



OPEN Cognitive traits modulate the effects of images and familiarity on judgments of news accuracy

Lorenzo Gagliardi¹✉, Marta Caserotti¹, Alessandra Tasso², Teresa Gavaruzzi³, Lorella Lotto¹, Roberta Sellaro¹, Paolo Giraldi⁴ & Enrico Rubaltelli¹

Recent research has shown that judgments of truth about news are influenced by the ease with which we process such information (i.e., processing fluency); for instance, familiarity with information increases perceived accuracy (i.e., illusory truth effect), but also the presence of decorative photos influences our beliefs about the accuracy of claims (i.e., truthiness effect). In this study, we present results from a survey experiment conducted on an Italian sample of university students (N = 300) where participants were presented with a set of 40 news (half real and half fake), under two conditions (no image vs image), and were asked to report perceived accuracy, familiarity and sharing intentions. Participants also completed a set of tests investigating cognitive traits: cognitive reflection test, numeracy scale, intellectual humility questionnaire. Our findings provide evidence for the truthiness effect and the illusory truth effect. Cognitive traits significantly moderated these effects: higher cognitive reflection reduced the association between familiarity and perceived accuracy and strengthened the contrast between news with vs. without images, suggesting nuanced interactions between analytic thinking and fluency-based biases. Numeracy, on the other hand, was associated with improved detection of fake news but it also amplified the illusory truth effect, indicating that familiarity may sometimes override deliberative thinking. Finally, intellectual humility played a limited role but was associated with higher perceived accuracy in the absence of images. These results shed light on the complex interplay between cognitive traits and fluency-based biases in news perception, providing theoretical and practical insights for interventions aimed at mitigating the spread of misinformation.

Keywords Misinformation, Fake news, Processing fluency, Cognitive styles, Cognitive reflection, Numeracy, Intellectual humility

Contemporary consumption of information largely revolves around a news diet that consists of a virtually endless stream of headlines, often encountered while navigating social media and online news outlets¹. As consumers of news, we are constantly guided and aided not only by the aesthetic of the content we encounter, which is specifically designed to be more appealing and easier to understand, but also by our own familiarity with such information, which builds up over time after repeated exposures. Indeed, recent research on news perception has found that various factors – including the presence of accompanying images (e.g.,²), prior familiarity with the news (e.g.,³), but also specific design features, such as layouts or fonts (e.g.,⁴) – increase the ease with which we process information, namely, cognitive fluency⁵. These factors significantly impact our judgments regarding the truthfulness of the claims being made. Such literature, however, has largely overlooked how individual differences in cognitive traits shape people's sensitivity to news features. In particular, while theoretical models predict that analytic cognitive traits—such as cognitive reflection and numeracy—should buffer individuals against fluency-based biases^{2,6}, empirical findings remain inconclusive (e.g.,^{6,7}), suggesting that the relationship between analytic thinking and fluency-driven judgments is more complex than initially expected. The present study aims to extend this line of research by examining how multiple cognitive traits (cognitive reflection, numeracy, and intellectual humility) relate to people's tendency to judge news accuracy as a function of familiarity and the presence of images. Images are ubiquitous in the online landscape: recent

¹Department of Developmental Psychology and Socialization, University of Padova, Italy, Via Venezia 8, 35131 Padova, Italy. ²Department of Human Studies, University of Ferrara, Italy, Via Paradiso, 12, 44121 Ferrara, Italy.

³Department of Medical and Surgical Sciences, University of Bologna, G. Via G. Massarenti 9, 40138 Bologna, Italy.

⁴Department of Environmental Sciences, Informatics and Statistics, University Ca' Foscari of Venice, Italy, Via Torino 155, 30172 Venice, Italy. ✉email: lorenzo.gagliardi@unipd.it

estimates suggest that up to 14 billion images are shared daily through social media⁸. Images are utilized to enhance the appeal of online content, as visuals more easily catch and hold readers' attention⁹—a very hard challenge in the contemporary economies of attention. Unsurprisingly, images have a strong effect on the way we judge information², as they increase the ease with which we process textual information¹⁰ and the tangibility of the content (e.g.,¹¹). Content creators, including news outlets and companies, regularly exploit images to influence users' experience. For instance, companies show the effectiveness of their product through pictorial probative content. News outlets, on the other hand, often use stock images – that is, generic images generated for specific purposes, with no probative value – to make titles more appealing and easier to engage with. For instance, an online magazine may share the news that the temperatures have reached a new record level by accompanying it with a generic picture of a thermometer.

Besides images, previous knowledge may also ease the processing of information¹². For instance, several studies have shown that repeated exposure to the same claims leads people to judge such information as more accurate. This is because they use processing fluency – which in turn increases with familiarity – as a marker for truthfulness (e.g.,¹³). It is plausible that people come across the same information several times while consuming news, as competing news outlets often publish the same stories but with different titles and images. When a piece of news becomes familiar enough to be perceived as a repetition, its perceived accuracy increases¹⁴. Over the past three decades, scholars have consistently found evidence of such fluency-induced biases which inflate judgments of accuracy of news. Researchers who focused on the effect of images termed such phenomenon as the “truthiness effect”²: individuals more often consider claims as true when accompanied by an image¹⁵. For example, Newman et al.¹⁶ found that claims made in a trivia game—such as whether a certain celebrity is dead or alive (e.g., “Nick Cave is dead”)—are perceived as more credible when supported by a picture of the celebrity. On the other hand, researchers who focused on the effect of familiarity on judgments of accuracy termed this phenomenon as “illusory truth effect” or simply “truth effect”³. This effect was first documented by Hasher et al.¹⁷, who exposed participants to different lists of claims, with some claims reappearing several times. Participants were then asked to rate the truthfulness of these statements, claims that were repeated and thus familiar to the participants were rated as more truthful than those that appeared only once. Previous literature has uncovered some important factors that moderate individuals' tendency to rely on processing fluency to judge accuracy, including age¹⁸, the presence of warnings exposing the information as fake¹⁹ or monetary incentives²⁰; however, evidence on cognitive traits remains scarce. Some authors^{2,6} discussed the possible role of cognitive styles in how much we use fluency as a proxy for truthfulness. Newman et al.⁶ hypothesized that people who score high on the Need for Cognition scale (NFC)—which measures how much people enjoy and engage in deep thinking and effortful cognitive activities²¹ – should rely less on fluency as a cue for accuracy as they would be more prone to focus on the actual evidence. However, Newman et al.⁶ did not find evidence that NFC plays a moderating role in the truthiness effect, although they did find that people high in NFC are actually more susceptible to the illusory truth effect. On the other hand, the same authors discussed that cognitive style (analytic vs. intuitive), as indexed by the cognitive reflection test (CRT;²²), may shed some light on how people rely on fluency. Specifically, they argued that individuals with a general proneness to intuitive reasoning may also be more prone to use fluency as a mental shortcut. However, a handful of studies (e.g.,⁷) failed to find evidence for a moderating effect of cognitive reflection on the illusory truth effect.

Numeracy is a cognitive trait which did not receive sufficient attention by previous literature on fluency-based biases. Broadly speaking, numeracy is defined as the ability to understand and use numeric information²³. In the field of misinformation, numeracy tests have been used to broaden the set of methodological tools to investigate cognitive styles²⁴, although evidence remains scarce. For instance, unpublished data from Ross et al.²⁵, but later discussed in Pennycook²⁴, showed that while higher scores on Cognitive Reflection Test – indicating a more analytic thinking style—predicted higher ability to discern between fake and real news and lower sharing intentions, higher levels of numeracy²⁶ were associated with a higher belief in real news, but not with belief in fake news or sharing intentions. Although previous research has discussed that people low in numeracy might be more susceptible to fluency-driven biases (e.g.,²⁷), no attempt was made to test the effect of numeracy on fluency-based biases in news perception.

