In Case of Doubt for the Speculation? When People Falsely Remember Facts in the News as Being Uncertain

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Abstract

Modern media report news remarkably fast, often before the information is confirmed. This general tendency is even more pronounced in times of an increasing demand for information, such as during pressing natural phenomena or the pandemic spreading of diseases. Yet, even if early reports correctly identify their content as speculative (rather than factual), recipients may not adequately consider the preliminary nature of such information. Theories on language processing suggest that understanding a speculation requires its reconstruction as a factual assertion first—which can later be erroneously remembered. This would lead to a bias to remember and treat speculations as if they were factual, rather than falling for the reverse mistake. In six experiments, however, we demonstrate the *opposite* pattern. Participants read news headlines with explanations for distinct events either in form of a fact or a speculation (as still being investigated). Both kinds of framings increased participants' belief in the correctness of the respective explanations to an equal extent (relative to receiving no explanation). Importantly, however, this effect was not mainly driven by a neglect of uncertainty cues (as present in speculations). In contrast, our memory experiments (recognition and cued recall) revealed a reverse distortion: a bias to falsely remember and treat a presented “fact” *as if* it were merely speculative. Based on these surprising results, we outline new theoretical accounts on the processing of (un-)certainty cues which incorporate their broader context. Particularly, we propose that facts in the news might be remembered differently once they are presented among speculations.

Keywords: memory biases, uncertainty cues, language processing

“[I]f any opinion is compelled to silence, that opinion may, for aught we can certainly know, be true. To deny this is to assume our own infallibility.” Mill (1859/1975, p. 75)

With this statement from Mills seminal work “On Liberty”, he not only pointed to a cornerstone of freedom of speech but also opposed the widespread view that allowing for the free utterance of potentially ‘false’ ideas would lead to a misdirection of public opinion. Today, this basic demand for a ‘free marketplace’ of ideas might appear in a new light: Modern media enable a fast and almost unstrained dissemination of any type of information—even those pieces that are patently false or purely speculative. In view of the spreading of so called “fake news” or preliminary explanations that later might turn out to be false the question arises how recipients *consider* relevant cues indicating the doubtfulness or uncertainty of a given message. The pressing need to understand this became even more self-evident regarding the recent pandemic spreading of Covid-19 which evoked numerous reports on as-yet unconfirmed content (although this research project started prior to the outbreak). The present work sets its focal point on how recipients respond to one specific kind of uncertainty cue, namely, its indication through framing a content as *speculation* instead of *fact*.

Sometimes, even reputable newspapers differ in the amount of uncertainty they express concerning one-and-the-same event, as can be illustrated by two headlines, both appearing on 25th of July 2019. According to the New York Times, “Russia targeted election systems in all 50 states [...]”, whereas according to the Washington Post, this was only “probably” the case (see Figure 1). However, even if news reports correctly expose insufficiently confirmed information as speculative rather than factual, for instance, by using adverbs such as “probably” (as in headline 2, Figure 1), it remains unclear how recipients mentally represent such subtle but often *crucial* differences in wording. In the current work,

we strive to outline potential theoretical models on the processing and remembering of linguistic uncertainty cues. As, to the best of our knowledge, such theoretical models are still lacking, hypotheses for possible belief and memory distortions can only be derived from neighbouring fields, such as negation research. Strikingly, however, it remains an open question whether such models, rooted in a dichotomized understanding of true and false, could be informative for the processing of uncertainty cues or whether new theoretical approaches are needed. The present work sought to address this by examining the existence and peculiarity of potential biases that emerge in believing and remembering causal explanations on the news that were formulated either as *speculation* or *fact*.

A)

Russia Targeted Election Systems in All 50 States, Report Finds

B)

Russians probably targeted election systems in all 50 states, Senate panel's report says

Figure 1. Screenshot sources: A) Sanger, D. E. and Edmondson, C. (2019, July 25). Russia Targeted Election Systems in All 50 States, Report Finds, *New York Times*, Retrieved from <https://www.nytimes.com/2019/07/25/us/politics/russian-hacking-elections.html>
 B) Demirjian, K. and Itkowitz, C. (2019, July 25). Russians probably targeted election systems in all 50 states, senate panel's report says, *Washington Post*, p. 1. Retrieved from https://www.washingtonpost.com/national-security/senate-intelligence-panel-releases-first-chapter-of-bipartisan-report-into-russian-meddling/2019/07/25/63bce4f4-af0c-11e9-bc5c-e73b603e7f38_story.html.

Speculations Versus Facts: Cues of Uncertainty from a Linguistical Perspective

In order to understand how recipients process and remember speculative (as compared to factual) formulations, it seems important to first look at their linguistical function. A

speculation such as “Russians probably targeted election systems” can be decomposed into two parts: first, its *propositional content* (here “Russians targeted election systems”) and, second, its *modality*, which, in this case, is indicated by the adverb “probably”—but might also be signalized through other linguistic subtleties, such as framing a content as a question (“Did Russians target election systems?”) instead of a fact. The study of modality has a long philosophical tradition, dating back at least to ancient Greek philosophers such as Aristotle (De Haan, 2013). In contrast, its linguistical description is comparatively new. Palmer (1986/2001) distinguished between two basic linguistic categories, deontic and epistemic modality: the former is “containing an element of will” (e.g., “Russians *should* have targeted election systems”), whereas the latter, which is indicated through speculation, does not (Jespersen, 1924/2013, p. 320). This latter category of *epistemic modality* has several defining characteristics which might be instructive for forming hypotheses concerning the way recipients process speculations.

To begin with, according to Chung and Timberlake (1985), epistemic modality describes the “actuality of an event in terms of alternative possible situations, or worlds” (p. 242). This means that information presented as speculative differs from information framed as a fact in such a way that the former does not necessarily refer to conditions of the ‘actual world’, but rather conveys that a state of affairs is merely *one* possibility among others. Dealing with speculations, therefore, always involves dealing with potential *alternatives*.

Further, as language can express varying degrees of uncertainty, some authors have stressed that the epistemic modality of an utterance entails a *probabilistic* meaning (Nuyts, 2001). Yet, empirical findings indicate that speculative formulations including linguistic cues of uncertainty, such as “probably” or “could”, can be identified only with a broad and vague instead of a precise spectrum of numerical probabilities (Brun & Teigen, 1988; Budescu & Wallsten, 1985; Lichtenstein & Newman, 1967). In line with this observation, the epistemic

modality of an utterance is widely considered to carry a *distinct* communicative function, compared to uncertainty that is represented through numbers. Thus, whereas numbers suggest an (often misleading) impression of an exact assessment of chances, *linguistic* uncertainty cues might also expose the absence of any knowledge (Druzdzel, 1989; Teigen, 1988). Accordingly, and in contrast to probabilities, speculative formulations can reveal a *speaker's relationship* towards a proposition—such as in particular his or her *distancing* from a content due to doubts or missing evidence (e.g., Lyons, 1977; Palmer, 1986/2001).

In the following, we outline in what respect these linguistic functions of epistemic modality could be informative for developing theoretical models on how recipients process speculative compared to factual formulations. Notably, the question arises how epistemic information is mirrored in a reader's mental representation. Is the act of understanding the *uncertainty* of a speculation governed by the same mental processes as understanding the *certainty* of the fact? Or do both kinds of processes differ substantially?

Indications for Biases in Believing and Remembering Speculative Formulations:

Linking Uncertainty Cues to Models on Negation

Thus far, psychological research on this question is scarce, with existing work being rather fragmented and diverse in terminology. For instance, expressions of uncertainty are considered as tools of disparate concepts, such as 'innuendo' (Wegner et al., 1981), as part of 'powerless speech' (Hosman, 1989) or 'politeness' (Holtgraves & Perdeu, 2016). Yet, there is one adjoining field of psychological research that might be suitable for generating hypotheses about how humans process speculations—namely, research on negation. Indeed, negations and linguistic uncertainty cues—as present in speculations—share structural and functional commonalities which suggest that existing models on the processing and

remembering of the former could also be of relevance for the latter (Pandelaere & Dewitte, 2006).

To be more precise, some previously described defining features of speculative formulations also apply to negations: Notably, both linguistic cues of uncertainty and negations constitute operators that modify the basic meaning of an otherwise affirmative factual formulation. As such, first, uncertainty cues *as well as* negations indicate that a speaker *distances* him- or herself from uttered ‘facts’ or ‘events’, as in the latter case, by emphasizing their falsehood (e.g., “Russians did not target...”). Second, negations also point toward *alternatives*, particularly, they refer to both the factual *and* the negated state of affairs (see Dudschig & Kaup, 2018; Hasson & Glucksberg, 2006; Wirth et al., 2019 for a similar argumentation). Building on these functional commonalities, we first introduce psychological approaches explaining how humans process and represent negations in contrast to factual affirmations. Then, we derive predictions on how these models may apply to uncertainty expressions.

In a psychological sense, a negation can be understood as the mental operation of unaccepting the truth of an idea or information one is confronted with (Gilbert, 1991). Over the past decades, two major approaches regarding the way unacceptance is mentally represented emerged: Intuitively, it might seem plausible to follow the cartesian approach, which suggests that mental representations are based on two distinct, succeeding processes: First, *comprehension* targets the pure semantic content of an utterance. Only thereafter, *acceptance* or *unacceptance* results from evaluating this content as being true or false (e.g., Zimbardo & Leippe, 1991). However, Gilbert et al. (1990; see also Gilbert, 1991; Gilbert, et al, 1993) opposed this intuitive view. Instead, they suggested acceptance and unacceptance to be asymmetrical processes and postulated that “belief is first, easy, and inexorable [whereas] [. . .] doubt is retroactive, difficult, and only occasionally successful” (p. 231). Critically, this

latter perspective states that comprehending information inherently entails the initial acceptance of its truth.

