

# Effects of Associative Inference on Individuals' Susceptibility to Misinformation

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Associative inference is an adaptive process of memory that allows people to recombine associated information and make novel inferences. We report two online human-subject experiments investigating an associative inference version in which participants viewed overlapping real-news pairs (*AB&BC*) that could later be linked to support inferences of misinformation (*AC*). In each experiment, we examined participants' recognition and perceived accuracy of snippets of news articles presented as tweets across two phases. At Phase 1, only real-news tweets were presented, which were associated with political news of Phase 2 at three levels: real, fake, and fake with inference. In Experiment 2, participants' cognitive ability was also assessed. Participants recognized more but gave lower accuracy ratings for the fake news with inference than the fake news in both experiments. The effect of associative inference was more evident in the perceived accuracy ratings for participants of higher cognitive ability than those of lower cognitive ability. We conclude that associative inference can make people become susceptible to misinformation. We also discuss the results in terms of why associative inference made people susceptible to misinformation in the relatively automatic familiarity judgment (i.e., recognition) but not the relatively controlled and effortful semantic judgment (i.e., accuracy rating).

## Public Significance Statement

The present study shows that associative inference, an adaptive cognitive mechanism, can make participants susceptible to misinformation in the recognition judgment. However, participants, especially those of higher cognitive ability, gave lower accuracy ratings for fake news with associative inference than that without associative inference, indicating less susceptibility to the semantic judgment.

**Keywords:** associative inference, fake news, cognitive ability, political-stance congruency

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Misinformation, or fake news, refers to false or fabricated information written and published to mimic legitimate news articles (Lazer et al., 2018). The ubiquitousness of social media platforms and individuals' extended use of them for news consumption (Gottfried & Shearer, 2017; Matsa & Shearer, 2018) paved the way for a proliferation of misinformation (Lazer et al., 2018). It has even been reported that fake news diffuses faster than real news on

social media platforms (Silverman et al., 2016; Vosoughi et al., 2018), especially disrupting people's immediate response to political events, including the 2016 and 2020 United States presidential elections (Funke, 2020; Grinberg et al., 2019) and the 2016 Brexit Referendum (Rosenberg, 2016). Yet, fake news is an age-old problem (Mansky, 2018), which has been evident throughout the development of writing systems (Marcus, 1992), the printing press (Rosaldo, 1981), and modern newspapers (Gullason, 1959). Instead of decrying the role those emerging technologies have played in the current issues of misinformation, therefore, it is critical to understand cognitive mechanisms contributing to people's susceptibility to misinformation.

Prior studies have examined different cognitive factors that affect people's *belief* in misinformation. For example, people tend to use fluency as a heuristic to judge the information accuracy, that is, repeated statements are rated as more probably true than novel statements (Begg et al., 1992; Hasher et al., 1977; see Dechêne et al., 2010 for a review). Such results have been obtained even when participants are told that the news headlines were disputed by a fact-checking organization (Pennycook et al., 2018; Seo et al., 2019). Individuals' cognitive ability also correlates to their susceptibility to believing in fake news (e.g., Pennycook & Rand, 2019). Liberals generally perform better than conservatives on cognitive ability evaluations (Jost, 2017), and the cognitive-processing-style differences may contribute to the results that conservatives (i.e., more intuitive) were more likely than liberals (i.e., more deliberative) to

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believe in and spread misinformation (Baron & Jost, 2019). People's susceptibility to *misremembering* novel, suggested events as "old" has been extensively investigated in the past 40 years (see Loftus, 2005; Pickrell et al., 2016, for reviews). Prior work has shown that individuals are likely to form false memory about events that agree with their self-identified political orientation (e.g., Frenda et al., 2013), indicating a *political-stance congruency effect*. An association between false memory and individuals' cognitive ability is also evident. Previous studies have found that participants with lower cognitive ability are more likely to remember fake news in line with their pre-existing beliefs than those with higher cognitive ability (e.g., Murphy et al., 2019).

Although it is critical for people to precisely remember past events that occurred in a particular time and place (Davis & Loftus, 2007), whether people can hold accurate knowledge judgments on misinformation statements matters more nowadays (Marsh & Stanley, 2020). That is mainly because effective and efficient source monitoring is difficult to achieve given various news media channels, including printed publications, radio, television, news web sites, and social media platforms (Shearer, 2021). The distinction between specific event retrieval and general knowledge has been captured by two forms of memory: *episodic* memory and *semantic* memory (Tulving, 1972, 1983). Semantic memory can be distinguished from episodic memory by lacking associations with a particular learning time and place.

News articles are typically about individuals, places, and things, with whom or which people are familiar or interested. Thus, when individuals read news headlines or tweets about news on social media, the information processing of these events is based on their prior knowledge that is relevant to the current events (Roediger & Gallo, 2016; Roediger & McDermott, 2000). Moreover, people tend to recombine the elements from prior knowledge that share a common feature flexibly and make new connections that they have not directly experienced (Bransford & Franks, 1971; Roediger & McDermott, 1995), indicating the adaptive ability.

In this work, we focus on an adaptive, constructive process of memory, also known as *associative inference* (Preston et al., 2004; Zeithamova & Preston, 2010). Prior studies have shown that people can flexibly recombine the elements of *past experience* associated with a common entity or event and are more likely to recognize a false associative inference that they have not directly experienced

(e.g., Preston et al., 2004). While previous work has examined people's false *episodic* memory about prior associations with overlap (Carpenter & Schacter, 2017), people's false *semantic* memory (i.e., knowledge) of an inferred event has not been reported.

Besides episodic closeness, semantic relations are salient between news articles. Take Figure 1 as an example. The *AB&BC* pairs present two pieces of associated information (i.e., knowledge): (a) There was a report about the seizure of roughly 90 pounds of cocaine hidden in the chain storage space of Ping May and (b) Mitch McConnell was connected to the shipping company. The "success" of inferred misinformation *AC*, "Cocaine Mitch," depends on whether people believe in Mitch McConnell's strong antidrug stance and are aware of his wife's family owned and operated the shipping company (Kasprak, 2019). Since people's political ideology can shape their perception of political news (Nir, 2011), they may tend to believe in information about particular figures and events that meet their expectations, suggesting false semantic memory of an inferred event (*AC*).

We examine the effects of associative inference on people's *recognition* and *perceived accuracy rating* of fake news. In the following, we first review the evidence regarding the effect of associative inference on episodic memory and describe its potential role in people's susceptibility to semantic memory (i.e., general knowledge). Then, we describe other factors, that is, political-stance congruency and cognitive ability, which might interact with associative inference and influence people's recognition and perceived accuracy rating of political misinformation. We further report two online experiments that tested our research questions (RQs). Finally, we discuss our key findings and conclude the paper.

## Associative Inference

Human memory has been described as an optimization of information retrieval (Anderson & Milson, 1989). For example, Bransford and Franks (1971) conducted three experiments showing that participants spontaneously integrated the information expressed by a number of nonconsecutive but semantically related sentences (e.g., The ants in the kitchen ate the jelly which was on the table. The jelly was sweet.) into holistic semantic ideas (e.g., The ants in the kitchen ate the sweet jelly that was on the table.) other than simply a list of sentences experienced during acquisition. The sentences that contained the holistic semantic

**Figure 1**

*An Example of Associative Inference Triad (AB&BC → AC) in the Tweet Format With Hashtags*



*Note.* Left and center panels show an overlapping pair of real-news tweets (*AB&BC*) presented initially (Phase 1), and right panel shows one piece of inferred fake news (*AC*) presented afterward (Phase 2).

relations were never presented in any single sentence during the acquisition. Yet, participants were more confident of recognizing sentences expressing the complete idea than any single sentence, indicating that they made inferences based on associated sentences.

Associative memory errors have also been extensively studied using the “Deese–Roediger–McDermott (DRM) paradigm” (Deese, 1959; Roediger & McDermott, 1995), in which participants first study the lists of words that are semantically associated (e.g., table, sit, wood, rest). On the recall or recognition tasks afterward, participants’ performance of a single, nonpresented critical item (e.g., chair) is similar or even higher than those studied words, suggesting that people interpret associated words and make inferences about them (Roediger & Gallo, 2016; Roediger & McDermott, 2000).

Carpenter and Schacter (2017) conducted four experiments investigating participants’ false memory of associative inference on shared events. In their experiments, participants learned direct associations between two items, *AB* (e.g., a person *A* and a toy *B* in a room), and then learned direct associations that include an element of the previously studied pairs, *BC* (e.g., the toy *B* with a different person *C* in a room). The results from their experiments showed that participants were susceptible to false memory of associative inference on a shared event (*AC*): Participants tended to misattribute the details of the *BC* event to the *AB* event, for example, a brown couch in the *AB* event (man with truck), when in fact it was in the *BC* event (boy with truck).

While Carpenter and Schacter examined people’s false *episodic* memory about prior overlapping associations (*AB&BC*, also see Zeithamova & Preston, 2010), we focus on people’s false semantic memory of an inferred event (*AC*) in the context of online news consumption. As mentioned, news articles typically report public figures, places, or events with which people are familiar or interested. Thus, people’s general knowledge of the associative pairs may have impacts on their evaluation of the inferred information. Within the context of news consumption on social media, we aim to determine the consequence of reading overlapped real-news pairs (i.e., *AB&BC*) on people’s subsequent recognition and perceived accuracy rating of the inferred fake news (i.e., *AC*). The perceived accuracy rating task has been primarily used to understand people’s susceptibility to misinformation (e.g., Bago et al., 2020), reflecting people’s general knowledge from semantic memory. The recognition task, identifying whether a stimulus (e.g., a piece of fake news) is familiar (Cantor & Mischel, 1977; Seo et al., 2019), is critical to reflect possible memory errors that participants have for the associatively inferred fake news.