It is worth noting that, according to skilled decision theory²⁸, numeracy reflects a form of decision-making expertise that goes beyond mathematical computation, encompassing the ability to represent, interpret, and use quantitative information adaptively in uncertain contexts. Within Stanovich's²⁹ Tripartite Theory of Mind, such ability corresponds to the *reflective mind*, which monitors intuitive responses and recruits the *algorithmic mind* (fluid cognitive capacities) to achieve rational goals. In this framework, numeracy can be seen as part of the “mindware” supporting rational judgment—particularly probabilistic and risk reasoning. However, while both numeracy and cognitive reflection involve analytic engagement, recent evidence shows that they capture related but distinct processes. Sobkow et al.³⁰ demonstrated that numeracy and cognitive reflection load on separate latent factors: the former reflects domain-specific knowledge and representational skills, whereas the latter involves the capacity to detect and override intuitive but incorrect responses. Hence, numeracy is expected to influence news perception by facilitating the evaluation of probabilistic and evidential claims, while cognitive reflection contributes to resisting intuitive fluency cues that bias perceived accuracy.

Finally, another cognitive trait which received little attention is Intellectual Humility (henceforth, IH), which refers to the ability to acknowledge and accept limits in one's knowledge³¹. People with higher IH essentially have higher meta-cognitive skills as they can produce more accurate judgments about their own knowledge. They may also be more prone to revise their own beliefs and remain open during disagreement³². Furthermore, higher levels of IH are associated with higher NFC and higher scores on CRT³³. Overall, IH seems to be a sign of cognitive sophistication that may prevent people from relying on tangential cues, such as fluency, and encourage them to focus on the actual evidence when judging the accuracy of news.

Cognitive reflection, numeracy, and intellectual humility are conceptually related yet distinct constructs that capture complementary aspects of analytic cognition. Cognitive reflection and numeracy both index deliberate, effortful processing, but they differ in content and emphasis: while CRT measures the tendency to override intuitive responses and engage in reflective reasoning, numeracy reflects the ability to understand and apply quantitative information in uncertain contexts. According to Stanovich's²⁹ *Tripartite Theory of Mind*, both can be viewed as expressions of "reflective rationality," which operates independently from mere intelligence and predicts skilled decision-making. Intellectual Humility, in contrast, represents a metacognitive disposition rather than a cognitive ability per se—it involves awareness of one's cognitive limitations and openness to revising beliefs. Despite their conceptual differences, these constructs are moderately correlated, suggesting partial overlap in the broader domain of reflective and open-minded cognition (e.g., CRT–Numeracy: $r \approx 0.35$ – 0.50 ; CRT–IH: $r \approx 0.08$ – 0.20 ; Numeracy–IH: $r = 0.21$;^{34–37}).

To our knowledge, this is the first study to directly investigate the role of several cognitive traits (i.e., cognitive reflection, numeracy and intellectual humility) in moderating fluency-based biases in news judgments, and specifically the perception of accuracy and sharing intentions.

Hypotheses

Building on previous research on fluency-based biases in news perception, we aimed to replicate and extend results on two established effects: (1) the truthiness effect—the tendency to perceive information accompanied by images as more accurate—and (2) illusory truth effect—the tendency to perceive familiar information as more accurate. (Regarding truthiness effect, previous studies have mostly focused on the effect of non-probative images (i.e., images that do not provide evidence for the claim they accompany). However, in our study, we aim to check whether the presence of images accompanying claims affect the perceived accuracy of such information regardless of the function of the image. For this reason, the set of selected news included both news with probative and news with non-probative images as a way to investigate the overall effect. While this does not allow us to control for the function of the image, it might still be more ecologically valid. While consuming news, we do not encounter solely fake (or real) news that holds probative or non-probative images, but it's usually a mix of the two. Provided that the fake news we selected were actual fake news, it was not possible to control a priori the function of the image accompanying them). We also examined whether these effects are moderated by individual cognitive traits: cognitive reflection, numeracy and intellectual humility.

Truthiness effect

We first aim to test whether the presence of an image influences the perceived accuracy and sharing intentions of news items (main effects), thus we predict:

- H1a: News items presented with an image will be perceived as more accurate than those presented without an image.
- H1b: News items presented with an image will elicit higher sharing intentions.

We then aim to test whether this effect is moderated by cognitive traits, such that participants with greater reflective thinking and open-mindedness rely less on the presence of images as a cue for truth:

- H1c: Participants with higher CRT scores will report lower perceived accuracy and sharing intentions in the image condition compared to those with lower CRT scores.
- H1d: Participants with higher NUM scores will report lower perceived accuracy and sharing intentions in the image condition compared to those with lower NUM scores.
- H1e: Participants with higher IH scores will report lower perceived accuracy and sharing intentions in the image condition compared to those with lower IH scores.

Illusory truth effect

Next, we aim to test whether familiarity with a news item predicts higher perceived accuracy and sharing intentions (main effects), thus we predict:

- H2a: Higher familiarity will be associated with higher perceived accuracy of news items.
- H2b: Higher familiarity will be associated with higher sharing intentions.

We then examined whether this effect is moderated by cognitive traits—that is, whether individuals with higher reflective and open-minded thinking are less influenced by familiarity cues:

- H2c: Participants with higher CRT scores will show a weaker positive relationship between familiarity and perceived accuracy/sharing intention.
- H2d: Participants with higher Numeracy scores will show a weaker positive relationship between familiarity and perceived accuracy/sharing intention.
- H2e: Participants with higher IH scores will show a weaker positive relationship between familiarity and perceived accuracy/sharing intention.

Methods

Participants

We devised a survey experiment involving an Italian convenient sample of 300 participants. Our sample included 208 females (69,33%), 82 males (27,33%), and 10 participants reporting a different gender option (i.e., non-binary or preferring not to answer). Mean age was 23 years old ($SD = 2.31$, ranging from 18 to 37 years) and the large

majority of participants (about 91%) were university students. Participants were recruited through social media and received a payment of €15 as a participation fee for the study. The whole experiment had approximately one hour duration. Both the cognitive traits tests and the news tests were administered via Qualtrics and completed sequentially. Participants first completed the self-reported tests remotely and then proceeded to complete the news test in person.

Materials and procedure

This study was approved by the research group's University Ethical Committee for Psychological Research. All methods were performed in accordance with the relevant guidelines and regulations and with the Declaration of Helsinki. Informed consent was obtained from all participants prior to participation. In this experiment, each participant was presented with a set of 40 news items (half real and half fake, in random order). Each participant was randomly assigned to one of two between-subjects conditions: a *with images* condition and a *without images* condition. Each participant viewed only one version of the news stimuli. Following Pennycook and Rand's³⁸ experimental paradigm, For each news item, participants were asked to report their judgments of accuracy ("To the best of your knowledge, how accurate is the claim in the above headline?", response options: not at all accurate/not very accurate/somewhat accurate/very accurate), their familiarity with the news ("Have you seen or heard about this story before?", response options: yes/no/not sure) and their intention to share such news ("Would you consider sharing this story online (for example, through Facebook or X)?", response options: yes/no/maybe). Regarding the numerical scoring, perceived accuracy was measured on a 4-point scale (1 = Not at all accurate, 4 = Very accurate), familiarity was coded as -1 = Not familiar, 0 = Not sure, 1 = Familiar, and sharing intentions were coded as -1 = No, 0 = Maybe, 1 = Yes.

Each stimulus was designed to resemble a social media content, consisting of a small preview including a headline, a source and an image. In many cases, the image was inherently part of the news itself and, as such, it was probative (i.e., it provided evidence for the claim it accompanied); in other cases, the image was generic and was represented by a stock picture. For instance, one fake news reported a supposed geothermic phenomenon occurred in Finland, which made snowy trees look like domes. The actual fake news which circulated consisted of an AI-generated image of this supposed phenomenon. Other fake news, instead, were not image-based. For instance, one fake news reported an interview with a famous expert warning about the risk of "genome-transmitting insect-meal"; in this case, the image simply consisted of a stock picture representing a generic insect-meal. The complete set of experimental stimuli is publicly available on the open science framework (OSF) at this [link](#).

The news items were sourced from two types of outlets, depending on the status of the news – that is, whether it was fake or real. Fake news were selected through several databases run by independent Italian debunkers (e.g., Butac, Open), while real news was sourced from mainstream Italian newspapers (e.g. Il Corriere Della Sera, il Post). All sources included in the stimuli, for both real and fake news, were fictitious and generated with the help of ChatGPT 3.5 to appear as credible, authentic sources.