Indeed, this assumption of “initial acceptance” is mirrored in various cognitive-linguistic models on the processing of *negated* statements (Clark & Chase, 1972; Fiedler, et al., 1996; Hasson & Glucksberg, 2006; Loftus, 1975; Mayo et al., 2004; see also Foerster et al., 2019; Wirth et al., 2016, for a similar assumption concerning the negation of rules). These models agree on the basic premise that understanding a negation usually requires the activation of the to-be-negated and, thus, counterfactual content first, which is subsequently marked with an abstract negation tag (schema-plus-tag model). For instance, to understand the negation “Russians did not target election systems”, the recipient would first process the enclosed proposition (“Russians targeted election systems.”), and then mentally add a negation tag (i.e., “not true”). Importantly, this tag is considered to be a separate cognitive unit—which might be dissociated from the messages’ core concepts over time. In contrast, indicating a factual affirmation through language does not usually require the use of any operators, because such formulations are unmarked for evidentiality in most of the existing languages (for an exception see the language Tuyuca, see Barnes, 1984).

Based on this asymmetry, the schema-plus-tag model and related approaches (e.g. Kaup et al., 2006) propose that processing negations can create *false affirmative* memories of the to-be-negated content. Particularly, people should tend to remember a previously read negation as an affirmation (because the negation tag became “lost” in memory), whereas the opposite mistake of remembering affirmations as negations should be rather unlikely.

Prior work supports this idea: For instance, participants remembered objects whose presence in a house was initially negated more often as being *present* (relative to objects that were not mentioned at all; Fiedler et al., 1996; Maciuszek & Polczyk, 2017). In a similar vein, addressing news headlines, Pennycook et al. (2018) demonstrated that participants perceived

previously read fake news headlines that were explicitly marked as “disputed by fact checkers” as more accurate after a temporal delay (relative to “fake news” headlines that were not presented before: the so-called illusory truth effect; for further evidence see also Schwarz et al., 2007). Furthermore, Mayo et al. (2004) found that while affirmative statements were reproduced correctly in the long-run, negations provoked errors reflecting a loss of falsehood tags, as indicated by memories expressing the opposite of the original meaning (for related work on the reliance on misinformation from fictional stories see also Marsh & Fazio, 2006).

Taken together, these experiments underpin the notion that mental structures representing negated or disputed information differ from those representing affirmations. Thus, whereas negated or false ideas are explicitly tagged in memory as such, affirmations appear not to be. Indeed, some authors have even come to conclude that the resulting tendency to remember a negated idea as affirmative forms “one of the most robust effects in memory” (Mayo, 2015, p. 285).

Yet, despite a prevailing consensus that memory traces of negations tend to decay, some studies also disclosed limitations of the proposed schema-plus-tag conception. These again are relevant when considering whether negation research could inform models on the processing of speculations—as we do in the present work. Indeed, some studies indicate that the prevalence of negation-forgetting seems to decline if a negation does enable an affirmative inference (Hasson et al., 2005) or can be directly translated into a pre-existing schema that captures its meaning (Mayo et al., 2004). For instance, the negation “The man was not guilty” can be represented in terms of its affirmative counterpart “The man is innocent”, as “guilty” refers to a bipolar trait (see also the distinction of gist and verbatim memory, Brainerd & Reyna, 2019). Whenever such an alternative encoding structure is possible, errors of negation-forgetting should be less prevalent. This, in turn, renders the schema-plus-tag model to be particularly applicable to a negation that lacks one clear opposite alternative into which it

could be translated (as in our initial example “Russians did not target election systems”; for further boundary conditions see Wirth et al., 2019; Wirth et al., 2016).

Interestingly, it is precisely this constraint of the model that could support its suitability for speculations such as those being studied in the present work: It is literally impossible to translate a speculation into one clear opposite alternative without losing its actual meaning since, according to definition, a speculation expresses the coexistence of *multiple alternatives*. This theoretical argument provides a first indication that speculations may be mentally represented in a similar way as negations that imply multiple alternatives and, thus, provoke uncertainty themselves.

Still, it is important to consider that linguistic uncertainty cues also *differ* from negations in at least one crucial aspect: In particular, one might argue that uncertainty, including its verbal manifestation, refers to a continuum between two extremes, while negations, just as affirmative facts, refer to *discrete* categories at the respective ends of this continuum (i.e., true or false). Thus, theoretically, in order to cover a *spectrum* of uncertainty, an infinite number of discrete tags would be needed (e.g., ‘a little likely’; ‘likely’; ‘highly likely’, etc.). Yet, an *efficient* storage of uncertainty through its reduction to a discrete memory category does seem plausible in light of prior linguistic work: It aligns with the observation (outlined above) that linguistic uncertainty expressions carry a vagueness regarding their probabilistic meaning and, thus, correspond mostly to a broad instead of a precise range of probabilities in empirical studies (Brun & Teigen, 1988; Budescu & Wallsten, 1985; Lichtenstein & Newman, 1967). From this perspective, representing numerous nuances of uncertainty would be rendered obsolete, as they would lack an informative value.

In sum, it is possible that, but still unclear whether, people forget uncertainty cues in the way the schema-plus-tag model would predict. Rather, as the model was originally

developed for the case of negations, prior work generally examined a *binary* conception of factuality and falsehood—as for example, distinctions such as “accurate” versus “fake news” or “facts” versus “counterfactuals” indicate. Accordingly, ambiguities between both extremes, as expressed by linguistic uncertainty cues about the truth of specific information, were mostly spared (i.e., they were neither present in materials nor were they assessed as part of a memory task). Empirically, it thus remains an open question whether the schema-plus-tag model has an explanatory power beyond this dichotomy (see also Street & Richardson, 2015).

Building upon the proposed theoretical frame, the present work addressed this by investigating whether processing (i.e., the belief in and memory for) speculations could involve similar distortions as those demonstrated for negations that leave open multiple alternatives. For the first time, this allows us to gain an understanding of the mental structures representing uncertainty as compared to factuality—and to clearly move beyond a strict true-versus-false dichotomy by connecting theoretical approaches from different research fields.

Applying the Schema Plus Tag Model to Uncertainty Cues

Importantly, applying the *schema-plus-tag model* to linguistic cues of uncertainty (as present in speculations) requires taking into account that both facts and speculations can be considered to be *affirmative*. For instance, both the information “Russians targeted election systems” and “Russians *probably* targeted election systems” entail an affirmation, albeit to varying degrees of certainty. Therefore, applying the schema-plus-tag model to speculations (in contrast to negations) does result in modified predictions: Concerning the processing of negations, the model predicts a mental shift from the factual (negation) toward the counterfactual state of affairs (affirmation)—producing the tendency to falsely remember negations as affirmations. In contrast, the same model forecasts an *increase in certainty* for speculations, namely, a tendency to falsely remember and treat contents that are reported to be

uncertain as if they were a fact (rather than falling for the reverse mistake of remembering a fact as mere speculation).

This prediction reflects a novel approach, and we are not aware of any prior work studying the proposed effect. Nevertheless, research on the confusability of questions with statements provides initial support for this idea. Pandelaere and Dewitte (2006) conducted a series of experiments in which participants first read a list of different trivia statements (e.g. “Any meromorph function is a homomorph function”) and questions (e.g. “Do fresh water snakes swim upside down for about half of the time?”)—with the latter, we would argue, reflecting an uncertainty expression. Following a distraction stage, the participants reviewed each item as a question and as a statement. Their task was to indicate which of the two formats of each item had been presented initially. Across experiments, the participants tended to falsely remember previously read *questions* as *statements* (rather than vice versa). This provides initial support for the potential tendency to forget uncertainty cues (here in form of a question) that we proposed before. It should be noted, however, that this bias was observed for relatively artificial and uncontextualized sentences. Thus, whether the remembering of isolated questions is representative for the remembering of speculative versus factual information remains unclear. It therefore is still to be tested whether a “bias toward certainty” does also occur in more realistic and meaningful materials, such as speculative or factual explanations on the news. The present work investigated this (and finds the opposite pattern).

The Current Work: Belief in and Memory for Speculations Versus Facts

In six experiments, we examined how recipients process and remember linguistic cues of uncertainty. Due to its high prevalence in and relevance for society, especially in times of modern media, we chose to study this question in the context of news headlines that presented

information either as speculation or fact. More specifically, we sought to uncover a potential bias to falsely remember and treat speculations as if they were factual (rather than vice versa).

To address this hypothesis, all six experiments implemented the same basic paradigm, consisting of (1) a presentation stage, (2) a short distraction, and (3) an assessment stage. In the *presentation stage*, participants consecutively studied experimentally controlled headlines, which appeared in a news-like format with a short teaser below, each presenting a causal explanation for a distinct event (e.g., a crime, a disease, or a natural phenomenon). Depending on the experimental condition (manipulated within-participants), the given explanation for each event was either formulated as speculation or fact. In the case of the presentation as a *fact*, the headline consisted of a factual statement (e.g., “Fire in immigration office was caused by defective cable”), and the teaser indicated that investigations had confirmed the reported explanation (e.g., “Specialists confirm that fire was caused by a burning cable.”). In the case of the presentation as a *speculation*, the headline either represented a question (e.g., “Was fire in immigration office caused by a defective cable?”; Experiment 1A&B, 2A&B and 3) or was qualified by the modal auxiliary verb “might” (e.g., “Fire in immigration office might have been caused by a defective cable”; Experiment 4). The teaser then clarified that the proposed explanation was currently being investigated but not yet confirmed (e.g., “Specialists are now investigating whether the fire may have been caused by a burning cable.”). To include two controls, some further events were either presented not at all in the presentation stage or they were presented but without any explanation.

