing the individual study waves separately gives extremely similar results (see SI Sections S6–8 and S10), we feel confident in the replicability of our findings.

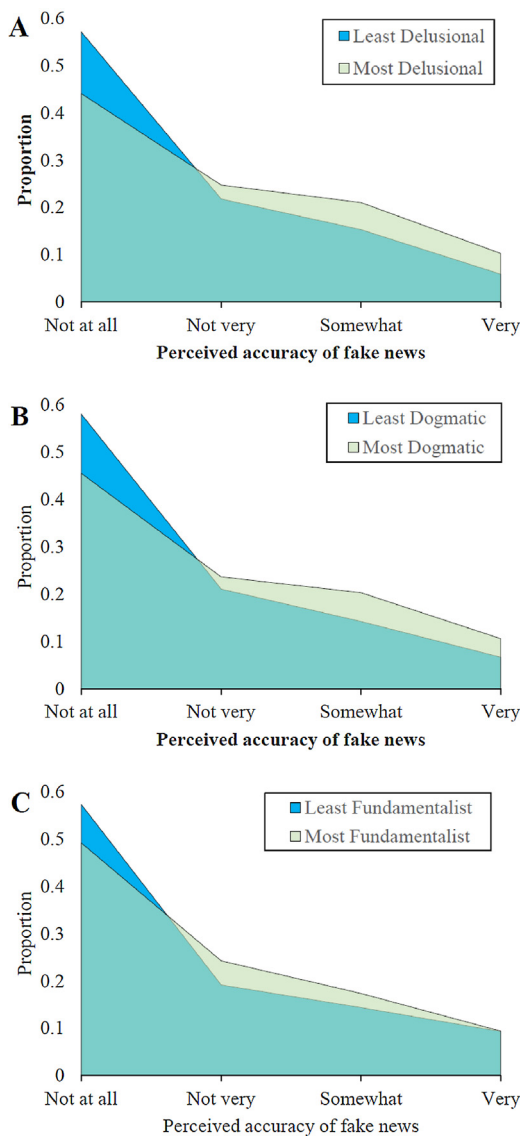
In accordance with our preregistered plans, outliers were detected using the method of Hubert and Van der Veeken (2008), as implemented in R's *RobustBase* package, because this method is robust to skewed data. Identified outliers were winsorized (see Fuller, 1991). To compare results with and without outliers (which are qualitatively similar), see SI Sections S6–7. For further information about outlier processing, see SI Section S9.

In all mediation analyses, measures of actively open-minded and analytic thinking were entered into the same mediation model (PROCESS Model 4; Preacher & Hays, 2008). This method was expected to provide insight into whether these variables could each explain unique variance in the relationship between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism. For each mediation model, 5000 bootstrapped samples and bias-corrected 95% confidence intervals were generated. All variables were standardized before entry into mediation models.

## Results

Zero-order correlations between all measures can be found in Table 2 (for the combined dataset) and SI Section S10 (for individual data collection waves). Delusion-like ideation, dogmatism, and religious fundamentalism were all positively correlated with belief in fake news (see Figure 2), but uncorrelated (delusion-like ideation and religious fundamentalism) or negatively correlated (dogmatism) with belief in real news. Delusion-like ideation, dogmatism, religious fundamentalism, and belief in fake news were all negatively correlated with analytic and actively open-minded thinking, whereas belief in real news was positively correlated with analytic and actively open-minded thinking.

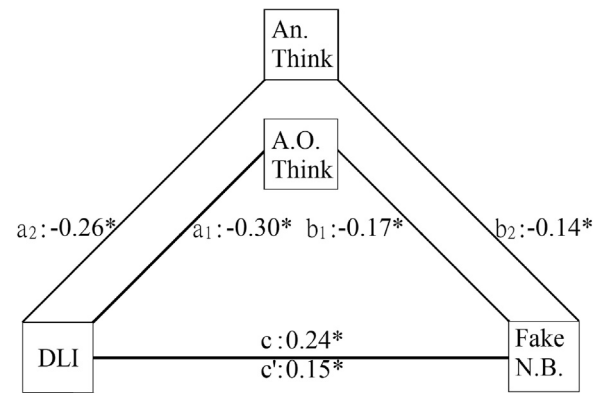
As a result, delusion-like ideation, dogmatism, and religious fundamentalism were negatively correlated with news sensitivity or “media truth discernment” (calculated as the difference between standardized real and fake news accuracy ratings, i.e., hits minus false alarms), whereas both cognitive style measures were positively correlated with media truth discernment. Furthermore, delusion-like ideation, dogmatism, and religious fundamentalism were associated with increased belief in all news, regardless of reality status (that is, these variables were associated with bias in news accuracy ratings, calculated as the sum of standardized fake and real news accuracy ratings, i.e., hits plus false alarms), whereas actively open-minded thinking, but not analytic thinking, was associated with a bias toward perceiving all news as inaccurate.



**Figure 2.** Distribution of the perceived accuracy of fake news as a function of delusion-proneness, dogmatism, and religious fundamentalism. Dark blue = lowest quintile, light blue = highest quintile. The y-axis of each graph is the proportion of all respondents who, on average, gave the response indicated on the x-axis.

### Mediation Analyses

Mediation analyses were conducted to examine whether the relationship between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism could be partially explained by analytic and actively open-minded thinking. As anticipated, the total effect of delusion-like ideation on belief in fake news was significant, ( $\beta = 0.24$ ,  $p < .001$ , 95% CI [0.18 0.30]). Delusion-like ideation predicted actively open-minded ( $\beta = -0.30$ ,  $p < .001$ , 95% CI [-0.36 -0.24]) and analytic thinking ( $\beta = -0.26$ ,  $p < .001$ , 95% CI [-0.32 -0.20]). When delusion-like ideation, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.17$ ,  $p < .001$ , 95% CI [-0.24 -0.11]) and analytic thinking ( $\beta = -0.14$ ,  $p < .001$ , 95% CI [-0.20 -0.08]) predicted belief in fake news.



**Figure 3.** The mediation model used to test the hypothesis that actively open-minded and analytic thinking are simultaneous mediators of the relationship between delusion-like ideation and belief in fake news. Numbers represent standardized coefficients. Paths are labeled according to the conventions of Baron and Kenny (1986). Path  $c$  = total effect. Path  $c'$  = direct effect. Paths  $a$  and  $b$  together depict the indirect effect of delusion-like ideation on belief in fake news. *DLI* = Delusion-like ideation. *An. Think* = Analytic thinking. *A.O. Think* = Actively open-minded thinking. *Fake N.B.* = Belief in fake news. \* $p < .05$ .

These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .15$ ,  $p < .001$ , 95% CI [0.09 0.21]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of delusion-like ideation on belief in fake news (through actively open-minded thinking: [0.03 0.07]; through analytic thinking: [0.02 0.06]) that did not overlap with zero. The full mediation model described through these regression results is depicted in Figure 3. A summary of all statistics for the regression models in this mediation analysis can be found in Table 3.

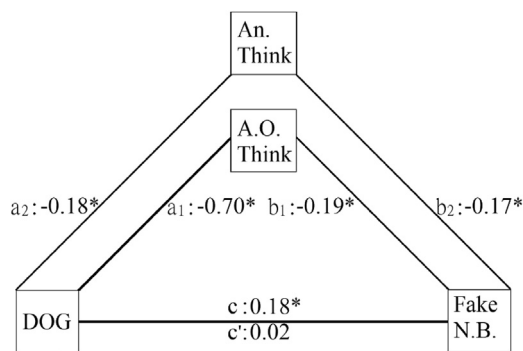
The total effect of dogmatism on belief in fake news was also significant,  $\beta = 0.18$ ,  $p = .001$ , 95% CI [.12 .25]. Dogmatism predicted actively open-minded ( $\beta = -0.70$ ,  $p < .001$ , 95% CI [-0.75 -0.65]) and analytic thinking ( $\beta = -0.18$ ,  $p < .001$ , 95% CI [-0.24 -0.12]). When dogmatism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.19$ ,  $p < .001$ , 95% CI [-0.28 -0.11]) and analytic thinking ( $\beta = -0.17$ ,  $p < .001$ , 95% CI [-0.23 -0.11]) predicted belief in fake news. These results suggested that dogmatism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = 0.02$ ,  $p = .679$ , 95% CI [-0.07 0.10]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of dogmatism on belief in fake news (through actively open-minded thinking: [0.08 0.20]; through analytic thinking: [0.02 0.05]) that did not overlap with zero. The full mediation model described through these regression results is depicted in Figure 4. A summary of

**Table 3**

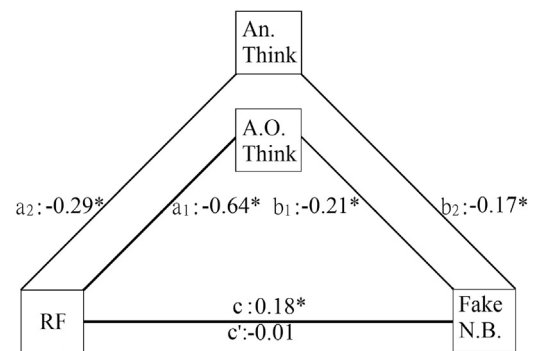
The Relationship Between Belief in Fake News and Delusion-like Ideation is Mediated by Cognitive Style

Criterion variable	Predictor(s)	Standard error	$\beta$ [95% CI]	<i>t</i>	<i>F</i>	<i>R</i> <sup>2</sup>
Analytic thinking	Delusion-like ideation	0.03	-0.26 [-0.32 -0.20]	8.49	72.09	.07
Actively open-minded thinking	Delusion-like ideation	0.03	-0.30 [-0.36 -0.20]	9.79	95.89	.09
Belief in fake news	Delusion-like ideation	0.03	0.24 [0.18 0.30]	7.68	58.92	.06
Belief in fake news	Analytic thinking	0.03	-0.14 [-0.20 -0.08]	4.28	41.05	.12
	Actively open-minded thinking	0.03	-0.17 [-0.24 -0.11]	5.14		
	Delusion-like ideation	0.03	0.15 [-0.09 -0.21]	4.67		

Note. The indirect effect through analytic thinking was significant, coefficient = 0.04, 95% CI = [0.02 0.06], as was the indirect through actively open-minded thinking, coefficient = 0.05, 95% CI = [0.03 0.07]. The indirect effects through these variables explained 37% of the total effect of delusion-like ideation on belief in fake news. Horizontal lines separate individual regression models.



