Beyond Reasonable Doubt?

When Uncertainty Spreads Across Pieces of News

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Summary

Via modern media, news can be shared in a matter of seconds, often even before its contents are sufficiently confirmed. This tendency might be amplified if the demand for information is high, such as in the case of unexpected disasters or new diseases that pandemically spread. Yet, even if speculative contents are disclosed by uncertainty expressions (e.g., "might") in the news, it remains unclear what memory consequences their presence could hold. This thesis addressed how recipients consider and reproduce subtle but critical differences in wording, indicating whether an articles' content is merely speculative and yet unconfirmed or confirmed through investigations. 13 Experiments provide the empirical basis for this.

Thus far, psychological models on the mental processing and memory of speculative language (e.g., "Arson might have caused the fire") are scarce. Yet, findings from adjoining fields could inspire initial hypotheses that are contradictory in direction. On the one hand, some research suggests that people may tend to forget uncertainty expressions, whereas the memory of facticity should prove robust and less prone to error. This perspective draws on models and findings from the related case of negation. However, these models conceptualize the uncertain statement as the unit of inquiry and thus neglect that speculations could also evoke more far-reaching effects. A second perspective taken in this thesis builds upon this potential constraint. From this perspective, uncertainty is not necessarily (only) remembered at the level of an individual statement or headline but can also elicit cross-item effects – that is, it can affect the reception and memory of unrelated pieces of news. Could intermingling speculations decrease the remembered certainty of jointly reported facts?

Across three manuscripts that comprise the chapters of this dissertation, I tested both proposed effects by investigating whether uncertainty might be forgotten after a while (Chapter 2) or spreads across memories (Chapter 3). My third manuscript (Chapter 4) combines the different perspectives of the previous chapters by testing how potential spreading effects – triggered by intermingling speculations – compare with those of negations, which formed the starting point of this work. All experiments had a similar design: The participants read a mixture of different short news articles, some of them reporting factual, some speculative, and some negated explanations. After a brief distraction phase, these articles had to be remembered using different memory measures (recognition and cued recall), or their subjective accuracy was assessed. Opposing the work in harmony with the first perspective (i.e., a forgetting of uncertainty cues), my results consistently support the latter

view, showing that intermingling speculations can lead facts to be remembered as mere speculation at a later point in time. Furthermore, I showed that in terms of cross-item effects, speculations differ from negations fundamentally.

In detail, my first series of experiments (Chapter 2) aimed to test whether uncertainty is neglected and tends to decay in memory over time. Addressing this question, my first two experiments indicated that both speculative, and factual formulations enhanced the participants' belief in the correctness of the presented explanations to a similar degree (compared with receiving no explanations at all). Crucially, however, these similar effects were not primarily provoked by a tendency to neglect uncertainty cues (as given in speculations). Instead, four additional memory experiments (recognition and cued recall) indicated an inverse distortion than was predicted by negation models. Participants tended to falsely treat, remember and reproduce a previously read "fact" as mere speculation later on (more so than falling for the reverse mistake). Could the presence of speculation have decreased the remembered certainty of factual news presented among them?

My second experimental series (Chapter 3) tested this by manipulating the *composition* of presented news. I found consistent evidence supporting the hypothesis that uncertainty spreads across all four experiments and different memory measures (recognition and cued recall). In detail, having read speculations lead the participants to remember facts as speculations, whereas the effect of having read facts on the memory of speculations was less pronounced. An uncertainty spreading emerged even when the participants encountered both types of news in a bock-wise manner (e.g., when all factual pieces of news were presented first). This allows conclusions on the underlying cognitive processes: Speculations in the news seem to not specifically alter the *encoding* of other messages but can overshadow memories that had been already stored, for instance by changing how these memories are retrieved.

My third experimental series (Chapter 4) showed that the detrimental influence of speculations on remembering facticity is unique and different from that of negations, and thereby connected both perspectives of my previous studies. Across three experiments I found that, unlike speculative news, negations did not provoke any spreading effects, neither causing facts to be remembered as negated nor as uncertain (or did so only at a negligible level). This difference could be explained by more distinct mental representations of negations and facts and a lower memory strength needed to remember facts as such if they were read among negations (instead of speculations) before.

Following these results, I propose that not the commonalities but the *differences* between negations and speculations are crucial for theory development about how humans mentally represent and remember uncertain information. Further, I conclude that memories on facts are less robust than presumed in classical language processing models. Instead, memory biases concerning factual formulations seem to be context-driven, as they depend on the mixture of presented news and specifically emerge when speculations are present. In this way, my findings question and extend existing models that focus so far only on a binary distinction between true and false. From a practical perspective, uncertainty spreading poses a challenge in getting confirmed news across. Speculation should therefore be reported with caution.