After the short distraction, the participants entered the *assessment stage*, which assessed different outcome variables across studies. In Experiments 1A and 1B, we assessed participants’ *belief* in a given explanation. To do so, for each event, we asked them to judge how likely they considered the respective explanation for this event to be true. In Experiments 2A and 2B, we assessed *memory accuracy* of the reported (un)certainty of an explanation via

different indicators (i.e., recognition and cued recall¹). Experiment 3 combined both these measures to investigate their interplay. Finally, Experiment 4 sought to replicate our findings, using other uncertainty expressions ('might' instead of questions).

To anticipate our results, we found that participants' belief in the correctness of an explanation was *equally* promoted by both previously read speculative and factual formulations (relative to receiving no explanation at all), pointing to the expected neglect of epistemic modality in news information. Surprisingly, however, this neglect did not seem to be caused by falsely remembering *speculations* as facts. Instead, our findings point toward a novel distortion: A bias to falsely remember and treat the *fact* as if it were merely speculation.

Experiment 1A: Subjective Probability of Speculations Versus Facts

Do recipients of news short news articles distinguish between previously read speculative versus factual formulations with regard to their later beliefs? We addressed this question by asking participants how likely they judged proposed explanations for different events to be true. These explanations were either previously presented in a news headline framed as a speculation, as a fact, or not presented before. Based on the schema-plus-tag model, we predicted a neglect of epistemic modality (uncertainty cues): We hypothesized that subjective probability judgements should mainly reflect the disparity between previously mentioned explanations and those that were not mentioned before. Probability judgements, however, should *not* reflect the disparity between mere speculations and stated facts. This would indicate that participants believe explanations presented as facts and speculations to be

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¹ The hypothesis of a bias to recognize speculations as facts might also be inferred via the assumption of familiarity-based recognition (without retrieval of the epistemic modality of a statement) rather than the decay of memory representations, as suggested by the schema plus-tag-model (for a related distinction, see McElree et al., 1999). Such a (hypothetical) recognition tendency can be distinguished from a memory bias by implementing a cued recall task in which familiarity-based recognition can be ruled out (since alternative response options are not displayed in this approach).

equally likely. Our hypothesis, analyses, exclusion criteria, and sample size were preregistered (<https://aspredicted.org/ng59k.pdf>). Studies were approved by the local ethics board. All data is available online (<https://osf.io/e9dwa/>).

Method

Participants. Our sample size ($N=100$) was determined by the following considerations: First, as this is the first study of its kind, a slightly less than medium effect size of $f = .20$ with correlations among repeated measures of .6 appeared plausible. For such values, an a-priori power analysis ($\alpha = .05$, $(1 - \beta) > .95$) suggested 45 participants for a one factorial within-participants design with four experimental conditions (G*Power; Faul et al., 2007). Second, we rounded this value to 50 in order to compensate for potential data exclusions. Finally, we doubled this sample size to compensate for potential noise in the online data collection as well as the fact that there is no previous research that could serve as a reliable basis for the effect size estimation.

One-hundred participants completed the survey via Prolific Academic. Data collection took place on October 17, 2018. In line with our preregistered exclusion criteria, we removed data from those participants who failed the attention check ($n=12$) or were suspicious of our hypothesis ($n=2$). The final sample consisted of $N = 86$ participants (52 females; $M_{\text{age}} = 37.1$ years; $SD_{\text{age}} = 12.2$ years; range 18 - 72 years).

Materials and Explanation Conditions.

Selection of Events. We selected 24 events from various news domains (such as criminology, ecology, or medicine) which allowed for several possible explanations. All events were related to real incidents (e.g., criminal cases, bark shredding of trees, bees dying, diseases etc.). We slightly adapted twelve of these events in terms of reference to reality to prevent participants from recognizing the material (e.g., by altering such details as the date,

place, or occurring names). Next, we assigned each event to one possible explanation, which either referred to a physical cause (e.g., a burning cable as a potential cause of fire) or the responsibility of a single person or group of persons (e.g., a person involved in a crime). According to current knowledge at the point in time of data collection, all explanations were officially considered to be unconfirmed.

Manipulating Explanation Condition. We created three different text variants for each event in a format similar to short previews of news articles on the Internet (i.e., a headline with a teaser below it). All three text variants included the same event description in the teaser. Only the headline and the last sentence of the teaser varied systematically according to condition (see Figure 2).

In the *speculative explanation condition*, the headline named a (potential) explanation of the respective event via a question (e.g., “Was ... caused by ...?”). The last sentence of the teaser indicated that this explanation was currently being investigated (and therefore not yet confirmed).

In the *confirmed explanation* condition, the headline was identical to the previous version except for two modifications: First, the explanation given in the headline was formulated as a fact (e.g., “... was caused by ...”). Second, the last sentence of the teaser posed the respective explanation as being confirmed through investigations (albeit its propositional content being identical to the speculative explanation condition). As such, the provided information in both conditions differed exclusively with regard to the expressed uncertainty of a given explanation.

Two further conditions served as controls (baseline). In the *no explanation* condition, the headline solely named the event, and the last sentence of the teaser indicated that no potential explanation for this event could yet be identified (e.g., “The cause of ... is still unclear”). In the *new explanation* condition, participants received no information via

headlines concerning a selected event and no potential explanation in the presentation stage. They were only asked later on to indicate the subjective probability of the respective explanation (in the assessment stage). Put differently, these explanations plus events were ‘new’ in the sense that participants read them for the first time during the assessment stage (and received no information whatsoever on them beforehand). This resulted in a total of four different explanation conditions manipulated within participants.

To assign the 24 events to these four conditions, we divided them into four groups, each consisting of six events. The reference to reality of the events (true vs. alienated) was balanced across these groups. In addition, event groups were formed as heterogeneously as possible with regard to the subject areas that they covered and the explanations they involved. The assignment of the four event groups to the experimental conditions was randomized across participants (via randomizer in Qualtrics).

A) **Was fire in immigration office caused by a defective cable?**

Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon. Specialists are now investigating whether the fire may have been caused by a defective cable.

B) **Fire in immigration office was caused by defective cable**

Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon. Specialists confirm that the fire was caused by a defective cable.

C) **Fire at immigration office**

Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon. The cause of the fire is still unclear.

Figure 2. Example for the different headline types presented in the presentation stage with (A) "Speculative explanation", (B) "Confirmed explanation" and (C) "No explanation". Events which were assigned to (D) the “New explanation” condition were not presented at all in this stage (but only in the later assessment stage).

Procedure. In the *presentation stage*, the participants were informed that this experiment concerned their perception of “different topics and newspaper articles” and that they would read “headlines of articles each with a short teaser” in the following. We asked the participants to engage with the short articles in a similar way as they would when reading the news: They indicated whether they would consider reading the corresponding article in full length by choosing between three response options (“no”, “maybe” and “yes”). The participants saw a total of 18 headlines from the three experimental conditions (no, speculative, and confirmed explanation, i.e., six headlines from each condition). The headlines were presented consecutively in random order, with one per page. To conceal the purpose of our experiment, we included six additional filler headlines. These fillers were randomly collected from or inspired by news sites on the Internet (such as the German SPIEGEL online) and did not follow the structure of our experimental conditions. Most importantly, these fillers did not refer to unexplained events or potential explanations (e.g., “The world's first floating farm making waves in Rotterdam” or “Europe to ban halogen light bulbs”).

Next, in the *distraction stage*, we assessed demographic information and a trait measure on personal need for structure (Neuberg & Newsom, 1993). This stage lasted approximately one minute².

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² In some other studies, participants were distracted *during* the encoding of new information rather than *between* encoding and retrieval. This was justified by the assumption that negation-forgetting only occurs if the processing resources are insufficient (these in turn are supposed to lead to information not being stored correctly). Yet, in the view of later studies, this assumption seems unsupported, as they show that negations become lost in memory even in the absence of any distraction (Fiedler et al., 1996; Maciuszek & Polczyk, 2017; Mayo et al. 2004; Pantazi et al., 2018). From this perspective, negation-forgetting is evoked by the *structure* of their mental representation (proposition and negation form two cognitive units whose association can decay over time as the schema-plus-tag model suggests) and not necessarily by the way in which negations are encoded (i.e., due to not storing a negation properly). Based on this research, we aimed to investigate our hypothesis under conditions in which sufficient mental resources were available. The distraction phase between presentation and retrieval (assessment stage) served to establish a mental distance to the read material (similar procedure as in Mayo et al., 2004; Pennycook et al., 2018).

Finally, in the *assessment stage*, participants read descriptions of all 24 events in random order (the same 18 events from the presentation stage and the remaining six events that were not presented before). For each event, they spontaneously indicated their belief in the correctness of a presented explanation (dependent variable) by rating its subjective probability. In detail, each question began with “How likely do you think that...was caused by...” and ended with the assigned explanation in the same wording as was used in the respective teaser of the constructed short news articles (1–*not likely at all* to 6–*very likely*).

Afterwards, we assessed control variables (attitudes towards the news media for exploratory analyses; four items, adapted from Tsfaty & Cappella, 2003) and an attention check (full list is available under <https://osf.io/e9dwa/>) asking participants not to answer a subsequent question. If any participants failed to follow this instruction, as was preregistered, they were excluded from analysis.

Design and Analyses. The study comprised a one factorial within-participants design with four conditions: Speculative versus confirmed versus no versus new explanation. Following our preregistration, differences between these conditions regarding the participants’ beliefs in an explanation were tested using repeated measures ANOVA. The key contrasts were between the conditions “speculative explanation” and “no explanation”, as well as between “speculative explanation” and “confirmed explanation”. We used *t*-tests for those specific comparisons. All reported *p*-values are corrected for multiple comparisons following the Bonferroni method (Bonferroni, 1936).