**Figure 4.** The mediation model used to test the hypothesis that actively open-minded and analytic thinking are simultaneous mediators of the relationship between dogmatism and belief in fake news. Numbers represent standardized coefficients. Paths are labeled according to the conventions of Baron and Kenny (1986). Path *c* = total effect. Path *c'* = direct effect. Paths *a* and *b* together depict the indirect effect of dogmatism on belief in fake news. *DOG* = Dogmatism. *An. Think* = Analytic thinking. *A.O. Think* = Actively open-minded thinking. *Fake N.B.* = Belief in fake news. \**p* < .05.



**Figure 5.** The mediation model used to test the hypothesis that actively open-minded and analytic thinking are simultaneous mediators of the relationship between religious fundamentalism and belief in fake news. Numbers represent standardized coefficients. Paths are labeled according to the conventions of Baron and Kenny (1986). Path *c* = total effect. Path *c'* = direct effect. Paths *a* and *b* together depict the indirect effect of religious fundamentalism on belief in fake news. *RF* = Religious fundamentalism. *An. Think* = Analytic thinking. *A.O. Think* = Actively open-minded thinking. *Fake N.B.* = Belief in fake news. \**p* < .05.

all statistics for the regression models in this mediation analysis can be found in SI Table S8.

The total effect of religious fundamentalism on belief in fake news was also significant,  $\beta = 0.18$ ,  $p < .001$ , 95% CI [0.11 .24]. Religious fundamentalism predicted actively open-minded ( $\beta = -0.64$ ,  $p < .001$ , 95% CI [-0.69 -0.59]) and analytic thinking ( $\beta = -0.29$ ,  $p < .001$ , 95% CI [-0.35 -0.22]). When religious fundamentalism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.21$ ,  $p < .001$ , 95% CI [-0.29 -0.13]) and analytic thinking ( $\beta = -0.17$ ,  $p < .001$ , 95% CI [-0.23 -0.11]) predicted belief in fake news. These results suggested that religious fundamentalism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake news ( $\beta = 0.01$ ,  $p = .852$ , 95% CI [-0.09 0.07]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of religious fundamentalism on belief in fake news (through actively open-minded thinking: [0.08 0.18]; through analytic thinking: [0.03 0.07]) that did not overlap with zero.

The full mediation model described through these regression results is depicted in Figure 5. A summary of all statistics for the regression models in this mediation analysis can be found in SI Table S9.

The results for belief in real news can be seen in SI Section S12. These results suggest that the mediation pathways presented above are specific to belief in fake news. At zero-order, belief in real news (unlike belief in fake news) did not correlate with delusion-like ideation. The indirect effect of delusion-like ideation on belief in real news via actively open-minded thinking competed with the direct effect of delusion-like ideation on belief in real news. Analytic thinking was not a significant mediator of the relationship between delusion-like ideation and belief in real news. This pattern contrasts with the complementary mediation effect of these cognitive styles that was observed for fake news. Although belief in real news (like belief in fake news) was correlated with dogmatism and religious fundamentalism at zero-order, the ability of actively open-minded and analytic thinking to explain the relationship between dogmatism/religious fundamentalism and news accuracy judgments appears to be specific to contexts in which fake news is being evaluated.

## Discussion

These studies established that delusion-prone individuals, dogmatic individuals, and religious fundamentalists are more likely to believe fake news. Mediation analyses suggested that these relationships may be partially or fully explained by reduced engagement in actively open-minded and analytic thinking, which may broadly discourage implausible beliefs.

These results build upon prior work relating analytic thinking to reduced belief in fake news (Pennycook & Rand, 2018a, 2018b) by suggesting that reductions in analytic thinking and a related concept, actively open-minded thinking (see Campitelli & Labollita, 2010), may increase belief in fake news across multiple groups of people. It follows from this suggestion that interventions designed to increase analytic thinking (Ward & Garety, 2017) or actively open-minded thinking (Gürçay-Morris, 2016) may help keep delusion-prone and dogmatic individuals, as well as religious fundamentalists, from falling for fake news. Because these interventions target specific mechanisms putatively contributing to belief in fake news, they may be more successful than previous interventions, such as explicit “warning” labels, which have sometimes inadvertently encouraged belief in un-warned fake news (see Pennycook & Rand, 2017). Future research should therefore examine these potential interventions’ efficacy.

The present studies also build upon prior research examining gullibility and implausible beliefs. Analytic reasoning has been argued to reduce gullibility (Krueger et al., 2019); a conjecture that is consistent with the negative correlation between engagement in analytic reasoning and belief in fake news observed here. The present studies also interface with prior research through their suggestion that increased engagement in analytic reasoning may improve the ability to discriminate real from fake news. Through this suggestion, the present research joins prior work (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2015; Pennycook & Rand, 2018b) in suggesting that analytic reasoning may promote the ability to discern statements constructed without concern for truth from more meaningful statements. Finally, the present studies interface with prior research through their suggestion that reduced engagement in analytic reasoning may promote the endorsement of multiple types of implausible beliefs. It follows from this suggestion that reduced engagement in analytic thinking may explain the associations between implausible ideas identified in previous research (e.g., between conspiracy theories and rejection of well-supported science; Lewandowsky, Oberauer, & Gignac, 2013).

Beyond these relationships with prior work, the present studies provide directions for future research on fake news. Such research might begin by investigating *why* belief in fake news is reliably associated with reduced engagement in analytic reasoning. Research on dual-process reasoning may provide insight into the underlying cause of this association. This research suggests that failures of conflict detection may pre-empt deliberative reasoning processes (Pennycook, Fugelsang, & Koehler, 2015). It follows from this suggestion that engagement in analytic reasoning may be correlated with belief in fake news because both depend on the ability to detect conflicts during reasoning.

Consistent with this possibility, research indicates that weakened conflict detection may explain the association between reduced analytic thinking, actively open-minded thinking (Pennycook, Fugelsang, & Koehler, 2015), and religious beliefs (Pennycook et al., 2014).

Future research might also build upon the present studies’ mediation analyses. In the present studies, the effect of delusion-like ideation on belief in fake news remained significant when indirect effects through analytic and actively open-minded thinking were simultaneously considered. Given that the direct effect of delusion-like ideation on belief in fake news was positive, this result suggests that additional indirect effects that might increase belief in fake news were missing from our mediation model (see Zhao, Lynch & Chen, 2010). Given that the content of fake news is often implausible (Pennycook & Rand, 2018a), the search for these missing indirect effects might begin with cognitive biases thought to increase or maintain delusion-prone individuals’ belief in the implausible. Two such biases are the bias toward reduced data gathering (Dudley, Taylor, Wickham, & Hutton, 2015) and the bias toward discounting evidence against one’s beliefs (Bronstein & Cannon, 2017). Reduced data gathering may increase delusion-prone individuals’ belief in fake news by reducing the chances that they encounter information that may contradict its content. This effect of reduced data gathering may be amplified by the fact that delusion-prone individuals may begin their information search by focusing on less reliable sources of information (Glöckner & Moritz, 2008). Even when information that may contradict fake news content is encountered by delusion-prone individuals, these individuals’ bias against disconfirmatory evidence may prevent this information from being fully considered.

The present studies’ implications for past and future research should be considered in the context of several limitations. One such limitation is that cross-sectional mediation analyses, like the ones conducted in the present studies, are biased estimators of causal processes that likely unfold over time (Maxwell & Cole, 2007). This limitation qualifies the present studies’ support for the hypothesis that reduced engagement in analytic and actively open-minded thinking might explain the relationship between belief in fake news and delusion-like ideation. Future research could address this limitation by examining whether reduced engagement in analytic reasoning predicts both belief in fake news and the endorsement of delusion-like ideation in a longitudinal dataset or by experimentally manipulating engagement in analytic reasoning. A second limitation of the present studies is that the small amount of variance explained in our regression models may prompt concerns that these models’ significance is entirely due to the large samples we recruited, which were required for the present studies to achieve adequate statistical power (see Fritz & MacKinnon, 2007). This limitation is mitigated somewhat by the pre-registration of our key analyses and the consistency of our results with prior research (e.g., Barron et al., 2018).

These limitations notwithstanding, the present studies suggest that delusion-prone and dogmatic individuals, as well as religious fundamentalists, are more likely than others to believe fake news, and that this may be in part because they



exhibit reduced analytic and actively open-minded thinking. This suggestion points to potential interventions that may keep individuals from falling for fake news and lays the groundwork for future fake news research. Pursuit of these avenues for future work may help address societal concerns associated with belief in fake news (e.g., its potential to inspire violence, Hsu, 2017).

### Conflict of Interest Statement

The authors declare that they have no conflict of interest.