### Political-Stance Congruency and Cognitive Ability

Individuals have been found to be particularly susceptible to fake news that is congruent with their preexisting opinions and attitudes, showing the political-stance congruency effect. For example, Frenda et al. (2013) recruited more than 5,000 participants in a survey posted online and asked participants’ memories for four news events of politics, one of which was false. Their results showed that participants’ political preferences appeared to guide the recognition of fabricated events: Participants who self-indicated as liberals were more likely to “remember” pro-liberal fake news, whereas conservatives were more likely to “remember” pro-conservative fake news. Gao et al. (2018) also reported the effects of political-stance congruency on people’s agreement of political news articles and their selection to read those articles. van der

Linden et al. (2020) recruited a representative sample of the U.S. adults online ( $N = 1,000$ ) and asked participants to report associations with fake news. They found that conservatives described major liberal outlets, such as the Cable News Network (CNN) as “fake news,” but liberals described well-known conservative outlets (e.g., Fox News) as “fake news.”

Prior studies have also indicated that conservatives are more likely to endorse misinformation than liberals (e.g., Garrett & Bond, 2021; Jost et al., 2018). Garrett and Bond (2021) analyzed a longitudinal data set collected over 6 months in 2019. The data set includes social media engagement data and a 12-wave panel study of American’s political knowledge about high-profile news, such as issues that Americans were mostly likely to encounter online. Each week, participants on the panel evaluated the accuracy of 21 statements (10 real, 10 false, and 1 placebo) with a 4-point scale (“definitely true,” “probably true,” “probably false,” and “definitely false”). They found that conservatives performed worse at distinguishing false claims from real ones, indicating lower sensitivity to misinformation than liberals.

Correlations between individuals’ cognitive ability and their susceptibility to misremembering (Murphy et al., 2019; Zhu et al., 2010) and misbelieving in (Pennycook & Rand, 2019) fake news are also evident. For example, Zhu et al. (2010) examined the correlation of various cognitive factors with false memory and found that false memory was significantly and negatively correlated with participants’ cognitive ability measures, such as Wechsler Adult Intelligence Scale vocabulary test (WAIS). Murphy et al. (2019) evaluated participants’ cognitive ability using Wordsum, a 10-item subset of WAIS (Wechsler, 2008), and obtained similar findings. Besides, Murphy et al. found that participants of lower cognitive ability showed a larger political-stance congruency effect, that is, those participants were more likely to report remembering the false story if it was in line with their political orientation. Pennycook and Rand (2019) evaluated participants’ critical thinking ability with the Cognitive Reflection Test (CRT; Frederick, 2005) and found that liberals tended to think more critically than conservatives in general. Moreover, participants’ CRT scores were negatively correlated with the accuracy ratings of fake news headlines but positively correlated with the accuracy ratings of real news. Altogether, the aforementioned findings indicate that compared to individuals with higher cognitive ability, those with lower cognitive ability are expected to be more susceptible to fake news with associative inference that is also congruent with their political ideology.

### Twitter Hashtag: Cues for Recognition

A Twitter hashtag is a bottom-up user-proposed tagging format that associates a user created tweet with an event or a context using a tag with the prefix pound symbol, # (e.g., # Ping May). Prior studies have shown that the use of hashtags is a popular element in communication among many social media users (Bonilla & Rosa, 2015; Bruns & Burgess, 2011; Columbia Broadcasting System/The Associated Press [CBS/AP], 2017). Besides the initial purpose of structuring and organizing information consumption voluntarily from users (Furnas et al., 2006), there is a top-down mechanism to promote information and agenda by using hashtags on social media, thus mobilizing public attention (Wang et al., 2016).

Moreover, several hashtags have been used in combination within a single tweet. Such occurrences of multiple hashtags visually

enhance the association among parts following #, which may serve as *cues* to facilitate the retrieval of relevant information about the tweet. Thus, the association among the hashtags could strengthen their effectiveness as cues in the recognition task (Murnane & Phelps, 1995) and consequently accentuate the associative inference in recognition and accuracy judgments.

## The Present Experiments

In this article, we describe two online human-subject experiments investigating the effects of associative inference on participants' recognition and perceived accuracy of real and fake political news using tweet formats. Experiment 1 focuses on the following three RQs. RQ1: Will participants recognize more and give higher accuracy ratings for fake news with associative inference than fake and real news without associative inference? RQ2: Will the effect of associative inference differ between news congruent and incongruent with participants' self-identified political ideology? RQ3: Will a larger effect of associative inference be evident for tweets with hashtags than tweets without hashtags?

We expected participants to recognize more and give higher accuracy ratings for fake news with associative inference than fake news without associative inference (RQ1). The effect of associative inference was expected to be more evident for news congruent with participants' self-identified political ideology than news incongruent with their political ideology (RQ2). We expected the effect of associative inference to be more evident for tweets that have associative inference keywords presented as hashtags than those that do not (RQ3).

Experiment 2 was conducted in part because of the unexpected results in Experiment 1. To foreshadow, we obtained higher recognition rates but lower accuracy ratings for fake news with associative inference than that without associative inference. Besides replicating Experiment 1, we investigated RQ4: How does an individual's cognitive ability influence the effects of associative inference? We expected participants with lower cognitive ability to be more influenced by associative inference and its interactions with political-stance congruency than those with higher cognitive ability.

### Experiment 1

Using a mixed design, we investigated the effects of associative inference and its interaction with political-stance congruency on participants' recognition and perceived accuracy of fake news. We also examined the influence of hashtags using tweet formats. Across two phases, there were three within-subject factors: *source-news type* (Phase 1), *news veracity* (Phase 2), and *political-stance congruency* (Phase 2). The two between-subject factors were *self-identified political ideology* (measured, Phases 1 and 2) and *tweet format* (varied, Phases 1 and 2).

## Method

### Transparency and Openness

We report how we determined our sample size, all manipulations, all measures, and all data exclusions in the study. Data were analyzed using IBM SPSS Statistics 26 and R (Version 4.1.1). News stimuli presented in the study, complete results of statistical analyses, and details of exploratory analyses can be found in online Supplementary Materials.<sup>1</sup> This study's design and its analysis were

not preregistered. Data used for SPSS and R analyses are available by emailing the corresponding author.

### Participants

An effect size of a three-way interaction of News veracity  $\times$  News stance  $\times$  Participants' self-identified political ideology,  $\eta_p^2 = .04$ , was reported by Pennycook and Rand (2019), indicating a small effect. Given our interest in the political-stance congruency, we combined the three-way interaction by examining the political-stance congruency effect of each political ideology group across the three news-veracity levels.

To detect a small effect size, Cohen's  $f = 0.10$ , power analysis using G\*Power 3.1 (Faul et al., 2007), suggested  $n = 408$  participants of two-way interaction of 3 (news veracity: real, fake, fake w/ inf.)  $\times$  3 (congruency effect of self-identified political ideology: liberal, moderate, conservative) with a power of 0.8, mixed analysis of variances (ANOVAs) test,  $\alpha = .05$ . Considering that there was relatively less control when conducting a study online and the between-subject design of hashtags, we doubled the sample size to ensure adequate power.

We recruited 800 Amazon Mechanical Turk (MTurk) workers in October 2019. All participants (a) were at least 18 years old, (b) had completed more than 100 human intelligence tasks (HITs) with a HIT approval rate of at least 95%, and (c) were located in the United States. Experiments 1 and 2 were conducted in accord with a protocol approved by the Pennsylvania State University's Institutional Review Board, and all participants consented to the participation.

After removing eight incomplete submissions, nine duplicated responses, and an extra 75 participants who selected at least one "Prefer not to answer" for questions at Phase 2, the numbers of participants that we accepted for the without (w/o) hashtags and with (w/) hashtags conditions were 376 and 332, respectively. Among a total of 708 participants, 57.2% were males. Participants' ages ranged from 18 to over 58 years, with 82.4% between 18 and 47 years. About 90.8% of the participants were college students or professionals who have a bachelor's or higher degree. Participants who answered "yes" for their participation in the 2016 U.S. presidential election took 83.8%, indicating that most of the participants were interested in political participation. About 41.2% of the participants self-identified as liberals, 35.2% as conservatives, and 23.6% as moderates, and 50.4% spent more than an hour on social media every day.

### Stimuli

Our online study was programmed using Qualtrics. We presented a total of 38 snippets of news articles, 30 of which were real. The real-news snippets were based on news articles reported from major news media, such as <https://washingtonpost.com>, <https://usatoday.com>, and <https://foxnews.com>. The eight snippets of fake news were excerpts of fact-checked fake news by <https://snopes.com>. For the real-news snippets, we intentionally excluded news articles that were debunked as real to minimize the controversy of their veracity. We presented 12 pairs of real-news snippets at Phase 1, and 12 snippets (four pieces of real news, eight pieces of fake news) at Phase 2. Moreover, we varied the fake news of Phase 2 at two levels: half with associative inference (*fake w/ inf.*) and the other half without associative inference (*fake*). Two extra snippets of real news were used for attention check.

<sup>1</sup> <https://doi.org/10.1037/xap0000418.supp>

Due to the main interest in associative inference, we started the news selection from the 12 snippets at Phase 2. Take the triad in Figure 1 as an example. We selected it as one trial because there was an associative inference between the keywords of fact-checked fake news, that is, Mitch McConnell (*A*), cocaine (*C*), and the keywords of real news, that is, Mitch McConnell (*A*), Ping May (*B*), and cocaine (*C*), reported by <https://snope.com> as evidence to debunk the fake news (Kasprak, 2019). *A*, *B*, and *C* represented keywords in the news, including a public figure, an event, and an entity. Critically, there was an overlapping keyword *B* in the real-news pairs at Phase 1 (i.e., *AB&BC*). The keywords *A* and *C* were also the same keywords of the inferred fake news at Phase 2 (i.e., *AC*). The snippets of real-news pairs at Phase 1 were identical to the excerpts of selected real news except that we added extra explanation for some pronouns, such as “Ping May” for the ship in Figure 1.