Results

As Figure 3 indicates, participants rated those explanations they had read before (during the presentation stage) to be more probable than explanations which they had not seen before. Confirming this visual impression, formal analyses yielded a main effect of the factor

explanation on subjective probability, $F(3, 85) = 16.37, p < .001, \eta^2 = .08$. Simple comparisons resulted in no significant difference between the two baseline conditions “no” and “new explanation”, $t(85) < 1, p_{corrected} = .362$. This indicates that both these conditions serve as commensurable controls. As expected, we found that subjective probability ratings were higher for explanations that were previously presented as confirmed than for those that were not presented before, as in the baseline conditions “no”, $t(85) = 4.60, p_{corrected} < .001$, and “new explanation”, $t(85) = 6.68, p_{corrected} < .001$. More importantly and as predicted, also explanations that were previously presented as merely being “speculative” (i.e. as being currently investigated) were later rated as subjectively more probable than those that were not presented before (no explanation, $t(85) = 2.95, p_{corrected} = .020$, new explanation, $t(85) = 4.61, p_{corrected} < .001$). The difference between “speculative” and “confirmed” explanations did not reach significance, $t(85) = 2.23, p_{corrected} = .171$. Descriptively, however, explanations that were first presented as being “confirmed” were later rated as slightly more probable than those which were first presented as “speculation” (see Figure 3).

Figure 3. Results of Experiment 1A. Mean probability ratings of explanations for the conditions “new”, “no”, “speculative”, and “confirmed explanation” with 95%-confidence intervals for within-participants comparisons (method: Cousineau-Morey intervals with

adaption by Baguley, 2012). Note: spec. = speculative explanation; conf. = confirmed explanation.

Discussion

The results of Experiment 1A suggest that previously read headlines framed as mere speculations (i.e., on explanations reported to be still “under investigation”) indeed influenced the subjective probability of the posed explanation (compared to the controls). Statistically, this influence did not differ from that of confirmed explanations (presented as ‘facts’), suggesting a neglect of epistemic modality. However, at least numerically, the results indicated a small difference between the two conditions that did explicitly name an explanation (speculative vs. confirmed explanations). We, therefore, repeated the experiment with a slightly longer distraction interval and an additional distraction task to check for the consistency of this pattern.

Experiment 1B: Subjective Probability of Speculations Versus Facts After Longer Distraction

This experiment was identical to Experiment 1A, with the exception that we used a slightly longer time interval (approximately five minutes) and included an additional distraction task in the distraction stage. As in Experiment 1A, we preregistered our hypothesis, analyses, exclusion criteria, and sample size (<https://aspredicted.org/i7xm4.pdf>).

Method

Participants. As in Experiment 1A, we recruited $N=100$ participants online from Prolific Academic. Data collection took place on November 7, 2018. Participants from Experiment 1A were not permitted to participate in Experiment 1B. One person decided to withdraw his or her data after debriefing (in line with ethical guidelines, this person’s data

was deleted prior to any analysis). Furthermore, following our preregistered criteria, we excluded data from participants who failed the attention check ($n=7$) or reported searching for the headlines on the Internet during the experiment ($n=2$). Accordingly, the final sample consisted of $N = 90$ participants (67 females; $M_{age}=35.9$ years, $SD_{age}=12.3$ years; range 19-70 years).

Materials and Procedure. The materials and procedure were identical to those of Experiment 1A, except for the prolonged distraction stage including an additional distraction task. Participants here engaged in the “lost at sea” task, for which they had to imagine themselves being lost at sea after a shipwreck and were asked to rank-order 15 items regarding their usefulness for survival. They, again, also completed further filler questionnaires at this stage.

Results

We were able to replicate the results of Experiment 1A. As Figure 4 indicates, the participants rated those explanations that they received during the presentation stage to be more probable than the (new) explanations that they had not seen before. Further, the subjective probability of explanations that were previously presented as confirmed did not differ from those that were framed to be speculative.

Confirming this visual pattern, we observed a significant main effect of the factor explanation condition on subjective probability, $F(3, 89) = 11.87, p < .001, \eta^2 = .06$. In line with Experiment 1A, simple comparisons yielded no significant differences between the two baseline conditions “no” and “new explanation”, $t(89) = 0.12, p_{corrected} > .99$. Again, the subjective probability was higher for explanations that were previously presented as confirmed than for those that were not presented at all (as in the baseline conditions “no”, $t(89) = 4.19, p_{corrected} < .001$, and “new explanation”, $t(89) = 3.96, p_{corrected} < .001$). Further,

explanations that were previously presented as speculative were later rated as more probable compared to the two baseline conditions (“no explanation”, $t(89) = 4.23$, $p_{corrected} < .001$, confirmed explanation, $t(89) = 3.87$, $p_{corrected} < .001$). Importantly, we did not find any difference between the “speculative” and “confirmed explanation” conditions, $t(89) = 0.27$, $p_{corrected} > .999$. Instead, speculative and confirmed explanations had almost identical effects on subjective probability ratings as depicted in Figure 4.

Figure 4. Results of Experiment 1B. Mean probability ratings of explanations for the conditions “new”, “no”, “speculative” and “confirmed explanation” with 95%-confidence intervals for within-participants comparisons. Note: spec. = speculative explanation; conf. = confirmed explanation.

Discussion

The results of Experiment 1B replicated those of Experiment 1A and revealed an even clearer pattern of effects. Whereas providing an explanation for an event (in the presentation stage) did influence its subjective probability later on (in the assessment stage), the epistemic modality of this explanation (i.e., the presence or absence of uncertainty cues) did not. This implies that the participants’ belief in the correctness of an explanation was equally increased by both previously read speculative and factual formulations. But how could this neglect of

epistemic modality be explained? Experiment 2A, 2B, 3 and 4 investigated this in terms of potential memory biases.

Experiment 2A: Recognition of Previously Read Explanations

Experiment 2A tested whether missing or false memories might explain the neglect of epistemic modality that we found in Experiments 1A and 1B. On closer inspection, similar effects of previously read speculative and factual formulations carry an ambiguity that, at this point, had not been resolved in our studies yet: As suggested by the schema-plus-tag model, recipients might tend to forget the uncertainty of a previously read speculation and, therefore, overrate its certainty. In principle, however, it is also possible to explain the very same neglect by a reverse distortion: Instead of forgetting the uncertainty of a speculation, people might also disregard the *certainty* of a fact. This would imply a bias towards the level of speculative rather than factual explanations—a tendency which the schema-plus-tag model would not be able to account for.

Experiment 2A addressed both possibilities by assessing participants' *recognition* of previously read headlines (instead of their belief in the proposed explanation). Following the considerations above, we aimed to decide between two opposing hypotheses: Recipients may either tend to remember speculations as facts more often than falling for the reverse mistake, as the schema-plus-tag model suggests. Alternatively, they may tend to remember facts as speculations. To examine both possibilities, we assessed *confusion mistakes* for speculative versus factual formulations.

Method

Participants. Again, 100 people from Prolific Academic completed this online study (December 19, 2018). Participants who took part in Experiments 1A or 1B were not permitted

to participate. Following the procedure from the previous studies, we excluded data from people who failed the attention check ($n=8$), reported searching for the headlines on the Internet ($n=1$), or indicated responding dishonestly ($n=1$). The final sample consisted of $N = 90$ participants (52 females, 1 other; $M_{\text{age}}=36.4$ years; $SD_{\text{age}}=12.0$ years; range 10 - 64 years).

Materials and Procedure. The materials and procedure of Experiment 2A were identical to those of Experiment 1B, except for the assessment stage. Here, participants completed a recognition task in which they indicated which of a list of different headlines they had read before in the presentation stage. More precisely, for each event, participants were asked to choose between four distinct response options. The first three options comprised the three different headline types (from the “speculative”, “confirmed” and “no explanation” conditions). They were depicted in a graphical design identical to that used before in the presentation stage (see Figure 2). With the fourth response option “none of these”, participants could indicate that they neither remembered a headline concerning the respective explanation nor the event to be explained.

Design and Analysis. To test for our opposing predictions, the analysis of this experiment focused on the number of confusion mistakes for speculative versus confirmed explanations as dependent variable (defined as speculations that were remembered to be facts *or* facts that were remembered to be speculations). For this reason, we reduced our main data set to only those two conditions of interest (accuracy values for all conditions are summarized in Table 1; see supplementary information for additional statistical analyses including all conditions). Furthermore, we excluded trials in which previously read explanations were considered unknown (16 %).

We specified generalized linear mixed effects models (GLME) with a logit link function to test whether the amount of confusion mistakes differed across these conditions, using the lme4 package in R (Bates et al., 2015). Accordingly, “epistemic modality” was

represented as the fixed effect in the model with the two levels, confirmed versus speculative explanation. Further, the models included a random intercept and random slope for participant (both random slope and random intercept were assumed to be uncorrelated).

Results

As Figure 5 indicates, participants were more likely to confuse confirmed explanations with speculative ones than falling for the reverse mistake. In line with this impression, the GLME analysis yielded a main effect of epistemic modality on confusion mistakes, $X^2(1) = 43.07, p < .001, R_m^2 = .10, R_c^2 = .23$. As depicted in Figure 5, the relative frequency of falsely remembering speculative explanations as being confirmed was *less than half as high* as the relative frequency of the reverse mistake of remembering confirmed explanations as being mere speculation. This indicates that the participants were biased toward the uncertain option rather than vice versa.

Table 1

Results of Experiment 2B. Accuracy rates across the four explanation conditions.

Explanation condition			
New	No	Speculative	Confirmed
.92	.83	.65	.47

Note. The table contains the *accuracy rates* for identifying a presented explanation in the recognition task as *not* having been read before (“New” and “No” explanation condition) or as having been presented before as *either* “speculative” or “confirmed”.