### Author Contributions

Tyrone D. Cannon and David G. Rand developed the study concept. All authors contributed to study design. Testing and data collection were performed by Gordon Pennycook, Michael V. Bronstein, and Adam Bear. Michael V. Bronstein, Gordon Pennycook, and Adam Bear performed data analysis and interpretation under the supervision of Tyrone D. Cannon and David G. Rand. Michael V. Bronstein drafted the manuscript, all other authors provided critical revisions. All authors approved the final version of the manuscript for submission.

### Appendix A. Supplementary Data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jarmac.2018.09.005>.

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## Supplementary Material

The supplementary material contained here-in reports additional information regarding Studies 1 and 2 from the main manuscript. In addition, this supplementary material details the results of a pilot study ( $n = 402$ ).

### Table of Contents

<b>Section</b>	<b>Title</b>
<b>SI Section S1.</b>	<b>Sample Demographics</b>
<b>SI Section S2.</b>	<b>Short Form AOT Scale</b>
<b>SI Section S3.</b>	<b>Scale Reliabilities</b>
<b>SI Section S4.</b>	<b>Order of Measure Administration—Pilot Study</b>
<b>SI Section S5.</b>	<b>Preregistration</b>
<b>SI Section S6.</b>	<b>Results from Individual Studies Presented Separately</b>
<b>SI Section S7.</b>	<b>Results from the Analysis of Individual Study Waves with Outliers Included</b>
<b>SI Section S8.</b>	<b>Serial Mediation Models</b>
<b>SI Section S9.</b>	<b>Notes on Outlier Analyses</b>
<b>SI Section S10.</b>	<b>Zero-order Correlations Between Study Variables</b>
<b>SI Section S11.</b>	<b>Summary of all Statistics from the Exploratory Mediation Analyses in the Main Manuscript</b>
<b>SI Section S12.</b>	<b>Results Pertaining to Belief in Real News</b>
<b>SI Section S13.</b>	<b>BCIS Self-certainty Mediates the Relationship Between Delusion-like Ideation and Belief in Fake News</b>
<b>SI Section S14.</b>	<b>The Relationship Between the Illusory Truth/Postdiction Effect and Belief in Fake News</b>

**SI Section S1. Sample Demographics**

Table S1

*Sample Demographics*

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	Pilot Study	Study 1	Study 2
<hr/>			
<b>Political Party</b>			
Democrat	171	196	193
Republican	88	117	127
Independent	125	165	112
Other	13	22	12
<hr/>			
<b>Sex</b>			
Male	210	240	221
Female	192	262	225
<hr/>			
<b>Education</b>			
Did not graduate high school	5	4	1
High school graduate	41	60	52
Some college but no degree	92	134	87
Associate's degree	72	70	62
Bachelor's degree	163	156	195
Master's degree	26	64	38

Doctoral degree	2	6	3
Professional degree	1	7	8
<hr/>			
<b>Age</b>	36.70 ( <i>SD</i> = 11.51)	37.48 ( <i>SD</i> = 11.99)	37.53 ( <i>SD</i> = 27.62)

*Note.* Totals for different demographics may not be identical due to individuals refusing to answer demographic questions.

## SI Section S2. Short form AOT Scale

The present studies employed a shortened form of the actively open-minded thinking scale. This short form consists of the following items (**Bold** = reverse scored):

1. A person should always consider new possibilities
2. People should always take into consideration evidence that goes against their beliefs
- 3. It is important to persevere in your beliefs even when evidence is brought to bear against them**
- 4. Certain beliefs are just too important to abandon no matter how good a case can be made against them**
- 5. One should disregard evidence that conflicts with your established beliefs**
6. Beliefs should always be revised in response to new information or evidence
- 7. No one can talk me out of something I know is right**
- 8. I believe that loyalty to one's ideals and principles is more important than "open-mindedness"**

### SI Section S3. Scale Reliabilities

Table S2  
*Internal consistencies of scales and measures*

	Pilot Study	Study 1	Study 2
Fake news accuracy ratings	$\omega_t = .83 (\alpha = .78)$	$\omega_t = .79 (\alpha = .74)$	$\omega_t = .81 (\alpha = .77)$
Real news accuracy ratings	$\omega_t = .63 (\alpha = .47)$	$\omega_t = .78 (\alpha = .71)$	$\omega_t = .80 (\alpha = .73)$
DOG scale	$\omega_t = .94 (\alpha = .93)$	$\omega_t = .94 (\alpha = .92)$	$\omega_t = .93 (\alpha = .91)$
RF scale	$\omega_t = .96 (\alpha = .95)$	$\omega_t = .97 (\alpha = .96)$	$\omega_t = .97 (\alpha = .96)$
AOT scale	$\omega_t = .89 (\alpha = .84)$	$\omega_t = .87 (\alpha = .81)$	$\omega_t = .90 (\alpha = .85)$
PDI Yes/No	$\omega_t = .86 (\alpha = .84)$	$\omega_t = .81 (\alpha = .78)$	$\omega_t = .83 (\alpha = .80)$
CRT	Not Administered	$\omega_t = .85 (\alpha = .77)$	$\omega_t = .81 (\alpha = .76)$

*Note.* The DOG scale measures dogmatism, the RF scale measures religious fundamentalism, the PDI (Peter's Delusion Inventory) assesses delusion-like ideation, the CRT (Cognitive Reflection Test) measures analytic thinking, and the AOT scale measures actively open-minded thinking. McDonald's (1999) Omega total was used because it is a more valid metric of internal consistency than Cronbach's alpha (Dunn et al., 2014). Cronbach's alpha is reported only because it is traditionally used in psychological research. PDI Yes/No scores (rather than PDI Total scores) are reported for the sake of consistency across studies (a technical error prevented the use of PDI Total scores in the pilot study).

#### **SI Section S4. Order of Measure Administration—Pilot Study**

In the pilot study, participants completed the fake and real news tasks along with several individual difference measures. The order in which these materials were presented was counterbalanced (i.e., the fake/real news task either preceded or followed all other individual difference measures). Individual difference measures (of dogmatism, delusion-like ideation, actively open-minded thinking, and religious fundamentalism) were presented in a fixed order. To discourage responses to any measure that were motivated by social desirability, the survey alternated between items from the measures of dogmatism, actively open-minded thinking, religious fundamentalism, and delusion-like ideation.



## SI Section S5. Preregistration

### Study 1

#### *Hypotheses*

For Study 1, we preregistered the primary hypothesis (for full document, see: <http://aspredicted.org/blind.php?x=hm9qn5>) that variance in the ability to discriminate real from fake news would be determined by two components: one related to delusion-proneness and the other related to one's tendency to engage in analytic thought and value evidence.

#### *Analyses*

Several modifications were made to these preregistered analyses. The first of these modifications was that although the illusory truth effect was measured in Study 1, as noted in our preregistration, data regarding this task were not reported in the main manuscript. These data were not reported because preregistered analyses provided no evidence that the illusory truth effect occurred. In Study 1, the illusory truth effect task was completed in two stages. In the first stage, participants rated the accuracy of thirteen false facts. In the second stage, they rated the accuracy of 26 false facts, 13 of which they had seen in stage one. Four alternate forms of the task were used. To examine whether the illusory truth effect occurred, the change in participants' accuracy ratings from the first to the second stage for repeated ratings was examined. Overall, participants' ratings in stages one ( $M = 2.67$ ,  $SD = 0.76$ ) and two ( $M = 2.65$ ,  $SD = 0.82$ ) of the task did not differ statistically, suggesting that the illusory truth effect did not occur as expected. Because the illusory truth effect did not occur as expected, hypotheses involving this effect were not examined.

The second modification made to these preregistered analyses was that news discrimination scores (capturing the difference in accuracy ratings for true and fake news) were not made the focus of the main manuscript; results for fake news were focused on instead. The reason for this shift in focus was that upon examining belief in real and belief in fake news separately, it was observed that belief in

real news (unlike belief in fake news) was not reliably associated with many of our variables of interest. In our pilot study, belief in real news was associated only with religious fundamentalism ( $\rho(400) = -.12, p = .013$ ) and AOT ( $\rho(400) = .10, p = .036$ ). In Study 1, belief in real news was associated only with religious fundamentalism ( $\rho(500) = -.10, p = .021$ ). In Study 2, belief in real news was associated with analytic thinking ( $\rho(444) = .12, p = .014$ ), AOT scores ( $\rho(444) = .14, p = .004$ ), and dogmatism scores ( $\rho(444) = -.15, p < .001$ ). Across samples, the only associations found at least twice were those between belief in real news and religious fundamentalism/AOT. For this reason, results concerning belief in fake news were focused on here-in.

The final modification made to the preregistered analyses for Study 1 concerned the use of principal component analysis (PCA). The preregistration for Study 1 noted that scores derived from the actively open-minded thinking scale (AOT), cognitive reflection test (CRT), illusory truth task, and PDI would be subjected to principal component analysis (PCA). As noted earlier, the illusory truth effect task was not viable. It was therefore not included in this analysis. Subjecting AOT, CRT, and PDI scores to PCA resulted in a single factor (loadings: Table S3). This factor appeared to represent tendency to value evidence and engage in analytic thought. This result was interpreted as implying that belief in fake news and delusion-like ideation might share common variance in the form of reduced actively open-minded and analytic thinking. This result is therefore broadly consistent with the mediation analyses reported in the main manuscript. However, it is not reported in the main manuscript because the lack of multiple factors in the results of this PCA makes these results theoretically uninteresting. Because only one component was derived from PCA, the planned regression analysis examining whether the factors derived from PCA would both predict news discrimination scores was not conducted.