The final set of news included in our study items was selected based on the results of a pilot study that evaluated a larger sample of news (40 real and 40 fake items). This pilot study, conducted with over 400 students, measured the same three dimensions for each news (i.e., familiarity, perceived accuracy, sharing intentions) along with perceived political orientation of the news. The final selection of 40 news items (20 real and 20 fake) aimed to encompass a wide variety of topics (e.g., environment, nutrition, wars) and to be representative of different levels of perceived accuracy. Specifically, to select the final set of stimuli, both fake and real news items that were included in the pilot study were first ranked in growing order of perceived accuracy (from the least to the most accurate). Then, we divided each set of news in quartiles, with news falling in the first quartile being considered as the least accurate and news falling in the last quartile being considered as the most accurate. Next, we selected small sets of news items (3 to 5) that corresponded to each quartile. This method allowed us to cover all the different levels of perceived accuracy.

Measures

Participants were also requested to complete a set of measures, including the Cognitive Reflection Test-2, the NUM and IH. Specifically, we used an adapted version of Cognitive Reflection Test-2 (henceforth, CRT)³⁹, consisting of three items of the original scale, which was designed to serve as an alternative measure to the classic CRT developed by Frederick²², aiming to measure propensity to give intuitive, but incorrect responses rather than more analytical correct ones. For each item of the scale, answers were computed as dichotomic (0 = wrong answer, 1 = right answer), thus higher scores on this scale indicate a greater propensity for analytic thinking (more right answers) vs. intuitive (more wrong answers). Next, we used the 4-item version of the numeric understanding measure²³, which consists of four mathematical problems of increasing complexity designed to assess the ability to understand and utilize numeric information. Exactly as we did with CRT-2, answers for this scale were computed as dichotomic (0 = wrong answer, 1 = right answer), thus higher scores on this scale indicate a greater ability to use numeric information (more right answers) vs. lower (more wrong answers). Finally, we employed a 22-item scale by Krumrei-Mancuso et al.⁴⁰ measuring Intellectual Humility, which is defined as humbleness with regard to the way one acquires and applies knowledge⁴¹ and captures several intercorrelated dimensions, including independence of intellect and ego, openness to revising one's viewpoint, respect for others' viewpoints, and lack of intellectual overconfidence. For instance, the scale includes items such as "I have at times changed opinions that were important to me, when someone showed me I was wrong" or "I am open to revising my important beliefs in the face of new information". Participants were asked to report their level of agreement on a scale from 1 to 5. For the purpose of this study, we employed IH unidimensionally, computing the average score for each participant. Regarding news perception, we computed indices for real and fake news. Perceived accuracy ratings (1–4 scale) were averaged within each category, whereas familiarity and

sharing intention responses (coded as -1, 0, or 1) were summed within each category. These composite indices were used in the subsequent analyses.

The study was part of a larger project investigating fake news. Here we report the measures that are relevant to test the study hypotheses. The complete list of additional measures not included in this study is provided in the Supplementary Online Materials.

Statistical analyses

All statistical analyses were conducted using Stata. Descriptive statistics were first computed to examine the overall distributions of the main variables of interest—perceived accuracy, familiarity with the news, and sharing intentions—across experimental conditions (image vs. no image; real vs. fake news). To test for the presence of fluency-based biases, two non-parametric Mann–Whitney U tests were performed to assess differences in perceived accuracy and sharing intentions between the image and no-image conditions (i.e., the truthiness effect). The illusory truth effect was assessed through multiple linear regression models, using familiarity with the news as a predictor of perceived accuracy and sharing intentions.

To examine the moderating role of cognitive traits—namely, cognitive reflection (CRT), numeracy (NUM), and intellectual humility (IH)—on fluency-based effects, a series of hierarchical ordinary least squares (OLS) regression models were fitted using first perceived accuracy and then sharing intentions as dependent variables. First models included familiarity with the news, CRT, NUM, IH, two dummy variables representing the treatment (0= image, 1=no image) and the status of the news (real=0, fake=1) respectively, and an interaction term including the product of familiarity and the status of the news. Second model also included three interaction terms, considering the interaction of each cognitive trait (cognitive reflection, numeracy and intellectual humility) and the treatment; and other three interaction terms, considering each cognitive trait and the status of the news (fake or real). Third model also included other three interaction terms, considering each cognitive trait and familiarity with the news. Models tested whether these individual differences amplified or attenuated the effects of image presence and familiarity on perceived accuracy and sharing intentions. All models controlled for the veracity of the news (real vs. fake), and interaction terms were used to explore whether the effects differed depending on the status of the news. Statistical significance was set at $p < 0.05$. Although the study was not preregistered, all hypotheses and analyses were theory-driven and based on previous evidence linking individual cognitive traits to biases associated with processing fluency. Accordingly, the reported analyses should be regarded as confirmatory.

Results

First, we looked into the general levels of perceived accuracy, familiarity and sharing intentions of the news. The means show a low degree of variability and rather small differences across conditions for the main variables in the study (see Table 1). The biggest difference was detected in perceived accuracy, as real news on average is regarded as more accurate than fake news, and such difference was found to be significant through a Mann–Whitney test ($z = 26,826$, $p\text{-value} < 0.001$, $r = 0.25$). Participants were overall unfamiliar with the news but had a slightly higher degree of familiarity with real news than with fake news ($z = 7.057$, $p\text{-value} < 0.001$, $r = 0.07$). Finally, participants on average did not have the intention to share the presented news, regardless of the condition ($z = 0.373$, $p\text{-value} = 0.709$, $r = 0.00$). Overall, these results suggest that participants had moderately accurate perceptions of accuracy but were rather unfamiliar and non-intentioned to share the news.

To assess the reliability of the individual difference measures, we computed Cronbach's alpha coefficients. Internal consistency was acceptable for the Intellectual Humility Questionnaire ($\alpha = 0.82$). As expected for brief cognitive tasks with dichotomous scoring, lower reliability values were observed for the Cognitive Reflection Test-2 ($\alpha = 0.55$) and the Numeracy scale ($\alpha = 0.43$), in line with previous literature on these measures (e.g., ^{22,23}). Internal consistency was not assessed for the news-related variables (familiarity, perceived accuracy, and sharing intentions), as they represent distinct constructs rather than items of a single scale.

Regarding the average levels of cognitive traits, we found a high prevalence of analytic thinking in the sample, with over 70% of the participants giving three correct answers out of three on the CRT. Results on NUM, instead, were more mixed, with the median number of correct answers being 2 out of 4. Finally, the average level of intellectual humility was 3.79 (SD = 0.438, on a scale from 1 to 5).

We then proceeded to compute a correlation matrix for the main variables of the study across conditions (see Tables 2 and Table 3). Overall, the coefficients were rather small. However, for both fake and real news, the

Variable	Condition	M	SD
Perceived accuracy	Fake	2.21	0.86
	Real	2.63	0.78
Familiarity	Fake	-0.72	0.61
	Real	-0.64	0.67
Sharing intentions	Fake	-0.88	0.39
	Real	-0.88	0.40

Table 1. Descriptive statistics for the main variables across real vs. fake news. Perceived accuracy was measured on a 4-point scale (1 = Not at all accurate, 4 = Very accurate). Familiarity was coded as -1 = Not familiar, 0 = Not sure, 1 = Familiar. Sharing intentions were coded as -1 = No, 0 = Maybe, 1 = Yes.

Variable	1	2	3	4	5	6
1. Familiarity	1.00					
2. Perceived accuracy	0.31***	1.00				
3. Sharing intentions	0.13***	0.25***	1.00			
4. Cognitive reflection (CRT)	-0.03**	-0.08	-0.08***	1.00		
5. Numeracy	-0.06***	-0.06***	-0.05***	0.13***	1.00	
6. Intellectual humility	-0.05***	-0.03*	-0.08***	-0.05***	0.09***	1.00

Table 2. Correlation matrix for the main variables in the study, considering only data collected on fake news. Coefficients are shown with *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

Variable	1	2	3	4	5	6
1. Familiarity	1.00					
2. Perceived accuracy	0.36***	1.00				
3. Sharing intentions	0.01	0.04***	1.00			
4. Cognitive reflection (CRT)	-0.04***	0.03**	-0.08***	1.00		
5. Numeracy	-0.06***	0.01	-0.05***	0.13***	1.00	
6. Intellectual humility	-0.05***	-0.02	-0.09***	-0.05***	0.09***	1.00

Table 3. Correlation matrix for the main variables in the study, considering only data collected on real news. Coefficients are shown with *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. **Truthiness effect*.

highest correlations were found between perceived accuracy and familiarity. A weak correlation was also found between sharing intentions and perceived accuracy of fake news. All other correlations were very low.