Figure 5. Results of Experiment 2A: Memory for headlines depending on whether they were previously presented as ‘confirmed’ (left graph) and ‘speculative’ (right graph); bars indicate the relative frequency with which the respective event and explanation were remembered as being new vs. not explained before (no) vs. speculative (spec.) vs. confirmed (conf). 95%-confidence intervals are depicted for within-participants comparisons. Note that the GLME exclusively referred to the two conditions of interest: speculative and confirmed explanations. Confusion mistakes refer to explanations that were initially presented as confirmed but remembered as speculative and to explanations that were initially presented as speculative but remembered as confirmed.

Discussion

As expected, most mistakes occurred in remembering whether a previously read explanation was reported as merely *speculative* versus *confirmed*. In contrast to the predictions from linguistic theories and models of negation research, however, the participants tended to recognize previously read “facts” as being “speculations” much more often than vice versa. This indicates that when trying to recognize the information given before, people seemed to neglect the certainty of reported *facts* more so than the uncertainty of speculations.

However, it is possible that the tendency to erroneously remember facts as having been presented as speculative might have (partly) resulted from confronting participants with

predefined response options in the recognition paradigm. As one of these options explicitly reported the event's explanation as being uncertain, this could have led participants to use more cautious strategies overall in evaluating incomplete memories. In other words, participants might not have tended to falsely remember facts as uncertain if they had not been directly confronted with an uncertain response option as part of the recognition measure. In this case, our results would have been triggered by methodological affordances and subsequent response biases, rather than memory distortions. With Experiment 2B, we rule out this methodological explanation by changing the recognition to a cued recall task.

Experiment 2B: Cued Recall of (Speculative Versus Confirmed) Explanations

We conducted Experiment 2B to assess the robustness of our finding that people tend to remember “facts” as speculations by one important change to the design of Experiment 2A. Instead of assessing memories via a recognition task, the participants were asked to *reproduce* the information from previously read explanations (cued recall). Doing so enables us to rule-out that the tendency to remember explanations in headlines as speculative in Experiment 2A arose due to the implemented response format highlighting the existence of uncertainty. If this bias stems from memory distortions, rather than methodological artefacts and resulting response biases, we should observe the same pattern of confusions on a cued recall task which does not suggest the presence of uncertainty by predefined response options. We preregistered our hypothesis, the applied general linear mixed effects model, coding scheme, exclusion criteria, and sample size (<https://aspredicted.org/ei5id.pdf>).³

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³ As a secondary analysis, we also preregistered to compare the relative confusion rate in both conditions (“speculative” vs. “confirmed explanation”) using a repeated measures *t*-test. However, due to too many missing values this analysis turned out to be rather inappropriate. Consequently, it will not be reported in the results section.

Method

Participants. Following the previous studies, participants were recruited online from Prolific Academic. The participants who took part in our prior studies⁴ were not permitted to participate. One-hundred and one participants completed the survey on August 12, 2019. In accordance with our preregistration, we excluded data from people who failed the attention check ($n=6$) or indicated responding dishonestly ($n=1$). Further, seven participants were not included in the final sample due to missing data (either because they did not correctly remember any of the explanations or because all their reproduced memories were ambiguous regarding the degree of certainty they expressed, e.g., because they were not formulated in full sentences). The final sample consisted of $N = 87$ participants (52 females, 1 other; $M_{\text{age}}=35.2$ years; $SD_{\text{age}}=11.7$ years; range 19-75 years).

Materials and Procedure. The experimental design was identical to that of Experiment 2A, with the following exceptions: First and most importantly, we changed the assessment of the dependent variable to a cued recall paradigm. In detail, we asked the participants to *freely reproduce* the main message of each headline as completely and as accurately as they could remember it. As a brief cue, they saw a short prompt of each headline's topic which was identical to the event description (first sentence) in the respective teaser presented in the previous presentation stage (e.g., "Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon", see Figure 2 for the corresponding headlines). Importantly, this prompt was unspecific regarding the experimental conditions, as it did not contain any information on the potential explanations for the described event and particularly no reference to their epistemic modality. To reduce potential ambiguities concerning the epistemic information that

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⁴ Chronologically, we conducted Experiment 3 before we conducted Experiment 2B. For the sake of comprehensibility, we changed the order of reporting both experiments in this manuscript.

participants' answers expressed, we asked them to imagine that they were talking to a friend about the content of the headlines they had read before and to write down their memories in full sentences.

Second, the number of items was reduced by only including the confirmed and speculative explanation condition and six additional filler headlines. Each participant was thus presented with 18 items. This served to reduce task difficulty and to ensure that the participants were able to meaningfully respond to all items in the cued recall task. To disguise the structure of the experimental design, the filler headlines were prompted in the assessment stage as well.

Coding. In a first step, answers were coded with regard to the correctness of the reproduced explanations. False answers were excluded from further analysis. In a second step, *correctly remembered* explanations were classified in terms of the certainty or uncertainty they expressed. Following our preregistration, reproduced explanations that were qualified by words like “presumably”, “probably”, “potentially”, “could”, “may” or “might” or formulations such as “researchers investigate / presume / suspect / believe”, “there is a theory that” or “the article discussed whether” were classified as “*remembered speculative explanation*”. In contrast, answers that (a) expressed a definite causal relationship and (b) did not contain qualifiers (e.g. factual formulations like “the cause was” or “investigations confirmed that”) were classified as “*remembered factual explanation*”. Formulations such as “apparently, this was caused by” were also considered to belong to this category. The reasoning behind this decision was that expressions such as “apparently” express doubts of the participant, but not remembered uncertainty in the news coverage.⁵

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⁵ This categorisation system reflects a conservative approach with regard to our hypothesis. Results do not change if memories including the word “apparently” are assigned to the category “remembered speculation”.

Some cases were ambiguous in terms of the certainty they conveyed. These cases were neither classified as remembered fact nor as speculation and therefore were excluded from our main analysis (6 %). They included factually formulated answers that expressed a correlation instead of causation (e.g. “was related to”) or factually formulated answers that correctly reproduced the content of an explanation (e.g. “They found aluminium particles in the bee keepers’ dwellings”), however, without explicitly naming its causal relation to the respective event (e.g. the dying of bees).

We had two independent raters (blind to experimental condition) who assessed the participants’ answers based on this coding scheme. The estimated interrater reliability (Krippendorff’s alpha) concerning the correctness of a reproduced explanation was .93, CI = [.91, .95]. The interrater reliability concerning the certainty or uncertainty that an answer expressed was Kappa = .96, CI = [.93, .98]. Both encodings yielded the same results regarding the statistical tests. For the sake of brevity and simplicity, only the results based on the codings of Rater 1 are reported.

Design and Analysis. The experiment comprised a within-participants design with the factor “epistemic modality” (confirmed vs. speculative explanation). Confusion mistakes regarding the reproduced certainty or uncertainty of an explanation served as our key dependent variable. In order to test whether the number of confusion mistakes differed for previously read confirmed versus speculative explanations, we repeated the GLME analysis of Experiment 2A: “Epistemic modality” was represented as the fixed effect with the two levels, confirmed versus speculative explanation. Furthermore, the model included a random intercept and random slope for participant (both assumed to be uncorrelated).

Results

Figure 6 indicates that the participants were more likely to reproduce factual explanations as being merely speculative ones rather than vice versa. Confirming this visual impression, the GLME analysis indicated that the overall probability of confusion mistakes differed across the two experimental conditions “speculative” and “confirmed explanation”, $\chi^2(1) = 11.54, p < .001, R_m^2 = .04, R_c^2 = .23$. Although, on average, 13 % of the speculative explanations presented first were falsely reproduced as being certain (Figure 6), we again found a higher frequency of falling for the reverse mistake of reproducing confirmed explanations as speculative. This pattern replicates the results found in Experiment 2A. Specifically, it points towards a distortion that is a reverse of the statement bias: A tendency to falsely remember and treat a previously presented fact *as if* it were merely a speculation and therefore not yet confirmed.

Figure 6. Results of Experiment 2B. Relative frequency of remembering explanations either as certain or uncertain depending on whether they were initially presented as confirmed (left pair of bars) vs. speculative (right pair of bars) with 95%-confidence intervals for within-participants comparisons. Confusion mistakes represent explanations that were presented as confirmed, but remembered as uncertain, as well as explanations presented as speculative, but remembered as certain.

Discussion

Replicating Experiment 2A, the participants tended to remember previously read factual explanations as more uncertain (e.g., as being merely a theory or speculation) than originally communicated (i.e. as being proven through scientific or official investigations)—and more often so than falling for the reverse mistake of remembering speculations as facts. The consistent result patterns across both Experiments 2A and 2B using distinct paradigms to assess memory strongly suggest that the bias to remember facts as being merely speculative expresses a memory distortion rather than an artefact of the experimental procedure or a bias that concerns response behaviour alone. Specifically, as the participants were *not* confronted with a *choice* between distinct response options (question vs. statement) in Experiment 2B but were supposed to freely reproduce what they had read before, a response bias in the sense that participants simply "chose" questions more often than statements seems to be an unlikely explanation of our results.

Viewed from a broader perspective, these findings indicate that the neglect of epistemic modality concerning people's *belief* in explanations (found in Experiment 1A and 1B) could be at least partly explained by a bias that contradicts predominant theorizing: Our participants did not seem to forget the uncertainty of a speculation. Rather, they seemed to neglect the certainty of a presented fact, leading them to treat ideas that were reported to be confirmed as if they were merely speculation.