Table S3  
*Results of PCA*

Variable	Factor Loading Coefficient
Delusion-like ideation (PDI Total Score)	-.60
Analytic thinking (CRT)	.70
Actively open-minded thinking	.70
Belief in fake news	-.63

## Study 2

### *Hypotheses*

We preregistered our primary hypothesis (for full document, see:

<http://aspredicted.org/blind.php?x=fa8ez3>) that “higher-order (e.g., analytic reasoning, valuation of evidence) and lower-order (perceptual mistiming, increased effect of fluency [the ease or speed with which information is recalled from memory] on judgments of accuracy) factors associated with delusional belief would explain variance in belief in fake news.”

### *Analyses*

The correlational analysis reported in the main manuscript (Table 2) was preregistered:

“As a preliminary analysis, we will attempt to replicate the positive correlation between PDI scores and fake news accuracy ratings that was observed in a pilot study.”

The preliminary analysis meant to check that the illusory truth effect occurred was also preregistered:

“Illusory truth effect scores will be calculated as the difference in accuracy ratings (on average) given to items presented in both phase 1 and phase 2 of the illusory truth portion of the study. To ensure that an illusory truth effect occurred, illusory truth effect scores will be subjected to a single item t-test

against zero (this analysis will be conducted separately for each version of the illusory truth task); significant results would indicate that the illusory truth effect occurred as expected”

Our primary mediation analysis was also preregistered:

“We will examine whether four individual difference variables (AOT, CRT, illusory truth, and postdiction scores) significantly mediate the relationship between PDI scores and belief in fake news. We will examine this by entering each of these variables into separate mediation models (PROCESS macro for SPSS, Model 4, with 5000 bootstrapped samples and bias-corrected 95% confidence intervals will be employed).” Only two variables, the illusory truth and postdiction effects, were entered separately as preregistered. This modification was made because, in retrospect, Study 1 had already established that AOT and analytic thinking were independent mediators of the relationship between belief in fake news and delusion-like ideation. It was thought that replicating this result by entering AOT and analytic thinking into a simultaneous mediation model would be a more useful demonstration of these mediation effects.

Our simultaneous mediation analysis (reported in SI) was preregistered as:

“We will also enter all four variables simultaneously into a mediation model (PROCESS Model 6) with fake news accuracy ratings as the criterion variable and PDI scores as the predictor variable. This will help quantify the extent to which the combination of mediator variables explains the relationship between PDI scores and belief in fake news.”

Our analysis deviated slightly from this preregistered version. In writing our preregistration, we expected that AOT, CRT, illusory truth, and postdiction scores would all help explain the relationship between PDI scores and fake news accuracy judgments. However, only two variables, AOT and CRT

scores, did so. In light of this, it was determined that only AOT and CRT scores should be included in the aforementioned simultaneous mediation analysis.

Our PCA analysis (reported in SI) was also preregistered:

“To examine the interrelationships between these mediators in explaining the relationship between PDI scores and belief in fake news, any variable that acts as either a significant ( $p < .05$ ) or marginally significant ( $p < .10$ ) mediator of this relationship (when entered alone into the mediation model) will be subjected to PCA with oblimin rotation. We anticipate that this will result in multiple components. We anticipate that AOT and CRT will load primarily onto one component, reflecting tendency to value evidence and engage in analytic thinking. We expect that illusory truth and postdiction scores will load most strongly onto a separate component or components (reflecting tendency to use fluency in judgments of accuracy and/or tendency to mistime thoughts and perceptions). Scores on each component will be calculated. These component scores will be entered as simultaneous mediators of the relationship between PDI scores and fake news accuracy ratings (PROCESS Model 6 will be employed). We anticipate that all component scores will be significant mediators of this relationship.”

This PCA ended up including AOT and analytic thinking. This PCA yielded a single component with identical positive loadings for both AOT (.81) and analytic thinking (.81). Because only one component was produced, the preregistered simultaneous mediation using the PCA results was not conducted.

## SI Section S6. Results from Individual Studies Presented Separately

### Pilot Study

#### Analyses.

The pilot study examined whether the putative relationships between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism could be partially explained by reduced actively open-minded thinking. The PROCESS macro for SPSS (Model 4; Preacher & Hays, 2008) was used to test each hypothesized mediation pathway. Data were bootstrapped 5000 times and bias-corrected 95% confidence intervals were produced. Outliers were identified using the method of Hubert and Van der Veeken (2008), as implemented in R's RobustBase package, because this method is robust to skewed data. Identified outliers were winsorized (see Fuller, 1991). Results with outliers (which were qualitatively similar) and information regarding outlier removal can be found in SI Sections S7/S9.

#### Results.

As anticipated, the total effect of delusion-like ideation on belief in fake news was significant,  $\beta = 0.26, p < .001, 95\% \text{ CI} = [0.17 \ 0.36]$ . Delusion-like ideation predicted actively open-minded thinking,  $\beta = -0.24, p < .001, 95\% \text{ CI} = [-0.34 \ -0.15]$ . When both actively open-minded thinking and delusion-like ideation were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -.23, p < .001, 95\% \text{ CI} = [-0.33 \ -0.14]$ . These results suggested that delusion-like ideation might exert an indirect effect on belief in fake news via actively open-minded thinking. Critically, when this indirect effect was taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .21, p < .001, 95\% \text{ CI} = [0.11 \ 0.30]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of delusion-like ideation on belief in fake news,  $[0.03 \ 0.09]$ , that did not overlap with zero.

The total effect of dogmatism on belief in fake news was also significant,  $\beta = 0.17, p < .001$ , 95% CI = [0.07 0.27]. Dogmatism predicted actively open-minded thinking,  $\beta = -0.71, p < .001$ , 95% CI = [-0.78 -0.65]. When both actively open-minded thinking and dogmatism were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -0.34, p < .001$ , 95% CI = [-0.47 -0.20]. These results suggested that dogmatism might exert an indirect effect on belief in fake news via actively open-minded thinking. Critically, when this indirect effect was taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = -0.07, p = .296$ , 95% CI = [-0.21 0.06]) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of dogmatism on belief in fake news, [0.15 0.34], that did not overlap with zero.

The total effect of religious fundamentalism on belief in fake news was also significant,  $\beta = 0.26, p < .001$ , 95% CI = [0.17 0.36]. Religious fundamentalism predicted actively open-minded thinking,  $\beta = -0.70, p < .001$ , 95% CI = [-0.77 -0.63]. When both actively open-minded thinking and religious fundamentalism were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -0.20, p = .004$ , 95% CI = [-0.33 -0.06]. These results suggested that religious fundamentalism might exert an indirect effect on belief in fake news via actively open-minded thinking. Critically, when this indirect effect was taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake news ( $\beta = 0.13, p = .061$ , 95% CI = [-0.01 0.26]) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of religious fundamentalism on belief in fake news, [0.05 0.23], that did not overlap with zero.

### **Discussion.**

This pilot study established a relationship between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism. As hypothesized, the results of this pilot study suggested that reduced AOT partially mediates the relationship between belief in fake news and

delusion-like ideation. Exploratory analyses indicated that reduced AOT fully mediates the association of belief in fake news with dogmatism and religious fundamentalism, as expected.

## **Study 1**

### **Analyses.**

Data collected in Study 1 were analyzed to examine whether reduced actively-open minded thinking would again mediate the relationship between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism in an independent dataset. These data were also used to examine whether reduced analytic thinking might mediate (over and above any effects of reduced AOT) the relationship between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism. These examinations were conducted by entering measures of actively open-minded and analytic thinking into a single mediation model (PROCESS Model 4) and producing 5000 bootstrapped samples and bias-corrected 95% confidence intervals.

### **Results.**

As anticipated, the total effect of delusion-like ideation on belief in fake news was significant, ( $\beta = 0.19, p < .001, 95\% \text{ CI} = [0.10 \ 0.28]$ ). Delusion-like ideation predicted actively open-minded ( $\beta = -0.23, p < .001, 95\% \text{ CI} = [-0.31 \ -0.14]$ ) and analytic thinking ( $\beta = -0.22, p < .001, 95\% \text{ CI} = [-0.31 \ -0.14]$ ). When delusion-like ideation, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -.15, p = .001, 95\% \text{ CI} = [-0.24 \ -0.06]$ ) and analytic thinking ( $\beta = -.18, p = .001, 95\% \text{ CI} = [-0.27 \ -0.09]$ ) predicted belief in fake news. These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .12, p = .008, 95\% \text{ CI} = [0.03 \ 0.20]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of delusion-like ideation on



belief in fake news (through actively open-minded thinking: [0.01 0.06], through analytic thinking: [0.02 0.07]) that did not overlap with zero.

The total effect of dogmatism on belief in fake news was also significant,  $\beta = 0.15, p = .001$ , 95% CI = [.06 .24]. Dogmatism predicted actively open-minded ( $\beta = -0.70, p < .001$ , 95% CI = [-0.76 - 0.64]) and analytic thinking ( $\beta = -0.20, p < .001$ , 95% CI = [-0.29 -0.11]). When dogmatism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.18, p = .004$ , 95% CI = [-0.30 -0.06]) and analytic thinking ( $\beta = -0.20, p < .001$ , 95% CI = [-0.29 -0.11]) predicted belief in fake news. These results suggested that dogmatism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = -0.02, p = .782$ , 95% CI = [-0.13 0.10]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of dogmatism on belief in fake news (through actively open-minded thinking: [0.04 0.20], through analytic thinking: [0.02 0.07]) that did not overlap with zero.