Zusammenfassung

Über moderne Medien können Nachrichten in Sekundenschnelle geteilt werden, oftmals noch bevor ihr Inhalt ausreichend bestätigt ist. Diese Tendenz kann sich verstärken, wenn die Nachfrage nach Informationen groß ist, wie im Falle unerwarteter Katastrophen oder neuer Krankheiten, die sich pandemisch ausbreiten. Doch selbst wenn spekulative Inhalte durch Unsicherheitsausdrücke (z. B. „könnte") in den Nachrichten offengelegt werden, bleiben ihre Erinnerungskonsequenzen unklar. In dieser Arbeit wurde untersucht, wie Rezipienten subtile, aber entscheidende Unterschiede in der Wortwahl berücksichtigen und reproduzieren, die anzeigen, ob der Inhalt eines Artikels lediglich spekulativ und noch unbestätigt oder durch Untersuchungen bestätigt ist. 13 Experimente liefern hierfür die empirische Grundlage.

Psychologische Modelle zur mentalen Verarbeitung und Erinnerung spekulativer Sprache (z.B. „Brandstiftung könnte das Feuer verursacht haben") sind bisher kaum vorhanden. Erkenntnisse aus angrenzenden Bereichen könnten jedoch zu ersten Hypothesen anregen, die in ihrer Richtung gegensätzlich sind. Einerseits deuten einige Studien darauf hin, dass Menschen dazu neigen, Ausdrücke von Unsicherheit und Spekulation zu vergessen, während sich die Erinnerung an faktische Formulierungen als vergleichsweise robust und wenig fehleranfällig erweisen sollte. Diese Perspektive stützt sich auf Modelle und Erkenntnisse des verwandten Feldes der Negationsforschung. Diese Modelle konzeptualisieren jedoch die *einzelne* spekulative Formulierung als Untersuchungseinheit und vernachlässigen somit, dass der Bericht von Spekulationen auch weiterreichende Effekte nach sich ziehen könnte. Auf dieser potenziellen Einschränkung baut eine zweite Perspektive auf, die in dieser Arbeit eingenommen wird. Aus dieser Perspektive wird Unsicherheit nicht notwendigerweise (nur) auf der Ebene einer einzelnen Aussage oder Schlagzeile erinnert, sondern kann auch artikelübergreifende Effekte hervorrufen – das heißt, sie kann die Rezeption und Erinnerung an inhaltlich unzusammenhängende Nachrichten beeinflussen. Könnte die gemischte Präsentation von Spekulationen und Fakten die erinnerte Sicherheit letzterer verringern?

In drei Experimentalreihen, die die Kapitel dieser Dissertation bilden, habe ich beide Effekte getestet, indem ich untersuchte, ob Unsicherheit nach einer Weile vergessen wird (Kapitel 2) oder sich über Erinnerungen hinweg ausbreitet (Kapitel 3). Meine dritte Experimentalreihe (Kapitel 4) kombiniert die verschiedenen Perspektiven der vorangegangenen Kapitel, indem sie potenzielle Ausbreitungseffekte – ausgelöst durch das

Untermischen von Spekulationen – mit denen von Negationen vergleicht. Letztere bildeten den theoretischen Ausgangspunkt dieser Arbeit. Alle Experimente hatten ein ähnliches Design: Die Teilnehmer lasen eine Mischung aus verschiedenen Kurznachrichten, die teils faktische, teils spekulative und teils negierte Erklärungen berichteten. Nach einer kurzen Ablenkungsphase mussten diese Artikel mit Hilfe verschiedener Gedächtnismaße (Wiedererkennung und hinweisbasierte Wiedergabe) erinnert oder ihre subjektive Richtigkeit beurteilt werden. Im Unterschied zu früheren Arbeiten, die ein Vergessen von Unsicherheitshinweisen nahelegen, stützen meine Ergebnisse durchweg die alternative Sichtweise einer Ausbreitung von Unsicherheit. Sie zeigen, dass ein Untermischen von Spekulationen dazu führen kann, dass auch Fakten zu einem späteren Zeitpunkt als reine Spekulation erinnert werden. Darüber hinaus konnte ich zeigen, dass sich Spekulationen in Bezug auf artikelübergreifende Effekte grundlegend von Negationen unterscheiden.