Next, we looked into the main effect of images on judgments about the accuracy and the sharing intentions of the news. To do so, we ran two Mann–Whitney tests comparing mean levels of perceived accuracy and mean sharing intentions across conditions (image vs no image). Overall, we found two significant differences between judgments across conditions, and specifically, when participants were presented with news accompanied by images, they reported higher levels of perceived accuracy ($z = 7.610$, $dif. = 0.117$, $p < 0.001$, $r = 0.07$) and higher sharing intentions ($z = 7.551$, $dif. = -0.059$, $p < 0.001$, $r = 0.07$). However, such differences were rather small, with sharing intentions being only slightly less negative in the image condition. Overall, these results replicate previous literature, showing a small truthiness effect, thus confirming H1a and H1b. To further examine how cognitive traits moderated the influence of images on perceived accuracy, we turned our attention to the regression models reported in (Table 4). These models included the interaction terms between the experimental treatment (image vs. no image) and each cognitive trait (cognitive reflection, numeracy, and intellectual humility), as well as their interactions with the status of the news (real vs. fake). (Across the three models, the proportion of explained variance (R^2) slightly increased with the inclusion of additional predictors and interaction terms. Model 1, which included the main effects of familiarity, cognitive traits, and experimental conditions, explained 16.8% of the variance in perceived accuracy. Model 2, which added interactions between cognitive traits and experimental conditions (image vs. no image; real vs. fake), explained 17.0%, while Model 3, which further incorporated interactions between cognitive traits and familiarity, explained 17.1% of the variance. F-tests comparing nested models confirmed that these incremental increases were statistically significant (*Model 2 vs. Model 1*: $F(6, 11\ 634) = 6.76$, $p < 0.001$; *Model 3 vs. Model 2*: $F(3, 11\ 634) = 2.82$, $p = 0.037$), indicating that the inclusion of interaction terms significantly improved model fit. However, the overall explained variance remained small, suggesting that additional factors not captured by the current models likely contribute to individual differences in perceived accuracy. A similar pattern was found for models in (Table 5), using sharing intentions as the dependent variable. The comparison between Model 1 and Model 2 indicated a significant improvement ($F(5, 11\ 635) = 9.08$, $p < 0.001$), whereas the change from Model 2 to Model 3 was not significant ($F(3, 11\ 632) = 1.75$, $p = 0.155$). However, the overall R^2 values remained small).

Results showed a significant main effect of cognitive reflection on perceived accuracy ($\beta = 0.082$, $p < 0.001$), indicating that higher CRT scores (i.e., greater analytic thinking) were associated with higher judgments of accuracy overall. This pattern held regardless of whether the news was fake, as the interaction between CRT and news status was not significant ($\beta = -0.021$, $p = 0.297$). However, the effect of cognitive style varied significantly across conditions, as shown by the significant interaction between treatment and CRT ($\beta = -0.068$, $p < 0.001$; see Fig. 1). Specifically, the positive association between CRT and perceived accuracy was significantly weaker when news items were presented without images compared with when images were shown. This pattern indicates that analytic thinkers tended to judge news as somewhat more accurate overall, but in the absence of images, higher CRT scores were associated with only minimal increases in perceived accuracy, suggesting that analytic processing exerted a reduced influence on judgments when visual cues were not available. Overall, H1c was not supported, as the expected mitigating role of cognitive reflection in the image condition did not emerge. Numeracy and intellectual humility did not show a consistent pattern across treatment conditions. Interaction terms indicated that in the absence of images, higher numeracy ($\beta = 0.33$, $p = 0.011$) and higher intellectual

Predictor	Model 1	Model 2	Model 3
Familiarity	0.412***	0.415***	0.572***
Cognitive reflection (CRT)	0.037***	0.082***	0.069***
Numeracy	-0.010	-0.001	0.012
Intellectual humility (IH)	-0.004	-0.021	-0.037
Treatment	-0.066***	-0.218	-0.169
Fake	-0.368***	-0.163	-0.154
Fake × Familiarity	0.024	0.019	0.019
Fake × Treatment	-0.052*	-0.056*	-0.054*
Treatment × CRT	-	-0.068***	-0.074***
Treatment × Numeracy	-	0.033**	0.036***
Treatment × IH	-	0.069**	0.058*
Fake × CRT	-	-0.021	-0.022
Fake × Numeracy	-	-0.047***	-0.046***
Fake × IH	-	-0.017	-0.017
Familiarity × CRT	-	-	-0.026*
Familiarity × Numeracy	-	-	0.023**
Familiarity × IH	-	-	-0.036
Constant	2.866***	2.798***	2.867***
R ²	0.1676	0.1704	0.1710

Table 4. OLS regression models predicting perceived accuracy (N = 300). Three OLS models using perceived accuracy as the dependent variable and a set of predictors, including familiarity with the news, Cognitive Reflection Test (CRT), numeracy, intellectual humility (IH), an interaction term between status of the news and familiarity, two dummy variables indicating presence/absence of images (Treatment = 0 = image; Treatment = 1 = no image) and status of the news (real = 0, fake = 1), and a set of interaction terms between cognitive traits (CRT, NUM and IH) and treatment/status of the news/familiarity. OLS unstandardized coefficients are shown with *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

humility ($\beta = 0.068$, $p = 0.038$) predicted higher judgments of perceived accuracy. These findings run counter to H1d and H1e, suggesting that higher numeracy and humility did not buffer against fluency-driven biases as hypothesized (see Fig. 2). Furthermore, numeracy was negatively associated with perceived accuracy when the news was fake ($\beta = -0.068$, $p < 0.001$).

Next, we examined whether cognitive traits also moderated the relationship between images and sharing intentions (see Table 5). Consistent with the main effect predicted by H1b, the presence of images increased intentions to share news items. Across all models, higher scores in cognitive reflection, numeracy, and intellectual humility were generally associated with lower sharing intentions. However, interaction terms (Treatment × CRT, Treatment × NUM, Treatment × IH) revealed that this negative effect was reduced in the absence of images. Specifically, when news was presented without images, higher cognitive reflection ($\beta = 0.045$, $p < 0.001$), numeracy ($\beta = 0.022$, $p < 0.001$), and intellectual humility ($\beta = 0.042$, $p = 0.011$) predicted higher sharing intentions, providing partial support for H1b, H1d, and H1e. Finally, the status of the news (fake vs. real) did not significantly moderate the effects of cognitive traits on sharing intentions.

Illusory truth effect

Next, we looked into the effect of familiarity with the news on the perceived accuracy and the sharing intentions. To do so, we relied on the same multiple linear regression models reported in (Table 4), this time focusing on familiarity as the key predictor. Results show that participants with a higher familiarity with the news were more likely to report higher levels of perceived accuracy ($\beta = 0.412$, $p < 0.01$) across all model specifications, supporting the illusory truth effect and confirming H2a. Notably, this effect was not moderated by the status of the news (fake vs. real), as indicated by the non-significant interaction term ($\beta = 0.024$, $p = 0.375$).

We then repeated the same analysis using sharing intention as the dependent variable (see Table 5), adding perceived accuracy as a covariate, and another interaction term between the status of the news and familiarity. Results show that participants who perceived news to be more accurate showed a higher willingness to share them ($\beta = 0.02$, $p = 0.004$). (Interestingly, this effect was increased when the news was fake, as shown by the interaction term between the status of the news (fake vs. real) and perceived accuracy ($\beta = 0.086$, $p < 0.001$). However, more generally, sharing intentions were negatively associated with lack of images ($\beta = -0.05$, $p < 0.001$) and the news being fake ($\beta = -0.156$, $p < 0.001$). However, familiarity did not have a significant main effect on sharing intentions, failing to provide support for H2b. Interestingly, the interaction between familiarity and news status was significant ($\beta = 0.039$, $p < 0.001$), indicating that familiarity increased sharing intentions only when the news was fake. Finally, higher scores on cognitive reflection, numeracy, and intellectual humility predicted lower sharing intentions overall ($\beta = -0.043$, -0.022 , and -0.11 , respectively; all $p < 0.001$). These results suggest that higher cognitive sophistication generally reduces the tendency to share news, although not specifically as a function of familiarity.