The total effect of religious fundamentalism on belief in fake news was also significant,  $\beta = 0.13, p = .003$ , 95% CI = [.04 .22]. Religious fundamentalism predicted actively open-minded ( $\beta = -0.61, p < .001$ , 95% CI = [-0.68 -0.54]) and analytic thinking ( $\beta = -0.25, p < .001$ , 95% CI = [-0.34 - 0.17]). When religious fundamentalism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.19, p = .001$ , 95% CI = [-0.30 -0.08]) and analytic thinking ( $\beta = -0.21, p < .001$ , 95% CI = [-0.29 -0.12]) predicted belief in fake news. These results suggested that religious fundamentalism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake news ( $\beta = -0.04, p = .493$ , 95% CI = [-0.15 0.07]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects

of religious fundamentalism on belief in fake news (through actively open-minded thinking: [0.05 0.18], through analytic thinking: [0.03 0.09]) that did not overlap with zero.

### **Discussion.**

The results of Study 1 indicated that reduced analytic and actively open-minded thinking together partially mediated the relationship between belief in fake news and delusion-like ideation. These results were consistent with those of the pilot study. The results of Study 1 also indicated that reduced analytic and actively open-minded thinking together fully mediated the association of belief in fake news with dogmatism and religious fundamentalism. Study 1 also revealed that the mediation effects exerted by actively open-minded and analytic thinking were somewhat independent of one another. In this way, Study 2 extended the results of the pilot study.

## **Study 2**

### **Analyses.**

The analyses in Study 2 were meant to examine whether the results of Study 1 would replicate in an independent dataset.

### **Results.**

The results of Study 2 replicated those of Study 1. As anticipated, the total effect of delusion-like ideation on belief in fake news was significant, ( $\beta = 0.32, p < .001, 95\% \text{ CI} = [0.23 \ 0.40]$ ). Delusion-like ideation predicted actively open-minded ( $\beta = -0.38, p < .001, 95\% \text{ CI} = [-0.47 \ -0.29]$ ) and analytic thinking ( $\beta = -0.29, p < .001, 95\% \text{ CI} = [-0.39 \ -0.21]$ ). When delusion-like ideation, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -.19, p < .001, 95\% \text{ CI} = [-0.29 \ -0.09]$ ) and analytic thinking ( $\beta = -.11, p = .025, 95\% \text{ CI} = [-0.20 \ -0.01]$ ) predicted belief in fake news. These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .21, p < .001, 95\% \text{ CI} = [0.12 \ 0.31]$ ) was less

strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of delusion-like ideation on belief in fake news (through actively open-minded thinking: [0.03 0.11], through analytic thinking: [0.01 0.06]) that did not overlap with zero.

The total effect of dogmatism on belief in fake news was also significant,  $\beta = 0.22, p = .001$ , 95% CI = [.13 .31]. Dogmatism predicted actively open-minded ( $\beta = -0.68, p < .001$ , 95% CI = [-0.75 - 0.61]) and analytic thinking ( $\beta = -0.16, p = .001$ , 95% CI = [-0.25 -0.07]). When dogmatism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.23, p = .001$ , 95% CI = [-0.36 -0.10]) and analytic thinking ( $\beta = -0.15, p = .002$ , 95% CI = [-0.24 -0.06]) predicted belief in fake news. These results suggested that dogmatism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = 0.04, p = .503$ , 95% CI = [-0.08 0.16]) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of dogmatism on belief in fake news (through actively open-minded thinking: [0.07 0.25], through analytic thinking: [0.01 0.05]) that did not overlap with zero.

The total effect of religious fundamentalism on belief in fake news was also significant,  $\beta = 0.22, p < .001$ , 95% CI = [.13 .31]. Religious fundamentalism predicted actively open-minded ( $\beta = -0.64, p < .001$ , 95% CI = [-0.71 -0.57]) and analytic thinking ( $\beta = -0.33, p < .001$ , 95% CI = [-0.42 - 0.24]). When religious fundamentalism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.25, p < .001$ , 95% CI = [-0.36 -0.13]) and analytic thinking ( $\beta = -0.15, p = .003$ , 95% CI = [-0.24 -0.05]) predicted belief in fake news. These results suggested that religious fundamentalism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake

news ( $\beta = 0.01, p = .835, 95\% \text{ CI} = [-0.11 \ 0.13]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of religious fundamentalism on belief in fake news (through actively open-minded thinking: [0.09 0.24], through analytic thinking: [0.02 0.08]) that did not overlap with zero.

### **Discussion.**

Study 2 replicated the results of Study 1. Study 2 again suggested that reduced analytic and actively open-minded thinking together partially mediated the relationship between belief in fake news and delusion-like ideation. Like Study 1, Study 2 indicated that reduced analytic and actively open-minded thinking together fully mediated the association of dogmatism and religious fundamentalism with belief in fake news. In accordance with Study 1, Study 2 suggested that the mediation effects exerted by actively open-minded and analytic thinking were somewhat independent of one another.

## **SI Section S7. Results from the Analysis of Individual Study Waves with Outliers Included**

### *Mediation Analyses in the Pilot Study*

The results of the mediation analyses in the pilot study when outliers were included were also extremely similar to those obtained after outliers were winsorized. As anticipated, these analyses found that the total effect of delusion-like ideation on belief in fake news was significant,  $\beta = 0.27$ ,  $p < .001$ , 95% CI = [0.17 0.36]. Delusion-like ideation predicted actively open-minded thinking,  $\beta = -0.24$ ,  $p < .001$ , 95% CI = [-0.34 -0.15]. When both delusion-like ideation and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -.23$ ,  $p < .001$ , 95% CI = [-0.32 -0.13]. Critically, when this indirect effect was taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .21$ ,  $p < .001$ , 95% CI = [0.12 0.31]) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of delusion-like ideation on belief in fake news, [0.03 0.09], that did not overlap with zero.

These analyses also found that the total effect of dogmatism on belief in fake news was significant,  $\beta = 0.17$ ,  $p < .001$ , 95% CI = [0.07 0.26]. Dogmatism predicted actively open-minded thinking,  $\beta = -0.72$ ,  $p < .001$ , 95% CI = [-0.79 -0.65]. When both dogmatism and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -0.33$ ,  $p < .001$ , 95% CI = [-0.46 -0.19]. Critically, when this indirect effect was taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = -0.07$ ,  $p = .334$ , 95% CI = [-0.20 0.07]) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of dogmatism on belief in fake news, [0.14 0.34], that did not overlap with zero.

These analyses also found that the total effect of religious fundamentalism on belief in fake news was significant,  $\beta = 0.26$ ,  $p < .001$ , 95% CI = [0.16 0.36]. Religious fundamentalism predicted actively open-minded thinking,  $\beta = -0.71$ ,  $p < .001$ , 95% CI = [-0.78 -0.64]. When both religious

fundamentalism and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded thinking predicted belief in fake news,  $\beta = -0.19, p = .006, 95\% \text{ CI} = [-0.00 \ 0.27]$ . Critically, when this indirect effect was taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake news ( $\beta = 0.13, p = .050, 95\% \text{ CI} = [0.00 \ 0.27]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of religious fundamentalism on belief in fake news,  $[0.04 \ 0.23]$ , that did not overlap with zero.

### *Mediation Analyses: Study 2*

The results of the mediation analyses in Study 2 when outliers were included were extremely similar to those obtained after outliers were winsorized. As anticipated, the total effect of delusion-like ideation on belief in fake news was significant, ( $\beta = 0.32, p < .001, 95\% \text{ CI} = [0.23 \ 0.41]$ ). Delusion-like ideation predicted actively open-minded ( $\beta = -0.39, p < .001, 95\% \text{ CI} = [-0.47 \ -0.30]$ ) and analytic thinking ( $\beta = -0.29, p < .001, 95\% \text{ CI} = [-0.38 \ -0.21]$ ). When delusion-like ideation, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -.17, p = .001, 95\% \text{ CI} = [-0.27 \ -0.08]$ ) and analytic thinking ( $\beta = -.11, p = .018, 95\% \text{ CI} = [-0.21 \ -0.02]$ ) predicted belief in fake news. These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .22, p < .001, 95\% \text{ CI} = [0.12 \ 0.31]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of delusion-like ideation on belief in fake news (through actively open-minded thinking:  $[0.03 \ 0.11]$ , through analytic thinking:  $[0.01 \ 0.07]$ ) that did not overlap with zero.

The total effect of dogmatism on belief in fake news was also significant,  $\beta = 0.22, p = .001, 95\% \text{ CI} = [.13 \ .31]$ . Dogmatism predicted actively open-minded ( $\beta = -0.69, p < .001, 95\% \text{ CI} = [-0.76 \ -0.62]$ ) and analytic thinking ( $\beta = -0.17, p = .001, 95\% \text{ CI} = [-0.26 \ -0.08]$ ). When dogmatism, analytic

thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.21, p = .001, 95\% \text{ CI} = [-0.34 -0.09]$ ) and analytic thinking ( $\beta = -0.16, p = .001, 95\% \text{ CI} = [-0.25 -0.06]$ ) predicted belief in fake news. These results suggested that dogmatism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of dogmatism on belief in fake news ( $\beta = 0.05, p = .464, 95\% \text{ CI} = [-0.08 0.17]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of dogmatism on belief in fake news (through actively open-minded thinking:  $[0.06 0.24]$ , through analytic thinking:  $[0.01 0.05]$ ) that did not overlap with zero.