Likewise, we first identified two keywords (i.e., *A* and *C*) for each snippet of the other two veracity levels (i.e., fake, real) at Phase 2. Since there was no associative inference across the two phases, we selected two real news from the major news media, each of which contained the keywords *A* and *C*, respectively. We denoted those eight real-news pairs at Phase 1 as the *AX&YC* type, indicating that there was no keyword overlapping within each pair. We also controlled the release time of the selected real-news pairs, both of which were published before the associated news at Phase 2. In summary, the three veracity levels at Phase 2 and the news triads across the two phases are as follows:

- Fake *w/ inf.* (*AB&BC* → *AC*): Four pairs of real news at Phase 1 were fake related and in the *AB&BC* type. For each pair, two keywords of each tweet overlapped through one common keyword (e.g., *A*: Mitch McConnell, *B*: Ping May, and *C*: cocaine). At Phase 2, the other keyword from each tweet (i.e., *A* and *C*) were also the keywords of the fake news at Phase 2, affording an associative inference (*inf.*).
- Fake (*AX&YC* → *AC*): The remaining four pairs of fake-related, real news at Phase 1 were in the *AX&YC* type,

which had no overlap between keywords in each pair (e.g., *A*: Germany, *X*: Ramstein Air Base, *Y*: CNN, and *C*: Trump). For Phase 2, one keyword from each real tweet from Phase 1 (i.e., *A* and *C*) was repeated in the fake news without associative inference.

- Real (*AX&YC* → *AC*): The four pairs of real-related, real news at Phase 1 was also in the *AX&YC* type, which did not have keyword overlap for each pair (e.g., *A*: Supreme Court, *X*: Apple, *Y*: Capitol Hill, and *C*: House Republicans). The keywords *A* and *C* were also keywords of the real news at Phase 2.

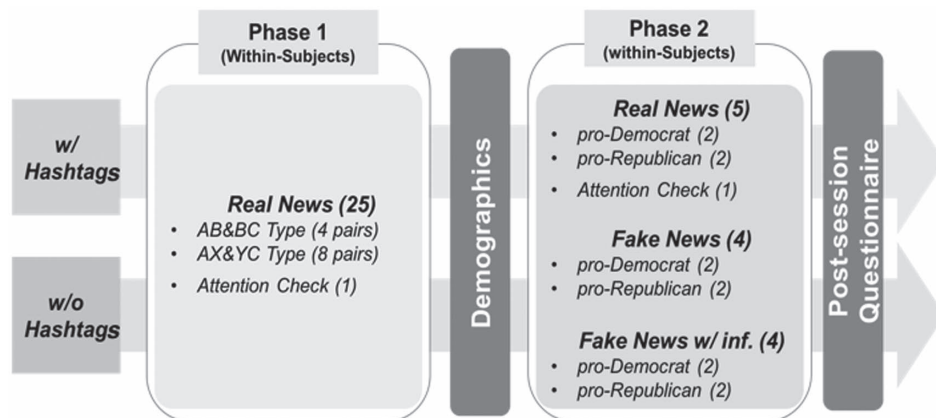
Moreover, news at Phase 2 was politically related. For each veracity level, half of the news was *pro-Republican*, and the other half was *pro-Democrat*. The stance of each news was first labeled by each author separately and then finalized based on a group consensus afterwards. The snippets of news articles were presented in tweet formats. For each tweet, we created one version *w/o hashtags* and the other version *w/ hashtags*. Both versions were the same except that keywords of each tweet were listed after pound symbols in the *w/ hashtags* version. We rendered hashtags in gray to exclude the possible confounding of blue color highlighting (see Figure 1). We also used an identical user account and blurred the user’s name and image in each tweet to control potential impacts from the source (Visentin et al., 2019).

## Procedure

Figure 2 shows the flowchart of Experiment 1. Participants who accepted the HIT on Amazon MTurk were directed to a survey on Qualtrics. After informed consent, participants were randomly assigned to the *w/ hashtags* condition or the *w/o hashtags* condition. The procedures for those two conditions were identical.

**Phase 1: Real-News Source.** At Phase 1, participants viewed 12 pairs of real news, four of which were in the *AB&BC* type and the remaining eight were in the *AX&YC* type. The 12 pairs were presented in a randomized order, while tweets of each pair were

**Figure 2**  
Overview of Experiment Flowchart for Experiment 1



Note. The number of news pieces (pairs) in each condition is shown in the parentheses.

presented in the fixed order of *AB&BC* or *AX&YC*. For each tweet, participants were instructed to read it first and then to decide whether they had seen or heard about it before (response options: “Yes,” “Unsure,” “No”). After the recognition task, participants rated the accuracy of the tweet on a 5-point scale with response options: *Very Inaccurate* (1), *Quite Inaccurate* (2), *Moderate* (3), *Quite accurate* (4), *Very accurate* (5). A “Prefer not to answer” was provided as the last option for both recognition and perceived accuracy rating tasks.

After Phase 1, participants filled out a demographic questionnaire, including age, gender, and education. The short survey served as a distraction to draw participants’ attention intentionally (Van Dillen & Koole, 2007) and prevented their working memory from keeping tweets of Phase 1 active.

**Phase 2: Associated News w/ and w/o Inf.** After the demographic questionnaire, Phase 2 started. Participants completed the two tasks that were the same as Phase 1 for eight pieces of fake news and four pieces of real news. Critically, the veracity of news at Phase 2 varied across three levels. Four pieces of fake news *w/ inf.* were trials from the *AB&BC* → *AC* triads. The other four pieces of fake news and the four pieces of real news were trials from *AX&YC* → *AC* triads. For each veracity level, half of the tweets were pro-Republican, and the other half were pro-Democrat. The 12 pieces of news were presented in a randomized order.

**Postsession Questionnaire.** After Phase 2, participants rated their political ideology using a 5-point scale from 1 (*Very Liberal*) to 5 (*Very Conservative*). Then, we presented the four pieces of fake news *w/ inf.* to each participant with her/his perceived accuracy ratings. For each tweet, we asked participants to choose factors that they had considered for accuracy rating with nine options (1: “Source,” 2: “Writing Style,” 3: “Content,” 4: “Web search results,” 5: “News presented in Stage 1,” 6: “News that I saw before this study,” 7: “Opinions from others,” 8: “Others,” 9: “Prefer not to answer”). If a participant chose the fifth option, we further asked her/him to explain how it influenced the accuracy rating decision with an open-ended question.

Considering the textual nature of tweets, we presented one piece of real news for attention check (Hauser & Schwarz, 2016) to prompt participants’ reading of each tweet at Phases 1 and 2, respectively. At the beginning of the study, we informed participants that there was one tweet with a specified correct answer for the attention check at each phase. They were asked to choose the specified option to pass the check. If participants failed either attention check question, the survey ended. Each participant was allowed to participate only once in the experiment. The whole study was self-paced by the participants. On average, participants took about 15.4 min to complete the study, with a median completion time of 13.8 min. Participants who passed the attention check and completed the study received compensation of 1.5 U.S. dollars, which is typical for MTurk based studies (e.g., Gao et al., 2018; Yaqub et al., 2020).

## Results

The selection process of news triads across the two phases (see the Stimuli section) might result in the pro-Democrat and pro-Republican news trials being imbalanced in political strength. So we evaluated the intensity of news stance (*pro-Democrat*, *pro-Republican*) across

the three news-veracity levels (*real*, *fake*, *fake w/ inf.*) at Phase 2 (see evaluation details and all news stimuli in the [Supplemental Materials](#)). The overall intensity was similar across the three news-veracity levels,  $F(2, 582) = 1.18, p = .307, \eta_p^2 = .004$ . However, the two-way interaction of News stance × News veracity showed a nonsignificant trend,  $F(2, 582) = 2.52, p = .081, \eta_p^2 = .009$ . Specifically, the news stance was balanced in the real level,  $t(194) = -1.56, p = .121$ , and the fake level,  $t < 1.0$ . However, the intensity of pro-Republican news (1.16) was stronger than that of the pro-Democrat news (1.03) for the fake news *w/ inf.*,  $t(193) = -2.40, p = .017$ . Thus, we examined the effect of congruency in general but not the differences across participants’ self-identified political ideology at Phase 2. Also, we excluded the results of moderates ( $n = 167$ ) from data analysis due to the minimal political-stance congruency. Thus, the results of the remaining 541 participants were included in the data analysis.

However, considering that such imbalanced strength may reflect that political misinformation disproportionately promotes events favored by conservatives (Garrett & Bond, 2021), we conducted exploratory analyses to understand the interaction between political-stance congruency and participants’ self-identified political ideology, as well as their interaction with associative inference (see details in [Supplementary Materials](#)). To give an indication beforehand, we found that the congruency effect varied between liberals and conservatives. We discuss its implications in the General Discussion.

Since the critical comparison concerns the recognition and perceived accuracy measures across the three veracity levels at Phase 2, we first report those results and how they were impacted by the political-stance congruency and the tweet formats. We then turn to the results of the real-news source at Phase 1 and discuss how they influenced the obtained results at Phase 2.

## Phase 2

Recognition and perceived accuracy results were entered into 3 (news veracity: real, fake, fake *w/ inf.*) × 2 (political-stance congruency: congruent, incongruent) × 2 (format: *w/o* hashtags, *w/* hashtags) mixed ANOVAs with a significance level of .05. Post hoc tests with Bonferroni correction were performed, testing all pairwise comparisons with corrected  $p$  values for possible inflation. Because the sphericity assumption was violated for terms involving the factors of news veracity (epsilons less than .99), the reported  $p$  values were adjusted by Greenhouse–Geisser correction (Girden, 1992).