Predictor	Model 1	Model 2	Model 3
Perceived accuracy	0.020***	0.021***	0.021***
Familiarity	-0.012	-0.013	0.077
Cognitive reflection (CRT)	-0.043***	-0.065***	-0.062***
Numeracy	-0.010***	-0.022***	-0.022***
Intellectual humility (IH)	-0.074***	-0.095***	-0.110***
Treatment	-0.050***	-0.372***	-0.355***
Fake	-0.156***	-0.196***	-0.189***
Fake × perceived accuracy	0.086***	0.085***	0.086***
Fake × Familiarity	0.039***	0.039***	0.038***
Fake × Treatment	0.010	0.010	0.010
Treatment × CRT	0.045***	0.045***	0.045***
Treatment × Numeracy	–	0.022***	0.023***
Treatment × IH	–	0.042**	0.037**
Fake × CRT	–	0.000	0.001
Fake × Numeracy	–	0.006	0.006
Fake × IH	–	0.007	0.005
Familiarity × CRT	–	–	0.005
Familiarity × Numeracy	–	–	0.000
Familiarity × IH	–	–	-0.027**
Constant	-0.505***	-0.346***	-0.298***
R ²	0.0521	0.0547	0.0563

Table 5. OLS regression models predicting sharing intention (N = 300). Three OLS models using perceived accuracy as the dependent variable and a set of predictors, including familiarity with the news, Cognitive Reflection Test (CRT), numeracy, intellectual humility (IH), an interaction term between status of the news and familiarity, two dummy variables indicating presence/absence of images (Treatment = 0 = image; Treatment = 1 = no image) and status of the news (real = 0, fake = 1), and a set of interaction terms between cognitive traits (CRT, NUM and IH) and treatment/status of the news/familiarity. OLS unstandardized coefficients are shown with *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

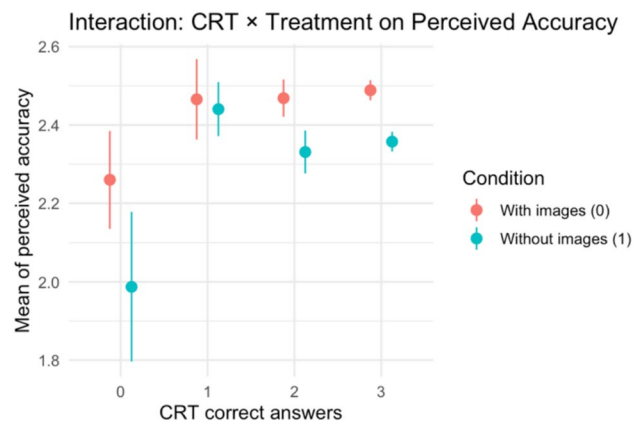


Fig. 1. Interaction between cognitive reflection test (CRT) scores and treatment condition on perceived news accuracy.

Next, we tested whether cognitive traits moderated the relationship between familiarity and perceived accuracy (Table 4, Model 3). Results showed that, even under this model specification, familiarity retained a strong positive main effect on perceived accuracy ($\beta = 0.572$, $p < 0.001$), further supporting H2a. However, the moderating role of cognitive reflection was weak. Although the interaction between CRT and familiarity was in the expected direction ($\beta = -0.026$, $p = 0.078$) of H2c, the effect was small and only marginally significant. As shown in Fig. 3, the positive association between familiarity and perceived accuracy remained largely stable across levels of CRT, with only a slight tendency for this effect to weaken among participants with higher CRT scores.

Conversely, numeracy strengthened the effect of familiarity, contrary to H2d, as higher numeracy scores amplified the association between familiarity and perceived accuracy ($\beta = 0.023$, $p = 0.023$; see Fig. 4). Finally, no

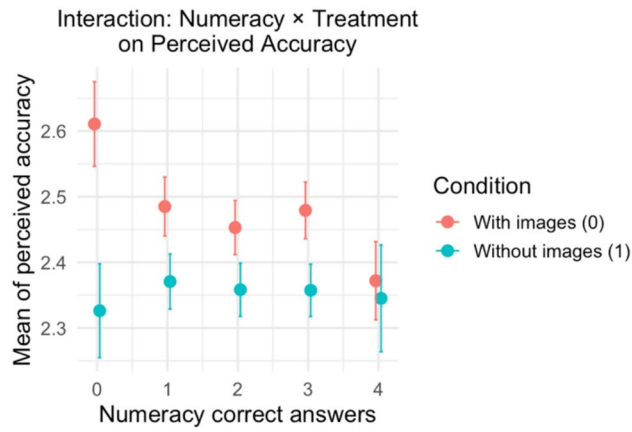


Fig. 2. Interaction between numeracy and treatment condition on perceived news accuracy.

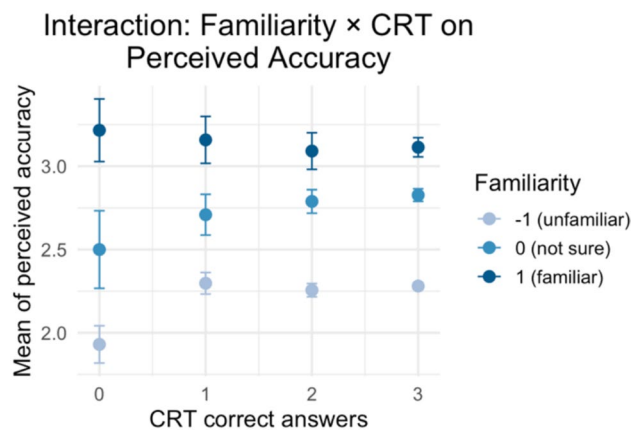


Fig. 3. Interaction between familiarity and cognitive reflection test (CRT) scores on perceived news accuracy.

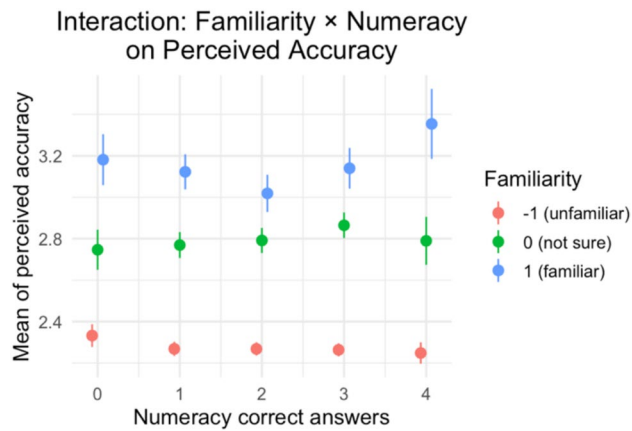


Fig. 4. Interaction between familiarity and numeracy on perceived news accuracy.

significant interaction was found between intellectual humility and familiarity (i.e., Familiarity × IH), indicating that H2e was not supported. Thus, while analytic thinking appeared to buffer—albeit weakly—against fluency-driven bias, higher numeracy exerted the opposite effect, and intellectual humility did not play a moderating role.

Finally, familiarity did not have a consistent main effect on sharing intentions across all model specifications (see Table 5). Although H2b predicted that higher familiarity would increase intentions to share news items,

this relationship was not significant overall. We then tested whether cognitive traits moderated the association between familiarity and sharing intentions. Interaction terms indicated that neither cognitive reflection nor numeracy significantly influenced this relationship (i.e., Familiarity×CRT; Familiarity×NUM), providing no support for H2c and H2d in the context of sharing intentions. However, intellectual humility significantly moderated the effect of familiarity (i.e., Familiarity×IH): for participants with higher IH scores, the effect of familiarity on sharing intentions was reduced ($\beta = -0.027$, $p = 0.031$). This pattern offers support for H2e, suggesting that individuals with greater openness and self-reflectiveness were less likely to let familiarity drive their willingness to share news.