The total effect of religious fundamentalism on belief in fake news was also significant,  $\beta = 0.22, p < .001, 95\% \text{ CI} = [.13 .32]$ . Religious fundamentalism predicted actively open-minded ( $\beta = -0.66, p < .001, 95\% \text{ CI} = [-0.73 -0.59]$ ) and analytic thinking ( $\beta = -0.33, p < .001, 95\% \text{ CI} = [-0.42 -0.24]$ ). When religious fundamentalism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = -0.23, p < .001, 95\% \text{ CI} = [-0.35 -0.11]$ ) and analytic thinking ( $\beta = -0.15, p = .002, 95\% \text{ CI} = [-0.25 -0.06]$ ) predicted belief in fake news. These results suggested that religious fundamentalism might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of religious fundamentalism on belief in fake news ( $\beta = 0.02, p = .705, 95\% \text{ CI} = [-0.10 0.14]$ ) was less strong than the total effect. The significance of this decrease in strength was confirmed by 95% CIs for the completely standardized indirect effects of religious fundamentalism on belief in fake news (through actively open-minded thinking:  $[0.07 0.23]$ , through analytic thinking:  $[0.02 0.09]$ ) that did not overlap with zero.

## SI Section S8. Serial Mediation Models

Additional exploratory analyses in Study 1 examined the extent to which the combination of reduced actively open-minded and analytic thinking could explain the relationships between belief in fake news and delusion-like ideation, dogmatism, and religious fundamentalism. For these analyses, PROCESS Model 6 was used because (unlike Model 4) it allows for serial mediation and should therefore give an upper-bound estimate of the explanatory power of actively open-minded and analytic thinking. Data were bootstrapped 5000 times and bias-corrected 95% confidence intervals were generated.

The total effect of delusion-like ideation on belief in fake news was significant,  $\beta = 0.19$ ,  $p < .001$ , 95% CI = [0.10 0.28]. Delusion-like ideation predicted actively open-minded thinking,  $\beta = -0.23$ ,  $p < .001$ , 95% CI = [-0.31 -0.14]. When actively open-minded thinking and delusion-like ideation were simultaneously entered into the regression model, both actively open-minded thinking ( $\beta = 0.29$ ,  $p < .001$ , 95% CI = [0.20 0.37]) and delusion-like ideation ( $\beta = -0.16$ ,  $p < .001$ , 95% CI = [-0.24 -0.07]) predicted analytic thinking. When analytic thinking, actively open-minded thinking, and delusion-like ideation were simultaneously entered into the regression model, analytic thinking ( $\beta = -0.18$ ,  $p < .001$ , 95% CI = [-0.27 -0.09]) and actively open-minded thinking ( $\beta = -0.15$ ,  $p < .001$ , 95% CI = [-0.24 -0.06]) predicted belief in fake news. These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = 0.12$ ,  $p = .009$ , 95% CI = [.03 .20]) was less strong than the total effect.

Examination of individual potential mediators revealed that the indirect effect of delusion-like ideation on belief in fake news via reduced analytic thinking was significant (95% CI = [0.01 0.05]), as was the indirect effect relating these variables via reduced actively open-minded thinking (95% CI = [0.02 0.06]). The indirect effect of delusion-like ideation on belief in fake news through actively open-



minded thinking and then through analytic thinking was also significant (95% CI = [0.01 0.02]), suggesting the presence of a serial mediation effect involving these variables.

In this mediation model the ratio of the indirect effect of delusion-like ideation on belief in fake news (through reduced analytic and actively open-minded thinking) to the total effect was 0.39 (95% CI = [0.21 0.81]). This result suggests that approximately one-third of the relationship between belief in fake news and delusion-like ideation is explained by the combination of reduced analytic and actively open-minded thinking.

This exploratory analysis was repeated using data from Study 2. The total effect of delusion-like ideation on belief in fake news was significant,  $\beta = 0.32, p < .001, 95\% \text{ CI} = [0.23 \ 0.40]$ . Delusion-like ideation predicted actively open-minded thinking,  $\beta = -0.40, p < .001, 95\% \text{ CI} = [-0.47 \ -0.29]$ . When actively open-minded thinking and delusion-like ideation were simultaneously entered into the regression model, both actively open-minded thinking ( $\beta = 0.24, p < .001, 95\% \text{ CI} = [0.15 \ 0.34]$ ) and delusion-like ideation ( $\beta = -0.20, p < .001, 95\% \text{ CI} = [-0.30 \ -0.11]$ ) predicted analytic thinking. When analytic thinking, actively open-minded thinking, and delusion-like ideation were simultaneously entered into the regression model, analytic thinking ( $\beta = -0.10, p = .025, 95\% \text{ CI} = [-0.20 \ -0.01]$ ) and actively open-minded thinking ( $\beta = -0.19, p < .001, 95\% \text{ CI} = [-0.29 \ -0.09]$ ) predicted belief in fake news. These results suggested that delusion-like ideation might exert indirect effects on belief in fake news via actively open-minded and analytic thinking. Critically, when these indirect effects were taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = 0.21, p < .001, 95\% \text{ CI} = [0.12 \ 0.31]$ ) was less strong than the total effect.

Examination of individual potential mediators revealed that the indirect effect of delusion-like ideation on belief in fake news via reduced analytic thinking was not significant (95% CI = [0.00 0.05]). The indirect effect of delusion-like ideation on belief in fake news via actively open-minded thinking was significant (95% CI = [0.03 0.11]). The indirect effect of delusion-like ideation on belief in fake news through actively open-minded thinking and then through analytic thinking was not

significant (95% CI = [0.00 0.02]), suggesting the lack of a significant serial mediation effect involving these variables.

In this mediation model the ratio of the indirect effect of delusion-like ideation on belief in fake news (through reduced analytic and actively open-minded thinking) to the total effect was 0.33 (95% CI = [0.17 0.55]). In tandem with the results of Study 1, this result suggests that approximately 36% of the relationship between belief in fake news and delusion-like ideation is explained by the combination of reduced analytic and actively open-minded thinking.

## SI Section S9. Notes on Outlier Analyses

As stated in our preregistration, outliers in the data presented in this manuscript were identified using the method of Hubert and Van der Veen (2008), as implemented in R's RobustBase package, because this method is robust to skewed data. This method was used because Shapiro-Wilk tests indicated that the major variables of interest in this study had non-normal distributions (Table S4). Using this method, one outlier AOT score was detected in the pilot study, and three outlier AOT scores were detected in Study 2. No outliers were detected in Study 1. No other outliers were detected. All identified outliers were winsorized.

Table S4  
*Shapiro-Wilk test values for major variables of interest*

Variable	Test Statistic (all: $p < .001$ , $df = 446$ )
Belief in real news	0.98
Belief in fake news	0.97
Delusion-like ideation (PDI Total Score)	0.88
Analytic thinking (CRT)	0.93
Dogmatism	0.98
Religious fundamentalism	0.92
Actively open-minded thinking	0.98
Illusory truth effect score	0.98
Postdiction effect score	0.96

*Note.* Data from Study 2. Similar results were found in data from the pilot study and Study 1.

## SI Section S10. Zero-order Correlations Between Study Variables

Table S5  
*Zero-order correlations between variables in the Pilot Study*

	2	3	4	5	6
1. Belief in fake news	.02	-.30*	.25*	.22*	.28*
2. Belief in real news		.10	-.01	-.09	-.12
3. A.O. thinking			-.22*	-.72*	-.69*
4. Delusion-like ideation (PDI Yes/No scores)				.10	.24*
5. Dogmatism					.66*
6. Religious fundamentalism					

*Note.* Non-parametric correlations (Spearman's rho) were reported because variable distributions were non-normal. Only correlations with p-values less than .001 are reported as significant and marked by an asterisk. A.O. Thinking = Actively open-minded thinking, PDI = Peters et al. Delusion Inventory.

Table S6  
*Zero-order correlations between study variables in Study 1*

	2	3	4	5	6	7
1. Belief in fake news	.13	-.24*	-.25*	.20*	.15	.14
2. Belief in real news		.06	.06	-.06	0.00	-.10
3. A.O. thinking			.33*	-.26*	-.71*	-.62*
4. Analytic thinking				-.23*	-.22*	-.26*
5. Delusion-like ideation					.16*	.30*
6. Dogmatism						.67*
7. Religious fundamentalism						

*Note.* Non-parametric correlations (Spearman's rho) were reported because variable distributions were non-normal. Only correlations with p-values less than .001 are reported as significant and marked by an asterisk. DOG = dogmatism scale, A.O. Thinking = Actively open-minded thinking.

Table S7  
*Zero-order correlations between variables in Study 2*

	2	3	4	5	6	7	8	9
1. Belief in Fake News	.02	-.32*	-.19*	.24*	.28*	.26*	-.03	.06
2. Belief in Real News		.14	.12	.06	-.15	-.07	-.04	-.01
3. Actively open-minded thinking			.33*	-.40*	-.69*	-.67*	.03	-.05
4. Analytic thinking				-.31*	-.21*	-.37*	.05	.00
5. Delusion-like ideation					.25*	.46*	.01	.13
6. Dogmatism						.61*	-.01	.03
7. Religious fundamentalism							-.06	.02
8. Illusory truth								.03
9. Postdiction								

*Note.* Non-parametric correlations (Spearman's rho) were reported because variable distributions were non-normal. Only correlations with p-values less than .001 are reported as significant and marked by an asterisk.