It is possible, however, that the act of explicit recollection (be it via recognition or cued recall) bears the potential to provoke more elaborate strategies in evaluating incomplete memories, which could in turn lead to more cautious judgements (see Roediger & Butler, 2011 for related effects of memory retrieval). This would imply that the results from Experiments 1A and 1B versus the results from Experiments 2A and 2B stem from different modes of memory retrieval. To counter this objection, we conducted Experiment 3.

Experiment 3: Inducing Explicit Recollection

In Experiment 3, we examined whether explicit recollection of epistemic information could influence how people's beliefs are affected by previously read headlines. Particularly, we tested whether the attempt to recollect the specific content of a headline has the potential to lower its impact on the participants' belief (e.g., by increasing the salience of one's own memory gaps). This is relevant in order to understand the relation between *explicit memories* of a headlines' content, such as the reported certainty of an explanation (as assessed in Experiment 2A and 2B), and the participants' *belief* in this explanation (as assessed in Experiment 1A and 1B).

On the one hand, if explicit recollection itself does reduce the participants' belief in an explanation's correctness, it would remain possible that the equal amount of belief in speculative and confirmed explanations that we found in Experiments 1A and 1B still resulted from a neglect of uncertainty cues. On the other hand, if explicit recollection itself does *not* lower participants' belief in the correctness of an explanation, this would support the conclusion that the beliefs we recorded in Experiment 1A and 1B mainly arose from the level of speculations rather than the level of facts. To investigate the impact of recollection on beliefs, we manipulated *whether or not* participants had to indicate their memories concerning an explanations' certainty *before* assessing their belief in its correctness. We preregistered our hypothesis, analysis, exclusion criteria, and sample size (<https://aspredicted.org/f4tp2.pdf>).

Method

Participants. As in our previous experiments, we recruited participants online from Prolific Academic (April 16, 2018). Participants who completed Experiments 1A, 1B, or 2A were not allowed to participate. In this experiment, we doubled our initial sample size to 200, as it included one additional between-participant condition (explicit recollection: Yes vs. No).

One person retracted her or his data after debriefing; accordingly, this data was deleted. In accordance with our preregistration, data from those people who failed the attention check (11) or indicated searching for the headlines on the Internet (1) were excluded from the analyses. The final sample consisted of $N = 187$ participants (120 females, $M_{\text{age}}=37.24$ years; $SD_{\text{age}}=13.15$ years; range 18 - 70 years).

Procedure. The procedure of Experiment 3 was identical to that of Experiment 1B, except that one half of the participants were asked to indicate whether an explanation had been previously presented as speculation or fact or was new (in an identical task to that in Experiment 2A) before they rated this explanations' subjective probability. The other half of the participants did not perform this recollection task and only indicated the subjective probability of each explanation.

Design and Analyses. In our preregistration, we specified the comparison between confirmed and speculative explanations in both the recollection and no recollection conditions as the key analysis. Accordingly, we preregistered a 4 (explanation: new vs. no vs. speculative vs. confirmed; within) x 2 (recollection: yes vs. no; between) mixed-design ANOVA. Furthermore, we sought to replicate the finding of Experiment 2A and 2B by comparing the amount of confusion mistakes for speculative and confirmed explanations *within the condition with recollection*. For consistency with Experiments 2A and 2B, we decided to apply the same GLME with binomial distribution to this data set.⁶ Again, we only entered the conditions of interest (epistemic modality: speculative vs. confirmed explanation) into this model. Accordingly, “epistemic modality” was specified as the fixed effect with the two levels, confirmed versus speculative explanation. Furthermore, we excluded all trials in which

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⁶ This model slightly differs from the model we preregistered (binomial instead of Poisson distribution + modified random effects). Results concerning our hypotheses, however, were not influenced by these modifications.

previously read explanations were considered unknown (17 %). The model comprised a random intercept and random slope for participant (which were both modeled to be uncorrelated).

Results

The Effect of Recollection on Beliefs. As depicted in Figure 7, the participants rated both speculative and confirmed explanations as *more probable* after explicit recollection (compared with no recollection). With regard to inferential statistics, the 4 (new vs. no vs. speculative vs. confirmed explanation) x 2 (recollection: yes vs. no) mixed-design ANOVA revealed a significant interaction effect of explanation condition and recollection on subjective probability ratings, $F(3, 185) = 3.40, p = 0.018, \eta^2 = .007$. Confirming the visual impression, a follow-up ANOVA including only the two conditions of interest (confirmed versus speculative explanation) revealed a main effect of recollection (yes vs. no) on subjective probability, $F(1, 185) = 4.69, p = .032, \eta^2 = .03$, but no interaction effect between explanation and recollection, $F(1, 185) = 0.46, p = .500, \eta^2 = .0005$. Consequently, the attempt to recollect the certainty or uncertainty of an explanation did not lower but rather strengthened the participants' belief in the correctness of both previously read facts as well as speculations.

Figure 7. Results of Experiment 3: Subjective probability of an explanation depending on the type of previously presented headline (new / no / spec. = speculative; conf. = confirmed) as well as on explicit recollection of the headline's content (yes / no) with SEM.

Confusion Mistakes in Remembering the (Un-)Certainty a Headline Expressed.

Replicating the results of Experiments 2A and 2B, we again observed that participants in the recollection condition were more likely to confuse factual explanations with speculative ones than vice versa (Figure 8). The GLME analyses confirmed a main effect of epistemic modality, indicating that the overall probability of confusion mistakes differed for previously presented speculative versus confirmed explanations, with $X^2(1) = 31.09, p < .001, R_m^2 = .07, R_c^2 = .19$. As depicted in Figure 8, the relative frequency of falsely remembering speculative explanations as factual was less than half as high than the relative frequency of making the opposite mistake.

Figure 8. Results of the *Recollection* Condition of Experiment 3: Relative frequency of remembering a headline as new vs. including no vs. a spec.=speculative vs. a conf.=confirmed explanation, depending on whether the headline was previously presented as confirmed (left graph) or as speculative (right graph); with 95%-confidence intervals for within-participants comparisons. Note that the GLME exclusively referred to the two conditions of interest: speculative and confirmed explanations.

Discussion

The results of Experiment 3 show that the act of explicit recollection (yes vs. no) did not lead to *decreased* beliefs in the accuracy of a previously read explanation. This contradicts the idea that the attempt to remember what one had read before provokes more cautious judgements by, for example, increasing the salience of missing memories. On the contrary, retrieving an explanation from memory did rather heightened its believability, *although* most of the explanations were remembered as being merely speculative. This (together with the findings of the recognition task) suggests that not the “fact” but rather the speculation formed a baseline for the memories and judgements that we recorded in our studies.

Experiment 4: Generalizing Findings to other Expressions of Uncertainty

In all the experiments reported above, a speculation was introduced to the recipient by formulating a question instead of a fact. In order to ensure that the tendency to remember factual news as being merely speculative is not just a peculiarity of this specific kind of uncertainty cue, we extended our findings to other ways of expressing a speculation within this experiment. In particular, one might object that Betteridge's law ("*any* headline that ends in a question mark can be answered by the word 'No'")⁷ advises against the usage of questions in headlines, as it is considered to be sensationalist. Yet, despite this "principle", questions are a rather common means of communicating uncertainty in news practice (e.g., "Should you get a Corona virus test if you think you have a cold? There might be no right answer." or "Can an air purifier help protect you against the coronavirus?", both published on Oct. 16, 2020 by the Washington Post). Beyond potential issues of using questions in headlines, we seek to draw conclusions on the way people represent reported uncertainty in general rather than for one specific form of its expression. With this in mind, Experiment 4 set out to examine whether our effects from Experiments 2A, 2B, and 3 replicate for headlines which include the modal auxiliary verb "might" instead of being formulated as questions.

Method

Participants. For this final experiment, we again collected data from 100 participants online via Prolific Academic (November 13, 2020). People who had already taken part in one of our previous studies were not eligible. As preregistered, data from those people who did not pass the attention check (4) or claimed to have searched for the headlines online during the experiment (2) were removed from the analyses. The final dataset included $N = 94$

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⁷ We would like to thank an anonymous reviewer for bringing up this principle and argument.

participants (65 females, 27 males, and 2 indicated “other”; $M_{\text{age}}=37.76$ years; $SD_{\text{age}}=14.62$ years; range 18 - 71 years).

Procedure. The methods were identical to that of Experiment 2A with the exception that we did not use questions as headlines here but instead statements—which were qualified as speculation by the modal auxiliary verb "might" (e.g., “Fire in immigration office might have been caused by a defective cable”). We chose this type of formulation, as modal auxiliary verbs were identified to belong to the most commonly used uncertainty markers in news articles, according to previous studies (Rubin, 2007, 2010). In addition, our material was inspired by a selection of recent headlines of the Washington Post which also used the word “might” to indicate a lack of evidence concerning a particular content (e.g., “Scientists find a mass grave in Tulsa that might be from 1921 race massacre”, published in Oct 22, 2020, or “Laker fans’ parties, celebrations might have fueled L.A. coronavirus spike, officials say”, published in Oct 27, 2020). Importantly, in the short articles that we used, each teaser remained unchanged from the previous studies and only the headlines were adapted (a former question was now framed as a statement qualified by the word ‘might’). In this way, the wording of each headline was altered but not its meaning.

Design and Analyses. In accordance with our previous memory experiments and our preregistration, we used GLME models to compare the amount of confusion mistakes for explanations that were initially presented as speculative or confirmed. Again, “epistemic modality” was defined as a fixed effect in this analysis with the two levels, confirmed versus speculative explanation. Furthermore, the models included a random intercept and random slope for participant (which were both assumed to be uncorrelated). In line with our standard protocol, trials in which a previously read explanation was not recognized as having been read before were excluded from this analysis (15 %).