Discussion

In this study, we found evidence for two fluency-induced biases in news judgment that are consistent with previous literature: the truthiness effect² and the illusory truth effect³. According to these two phenomena, images accompanying a news story and familiarity with the news, respectively, increase the ease with which the news is processed. In turn, fluency becomes a proxy that people use to judge the accuracy of the news. Specifically, regarding the truthiness effect, we found that accompanying news (both real and fake) with images slightly increases its perceived accuracy. Although the size of the effect was relatively small, this was consistent with previous between-subjects experiments on the truthiness effect². This pattern of results underscores the importance of contextual factors, such as the design of the content, in shaping beliefs about news. Users spreading fake news may leverage on people's tendency to use images as a proxy for truth to increase the perceived accuracy of such information, by designing ad hoc pictorial content which eases cognitive processing. Similarly, regarding the illusory truth effect, we found evidence that previous knowledge of such news, both real and fake, increases its perceived accuracy, thus, recognizing a piece of information as familiar may imply perceiving it as a repetition¹⁴, which in turn increases perceptions of accuracy.

However, it is important to note that different hypotheses were not supported by the data, and in some cases the observed results contradicted our initial expectations. This discrepancy suggests that the relationship between cognitive traits and news evaluation processes may be more complex than initially theorized. Previous research discussed that cognitive traits may play a role in shaping the tendency to use fluency as a proxy for judging news. Broadly speaking, a lack of sophistication in reasoning (i.e., an intuitive style of thinking, low numeracy and intellectual humility) may make people more prone to base their judgments on processing fluency when considering news, rather than deliberately reflecting on the quality of the news itself. To address this possibility, we investigated how cognitive traits moderate truthiness and illusory effects and found mixed results. Specifically, there were some inconsistencies in how different cognitive traits are associated with the effect of images and familiarity on news judgments. Indeed, although previous literature has found that such traits are partially inter-correlated (e.g.,^{33, 42}), in our study, cognitive reflection (i.e., CRT), numeracy and intellectual humility had a different effect on our dependent variables, also depending on the presence or absence of associated images. Specifically, we found that cognitive reflection was positively related to perceiving the news as being accurate, regardless of its status (fake vs. real). However, when news was *not* accompanied by images, higher cognitive reflection was associated with decreased perception of accuracy. From these results, we might speculate that the absence of images, which should generally reduce the ease of processing, may be perceived as a sign of inaccuracy by participants with a higher cognitive reflection. Furthermore, and coherently, higher cognitive reflection also reduced the effect of familiarity on news perception as participants scoring higher on CRT were more likely to perceive a familiar news as inaccurate.

Literature on the moderating role of cognitive reflection in fluency-based biases in news perception is still scarce. To our knowledge, no previous work had directly addressed the moderating role of cognitive reflection in the truthiness effect. In a previous work, Newman and Zhang² discussed that people more prone to engage in analytic thinking should be less likely to rely on fluency to judge news. However, a few studies^{7, 43, 44} found that the illusory truth effect was unmoderated by cognitive reflection. Our results showed instead that cognitive reflection does play a role in judgments of news accuracy. First, we found that higher levels of cognitive reflection predicted higher perception of accuracy, regardless of the news being fake or real, suggesting that it did not affect the ability to discern fake from real—although previous work identified cognitive reflection as a key factor in shaping individual's ability to discern fake news (e.g.,³⁸). Second, higher cognitive reflection predicted lower perceived accuracy only when news were presented without images and when participants were already familiar with the news. On the one hand, this may suggest that lack of images was taken as a sign of inaccuracy by more analytic thinkers. On the other hand, familiarity with the news may have induced skepticism in analytic thinkers, who may have recognized a familiar news as inaccurate, thus reversing the illusory truth effect.

Results also highlight the complexity of numeracy, as its role in shaping news judgments varied depending on several factors. Indeed, although numeracy did not affect the perception of accuracy per se, in the absence of images, higher levels of numeracy were associated with an increased perception of accuracy of the news. Furthermore, on average participants with higher levels of numeracy regarded fake news as inaccurate and, on the contrary, familiar news as accurate. Building on these results, we can speculate that: (i) higher numeracy is associated with an increased ability to judge fake news; (ii) numeracy moderates the two fluency-based biases in different ways, by increasing perception of accuracy in absence of image (reduced fluency) and by increasing it for familiar news (increased fluency). These results suggest that while increased analytic thinking through higher numeracy makes people less susceptible to fake news, it may still impact their judgments on news depending on contextual factors. We may speculate that highly numerate individuals may have a stronger confidence in the “gut feeling” of truthiness they get when they relate to news, especially the one they are already familiar with. Increased perception of accuracy for news without images may thus simply reflect higher independence from graphical content for highly numerate individuals. This may resonate with results showing higher confidence in highly numerate people⁴⁵ and lower reliance on graphical formats (e.g.,⁴⁶).

Finally, intellectual humility did not affect perceptions of accuracy per se, but in the absence of images, humbler subjects were more likely to judge the news as accurate. The construct of Intellectual Humility partly overlaps with other epistemic dispositions such as Actively Open-Minded Thinking⁴⁷, as both involve openness to revising one's beliefs. However, Intellectual Humility emphasizes a virtue-based recognition of one's cognitive limitations and motivation to seek accuracy⁴⁰, rather than a procedural tendency to engage with conflicting information. This distinction may help explain why Intellectual Humility did not play a decisive role in predicting perceived accuracy in our study. While traits such as cognitive reflection and numeracy directly affect analytic engagement with information, Intellectual Humility might influence belief revision and evidence evaluation in contexts that more explicitly require open-minded reasoning. Future studies including measures of Actively Open-Minded Thinking could further clarify this distinction.

Our results have important methodological and theoretical implications. Although previous literature did not directly address numeracy as a moderating factor for fluency-induced biases of news perception, numeracy is often discussed as an additional tool to test individual differences in cognitive sophistication and susceptibility to fake news. Furthermore, numeracy was found to produce divergent results from cognitive reflection²⁴ – specifically, it does not impact belief in fake news. (It should be noted, however, that in our study CRT and numeracy were weakly correlated ($r=0.12$). Although the correlation between Numeracy and CRT was relatively low, this result is not unexpected given that we employed the CRT-2³⁹ and the short *objective numeracy Scale*²³, which are designed to capture distinct aspects of analytic thinking. While both tests assess deliberative reasoning, the CRT primarily measures a person's tendency to override intuitive responses, whereas Numeracy reflects computational skill and numerical understanding. Previous research using similar measures has also found modest correlations between these constructs (e.g.,^{23, 39}), suggesting that they represent complementary rather than overlapping components of analytic thinking). In our study, however, higher numeracy scores predicted lower perception of accuracy for fake news, and thus more accurate news judgments. We also found that numeracy somewhat amplifies the illusory truth effect, as familiar news was judged as more accurate by subjects with higher scores in numeracy, in contrast with previous commentaries discussing how numeracy may lead to less reliance on fluency²⁷. Finally, numeracy was associated with increased perception of accuracy when news was presented without images, a condition which may have prompted more deliberation in participants—although this interpretation remains speculative, as no direct behavioral evidence was considered. Thus, it appears that the link between numeracy and fluency—and hence, between numeracy and perceived accuracy—depends on exactly *how* information is made easier to process.

Overall, these results provide interesting insights for interventions aimed at reducing belief in fake news. On the one hand, increasing people's ability to use numeric information or the ability to assess one's own knowledge through educational campaigns or pre-bunking interventions may lead to an increased ability to assess the accuracy of fake news. On the other hand, these cognitive traits may backfire when it comes to judging familiar news, because they seem to amplify their perception of accuracy. The ambivalent role of numeracy observed in this study may reflect a deeper cognitive trade-off between analytical skill and reflective monitoring. As suggested by *Skilled Decision Theory*²⁸, numeracy supports accurate interpretation of quantitative and probabilistic information, facilitating evidence-based evaluations of news claims. However, higher numeracy may also be associated with increased confidence and fluency in reasoning, which can occasionally strengthen intuitive coherence rather than challenge it. Within Stanovich's²⁹ *Tripartite Theory of Mind*, this pattern may emerge when the algorithmic resources associated with numeracy operate without sufficient engagement of the reflective mind—the system responsible for questioning initial impressions. Consistent with this view, Sobkow et al.³⁰ showed that numeracy and cognitive reflection represent distinct but related capacities: while numeracy enhances structured information processing, cognitive reflection governs the inhibition of intuitive yet misleading cues. Consequently, individuals high in numeracy may detect implausible or inconsistent news more effectively, yet still be more susceptible to the illusory truth effect when familiar or fluent statements evoke a false sense of validity.