Given the unbalanced intensity of news stance, the analyses on perceived accuracy ratings at Phase 2 in this and following experiments were also performed on data in each news trial (Barr, 2013; Barr et al., 2013). The accuracy ratings were analyzed using linear mixed-effects regression (LMER) with the lme4 package in R (Bates et al., 2011). LMER allows controlling of the random effect for participants without data aggregation (Brauer & Curtin, 2018). The models were the same as ANOVAs except that we included intercepts for participants and news trials (Barr, 2013; Brown, 2021). It is still under debate for an agreed, single standardized effect size for LMER (Rights & Sterba, 2018). To avoid any confusion, we reported the  $F$  values and  $p$  values of mixed-effect analyses (also see Pennycook et al., 2021) for the main effects and interaction results following the corresponding ANOVAs. We report the degree

of freedom with Satterthwaite approximation. The complete results are shown in Tables S13 and S14 of the supplementary materials. Both ANOVAs and mixed-effect analyses showed similar results. We discuss more details of the comparisons in the General Discussion.

**Effects of Associative Inference-Recognition.** Figure 3a depicts the results of average recognition rate. The main effect of news veracity was significant,  $F(2, 539) = 6.27, p = .002, \eta_p^2 = .011$ . Pairwise comparisons showed that participants' recognition rate of the fake news *w/ inf.* (24.2%) was higher than the fake news (21.1%),  $p_{\text{adj.}} = .001$ , neither of which were significantly different from the real news (22.9%),  $p_{\text{adj.}} \geq .108$ . The effect of political-stance congruency was also significant,  $F(1, 539) = 28.83, p < .001, \eta_p^2 = .051$ . Participants recognized more political-stance congruent news (24.7%) than political-stance incongruent news (20.8%). The congruency effect showed similar results across the three news-veracity levels,  $F < 1.0$ . No other terms were significant,  $F_s < 1.87$ .

**Effects of Associative Inference-Perceived Accuracy.** Results of the average perceived accuracy rating are shown in Figure 3b. There was a main effect of news veracity,  $F(2, 539) = 153.93, p < .001, \eta_p^2 = .222$  [ $F(2, 9) = 9.72, p = .006$ ]. Post hoc analysis showed significant differences for all pairwise comparisons,  $p_{\text{adj.}} \leq .032$ . Participants' perceived accuracy rating of the fake news *w/ inf.* (2.88) was lower than that of the fake news (3.05) and the real news (3.40), respectively. While participants can differentiate the fake news from the real ones, they rated the veracity of fake news as moderate and somewhat real. Opposite to the recognition results, participants seemed to be less susceptible to the fake news *w/ inf.* for the accuracy judgment.

The effect of political-stance congruency,  $F(1, 539) = 184.26, p < .001, \eta_p^2 = .255$  [ $F(1, 5936) = 318.02, p < .001$ ], and its interaction of news veracity,  $F(2, 539) = 5.65, p = .004, \eta_p^2 = .010$  [ $F(2, 5936) = 4.67, p = .009$ ], were significant. The congruency effect, that is, the difference between congruent (C) and incongruent (IC) trials, for the real news (C: 3.56, IC: 3.23), was smaller than that of the fake news (C: 3.29, IC: 2.80),  $p_{\text{adj.}} = .014$ , and the fake news *w/ inf.* (C: 3.13, IC: 2.62),  $p_{\text{adj.}} = .007$ , respectively. Yet, there was no significant differences between the two fake levels,  $p_{\text{adj.}} > .999$ .

## Phase 1

To understand the influence of real-news source at Phase 1, we examined participants' recognition rates and perceived accuracy ratings of the real-news pairs with 2 (source-news type: *AB&BC, AX&YC*)  $\times$  2 (self-identified political ideology: liberal, conservative)  $\times$  2 (format: *w/ o* hashtags, *w/* hashtags) mixed ANOVAs. We excluded an additional 35 participants who chose "Prefer not to answer" at Phase 1. Thus, both recognition and perceived accuracy measures were analyzed based on the results of the remaining 506 participants. Post hoc tests were conducted similar to those of Phase 2.

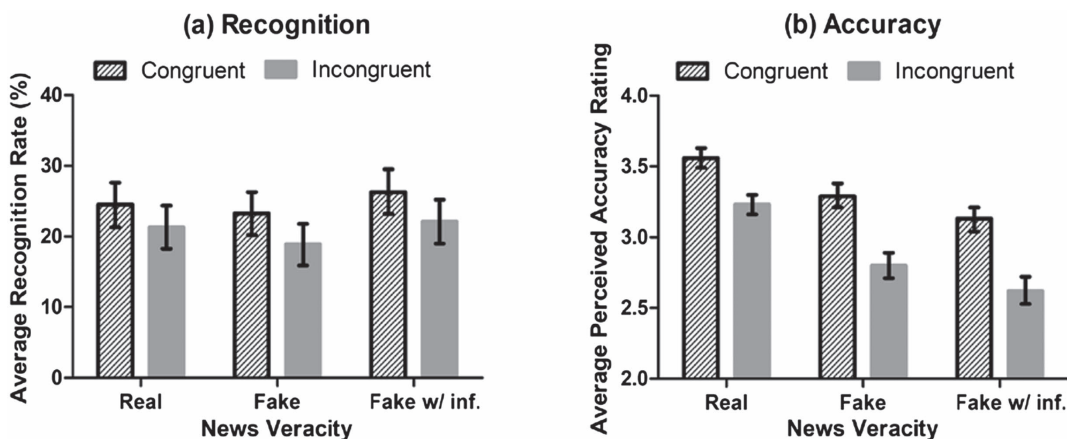
**Source-Recognition.** Figure 4a shows the results of the recognition rate for each condition. Participants' overall recognition rate was about 22%. Only the main effect of self-identified political ideology was significant,  $F(1, 502) = 9.23, p = .003, \eta_p^2 = .018$ . Participants self-identified as conservatives recognized more news (28.5%) than liberals (20.7%).

**Source-Perceived Accuracy.** Results of the perceived accuracy rating are shown in Figure 4b. The main effect of news type was significant,  $F(1, 502) = 15.58, p < .001, \eta_p^2 = .030$ . Participants rated both types of news as real but higher for the *AX&YC* type (3.55) than for the *AB&BC* type (3.47). Also, the effect of news type depended on participants' self-identified political ideology,  $F(1, 502) = 15.61, p < .001, \eta_p^2 = .030$ . Specifically, the higher accuracy rating of the *AX&YC* type than the *AB&BC* type was evident for liberals (*AX&YC* vs. *AB&BC*: 3.49 vs. 3.34),  $F(1, 270) = 32.85, p < .001, \eta_p^2 = .108$ , but not for conservatives (*AX&YC* vs. *AB&BC*: 3.61 vs. 3.61),  $F < 1.0$ . We fixed the order of news presentation (e.g., *AB&BC*) in each pair, so the obtained results suggest that liberals might have noticed the overlapping keywords for the pairs and gave lower accuracy ratings.

There was also a main effect of self-identified political ideology,  $F(1, 502) = 15.02, p < .001, \eta_p^2 = .029$ . Conservatives gave higher accuracy ratings (3.61) than liberals (3.41),  $p_{\text{adj.}} < .001$ . Thus, self-identified political ideology showed consistent impacts for both recognition and accuracy measures. No other terms were significant or approached significance,  $F_s < 1.1$ .

**Figure 3**

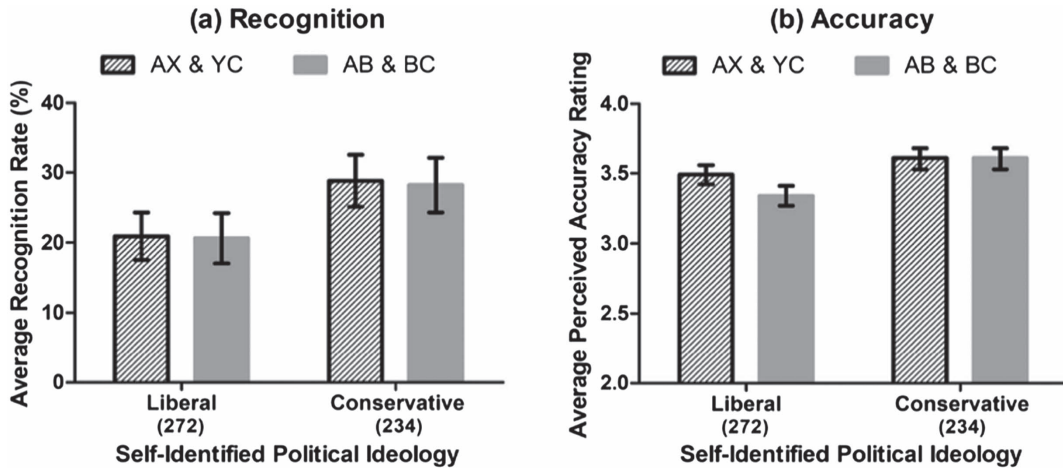
Average Recognition Rates (Left Panel) and Perceived Accuracy Ratings (Right Panel) by Political-Stance Congruency and News Veracity of Phase 2 in Experiment 1



Note. Error bars represent 95% confidence intervals.

**Figure 4**

*Average Recognition Rates (Left Panel) and Perceived Accuracy Ratings (Right Panel) by News Type and Self-Identified Political Group of Phase 1 in Experiment 1*



*Note.* The number of participants in the condition is shown in parentheses. Error bars represent 95% confidence intervals.