Results

Replicating Experiments 2A, 2B and 3, we observed the same tendency to remember factual explanations as being merely speculative (more so than vice versa). With regard to formal analysis, the model comparisons revealed a main effect of epistemic modality, showing that the overall probability of confusion mistakes differed depending on whether an explanation was initially presented as speculative or confirmed, with $X^2(1) = 97.39, p < .001$, $R_m^2 = .22$, $R_c^2 = .32$. As Figure 9 shows, the relative frequency of falsely remembering previously read factual explanations as being merely speculative was approximately three times as high as the relative frequency of remembering speculations as facts.

Figure 9. Results of Experiment 4: Relative frequency of remembered headline types (new vs. no vs. spec.=speculative vs. conf.=confirmed explanation) depending on whether a headline was previously presented as confirmed (left graph) or speculative (right graph) with 95%-confidence intervals for within-participants comparisons. The GLME again exclusively referred to the two conditions of interest: speculative and confirmed explanations.

Discussion

Experiment 4 demonstrates that the bias to remember reported facts as speculative generalizes to *other* uncertainty expressions and was therefore not driven by any specific characteristics of questions in the news headlines in our previous studies. This finding, in turn, suggests that even statements which are qualified by a modal auxiliary verb, and therefore arguably resemble the structure of negated statements to a greater extent, are processed differently than related models on negation research would predict. This finding further underscores the robustness of the bias that we found (mistaking facts as speculations) not only with respect to different memory measures but also across different materials.

General Discussion

Modern media allow for a dissemination of news in a remarkably fast manner—be it in case of pressing natural phenomena or the spreading of diseases, to give just a few examples. Accordingly, the information given is not at all times sufficiently confirmed but might also include mere possibilities. The present work examined the existence and peculiarity of potential biases in believing and remembering explanations from news that were either framed to be a *speculation* (yet to be investigated) or a *fact*. More specifically, we studied how recipients consider and reproduce subtle but often crucial differences in wording indicating (un-) certainty concerning the truth of a reported content (which we refer to as a content's epistemic modality).

As there was no existing model addressing the mental representation of linguistic uncertainty expressions, we borrowed our initial hypothesis from the field of negation research. Based on the schema-plus-tag model (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975) and related approaches (e.g. Kaup et al., 2006), as well as former results on the confusability of questions with statements (Pandelaere & Dewitte, 2006), we investigated the possibility of a specific distortion: Participants may more likely forget the *uncertainty* of a

speculation than the certainty of a fact. This reasoning stems from the basic assumption of “initial acceptance” that several cognitive-linguistic theories on language processing agree upon: Understanding a negation, a question, and potentially also a speculation should premise its reconstruction as factual assertion first—which can later be erroneously remembered.

Experiments 1A and 1B consistently indicated that reading short news articles on a speculative but not yet confirmed explanation systematically *increased* the belief in the correctness of this explanation (compared to two baseline conditions in which no such explanation was provided). More strikingly, however, the influence of speculative formulations did not substantially differ from that of factual ones, suggesting a *neglect* of epistemic modality. This finding is in line with results from innuendo literature showing, for example, that assessments of a person’s character were equally affected by both previously read leading questions (which arguably represent a specific kind of uncertainty cue) and by factual formulations in the news (Wegner et al., 1981). Classically, such findings were interpreted in terms of a loss of uncertainty cues. At closer inspection, however, similar effects of previously read speculative and factual formulations in former research do entail an ambiguity that was not yet resolved. The critical point is that these effects could either express that participants *overrated* the certainty of a speculation—as predicted by the schema-plus-tag model—or that they *underrated* the certainty of a fact. Unexpectedly, and in accordance with the latter option, four additional memory experiments in the present work indicated that a neglect of epistemic modality was not primarily driven by the tendency to forget uncertainty cues. Although a previously read speculation doubled the frequency of falsely recognizing the respective explanation as being a fact (relative to receiving no explanation)—on average, 13 % of the speculations presented first were falsely remembered to be factual in the cued recall task—the *opposite mistake* of remembering previously presented facts as mere speculations

turned out to be much more likely to occur (40-50 % of previously read facts were later remembered to be speculative).

Ruling-Out Potential Methodological Constraints

Within these experiments, potential (methodological) constraints that could have brought about these unexpected findings were eliminated step by step: First, one might argue that the tendency to recognize facts as speculations arose due to a *response bias* in the sense that the participants simply selected “speculations” more often than “facts” in the recognition task. This could be evoked, for instance, by strategical considerations such as regarding both types of confusion errors as being of different severity. To rule out this possibility, we conducted Experiment 2B in which we replaced the recognition task with a cued recall procedure: The results here showed that even when participants were not asked to *choose* between given response options, but *freely reproduced* what they had read before, the tendency to remember facts as being speculative information persisted. This points to a stable memory distortion rather than a response bias due to affordances of the recognition task.

A second question might concern whether our results are tied to one specific uncertainty expression or can be generalized across different ways of communicating uncertainty in the news. Supporting the latter, we found that the tendency to remember facts as speculations consistently occurred across different uncertainty expressions, namely, for both questions and statements that were qualified by the modal auxiliary verb “might” (Experiment 4). This finding further underscores the conclusion that the memory distortion toward speculation is a robust phenomenon with respect to different memory measures and different materials alike.

A third aspect might concern the relation between memory and belief judgements. Particularly, one might argue that the attempt to *explicitly recollect* a headline’s content could

provoke more cautious strategies in evaluating incomplete memories as compared to mere assessments of an explanation's believability. Ruling out this possibility, however, we found that the attempt to retrieve an explanation from memory did not lower (but rather heightened) its believability—even though 40 % of the factual headlines were remembered to be merely speculative (Experiment 3). This suggests that the act of explicit recollection did not *induce* the tendency to treat facts as speculations. Taken together with the findings on the recognition measure and cued recall, our results suggest that not the “fact” but rather the “speculation” formed a baseline of the memories *and* beliefs in the causal explanations we recorded.

Implications for New Models on the Processing of Uncertainty Cues

With regard to the development of new approaches to the processing of uncertainty cues, the observed memory distortion from fact toward speculation gives rise to an important implication for theory: The mental structures representing linguistic uncertainty expressions seem to differ from those of negations—despite structural and functional similarities of both (as was outlined in the introduction). Accordingly, whereas prior research has shown that particularly those negations that offer multiple interpretations tend to be disregarded or become lost in memory over time (Mayo et al., 2004), our findings revealed that uncertainty as present in speculations seems to *grow*. This conclusion stems from the observation that the participants recollected more uncertainty than was originally present in the news to be called to mind. This pattern contradicts the predictions derived from the schema-plus-tag model (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975). Further, it is opposed to prior research on the recognition of trivia questions which, at first glance, seem similar to the questions in headlines that we used in most of our experiments (Pandelaere & Dewitte, 2006). Yet, findings on trivia questions forecast a “statement bias”, namely, a tendency to forget

uncertainty cues in favour of a factual interpretation, which is in contrast to the “speculation bias” that we found.

In the following, we seek to outline new theoretical perspectives on uncertainty processing in order to explain these discrepancies. These perspectives are based on one common argument: The (un-)certainty cues investigated here differed from those which were used to demonstrate the “statement bias” in one important aspect, namely, the *presence of context*. To be more precise, Pandelaere and Dewitte (2006) varied uncertainty cues by formulating trivia statements and questions (e.g. “Do fresh water snakes swim upside down for about half of the time?”) and then presented them in an isolated manner. As such, there were barely any contextual cues to ascertain the meaning of formulating a question instead of a statement. In contrast, (un-)certainty cues in our materials entailed a specific communicative function: They explicitly related to the *degree of evidence* concerning a reported explanation in the news as was specified by a leading question or statement *and* an additional teaser. There are several ways of explaining why contextualized (un-)certainty cues might behave differently than it would be expected on the basis of prior work.

Considering a Headline’s Credibility. Notably, the schema-plus-tag model suggests that (un-)certainty cues are represented in an abstract manner via the presence or absence of a categorial tag. Giving (un-)certainty cues a specific and meaningful context, however, might have caused this context to be integrated into a message’s mental representation as well (e.g., by writing over the initial propositional representation in a subsequent processing step). On closer inspection, a *contextualized understanding* of epistemic modality is already anchored in one component of its definition (as described at the beginning of this manuscript), stating that linguistic cues of uncertainty not only modify the core meaning of a message but also point to the *relation* of this message to its source. This account is in reference to the idea of “situation

models” that differ substantially from propositional representations, as assumed by the schema-plus-tag model: While propositional representations reflect the *structure* of a message itself, such as its propositional content and epistemic modality, situation models refer to the conclusions that a reader might draw about the *actual state of affairs* (Zwaan & Radvansky, 1998; also known as the “gist” of a memory; e.g., Brainerd & Reyna, 2019).

These conclusions likely not only rely on a message itself, such as the (un-)certainty it expresses, but should be also affected by a conglomerate of cues in a message’s *broad context* once this context is given—such as, in particular, assumptions concerning the credibility of a headline’s source, conflicting prior knowledge, or distrust concerning the news media in general (Richter et al., 2009). The critical point is that situation models are conceptualized to represent a person’s distrust through references to potential alternative states of affairs (which would be, in our case, alternative explanations that come to mind). As such, situation models are indifferent to specific sources of distrust, be it evoked by the language used (such as by formulating a content as speculation instead of fact) or by assumptions concerning the trustworthiness of a message’s sender.

Considering this conception of situation models, the problem focus concerning an accurate reproduction of epistemic information seems to shift: Instead of *dissociating* abstract cues of uncertainty from core concepts, readers would rather *integrate* the communicated state of knowledge concerning an explanation with their own distrust, leading different sources of uncertainty to become blurred. This account might be consistent with the rationale that there were actual reasons to distrust the headlines in our experiments—which were neither accurate nor presented in the context of a specific source (except for the notion that the participants would read “headlines of news articles”). This, in turn, might have induced a bias to falsely remember factual formulations as speculative rather than falling for the reverse mistake.