This ambiguity calls for interventions that contextually impact also other moderators of judgments, such as cognitive reflection, which has been proven to moderate the effect of familiarity. In other words, any intervention to mitigate beliefs in fake news should take into account the complex interplay between these different, although related, cognitive traits, and thus should adopt a more holistic approach.

This study has some limitations. Regarding the results, it is worth noting that, although the observed effects were statistically significant, they were generally small in magnitude. Therefore, the present results should be interpreted with caution. Regarding the experimental design, although we followed a relatively standard procedure for the creation of the stimuli, materials may still entail some degree of bias, both in terms of the selection of the news and in terms of how realistic they were. To counteract this issue, we made sure that (i) the news selection was based on the work of independent fact-checkers and that (ii) the stimuli looked as close as possible to real content usually shared on social networks. We also ran a pilot study to make sure that the topics covered by the news were overall balanced in terms of perceived accuracy. Still, both familiarity and sharing intention scores in our study were overall low. This likely may reflect participants' reputational caution when imagining sharing potentially unreliable content. In addition, the format of the news items (link previews resembling Facebook/Twitter posts) might not correspond to young participants' usual sharing habits or preferred platforms, further reducing declared sharing intentions. Second, the sample may not be representative enough of the whole population (i.e., they were students, with a strong gender imbalance) and this may limit the possibility to generalize our results, calling for extensions and replications with more representative pools of subjects. Third, although our participants received a monetary incentive to participate in our study, their answers were not incentivized for accuracy. Several studies in misinformation (e.g.,⁴⁸) in fact show that monetary incentives largely increase accuracy of judgments. However, our choice is justified by the fact that the main focus was not on the individual susceptibility to fake news per se, but rather on how certain factors are associated

with judgments of accuracy and sharing intentions of news in general. Finally, our image manipulation did not distinguish between probative and non-probative images, which may have introduced uncontrolled variability in participants' evaluations. Moreover, fictitious news sources were generated using ChatGPT to avoid confounds related to pre-existing trust or familiarity with real outlets. While this procedure ensured control over source effects, it may also have reduced ecological validity by making the stimuli less realistic.

Future research may consider other moderators of fluency-based biases in news perception. For instance, political orientation may play an important role, as reliance on fluency might be moderated by partisanship, with people having a stronger incentive to pay higher attention to evidence when confronted with news they perceive as aligned with their own political beliefs⁴⁹. Moreover, future research efforts could focus on experimentally priming cognitive traits (e.g., appeals to rationality, time pressure) to see how these manipulations mitigate or enhance fluency-based biases. Furthermore, future studies could further disentangle the role of familiarity from other cues that participants may use to judge news authenticity (e.g., the presence of images or news status). This could be achieved by employing artificially generated news items, for which participants have no prior exposure. Such a design would allow researchers to test whether familiarity alone—independent of prior real-world encounters—can still drive accuracy judgments and sharing intentions, providing a more controlled test of the illusory truth effect. Altogether, such studies would provide further insights into the design of pre-bunking interventions.

Conclusion

Overall, this study provides useful insights, both theoretically- and practically wise, into the individual differences in susceptibility to biases related to news perception. Misinformation may be heavily driven, among other things, by the sense of truthiness we get when interacting with news. For this reason, it is fundamental to study how our cognitive traits moderate the way news features and our previous experience with it shape our judgments. This study contributes to previous literature showing that fluency-based biases may not be as robust as previously thought⁷ and shows that they may be subject to individual differences rooted in cognition.

Data availability

The data that support the findings of this study are available from the corresponding author upon request.

Received: 7 May 2025; Accepted: 25 February 2026

Published online: 31 March 2026

References

1. Pew Research Center. Social media and news fact sheet. (accessed 18 February 2025); <https://www.pewresearch.org/journalism/fact-sheet/social-media-and-news-fact-sheet/>
2. Newman, E. J. & Zhang, L. Truthiness. In *The Psychology of Fake News* (eds Newman, E. J. & Zhang, L.) (Routledge eBooks, 2020).
3. Nadarevic, L. Illusory truth effect. In *Cognitive Illusions* (ed. Pohl, R. F.) (Routledge, 2022).
4. Okuhara, T., Ishikawa, H., Okada, M., Kato, M. & Kiuchi, T. Designing persuasive health materials using processing fluency: a literature review. *BMC Res. Notes* <https://doi.org/10.1186/s13104-017-2524-x> (2017).
5. Oppenheimer, D. M. The secret life of fluency. *Trends Cogn. Sci.* **12**, 237–241. <https://doi.org/10.1016/j.tics.2008.02.014> (2008).
6. Newman, E. J., Jalbert, M. C., Schwarz, N. & Ly, D. P. Truthiness, the illusory truth effect, and the role of need for cognition. *Conscious. Cogn.* **78**, 102866. <https://doi.org/10.1016/j.concog.2019.102866> (2020).
7. De Keersmaecker, J. et al. Investigating the robustness of the illusory truth effect across individual differences in cognitive ability, need for cognitive closure, and cognitive style. *Pers. Soc. Psychol. Bull.* **46** (2), 204–215. <https://doi.org/10.1177/0146167219853844> (2020).
8. Broz, M., (access 29 October 2025); *Photo statistics: How many photos are taken every day?* Photutorial. <https://photutorial.com/photos-statistics/> (2025).
9. Li, Y. & Xie, Y. Is a picture worth a thousand words? An empirical study of image content and social media engagement. *J. Mark. Res.* **57** (1), 1–19. <https://doi.org/10.1177/0022243719881113> (2020).
10. Zhang, L., Newman, E. J. & Schwarz, N. When photos backfire: Truthiness and falsiness effects in comparative judgments. *J. Exp. Soc. Psychol.* **92**, 104054. <https://doi.org/10.1016/j.jesp.2020.104054> (2020).
11. Caserotti, M., Vacondio, M., Maze, M. & Priolo, G. Look behind me! highly informative picture backgrounds increase stated generosity through perceived tangibility, impact, and warm glow. *Front. Psychol.* <https://doi.org/10.3389/fpsyg.2022.800199> (2022).
12. Dechêne, A., Stahl, C., Hansen, J. & Wänke, M. The truth about the truth: A meta-analytic review of the truth effect. *Pers. Soc. Psychol. Rev.* **14** (2), 238–257. <https://doi.org/10.1177/1088868309352251> (2010).
13. Hassan, A. & Barber, S. J. The effects of repetition frequency on the illusory truth effect. *Cognit. Res. Principles Implicat.* <https://doi.org/10.1186/s41235-021-00301-5> (2021).
14. Arkes, H. R., Boehm, L. E. & Xu, G. Determinants of judged validity. *J. Exp. Soc. Psychol.* **27** (6), 576–605. [https://doi.org/10.1016/0022-1031\(91\)90026-3](https://doi.org/10.1016/0022-1031(91)90026-3) (1991).
15. Derksen, D. G., Giroux, M. E., Newman, E. J. & Bernstein, D. M. Stable truthiness effect across the lifespan. *Dev. Psychol.* **58** (5), 913–922. <https://doi.org/10.1037/dev0001334> (2022).
16. Newman, E. J., Garry, M., Bernstein, D. M., Kantner, J. & Lindsay, D. S. Nonprobative photographs (or words) inflate truthiness. *Psychon. Bull. Rev.* **19** (5), 969–974. <https://doi.org/10.3758/s13423-012-0292-0> (2012).
17. Hasher, L., Goldstein, D. & Toppino, T. Frequency and the conference of referential validity. *J. Verbal Learn. Verbal Behav.* **16**, 107–112 (1977).
18. Brashier, N. M., Umanath, S., Cabeza, R. & Marsh, E. J. Competing cues: Older adults rely on knowledge in the face of fluency. *Psychol. Aging.* **32** (4), 331–337. <https://doi.org/10.1037/pag0000156> (2017).
19. Jalbert, M., Schwarz, N. & Newman, E. Only half of what I'll tell you is true: Expecting to encounter falsehoods reduces illusory truth. *J. Appl. Res. Mem. Cogn.* **9** (4), 602–613. <https://doi.org/10.1016/j.jarmac.2020.08.010> (2020).
20. Speckmann, F. & Unkelbach, C. Monetary incentives do not reduce the repetition-induced truth effect. *Psychon. Bull. Rev.* **29** (3), 1045–1052. <https://doi.org/10.3758/s13423-021-02046-0> (2022).
21. Cacioppo, J. T. & Petty, R. E. The need for cognition. *J. Pers. Soc. Psychol.* **42** (1), 116–131. <https://doi.org/10.1037/0022-3514.42.1.116> (1982).