### Synthesis of Phases 1 and 2

Participants' recognition rates did not differ between the two types of real news at Phase 1, indicating a similar familiarity level. However, liberals gave lower accuracy ratings for the *AB&BC* type than for the *AX&YC* type, implying that they might have noticed the overlapping keywords of the *AB&BC* pairs at Phase 1 and became suspicious of the perceived accuracy. Effects of associative inference were revealed in both measures at Phase 2. Participants recognized more the fake news *w/ inf.*, indicating more memory errors. Participants gave the lowest accuracy rating for the fake news *w/ inf.*, which was contrary to our expectation but in agreement with the lower accuracy ratings for the *AB&BC* pairs at Phase 1. Thus, participants' susceptibility to fake news with associative inference was mainly revealed in the relatively automatic recognition task.

### Postsession Questionnaire Results

We asked participants to select factors that they considered for the accuracy ratings of the fake news *w/ inf.* in the postsession questionnaire. We collected 418 responses to the open-ended question in total. Collapsed across all four fake news *w/ inf.*, the top option chosen by the participants was "Content" (55.4%). Only 19.3% of the participants selected "News presented in Phase 1." After disregarding meaningless responses such as "Yes" or "nice," we did a thematic analysis (Braun & Clarke, 2006) using the remaining 180 meaningful responses. The first two co-authors and two undergraduate students working in the lab performed the thematic analysis independently at first. Then, they discussed the results and finalized the thematic analysis together. Three major themes were identified as follows:

**Association Between the Two Phases.** Among the 180 answers, 51.7% of the participants indicated that when they gave accuracy ratings for the fake news *w/ inf.* at Phase 2, they noticed its connection with news at Phase 1. For example, P6 answered, "There was a connection between the ship, its name, the drugs, and

McConnell." While 26.1% of the answers did not describe any further implications about the connection, about 25.6% mentioned that the news was repeated between the two phases, which increased participants' perceived accuracy of the news. For instance, P8 replied, "There was a reference to it in stage 1, so since it was repeated I thought maybe there's some truth to it." For all 93 participants who indicated the theme of association between the two phases, 66.7% of them were liberals and 33.3% were conservatives.

**Verbatim Recall.** Forty-six (25.6%) participants noticed the gap between the news in two phases. They recalled the details of news articles at Phase 1 and detected the distorted or exaggerated parts at Phase 2. For example, P197 answered,

During Phase 1, the article mentioned that Mitch McConnell had ties to the company Ping May, not that he was the ship's owner. Even if he does partly or fully own the ship, this article seems manipulative in the way it expresses this. It tries to create a more negative view of McConnell's participation, if any.

Among the 46 participants, 73.9% were liberals and 26.1% were conservatives.

**Gist-Based Recall.** There were 40 (22.2%) participants, reporting that they made the accuracy rating decision based on their prior knowledge or belief on the news articles. For example, P193 explained,

In Stage 1 they noted that McConnell had a relationship with the Chinese company who owned the shipping containers. This is the extent of what I have heard on the news. I chose that answer because it confirmed what I already believed to be true.

For those participants, 72.5% were liberals and 27.5% were conservatives.

### Discussion

In Experiment 1, we evaluated the effect of associative inference and its interaction with political-stance congruency on participants'



recognition and perceived accuracy ratings of real and fake news across two phases (RQ1 & RQ2). With similar recognition rates for both types of real news (*AB&BC* and *AX&YC*) at Phase 1, the effect of associative inference was revealed in the recognition measure at Phase 2 (RQ1). Participants showed higher recognition rates for the fake news with associative inference than that without associative inference. Moreover, the recognition rates for the fake news with associative inference were similar to those for the real news, suggesting increased memory errors due to associative inference.

Participants gave lower perceived accuracy ratings for the *AB&BC* type at Phase 1 and the fake news with associative inference at Phase 2 (RQ1), indicating that they might be aware of the overlap at Phase 1, as well as the associative inference between phases (i.e., *AB&BC* → *AC*). Subjective measures in the thematic analysis confirmed that some participants noticed the gap between news at Phase 2 and the associated pairs at Phase 1.

The effect of political-stance congruency was evident for both recognition and perceived accuracy measures at Phase 2. Compared to the real news, participants revealed larger political-stance congruency for the accuracy ratings of fake news in general, indicating limited effects of associative inference (RQ2). The tweet formats did not show any significant effects (RQ3).

## Experiment 2

The results of Experiment 1 revealed the effects of associative inference in both measures. We aim at replicating those results in Experiment 2. Because individuals of lower cognitive ability have shown a larger political-stance congruency effect (Murphy et al., 2019) and higher false recognition of fake news (Zhu et al., 2010), we also added cognitive ability tests examining the impact of cognitive ability on the effects of associative inference (RQ4). We expected participants of lower cognitive ability to be more influenced by associative inference than those of higher cognitive ability.

## Method

### Participants

Since a similar number of participants have been identified as of lower or higher cognitive ability (e.g., Murphy et al., 2019), we recruited an extra 1,600 MTurk workers in November 2019. The requirements to participate were the same as in Experiment 1, and any participants enrolled in Experiment 1 were excluded from participation. Using the same criterion as Experiment 1, we included 1,353 participants' results for data analysis.

Participants' demographic information shows a similar pattern to Experiment 1. Among the 1,353 participants, 48.4% were males. Participants' ages ranged from 18 to over 58 years, with 82.6% between 18 and 47 years. About 93.2% of the participants were college students or professionals who have a bachelor's or higher degree, and 78.8% indicated that they voted in the 2016 presidential election. Same as Experiment 1, most participants in Experiment 2 were also somewhat interested in political participation. About 46.2% of the participants were self-identified as liberals, 26.9% as conservatives, and 26.9% as moderates.

Participants' cognitive ability was categorized based on their total scores on Wordsum and the CRT-2 (Thomson & Oppenheimer, 2016). In the literature, participants who correctly answered eight or

more items in Wordsum (e.g., Murphy et al., 2019) or half of the four CRT-2 items (e.g., Thomson & Oppenheimer, 2016) were categorized as having higher cognitive ability. Thus, we adopted 10 as a criterion to divide between lower and higher cognitive ability (Lee et al., 2020). For a total of 14 questions, 781 (57.7%) participants who gave 10 or more correct answers were labeled as having a higher cognitive-ability-test score. The remaining 572 participants were categorized as having a lower cognitive-ability-test score. Participants with a lower cognitive-ability-test score for conservatives, liberals, and moderates were 52.8%, 36.3%, and 39.2%, respectively.

### Stimuli and Procedure

Stimuli and procedures were identical to Experiment 1 except as noted. First, only the *w/hashtags* condition was examined since no effect involving tweets format was significant in Experiment 1. Second, we added two cognitive ability tests, the CRT-2 (Thomson & Oppenheimer, 2016) and Wordsum (Wechsler, 2008), after the demographic questions but before Phase 2. Participants answered four questions in the CRT-2, which measured their tendency to override an incorrect "gut" response, for example, "If you are running a race and you pass the person in the second place, what place are you in?" The intuitive answer is "first," but the correct one is "second." Participants' intelligence scale of vocabulary was measured with 10 items in Wordsum. For each item, we showed participants one word in capital letters (e.g., SPACE) with five options (e.g., captain, school, noon, board, room). Participants chose one word that comes closest to the meaning of the word in capital letters. Options of "do not know" and "prefer not to answer" were also provided for both tests. Third, due to more than half meaningless replies for the open-ended questions in Experiment 1, we presented a piece of randomly selected fake news *w/ inf.* in the postsession questionnaire. Finally, we changed the specified correct answer to the attention check, reducing the influence of possible exposure to the attention check question of Experiment 1 (Chmielewski & Kucker, 2020; Gray et al., 2016).

## Results

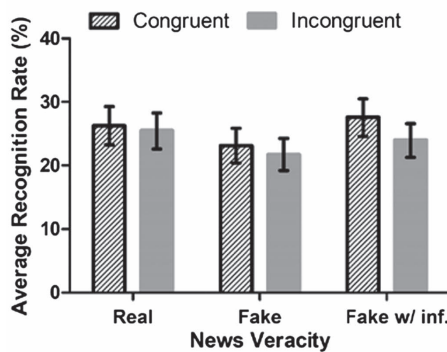
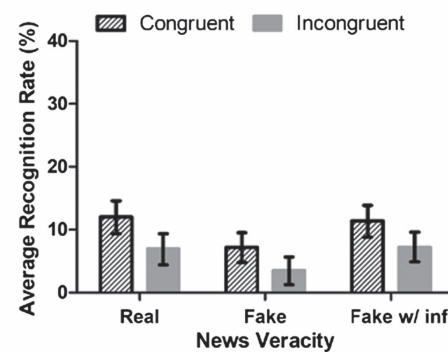
### Phase 2

Same as Experiment 1, we first report the results of Phase 2 and then turn to the results of the real-news source at Phase 1. Furthermore, we excluded participants who self-identified as moderates ( $n = 364$ ), so a total of 989 participants were included for our data analysis. Analyses of the recognition rates and perceived accuracy ratings were conducted in the same way as in Experiment 1 except that the factor of *tweet format* was replaced by the *cognitive-ability-test score* (lower, higher).

**Effects of Associative Inference-Recognition.** Figure 5 shows the recognition results of Phase 2. The main effect of news veracity was significant,  $F(2, 987) = 23.33, p < .001, \eta_p^2 = .023$ . Recognition rate of the fake news (13.9%) was lower than that of the real news (17.7%) and the fake news *w/ inf.* (17.5%),  $p_{\text{adj.}} < .001$ . Yet, the difference between the latter two groups was not significant,  $p_{\text{adj.}} > .999$ . There was a main effect of political-stance congruency,  $F(2, 987) = 36.81, p < .001, \eta_p^2 = .036$ , but its higher order interactions were not significant,  $F_s \leq 1.17$ .