It should be noted, however, that a potential confusion of a communicated state of knowledge (through linguistic (un-)certainty cues) with one's own distrust created by a headline's source or content seems to contrast with some findings of prior work, showing, for example, that the consideration of uncertainty cues in news headlines was unaffected by the reliability of a source (Wegner et al., 1981). Furthermore, Pandelaere and Dewitte (2006) demonstrated that the "statement bias" was equally pronounced for contents that participants judged to be certainly false as for those that were judged to be true, suggesting that the believability of a content is tangential to memory distortions concerning (un-)certainty cues.

Encoding Under Suspicion: Does Uncertainty Spread? The *context* of (un-)certainty cues can be also considered in a different sense. Whereas the aforementioned explanation concerned the perceived credibility of a headline in the context of its source or prior knowledge, a broader alternative account sets its focus on the possibility that the presented headlines might have affected the processing of each other. This perspective proposes that uncertainty cues in the presented speculations might have *spilled over* to other, unrelated headlines which were encountered among them. Doing so, it aims at the question whether participants might *not* have tended to remember facts as uncertain if they had not been confronted with speculations beforehand.

There are several ways of conceptualizing such a spill over of uncertainty cues: First, reading speculations might create *general* uncertainty that affects the processing of other news. Indeed, some prior findings and theoretical work might corroborate this idea: On the empirical side, a recent study showed that confronting participants with "fake news" warnings can induce a general sense of scepticism towards subsequent "fake news". Particularly, such warnings did not exclusively affect the specific statements that they were attached to (Pennycook et al., 2018). On the theoretical side, some approaches propose that a "mindset of

distrust” can evoke incongruent thoughts on a given message, leading in turn to more complex situational structures of representation, that are discussed to eliminate or at least weaken typical biases towards affirmation (Mayo, 2015; Richter et al., 2009). Given that pointing out alternatives is a basic and defining function of speculations (as outlined in the introduction), they might evoke, in a similar way, incongruent thoughts on unrelated messages, such as factual news. This might have led participants to remember reported facts as uncertain—because when trying to recollect what they had previously read, potential counter scenarios came to mind. It is a novel and consequential question whether general scepticism or a “mindset of distrust” could also be triggered by the mere processing of speculations (such as explanations that are reported as being investigated), which, in contrast to “fake news” warnings, do not refer to any attempt of fraud.

Second, besides creating general scepticism, a spill over of uncertainty cues could also be explained by speculations appearing particularly *salient* to the reader. This might cause them to overshadow the reconstruction of previously read factual news. A higher salience of speculative compared to factual news could be explained by several factors, such as speculations being explicitly marked in language as such, being potentially more complex to process or due to being rather unusual to participants as they are reported less frequently in the news. Future studies could further explore these possible mechanisms of a spill over of uncertainty cues.

Implications for Negation Research

Beyond establishing the first cornerstones for theoretical models on the processing of uncertainty cues, our observation of a memory distortion from fact toward speculation (rather than vice versa) arguably also relates to research on negation. This is because the latter commonly shares the ‘recollection of facts’ as a category of reference with our studies

(Gilbert et al., 1990; Gilbert, 1991; Gilbert et al., 1993; Mayo et al., 2004). Specifically, the observation that people rendered facts as mere speculation indicates that the recollection of the former is less stable than is assumed by previous work in which facts were contrasted with negations. Linking up with the preceding account on a “spill over” of uncertainty cues, these findings might point toward one fundamental difference between the ways how negated and speculative contents are processed: Although both negations (e.g., “X is not the case”) and speculations (e.g., “X may be the case”) share structural and functional communalities and, in particular, are both considered to involve the processing of alternative states of affairs, this tension can often be *resolved* for a negation as soon as it is accurately understood. Even such negations that do not directly imply a specific affirmation certainly do rule out the one alternative that was explicitly named and negated (empirical evidence for a shift in accessibility of different alternatives during negation processing can be found in Hasson & Glucksberg, 2006). In contrast, for speculations, the tension between proposed alternatives (X is the case or is not the case) must remain unsolved by definition—which might, in turn, tune cognitive processes toward incongruent thoughts (i.e., alternative possibilities) in a more general way than is the case for negations. In a similar vein, uncertainty cues might also appear more salient to the reader as compared to negations because the former are potentially more complex to process (as conflicting alternatives here remain unsolved). This again could lead to factual formulations being “overshadowed” by jointly presented speculations, whereas this effect might be absent (or smaller) for negations. In this sense, future research could address whether speculations differ from negations in their *scope of influence* on the recollection of unrelated messages, such as those that report an explanation as being a fact.

Besides these content-related aspects, our findings could also point toward methodological constraints of some prior studies on negation. As we outlined in the introduction, experiments on negation processing are classically grounded on a dichotomous

distinction between falsehood and truth. Forcing participants into making a binary choice, however, reduces the possible result patterns that can be observed. This argument might be further underscored by the finding that memory and response biases concerning the truth of a content appear distinctively different in the few studies that enclosed an additional uncertain option (Street & Richardson, 2015; Nadarevic & Erdfelder, 2013, 2019). This again stresses the importance of going beyond a dichotomous true-false conception when trying to draw general conclusions on how factuality and falsehood are represented in mind. Following up on this, future research should thus address the parallels and differences of negation and speculation processing in more depth, taking into account content-related and methodological aspects alike.

Practical Implications

Beyond the theoretical considerations outlined above, our findings also offer practical implications. Is it harmful to raise a speculation—because it can provoke misconceptions, as classical research on negations or phenomena such as the “statement bias” suggest? In sum, the answer to this question seems to be mixed: On the one hand, we indeed found false factual memories after reading speculations. Furthermore, merely reading a speculative explanation that was under investigation, but not yet confirmed, did increase its believability in a systematic manner.

On the other hand, it is important to put these results in relation to other kinds of mistakes that arose: Our data suggest that most of the presented explanations—and almost half of the factual ones—were reproduced as being uncertain: On average, 40 – 50 % of factual explanations presented first were falsely remembered as being merely investigated but not yet confirmed (recognition task, Experiment 2 A, 3 & 4). While these results show that memories on epistemic information are fragile, they also cast a positive light on human

capabilities to deal with abbreviated yet meaningful messages. Our findings suggest that people seem to process news headlines in a less mechanistic, but more contextualized manner than was initially expected on the basis of prior work (though the question of moderating factors, such as individual differences is still to be examined; e.g. Brashier & Schacter, 2020).

Nonetheless, one should not disregard that there are circumstances that turn the recollection of facts as uncertain to be consequential: One example for this is the questioning of harmful effects of human activities that are actually very much confirmed, such as an anthropogenic climate change. As such, our findings point to the necessity of investigating the applied question of how to effectively spread confirmed information to recipients (rather than prevent uncertain information to be misremembered as a fact). The pressing need for this becomes apparent, for instance, also in relation to the current pandemic spreading of Covid-19, a situation in which most provided information is still relatively preliminary. The few fairly confirmed pieces of information, however, are of high relevance and literally can contribute to saving lives if recipients treat them as the facts that they are, rather than as mere speculations.

Conclusions

Representing the (un-)certainty of information is an oftentimes neglected field in research on misconceptions and biases which was, to this day, mainly based on a dichotomized understanding of falsehood and truth. The present work sought to investigate the existence and peculiarity of potential biases in believing and remembering news that were either formulated as speculations or facts. Interestingly, as it turned out, we observed stable evidence pointing toward a novel distortion: When reading short news articles, recipients tended to neglect the *certainty* of a communicated “fact” (rather than the *uncertainty* of a speculation). Specifically, they were biased to treat and remember explanations that were

reported to be certain as if they were merely speculative, rather than falling for the reverse mistake. Our surprising finding urges for future research to further investigate the theoretical foundations of this tendency of believing and remembering from fact toward speculation. Further, our results point to the relevance of the applied question of how to get confirmed information across to recipients of news having contents at every possible level of certainty.

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Appendix

Additional results on Experiment 2A: Overall Rate of Correct Responses

We specified generalized linear mixed effects models (GLME) with a logit link function to examine whether the overall rate of correct responses differed for the four explanation conditions, using the lme4 package in R (Bates et al., 2015). Accordingly, “explanation condition” was represented as fixed effect in the model with the four stages “new”, “no”, “investigated” and “confirmed”. A GLME analysis indicated that the model with the best fit included both item and participant as random intercepts. Importantly, this analysis revealed a main effect of “explanation condition” on the overall rate of correct responses, $X^2(3) = 357.15, p < .001, R_m^2 = .22, R_c^2 = .34$. As depicted in Figure 5, the relative frequency of correct responses was highest for headlines that were not presented before (“new explanation”), followed by the “no explanation” condition (which differed from the previous condition, $\beta = -0.88, se = 0.20, z = -4.41, p < .001$), and the “speculative explanation” condition (which in turn differed from the “no explanation” condition, $\beta = -1.08, se = 0.15, z = -7.04, p < .001$). Interestingly, the highest error rate was found in recognizing headlines that had reported the respective explanations as being “confirmed” (with the relative frequency of correct responses being significantly smaller compared to the “speculative explanation” condition, $\beta = -0.82, se = 0.13, z = -6.21; p < .001$).

Figure 10. Results of Experiment 2A. Relative frequency of correct answers depending on the four explanation conditions with confidence intervals for within-participants comparisons. “New” expresses the relative frequency of *correct rejections* of new items (that had not been previously presented); and “no”, “spec.” (=speculative explanation) and “conf.” (=confirmed explanation) refer to the relative frequency of a *correct recognition* of previously presented items as belonging to the respective headline category.