22. Frederick, S. Cognitive reflection and decision making. *J. Econ. Perspect.* **19** (4), 25–42. <https://doi.org/10.1257/089533005775196732> (2005).
23. Silverstein, M. C., Bjälkebring, P., Shoots-Reinhard, B. & Peters, E. The numeric understanding measures: Developing and validating adaptive and nonadaptive numeracy scales. *Judgm. Decis. Mak.* **18**, e19. <https://doi.org/10.1017/jdm.2023.17> (2023).
24. Pennycook, G. A framework for understanding reasoning errors: From fake news to climate change and beyond. In *Advances in Experimental Social Psychology* (ed. Pennycook, G.) (Elsevier, 2022).
25. Ross, R. M., Rand, D. G. & Pennycook, G. Beyond “fake news”: Analytic thinking and the detection of false and hyperpartisan news headlines. *Judgm. Decis. Mak.* **16** (2), 484–504. <https://doi.org/10.1017/S1930297500008640> (2021).
26. Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S. & Garcia-Retamero, R. Measuring risk literacy: The Berlin numeracy test. *Judgm. Decis. Mak.* **7** (1), 25–47. <https://doi.org/10.1017/S1930297500001819> (2012).
27. Dohle, S. & Montoya, A. K. The dark side of fluency: Fluent names increase drug dosing. *J. Exp. Psychol. Appl.* **23** (3), 231–239. <https://doi.org/10.1037/xap0000131> (2017).
28. Cokely, E. T. et al. Skilled decision theory: From intelligence to numeracy and expertise. In *The Cambridge Handbook of Expertise and Expert Performance* (eds Ericsson, K. A. et al.) (Cambridge University Press, 2018).
29. Stanovich, K. E. On the distinction between rationality and intelligence: Implications for understanding individual differences reasoning. In *The Oxford Handbook of Thinking and Reasoning* (eds Holyoak, K. J. & Morrison, R. G.) (Oxford University Press, 2012).
30. Sobkow, A., Olszewska, A. & Sirota, M. The factor structure of cognitive reflection, numeracy, and fluid intelligence: The evidence from the Polish adaptation of the Verbal CRT. *J. Behav. Decis. Making* <https://doi.org/10.1002/bdm.2297> (2023).
31. Porter, T. et al. Predictors and consequences of intellectual humility. *Nat. Rev. Psychol.* **1**, 524–536. <https://doi.org/10.1038/s44159-022-00081-9> (2022).
32. Porter, T. & Schumann, K. Intellectual humility and openness to the opposing view. *Self Identity* **17** (2), 139–162. <https://doi.org/10.1080/15298868.2017.1361861> (2018).
33. Krumrei-Mancuso, E. J., Haggard, M. C., Labouff, J. P. & Rowatt, W. C. Links between intellectual humility and acquiring knowledge. *J. Posit. Psychol.* **15**, 155–170. <https://doi.org/10.1080/17439760.2019.1579359> (2020).
34. Beebe, J. R. & Matheson, J. Measuring virtuous responses to peer disagreement: The intellectual humility and actively open-minded thinking of conciliationists. *J. Am. Philos. Assoc.* **9**, 426–449. <https://doi.org/10.1017/apa.2022.8> (2023).
35. Binnendyk, J. & Pennycook, G. Individual differences in overconfidence: A new measurement approach. *Judgment Decis. Making* <https://doi.org/10.1017/jdm.2024.22> (2024).
36. Erceg, N., Galić, Z. & Ružojić, M. A reflection on cognitive reflection – Testing convergent/divergent validity of two measures of cognitive reflection. *Judgm. Decis. Mak.* **15**, 741–755. <https://doi.org/10.1017/s1930297500007907> (2020).
37. Plohl, N. & Musil, B. Assessing the incremental value of intellectual humility and cognitive reflection in predicting trust in science. *Personality Individ. Differ.* **214**, 1–6. <https://doi.org/10.1016/j.paid.2023.112340> (2023).
38. Pennycook, G. & Rand, D. G. Lazy, not biased: Susceptibility to partisan fake news is better explained by lack of reasoning than by motivated reasoning. *Cognition* **188**, 39–50. <https://doi.org/10.1016/j.cognition.2018.06.011> (2018).
39. Thomson, K. S. & Oppenheimer, D. M. *Cognitive Reflection Test-2 (CRT, CRT-2)* (APA PsycTests, 2016).
40. Krumrei-Mancuso, E. J. & Rouse, S. V. The development and validation of the comprehensive intellectual humility scale. *J. Pers. Assess.* **98**, 209–221. <https://doi.org/10.1080/00223891.2015.1068174> (2016).
41. Stafford, S. P. Intellectual virtue in environmental virtue ethics. *Environ. Ethics* **32**, 339–352 (2010).
42. Otero, I., Salgado, J. F. & Moscoso, S. Cognitive reflection, cognitive intelligence, and cognitive abilities: A meta-analysis. *Intelligence* **90**, 101614. <https://doi.org/10.1016/j.intell.2021.101614> (2021).
43. Béna, J., Rihet, M., Carreras, O. & Terrier, P. Repetition could increase the perceived truth of conspiracy theories. *Psychon. Bull. Rev.* **30**, 2397–2406. <https://doi.org/10.3758/s13423-023-02276-4> (2023).
44. Jalbert, M. & Pillai, R. An illusory consensus effect: The mere repetition of information increases estimates that others would believe or already know it. *Collabra Psychol.* <https://doi.org/10.1525/collabra.124533> (2024).
45. Zhu, M. & Feldman, G. Revisiting the links between numeracy and decision making: Replication registered report of Peters et al. (2006) with an extension examining confidence. *Collabra Psychol.* <https://doi.org/10.1525/collabra.77608> (2023).
46. Fallon, E., Bargary, N., Quinn, F., Leavy, A. & Hannigan, A. Words and numbers: a comparative study of medical and journalism students’ descriptors of risk, numeracy and preferences for health risk communication. *BMC Med. Educ.* <https://doi.org/10.1186/s12909-024-05048-3> (2024).
47. Stanovich, K. E. & Toplak, M. E. Actively open-minded thinking and its measurement. *J. Intell.* **11** (2), 27. <https://doi.org/10.3390/jintelligence11020027> (2023).
48. Rathje, S., Roozenbeek, J., Van Bavel, J. J. & Van Der Linden, S. Accuracy and social motivations shape judgements of (mis) information. *Nat. Hum. Behav.* **7**, 892–903. <https://doi.org/10.1038/s41562-023-01540-w> (2023).
49. Gawronski, B. Partisan bias in the identification of fake news. *Trends Cogn. Sci.* **25**, 723–724. <https://doi.org/10.1016/j.tics.2021.05.001> (2021).

Acknowledgements

Authors would like to thank the scientific committees and scholars of 4th Annual CISEPS Workshop (University of Bicocca, Milan, Italy) on “Behavioral tools and Artificial Intelligence to combat misinformation”, to the 2025 “Subjective Probability, Utility and Decision-making” (SPUDM) Conference (Lucca, Italy) and to the “Giornata del Pensiero 2025” (Turin, Italy) for providing precious support and feedback on this paper.

Author contributions

Conceptualization: Gagliardi, Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Giraldi, Rubaltelli - Methodology: Gagliardi, Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Rubaltelli - Software: Gagliardi, Caserotti, Sellaro, Rubaltelli - Formal analysis: Gagliardi, Rubaltelli - Investigation: Gagliardi - Resources: Gagliardi, Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Rubaltelli - Data curation: Gagliardi, Rubaltelli - Writing—original draft: Gagliardi - Writing—Review & editing: Gagliardi, Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Giraldi, Rubaltelli - Visualization: Gagliardi - Supervision: Gagliardi, Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Giraldi, Rubaltelli - Funding acquisition: Caserotti, Tasso, Gavaruzzi, Lotto, Sellaro, Giraldi, Rubaltelli.

Funding

This work was funded by Progetti di Ricerca di Rilevante Interesse Nazionale (PRIN), EU-funded, and is part of the national project “Psychologically-tailored approaches to Debunk Fake News” (ID: 2022JLB83Z).

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to L.G.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2026