**SI Section S11. Summary of all Statistics from the Exploratory Mediation Analyses in the Main Manuscript**

Table S8

*The relationship between belief in fake news and dogmatism is mediated by cognitive style*

Criterion Variable	Predictor(s)	Standard Error	$\beta$ [95% CI]	$t$	$F$	$R^2$
Analytic thinking	Dogmatism	0.03	-0.18 [-0.24 -0.12]	5.59	31.21	.03
Actively open-minded thinking	Dogmatism	0.02	-0.70 [-0.75 -0.65]	29.62	877.31	.48
Belief in fake news	Dogmatism	0.03	0.18 [0.12 0.25]	5.76	33.18	.03
Belief in fake news	Analytic thinking	0.03	-0.17 [-0.23 -0.11]	5.20	33.09	.10
	Actively open-minded thinking	0.04	-0.19 [-0.28 -0.11]	4.37		
	Dogmatism	0.04	0.02 [-0.07 0.10]	< 1		

*Note.* The indirect effect through analytic thinking was significant, coefficient=0.03, 95% CI=[0.02 0.05], as was the indirect through actively open-minded thinking, coefficient=0.14, 95% CI = [0.08 0.20]. The indirect effects through these variables explained 90% of the total effect of dogmatism on belief in fake news. Horizontal lines separate individual regression models.

Table S9

*The relationship between belief in fake news and religious fundamentalism is mediated by cognitive style*

Criterion Variable	Predictor(s)	Standard Error	$\beta$ [95% CI]	$t$	$F$	$R^2$
Analytic thinking	RF	0.03	-0.29 [-0.35 -0.22]	9.15	83.69	.08
Actively open-minded thinking	RF	0.03	-0.64 [-0.69 -0.59]	25.28	639.14	.40
Belief in fake news	RF	0.03	0.18 [0.11 0.24]	5.51	30.33	.03
Belief in fake news	Analytic thinking	0.03	-0.17 [-0.23 -0.11]	5.17	33.04	.10
	Actively open-minded thinking	0.04	-0.21 [-0.29 -0.13]	5.21		
	RF	0.04	0.01 [-0.09 0.07]	< 1		

*Note.* The indirect effect through analytic thinking was significant, coefficient=0.05, 95% CI=[0.03 0.07], as was the indirect through actively open-minded thinking, coefficient=0.14, 95% CI = [0.09 0.19]. The indirect effects through these variables explained 100% of the total effect of religious fundamentalism on belief in fake news. RF = Religious fundamentalism. Horizontal lines separate individual regression models.



## SI Section S12. Results Pertaining to Belief in Real News

Participants in the present studies also completed measures of belief in real news. In the combined dataset (studies one and two) employed in the main manuscript, belief in real news was correlated (at zero-order; Spearman's rho) with AOT scores ( $\rho(945) = .10, p = .003$ ), CRT scores ( $\rho(945) = .09, p = .004$ ), dogmatism scores ( $\rho(945) = -.10, p = .002$ ), and religious fundamentalism scores ( $\rho(945) = -.09, p = .007$ ). Belief in real news was not correlated with the illusory truth effect ( $\rho(444) = -.04, p = .451$ ), with the postdiction effect ( $\rho(444) = .01, p = .810$ ), or with delusion-like ideation scores ( $\rho(945) = .01, p = .678$ ).

Given these results, we examined whether the relationship between dogmatism/religious fundamentalism and belief in real news might be explained by the combination of reduced analytic and actively open-minded thinking (as it is for fake news).

In the model examining actively open-minded and analytic thinking as potential simultaneous mediators, the total effect of delusion-like ideation on belief in real news was not significant,  $\beta = 0.04, p = .224, 95\% \text{ CI} = [-.02 .10]$ . Delusion-like ideation predicted actively open-minded ( $\beta = -0.30, p < .001, 95\% \text{ CI} = [-.36 -.24]$ ) and analytic thinking ( $\beta = -0.26, p < .001, 95\% \text{ CI} = [-.32 -.20]$ ). When delusion-like ideation, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = 0.10, p = .004, 95\% \text{ CI} = [.03 .17]$ ) and analytic thinking ( $\beta = 0.07, p = .033, 95\% \text{ CI} = [.01 .14]$ ) predicted belief in real news. These results suggested that delusion-like ideation might exert indirect effects on belief in real news via actively open-minded and analytic thinking. When these indirect effects were taken into account, the direct effect of delusion-like ideation on belief in real news ( $\beta = .09, p = .009, 95\% \text{ CI} = [0.02 0.16]$ ) became significant. The fact that this direct effect was stronger than the total effect was confirmed by a 95% CI for the completely standardized indirect effect of delusion-like ideation on belief in real news through actively open-minded thinking,  $[-0.05 -0.01]$ , that did not overlap with zero. However, the 95% CI for the completely standardized indirect effect of delusion-like ideation on belief in real news

through analytic thinking, [-0.04 0.00], overlapped with zero. These results suggest that there is a significant negative indirect effect of delusion-like ideation through actively open-minded thinking that competes with the positive direct effect of delusion-like ideation to determine belief in real news.

The total effect of dogmatism on belief in real news was significant,  $\beta = -0.07$ ,  $p = .029$ , 95% CI = [-.14 -.01]. Dogmatism predicted actively open-minded ( $\beta = -0.70$ ,  $p < .001$ , 95% CI = [-0.75 -0.65]) and analytic thinking ( $\beta = -0.18$ ,  $p = .001$ , 95% CI = [-0.24 -0.12]). When dogmatism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = 0.07$ ,  $p = .135$ , 95% CI = [-0.02 0.16]) and analytic thinking ( $\beta = -0.06$ ,  $p = .092$ , 95% CI = [-0.01 0.13]) did not predict belief in real news, which is inconsistent with the possibility that the relationship between belief in real news and dogmatism is mediated by these cognitive styles.

The total effect of religious fundamentalism on belief in real news was not significant,  $\beta = -0.06$ ,  $p = .059$ , 95% CI = [-.13 .00]. Religious fundamentalism predicted actively open-minded ( $\beta = -0.64$ ,  $p < .001$ , 95% CI = [-0.69 -0.59]) and analytic thinking ( $\beta = -0.29$ ,  $p < .001$ , 95% CI = [-0.35 -0.22]). When religious fundamentalism, analytic thinking, and actively open-minded thinking were entered simultaneously into the regression model, actively open-minded ( $\beta = 0.09$ ,  $p = .050$ , 95% CI = [0.00 0.17]) and analytic thinking ( $\beta = 0.06$ ,  $p = .092$ , 95% CI = [-0.01 0.13]) did not predict belief in real news, which is inconsistent with the possibility that the relationship between belief in real news and religious fundamentalism is mediated by these cognitive styles.

In summary, these analyses suggest that the mediation results presented in the main manuscript are specific to belief in fake news. At zero-order, belief in real news (unlike belief in fake news) did not correlate with delusion-like ideation. The indirect effect of delusion-like ideation on belief in real news via analytic and actively open-minded thinking competed with the direct effect of delusion-like ideation on belief in real news. This pattern contrasts with the complementary mediation effect of these cognitive styles that was observed for fake news. Although belief in real news (like belief in fake news)

was correlated with dogmatism and religious fundamentalism at zero-order, the ability of actively open-minded and analytic thinking to explain the relationship between dogmatism/religious fundamentalism and news accuracy judgments appears to be largely specific to contexts in which fake news is being evaluated.

### **SI Section S13. BCIS Self-certainty Mediates the Relationship Between Delusion-like Ideation and Belief in Fake News**

Metacognitive models of reasoning (e.g., Thompson, Prowse, Turner, & Pennycook, 2011) suggest that excessive confidence in fake news accuracy judgments may inhibit the engagement of analytic thinking processes, which the present studies suggest could reduce belief in fake news. As a result, one might expect that metacognitive self-certainty might encourage belief in fake news. To investigate this possibility, an exploratory analysis was conducted using the self-certainty subscale of the Beck Cognitive Insight Scale (BCIS; Beck, Baruch, Balter, Steer, & Warman, 2004) to determine whether self-certainty mediated the relationship between belief in fake news and delusion-like ideation. To conduct this analysis, data from Study 2 were bootstrapped 5000 times and bias-corrected 95% confidence intervals were generated.

The total effect of delusion-like ideation on belief in fake news was significant,  $\beta = 0.32$ ,  $p < .001$ , 95% CI = [0.23 0.41]. Delusion-like ideation predicted self-certainty,  $\beta = 0.17$ ,  $p < .001$ , 95% CI = [0.08 0.26]. When both self-certainty and delusion-like ideation were entered simultaneously into the regression model, self-certainty predicted belief in fake news,  $\beta = .15$ ,  $p = .001$ , 95% CI = [0.05 0.24]. These results suggested that delusion-like ideation might exert an indirect effect on belief in fake news via self-certainty. Critically, when this indirect effect was taken into account, the remaining (direct) effect of delusion-like ideation on belief in fake news ( $\beta = .29$ ,  $p < .001$ , 95% CI = [0.21 0.38]) was less strong than the total effect. The significance of this decrease in strength was confirmed by a 95% CI for the completely standardized indirect effect of delusion-like ideation on belief in fake news through self-certainty, [0.01 0.05], that did not overlap with zero. These results indicate that metacognitive self-certainty partially mediates the relationship between delusion-like ideation and belief in fake news, suggesting that it may be worthwhile to examine the meta-cognitive correlates of belief in fake news.

## **SI Section S14. The Relationship Between the Illusory Truth/Postdiction Effect and Belief in Fake News**

The present research also included analyses examining the relationship between belief in fake news and both the illusory truth and postdiction effects. These analyses were meant to examine whether these effects might help explain the portion of the relationship between delusion-like ideation and belief in fake news that was not explained by analytic and actively open-minded thinking (see SI Section S8).