**Figure 5**

*Average Recognition Rates by Political-Stance Congruency and News Veracity of Phase 2 in Experiment 2*

**(a) Lower Cognitive-Ability-Test Score (430)****(b) Higher Cognitive-Ability-Test Score (559)**

*Note.* Left panel shows the results for participants with a lower cognitive-ability-test score, and right panel shows the results for participants with a higher score. The number of participants in the condition is shown in parentheses. Error bars represent 95% confidence intervals.

Participants with a lower cognitive-ability-test score recognized more news (24.7%, see Figure 5a) than those with a high score (8.0%; see Figure 5b),  $F(1, 987) = 123.35, p < .001, \eta_p^2 = .111$ . The effect of political-stance congruency differed between the two score levels,  $F(1, 987) = 5.26, p = .022, \eta_p^2 = .005$ . Participants with a higher cognitive-ability-test score (C: 10.2%, IC: 5.9%) revealed a larger political-stance congruency effect than participants with a lower score (C: 25.7%, IC: 23.7%). The larger political-stance congruency revealed by the participants with a higher cognitive-ability-test score indicates that individuals with higher (vs. lower) cognitive ability (e.g., those engaging conscious and effortful information processing-as measured by the CRT-2), are relatively more biased toward news congruent to their political ideology (Kahan, 2012).

**Effects of Associative Inference-Perceived Accuracy.** Figure 6 shows the results of perceived accuracy of Phase 2. There was a main effect of news veracity,  $F(2, 987) = 284.39, p < .001, \eta_p^2 = .224 [F(2, 9) = 8.97, p = .007]$ . All pairwise comparisons among the three veracity levels were significant (real vs. fake vs. fake w/ inf.: 3.29 vs. 2.95 vs. 2.78),  $p_{\text{adj.}} < .001$ . The effect of political-stance congruency,  $F(1, 987) = 425.74, p < .001, \eta_p^2 = .301 [F(2, 10852) = 698.74, p < .001]$ , and its interaction with veracity,  $F(2, 987) = 31.68, p < .001, \eta_p^2 = .031 [F(2, 10852) = 20.95, p < .001]$ , were also significant. Post hoc pairwise comparisons showed the same results as Experiment 1. The political-stance congruency effect for the real news (C: 3.44, IC: 3.14) was smaller than that for the fake news (C: 3.22, IC: 2.68) and the fake news w/ inf. (C: 3.09, IC: 2.48),  $p_{\text{adj.}} < .001$ , while the latter two levels did not differ from each other,  $p_{\text{adj.}} = .329$ .

Same as the recognition results, the following effects were significant: the main effect of cognitive-ability-test score,  $F(1, 987) = 85.93, p < .001, \eta_p^2 = .080 [F(1, 987) = 85.93, p < .001]$ , and the two-way interactions of Cognitive-ability-test score  $\times$  Political-stance congruency,  $F(1, 987) = 33.85, p < .001, \eta_p^2 = .033 [F(1, 10869) = 55.21, p < .001]$ . Participants with a higher cognitive-ability-test score rated tweets more critically (2.84; see Figure 6b) than participants with a lower score (3.18; see Figure 6a).

The effect of political-stance congruency was more evident for the participants with a higher cognitive-ability-test score (C: 3.15, IC: 2.53),  $F(1, 558) = 410.95, p < .001, \eta_p^2 = .424$ , than for the participants with a lower score (C: 3.35, IC: 3.01),  $F(1, 429) = 94.51, p < .001, \eta_p^2 = .181$ . The three-way interaction of News veracity  $\times$  Cognitive-ability-test score  $\times$  Political-stance congruency was not significant,  $F < 1.29$ . Yet, the two-way interaction of Cognitive-ability-test score  $\times$  News veracity,  $F(2, 987) = 42.43, p < .001, \eta_p^2 = .041 [F(2, 10860) = 44.11, p < .001]$ , was significant. While participants with a higher score differentiated the three veracity levels clearly (see Figure 6b), participants with a lower score rated news as real in general (see Figure 6a). Moreover, the effect of news veracity was significant for participants with higher and lower scores,  $F_s > 45.31, p_s < .001, \eta_p^2 > .096$ , and all the post hoc pairwise comparisons were significant,  $p_{\text{adj.}} < .001$ .

**Phase 1**

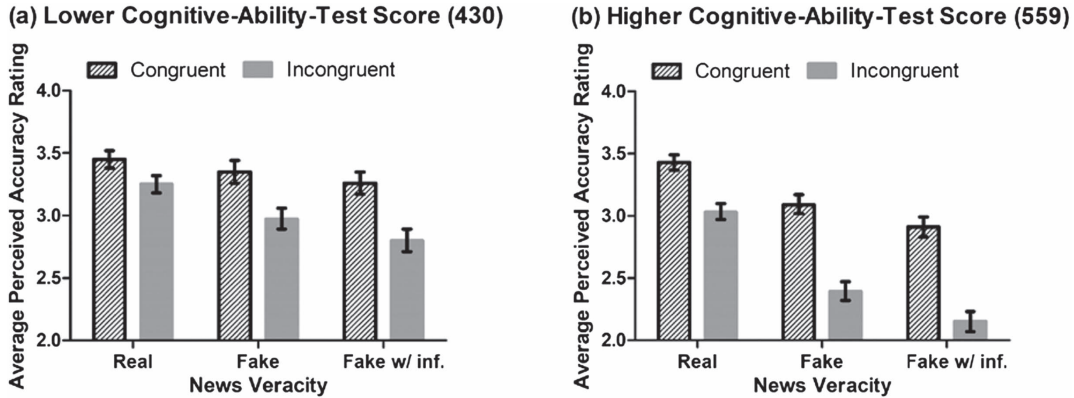
Similar to Experiment 1, we excluded extra 76 participants who chose “Prefer not to answer” at Phase 1 so that only the data of the remaining 913 participants were included for data analysis. Then, recognition and perceived accuracy measures were entered into 2 (source-news type: AB&BC, AX&YC)  $\times$  2 (self-identified political ideology: liberal, conservative)  $\times$  2 (cognitive-ability-test score: lower, higher) mixed ANOVAs.

**Source-Recognition.** Figure 7 shows the results of average recognition rate. Participants’ recognition rates of AX&YC type (18.5%) and AB&BC type (18.5%) showed no difference,  $F < 1.0$ . Liberals (18.2%) and conservatives (18.8%) also showed similar recognition results,  $F < 1.0$ . However, the two-way interaction of News type  $\times$  Self-identified political ideology was significant,  $F(1, 909) = 3.92, p = .048, \eta_p^2 = .004$ . While liberals recognized more news of the AX&YC type (18.6%) than the AB&BC type (17.8%), an opposite pattern was revealed for conservatives (AX&YC: 18.4%; AB&BC: 19.3%)

Moreover, participants with a lower cognitive-ability-test score recognized more news (25.9%) than participants with a higher score

**Figure 6**

Average Perceived Accuracy Ratings by Political-Stance Congruency and News Veracity of Phase 2 in Experiment 2



Note. Left panel shows the results for participants with a lower cognitive-ability-test score, and right panel shows the results for participants with a higher score. The number of participants in each condition is shown in parentheses. Error bars represent 95% confidence intervals.

(11.1%),  $F(1, 909) = 93.05, p < .001, \eta_p^2 = .093$ . The interaction of News type  $\times$  Cognitive-ability-test score was also significant,  $F(1, 909) = 9.59, p = .002, \eta_p^2 = .010$ . Better recognition for the AX&YC type than for the AB&BC type was evident for participants with a higher score (AX&YC: 11.8%; AB&BC: 10.5%),  $F(1, 542) = 5.92, p = .015, \eta_p^2 = .011$ . In contrast, participants with a lower score showed a nonsignificantly opposite pattern (AX&YC: 25.2%; AB&BC: 26.6%),  $F(1, 385) = 3.83, p = .051, \eta_p^2 = .010$ . No other terms were significant or approached significance,  $F_s \leq 2.16$ .

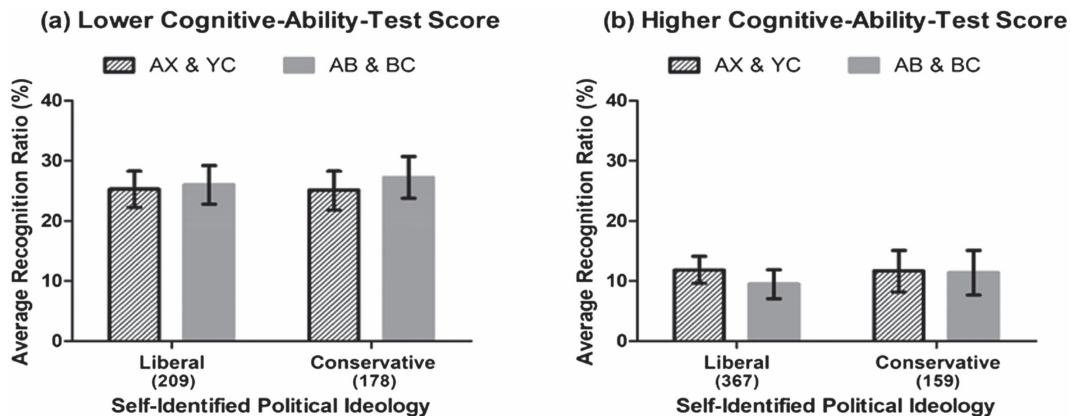
**Source-Perceived Accuracy.** Results of average perceived accuracy rating were shown in Figure 8. Same as Experiment 1, participants' perceived accuracy rating of the AX&YC type (3.47) was higher than that of the AB&BC type (3.39),  $F(1, 909) = 34.53, p < .001, \eta_p^2 = .037$ . Conservatives gave higher perceived accuracy

ratings (3.48) than liberals (3.38),  $F(1, 909) = 10.50, p = .001, \eta_p^2 = .011$ . There was also a two-way interaction of News type  $\times$  Self-identified political ideology,  $F(1, 909) = 19.64, p < .001, \eta_p^2 = .021$ . The effect of news type was significant for liberals,  $F(1, 574) = 66.93, p < .001, \eta_p^2 = .104$ , but not for conservatives,  $F < 1$ , replicating the findings of Experiment 1.

The main effect of cognitive-ability-test score (lower: 3.47, higher: 3.39),  $F(1, 909) = 6.21, p = .013, \eta_p^2 = .007$ , its interaction with news type,  $F(1, 909) = 10.37, p = .001, \eta_p^2 = .011$ , as well as its interaction with self-identified political ideology,  $F(1, 909) = 5.29, p = .022, \eta_p^2 = .006$ , were all significant. Specifically, for liberals, the effect of cognitive-ability-test score was not significant,  $F < 1.0$ . However, for conservatives, participants with a lower cognitive-ability-test score (3.56) gave higher rating than those with a higher

**Figure 7**

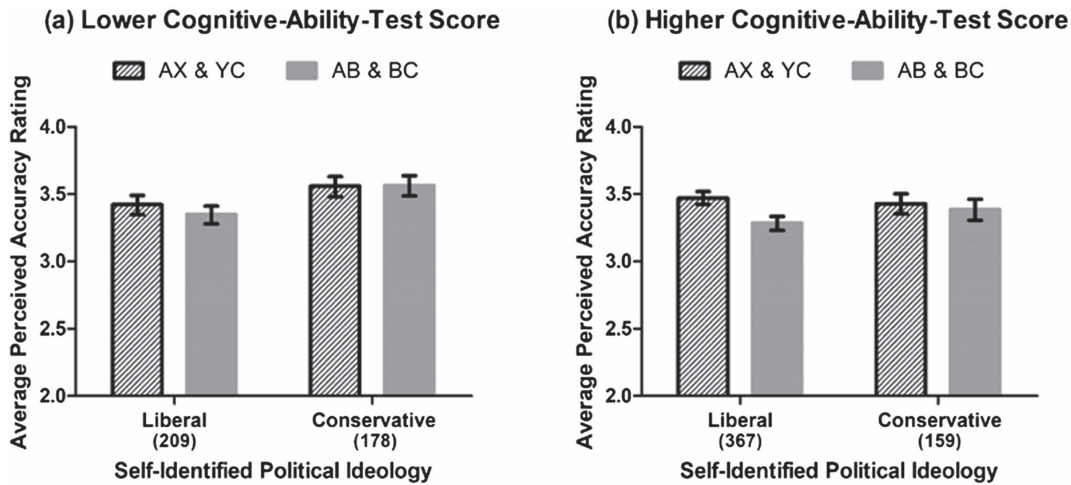
Average Recognition Rates by News Type and Self-Identified Political Ideology of Phase 1 in Experiment 2



Note. Left panel shows the results for participants with a lower cognitive-ability-test score, and right panel shows the results for participants with a higher score. The number of participants in each condition is shown in parentheses. Error bars represent 95% confidence intervals.

**Figure 8**

*Average Perceived Accuracy Ratings by News Type and Self-Identified Political Ideology of Phase 1 in Experiment 2*



*Note.* Left panel shows the results for participants with a lower cognitive-ability-test score, and right panel shows the results for participants with a higher score. The number of participants in each condition is shown in parentheses. Error bars represent 95% confidence intervals.

score (3.41),  $F(1, 335) = 9.03, p = .003, \eta_p^2 = .026$ . The main effect of news type was significant for participants with a higher cognitive-ability-test score,  $F(1, 542) = 44.50, p < .001, \eta_p^2 = .078$ , but not for those with a lower cognitive ability score,  $F(1, 385) = 3.30, p = .070, \eta_p^2 = .008$ . We did not obtain the three-way interaction of Cognitive-ability-test score  $\times$  News type  $\times$  Self-identified political ideology,  $F < 1.51$ , indicating that neither liberals' awareness of the associative inference was associated with their cognitive ability nor the awareness of participants with higher cognitive ability relied on their political ideology. No other terms were significant,  $F_s \leq 1.51$ .

### Synthesis of Phases 1 and 2

At Phase 1, participants recognized both types of news in a similar manner but gave lower ratings for the AB&BC type. In Phase 2, participants recognized more fake news *w/ inf.* but gave lower perceived accuracy ratings. Thus, we replicated the results of Experiment 1 for both measures.

### Postsession Questionnaire Results

In the postsession questionnaire, the questions and options were the same as those of Experiment 1 except that participants were asked about only one of the four fake news *w/ inf.*, which was randomly selected. With regard to factors impacting participants' accuracy rating of fake news *w/ inf.*, the top option chosen by the participants was also "Content" (56.4%), which was similar to the results of Experiment 1. About 21.0% of the participants selected the option "News presented in Stage 1."

**Thematic Analysis for the Open-Ended Question.** We collected 208 responses for the open-ended question in total. We disregarded meaningless responses such as "Yes" or "nice" and did the thematic analysis using the remaining 152 meaningful responses as Experiment 1. The top three themes were similar to those of Experiment 1: association between two phases (54.6%),

verbatim recall (27.0%), and gist-based recall (16.4%). Among the 83 participants who indicated the theme of association between the two phases, 61.4% of them were liberals, and 38.6% were conservatives. Among the 41 participants who indicated the theme of verbatim recall, 68.3% of them were liberals, and 31.7% were conservatives. Finally, among the 25 participants who indicated the theme of gist-based recall, 48.0% of them were liberals, and 52.0% were conservatives. In addition, participants of a higher cognitive-ability-test score for the three themes were 67.5%, 80.5%, and 56.0%, respectively.

### Discussion

Besides the major findings of Experiment 1 being replicated, there were a few critical findings in Experiment 2. Our results revealed that cognitive ability had impacts on participants' susceptibility to fake news for both recognition and perceived accuracy measures. The effect of associative inference was more evident in the perceived accuracy ratings for participants with a higher cognitive-ability-test score than those with a low score (RQ4). Also, participants with a higher (vs. lower) score showed larger political-stance congruency effects, opposite to previous findings (Murphy et al., 2019). We conjecture that it was mainly due to the manipulation of how news articles were associated across two phases. We did not obtain any interaction of Cognitive-ability-test score  $\times$  News veracity  $\times$  Political-stance congruency, suggesting that associative inference and cognitive ability may reveal different cognitive mechanisms contributing to individuals' susceptibility to fake news that is ideological congruent.

### General Discussion

Via two online human-subject experiments, we demonstrate the effects of associative inference on participants' fake news recognition and perceived accuracy measures. Regardless of news stance,

participants recognized more fake news with associative inference than that without associative inference. Results of Experiment 2 showed that such better recognition did not depend on participants' cognitive ability. In contrast, participants gave the lowest accuracy ratings for fake news with associative inference, and such effect of associative inference was more evident for participants of higher (vs. lower) cognitive ability. We also obtained larger political-stance congruency in both measures for participants of higher cognitive ability. Overall, these results indicate that the adaptive ability, that is, associative inference, can make people become susceptible to misinformation in the recognition task but not the accuracy rating task.

### Associative Inference Increased Recognition but Reduced Perceived Accuracy Rating

The recognition task or familiarity judgment mainly relies on people's intuitive response, which is automatic and less taxing (Jacoby, 1991; Mandler, 1980). However, the perceived accuracy rating task (i.e., semantic judgment) necessitates people's consideration of relevant knowledge, which requires extensive information search and retrieval, implying a relatively controlled and effortful process (Kahneman, 2011; Mansky, 2018). With more chances to experience real news in general, people typically recognize more and give higher perceived accuracy ratings for real news than for fake news (e.g., Pennycook et al., 2018; Seo et al., 2019). Yet, our Experiments 1 and 2 revealed that participants recognized more fake news with associative inference than that without inference. Moreover, the recognition rate of fake news with associative inference was similar to that of real news.

When participants viewed *AB&BC* pairs at Phase 1, the details of tweet *AB* could have been incorporated with those of tweet *BC* through the overlap of *B* (Shohamy & Wagner, 2008). Although the recognition rates of real-news sources (*AB&BC* type, *AX&YC* type) at Phase 1 were similar, the associative inference afforded by the *AB&BC* pairs might result in participants' more fluent processing of the fake news with inference than that without inference at Phase 2, suggesting the impacts of associative inference on relatively automatic recognition tasks. While prior research has mainly focused on the fluency introduced by repetition (e.g., Pennycook et al., 2018), our results revealed that the process of *inference* could be another contributor.

Despite the higher recognition rate, participants' perceived accuracy rating for fake news with associative inference was lower than that for fake news without inference, indicating that controlled and effortful processes of accuracy rating might make participants less susceptible to fake news with associative inference. Such explanation is also consistent with the finding that the effect of associative inference was more evident for the participants of higher cognitive ability (i.e., more deliberative) than those of lower cognitive ability (i.e., more intuitive).

Using a between-subject design, Lee et al. (2020) conducted a pilot study evaluating participants' susceptibility to fake news as a function of associative inference and its interaction with people's cognitive ability. Across two phases, their participants made recognition and perceived accuracy rating of identical fake news (Phase 2) as a function of how those pieces of fake news were associated with real news that they viewed initially (Phase 1). Compared to the conditions of fake news without associative inference and a control

(fake news irrelevant to the source real news), their participants, especially those of higher cognitive ability, tended to give higher perceived accuracy ratings to fake news with associative inference. Thus, besides the accuracy rating task, the *within-subject* design in our present study might have increased participants' awareness of the associative inference across phases, which encouraged intentional control (Jacoby et al., 1992) and resulted in the lower accuracy ratings for fake news with associative inference.