The illusory truth effect occurs when mere exposure to information increases its perceived accuracy (Begg, Anas, & Farinacci, 1992). Research indicates that delusional and delusion-prone individuals may experience an exaggerated illusory truth effect for emotional information (Moritz et al., 2012). The exaggeration of the illusory truth effect in these individuals may make them more likely to endorse repeatedly encountered implausible ideas. This effect may extend to belief in fake news, which is subject to the illusory truth effect (Pennycook, Cannon, & Rand, 2017). Consistent with this possibility, the illusory truth effect occurs even when one knows the repeated information to be inaccurate (Fazio et al., 2015).

The postdiction effect occurs when predictions (e.g., about which of several squares will change color) are influenced by events that individuals perceive as having occurred after the prediction was made (Bear & Bloom, 2016). This effect was examined because although beliefs and perceptions are often treated as separate entities, research indicates that deficits in the same underlying processes (e.g., prediction error signaling) may give rise to both abnormal perceptual experiences and implausible beliefs (Fletcher & Frith, 2009). Accordingly, it is plausible that the postdiction effect might capture deficits that increase individuals' willingness to endorse implausible beliefs. Consistent with this notion, prior research indicates that the postdiction effect is associated with delusion-like ideation (Bear, Fortgang, Bronstein, & Cannon, 2017). If the postdiction effect captures deficits that encourage a variety of implausible beliefs (beyond just delusion-like ideation), one might expect individuals who

more strongly exhibit the postdiction effect to be more likely to endorse implausible ideas advanced via fake news. We therefore asked whether individual differences in the tendency to exhibit the illusory truth effects and post-diction effects correlated with delusionality and belief in fake news, and – more importantly – whether such individual differences help to explain the relationship between delusionality and belief in fake news.

In order to examine these questions, participants in Study 2 completed a task designed to measure the postdiction effect. The task used to measure the postdiction effect in this study is fully detailed elsewhere (Bear et al., 2017). Briefly, participants were presented with a series of white squares and were asked to predict which would change color. Participants were given a variable amount of time to make a prediction before the color change occurred (0-4000 ms). After viewing the color change, participants reported whether or not their prediction was correct (or indicated that they did not have time to make a prediction). Previous studies using this task have shown that participants generally over-report correct predictions (vs. chance levels), despite the fact that the task offers participants no information that could be used to elevate correct prediction rates above chance levels. Thus, this over-reporting suggests that the color change exerts a postdictive influence on participants' predictions (Bear et al., 2017; Bear & Bloom, 2016). This effect is more apparent in participants endorsing more delusion-like ideation (Bear et al., 2017), especially when participants are given less time ( $\leq 250$  ms) to make their predictions.

Participants in Study 2 also completed a task designed to capture individual differences in the illusory truth effect. This task consisted of two stages. In the first stage, participants rated how interested they were in ten facts using a six-point scale (1="Very Uninteresting," 6="Very Interesting"). Participants were shown one of two sets of ten facts in this stage. Participants then completed the CRT and PDI along with the fake news and postdiction tasks. After completing these tasks, they viewed all twenty facts and rated their accuracy using a six-point scale (1="definitely false," 6="definitely true"). The illusory truth effect was quantified as the difference between the average accuracy rating for the

ten previously seen facts and the average rating for the ten facts that had not been previously seen in the study.

In order to better ensure that the measures of the postdiction and illusory truth effects were valid in the present study, they were examined via preliminary analyses. These preliminary analyses indicated that the postdiction effect occurred for predictions that the participants made in less than or equal to 250 ms. The postdiction effect increases the rate that participants endorse guessing the shape that will later change color above chance levels. Thus, if participants report more correct predictions than could be expected by chance, this would suggest that the postdiction effect occurred in the present study. When participants had less than or equal to 250 ms to guess which square would change color, they reported that their guesses were correct 52% of the time ( $SD = 16\%$ ), on average. This rate significantly exceeded chance (50%),  $t(443) = 3.32, p < .001$ .

Preliminary analyses also indicated that the illusory truth effect occurred in Study 2. Overall, items seen in both phases of the illusory truth effect task were rated as being more plausible than those seen in only the second phase of the task (Mean difference = 0.49,  $SD = 0.93$ ). A single item  $t$ -test against zero confirmed the significance of this difference,  $t(445) = 10.98, p < .001$ . Examining false and true facts separately and accounting for the different forms of the task used in this study (Form A, Form B) also indicated that the illusory truth effect had occurred in Study 2. False facts seen twice by participants who completed Form A were rated more highly ( $M = 3.57, SD = 0.91$ ) than the rating given to the same facts by participants who saw them only once as they completed Form B ( $M = 3.22, SD = 0.79$ ),  $t(444) = 4.33, p < .001$ . Similarly, false facts seen twice by participants who completed Form B were rated more highly ( $M = 4.21, SD = 0.99$ ) than the rating given to the same facts by participants who saw them only once as they completed Form A ( $M = 3.57, SD = 0.73$ ),  $t(403.01) = 7.73, p < .001$ . True facts seen twice by participants who completed Form A were rated more highly ( $M = 4.08, SD = 0.77$ ) than the rating given to the same facts by participants who saw them only once as they completed Form B ( $M = 3.61, SD = 0.73$ ),  $t(444) = 6.50, p < .001$ . Similarly, true facts seen twice by participants

who completed Form B were rated more highly ( $M = 4.55$ ,  $SD = 0.96$ ) than the rating given to the same facts by participants who saw them only once as they completed Form A ( $M = 4.03$ ,  $SD = 0.84$ ),  $t(433.44) = 6.04$ ,  $p < .001$ .

After ensuring that the postdiction and illusory truth tasks occurred in the present study, analyses turned to selecting a single-number summary of the postdiction effect. The postdiction effect has not previously been examined as a potential mediator variable. Because of this, previous studies have not needed to summarize the postdiction effect using a single number. In this study, two potential scoring schemes (Method A: the probability of participants reporting a correct prediction when they had less than 250 ms to make a prediction; Method B: the beta-weight describing how the log of the time participants had to make a prediction predicts the probability of predicting which square will change color) were considered. Ultimately, Method A was selected because it correlated with delusion-like ideation ( $\rho(444) = .13$ ,  $p = .005$ ) in the expected direction while Method B did not ( $\rho(446) = -.05$ ,  $p = .335$ ). This selection criterion was used because any potential mediator of the relationship between belief in fake news and delusion-like ideation would need to have a zero-order relationship with delusion-like ideation (see Baron & Kenny, 1986). This selection criterion was also used because based on previous research (Bear et al., 2017) it could be expected that an adequate summary of the postdiction effect would correlate positively with delusion-like ideation.

After completing these preliminary analyses, it was examined whether the postdiction and illusory truth effects would partially mediate the relationship between belief in fake news and delusion-like ideation. These potential mediators were investigated by entering them into separate mediation models (PROCESS Model 4, 5000 bootstrapped samples, bias-corrected 95% confidence intervals).

The results of Study 2 did not support the notion that the relationship between belief in fake news and delusion-like ideation was partially explained by the postdiction effect. The path between delusion-like ideation and the postdiction effect was significant,  $\beta = 0.10$ ,  $p = .030$ , 95% CI = [0.01 0.20]. However, when the postdiction effect and delusion-like ideation were both entered into the



regression model, the postdiction effect did not predict belief in fake news,  $\beta = 0.01$ ,  $p = .843$ , 95% CI = [-0.08 0.10]. Further, the strength of the prediction of belief in fake news by delusion-like ideation was not significantly decreased when the postdiction effect was added into the prediction model (completely standardized 95% CI for the indirect effect = [-0.01 0.01]).

Similarly, the results of Study 2 did not support the notion that the relationship between belief in fake news and delusion-like ideation was partially explained by the illusory truth effect. The path between delusion-like ideation and the illusory truth effect was not significant,  $\beta = 0.01$ ,  $p = .808$ , 95% CI = [-0.08 0.10]. When both the illusory truth effect and delusion-like ideation were included in the regression model, the illusory truth effect did not predict belief in fake news,  $\beta = -0.06$ ,  $p = .201$ , 95% CI = [-0.15 0.03]. Finally, the strength of the prediction of belief in fake news by delusion-like ideation was not significantly decreased when the postdiction effect was added into the prediction model (completely standardized 95% CI for the indirect effect = [-0.01 0.00]).

Through these results, Study 2 extended Study 1 by suggesting that two cognitive mechanisms (the illusory truth and postdiction effects) did not mediate the relationship between delusion-like ideation and belief in fake news. Failure to find these mediation effects is likely not the result of Type II error; simulation studies (Fritz & MacKinnon, 2007) indicate that the present research was adequately powered to detect even small mediation effects. The failure of the present research to observe evidence of a mediation pathway involving the illusory truth effect may result from the nature of the task used to measure this effect. Individual differences in popular cognitive tasks often have low reliability because of the limited between-subjects' variation that makes them popular (Hedge, Powell, & Sumner, 2017). This lack of reliability may make detecting mediation pathways involving the illusory truth effect especially difficult. The failure of the present research to produce evidence of a mediation pathway involving the postdiction effect may have been the result of the single-number summary of this effect employed in Study 2, which was used for the first time in the present research.

One notable limitation of these analyses may be their use of both false and true facts to examine the illusory truth effect. Although the illusory truth effect occurs for both false and true facts (Begg et al., 1992; Fazio et al., 2015; however, see Pennycook et al., 2017a), individual differences in the illusory truth effect for information one knows is false may be most predictive of belief in fake news given its striking disregard for truth (see Lazer et al., 2018). Future research could examine this possibility using a method similar to that of Fazio, Brashier, Payne, and Marsh (2015).

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