### Larger Political-Stance Congruency Revealed by Individuals of Higher Cognitive Ability

A motivated reasoning account has been proposed to explain people's belief in political fake news (Kahan, 2017; also see Van Bavel & Pereira, 2018 and van der Linden et al., 2020): People are more susceptible to fake news that is congruent with their political ideology. Studies have been conducted investigating the interaction between motivational reasoning and people's analytic reasoning ability on climate change (Kahan et al., 2012), data interpretation and causal inference (Kahan et al., 2017), as well as selective exposure of fake news (Knobloch-Westerwick et al., 2020). Results of those studies revealed an interaction between participants' ideology bias and their analytic thinking ability. Thus, a motivated system 2 (i.e., deliberative, analytic processes, Kahneman, 2011) reasoning account has been proposed to explain the fact that people of higher analytical reasoning increased their propensity to engage in ideologically motivated reasoning with explicit deliberation. In contrast, some studies obtained results indicating an opposite pattern: Participants of higher analytic or cognitive ability showed more tendency to reject or disbelieve fake news that was congruent to their political ideology, favoring a classical reasoning account (Murphy et al., 2019; Pennycook & Rand, 2019).

Scrutiny of the experimental designs for the classical reasoning account revealed that most of those studies have focused on *what* people believe. For example, Murphy et al. (2019) presented two fabricated and four authentic news stories of the 2018 Irish abortion referendum and asked participants (i.e., "Yes" and "No" voters) to select news that they believed were fake. More than half of the participants reported memory errors of at least one of the fabricated fake news, and participants were more likely to remember the fabricated news that was in line with their beliefs. Murphy and her colleagues evaluated participants' cognitive ability with Wordsum (Wechsler, 2008) and found that participants of higher cognitive ability were less likely to report the false memory and showed a smaller ideological-congruency effect than participants of lower cognitive ability.

Pennycook and Rand (2019)'s Experiment 2 evaluated participants' accuracy rating and share willingness of 12 fake and 12 real news headlines. For each veracity level, half of the news was Democrat-consistent and the other half was Republican-consistent. Participants' cognitive ability was evaluated by the CRT. They conducted correlational analysis between CRT performance and accuracy rating for fake and real news and found that more analytic participants were less likely to believe in political-consistent fake news than less analytic participants.

The experimental designs for the motivated system 2 reasoning account have also examined *how* people think (Kahan, 2012; Kahan et al., 2012, 2017). For example, Kahan et al. (2017) asked participants to interpret the presented data and draw causal

inferences. While participants of higher analytic ability showed better performance when the data were presented as results of a skin-rash treatment experiment, the same participants of higher analytic ability revealed larger political bias when the *same* data were presented as results of a gun-control ban. Specifically, for liberals of higher analytical ability, the increase of correct answer rates was more evident for the crime-decrease framing than for the crime-increase framing. However, an opposite pattern was evident for conservatives of higher analytic ability. Therefore, the interaction between cognitive ability and motivated reasoning mainly depended on how the questions were presented. If questions were presented congruently with how individuals interpret the question (e.g., liberals focused on crime decrease of gun control), individuals of higher analytic ability seemed to bypass the how aspect, revealing larger political bias than an incongruent presentation. Thus, Kahan et al.'s results suggest a congruency effect on the how aspect of information processing for participants of higher analytic ability.

We varied the association between news in two phases and obtained results showing larger political-stance congruency for participants of a higher cognitive-ability-test score than those with a lower score in our Experiment 2. Moreover, the effect of associative inference was more evident for participants with a higher cognitive-ability-test score, revealing that participants with a higher score paid more attention to how the news claims were associated across phases, as revealed by more participants with a higher score detected the gap between the two phases in the postsession questionnaire. Thus, our findings suggest that a framework focusing on both *what* and *how* aspects of human information processing may accommodate the seemingly contradictory findings between the accounts of classical reasoning (e.g., Pennycook & Rand, 2019) and motivated reasoning (e.g., Kahan, 2017; Van Bavel & Pereira, 2018).

In our exploratory analysis (see details in [Supplementary Materials](#)), we obtained results showing that liberals differentiated the two fake levels regardless of their cognitive-ability-test scores. Compared to conservatives, liberals tended to have higher integrative complexity when thinking about political issues, that is, they put more weight on structure rather than content (Tetlock, 1983). Participants self-identified as moderates and liberals gave lower accuracy ratings for the *AB&BC* pairs at Phase 1 in both experiments, indicating that their awareness of the association was equivalent. However, only liberals revealed a nonsignificantly larger political-stance congruency for fake news with associative inference at Phase 2. Moreover, such a trend was shown in both experiments and became more evident in Experiment 2. Thus, the exploratory analysis also implies that why people fall for fake news can be explained by *what* they think and *how* they think. Of course, this is a post hoc explanation, and future research needs to replicate and investigate the two aspects more thoroughly.

Recently, Pennycook et al. (2021) conducted a series of studies evaluating the effects of accuracy ratings on participants' subsequent sharing decisions. Across the experiments, they obtained results showing that implicit and explicit accuracy rating tasks increased people's attention to accuracy and thus reduced their sharing intentions. Although shifting attention to accuracy reduced the sharing of the fake news, it also reduced people's sharing of real news, shown in the results of their Study 6 (see their Figure 3, Panel d). Thus, the manipulation of explicit accuracy rating task may increase participants' *bias* to judge the news as fake in general,

raising the question of *how* to shift people's attention to reduce misbelief in fake news only.

### Ineffectiveness of Hashtags

We presented keywords of associative inference as hashtags to understand whether the associative inference would be enhanced. Results of our Experiment 1 revealed minimal effect of the hashtags. Rho and Mazmanian (2019) conducted an online study examining how the presence of political hashtags in Facebook news posts impacted people's attitudes toward related social issues. Compared to a group of participants who viewed those news posts without hashtags, participants in the hashtags group believed that news posts were more partisan and controversial. Participants also rated those news topics with less social importance and revealed less motivation to know more about the social issues related to the posts with hashtags.

The findings of Rho and Mazmanian seemed contrary to the nonsignificant effect of hashtags in our Experiment 1, but there are two critical differences in the experiment design that may contribute to the different results of those two studies. First, one hashtag related to the broad social issue (e.g., #MeToo or #BlackLiveMatters) was included in the news posts of Rho and Mazmanian. Thus, the effect reported by Rho and Mazmanian mainly indicated the top-down influence of hashtags in framing social issues during news consumption. However, we presented figure names, events, or entities in news articles as hashtags in our experiments. Results of our Experiment 1 primarily revealed that the co-occurrence of hashtags did not facilitate the association inference. Second, hashtags were presented twice (i.e., the end of top claim and the beginning of news title) in the posts of hashtag condition in Rho and Mazmanian (2019), and the first one was highlighted in bold (see their Figure 1A). Yet, we grayed out the hashtags in our experiment. Thus, the effects obtained in Rho and Mazmanian could be due to the visual enhancement of highlighting and the two-time presentation. The grayed-out presentation in our study is different from the typical hashtag color coding (i.e., blue color highlighting). Future work could consider using the blue-colored hashtags and examine whether it would increase participants' attention to the hashtags and consequently facilitate associative inference.

### Limitation and Future Work

Proper caution should be made to generalize our findings to other settings. First, we recruited MTurk workers as participants for the two experiments. The online convenience samples drawn from MTurk differ from nationally representative samples, although prior work compared MTurk samples with other benchmark national samples showing that MTurk respondents did not differ fundamentally from population-based respondents (Levy et al., 2016). Second, the ideological differences between liberals and conservatives in the MTurk might not be the same as the divisions of liberals and conservatives in the mass public (Clifford et al., 2015). Although the results of political-stance congruency effect comparisons obtained in the present study are informative to understand the ideological differences of the U.S. population, future works should consider evaluations using a population-representative sample.

Third, the current work only evaluated a small set of pro-Democrat and pro-Republican news claims. To understand the

possible influence of imbalanced political ideology across the selected news trials, we analyzed the perceived accuracy ratings in each experiment using LMER. In general, the average results and the item-effect analyses across news trials showed similar patterns. Therefore, the results of the present study can account for sources of variability from participants and news trials simultaneously. However, due to the intensity between the two political news stances varied across the veracity levels, we did not consider the political-stance congruency differences in the main analysis. In the future, a large set of news claims including more trials balanced in political-stance intensity should be considered. Also, the news claims in our study covered mainly politics. Including news articles on different topics, for example, health information, can improve the external validity of our study.

Fourth, we focused on the associative inference across two phases. Yet, keywords *A* and *C* were repeated across phases. Thus, the effect of repetition might have also contributed to the findings. Since the impact should be the same across the three veracity levels, it would have had a limited influence on the relative comparisons among the three levels. However, one control condition without repetition can be included in a future study to understand the effect. Future studies might also include real news with associative inference at Phase 2 and examine whether a similar pattern to the two fake levels will be obtained. Finally, our study only examined the impact of associative inference in the short term. A future study can reveal whether associative inference will increase by extending the gap between the two phases.

## Conclusion

The dissemination of fake news on social media platforms has become a global issue with critical sociopolitical implications. Mitigating the negative impact of fake news on people requires a better understanding of cognitive mechanisms that contribute to individuals' susceptibility to fake news. In this regard, we examined one such mechanism, associative inference, and its interaction with individuals' political-stance congruency and their cognitive ability. In two experiments, participants recognized more fake news with associative inference than that without, revealing their susceptibility to misinformation with associative inference. Our study is the first step in an investigation of adaptive cognitive mechanisms on people's susceptibility to fake news, which raises critical questions for further study.

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