Im Detail prüfte meine erste Experimentalreihe (Kapitel 2), ob Unsicherheit vernachlässigt wird und im Gedächtnis mit der Zeit abnimmt. Meine ersten beiden Experimente zeigten, dass sowohl spekulative als auch faktische Formulierungen den Glauben der Teilnehmer an die Richtigkeit der präsentierten Erklärungen in ähnlichem Maße verstärkten (verglichen mit dem Erhalt keinerlei Erklärungen). Entscheidend ist jedoch, dass diese ähnlichen Effekte nicht in erster Linie durch eine Tendenz zur Vernachlässigung von Unsicherheitshinweisen (wie sie bei Spekulationen gegeben sind) hervorgerufen wurden. Stattdessen deuteten vier zusätzliche Gedächtnisexperimente (Wiedererkennung und hinweisbasierte Wiedergabe) auf eine umgekehrte Verzerrung hin, als sie von Modellen der Negationsforschung nahegelegt wird. Die Teilnehmer neigten dazu, eine zuvor gelesene „Tatsache" später fälschlicherweise als bloße Spekulation zu behandeln, zu erinnern und zu reproduzieren (statt den umgekehrten Fehler zu machen). Könnte das Vorhandensein von Spekulationen die erinnerte Sicherheit faktisch formulierter Nachrichten verringert haben?

Meine zweite Experimentalreihe (Kapitel 3) untersuchte dies, indem die Zusammensetzung der präsentierten Nachrichten manipuliert wurde. In allen vier Experimenten und für verschiedene Erinnerungsmaße (Wiedererkennung und hinweisbasierte Wiedergabe) fand ich konsistente Belege für die Hypothese, dass sich Unsicherheit ausbreitet. So verringerte das Lesen von Spekulationen die erinnerte Sicherheit von gemeinsam präsentierten Fakten, während der Effekt des Lesens von Fakten auf die Erinnerung von Spekulationen weniger ausgeprägt war. Eine derartige Ausbreitung von Unsicherheit trat auch dann auf, wenn die Teilnehmer beide Arten von Nachrichten in separaten Blöcken lasen (z. B.

wenn alle faktischen Nachrichten zuerst präsentiert wurden). Dies lässt Rückschlüsse auf die zugrunde liegenden kognitiven Prozesse zu: Spekulationen in Nachrichten scheinen nicht spezifisch die Enkodierung anderer Nachrichten zu beeinflussen, sondern vielmehr bereits gespeicherte Erinnerungen zu überschatten, indem sie zum Beispiel die Art und Weise verändern, wie diese Erinnerungen abgerufen werden.

Meine dritte Experimentalreihe (Kapitel 4) zeigte, dass der negative Einfluss von Spekulationen auf das Erinnern von Faktizität besonders ist und sich von dem Einfluss von Negationen grundlegend unterscheidet. Sie verband damit beide Perspektiven meiner vorherigen Studien. In drei Experimenten fand ich heraus, dass Negationen im Gegensatz zu spekulativen Nachrichten keine Ausbreitungseffekte hervorriefen, d.h., weder dazu führten, dass Fakten als negiert noch als unsicher erinnert wurden (oder nur in vernachlässigbarem Ausmaß). Diese Diskrepanz könnte dadurch erklärt werden, dass die geistigen Repräsentationen von Negationen und faktischen Formulierungen unterschiedlicher sind als die von Vermutungen und faktischen Formulierungen. Zudem scheint weniger Erinnerungsevidenz erforderlich, um faktische Formulierungen als solche zu erinnern, wenn sie zuvor gemeinsam mit Negationen statt mit Spekulationen gelesen wurden.

Ausgehend von diesen Ergebnissen schlage ich vor, dass nicht die Gemeinsamkeiten, sondern die Unterschiede zwischen Negationen und Spekulationen entscheidend für die Entwicklung von Theorien darüber sind, wie Menschen unsichere Informationen geistig repräsentieren und erinnern. Außerdem komme ich zu dem Schluss, dass Erinnerungen an faktische Formulierungen weniger robust sind, als in klassischen Sprachverarbeitungsmodellen angenommen wird. Stattdessen scheinen Gedächtnisverzerrungen in Bezug auf faktische Formulierungen kontextabhängig zu sein, da sie von der Mischung der präsentierten Nachrichten abhängen und insbesondere dann auftreten, wenn auch Spekulationen berichtet wurden. Auf diese Weise stellen meine Ergebnisse bestehende Modelle in Frage, die sich bisher nur auf eine binäre Unterscheidung zwischen wahr und falsch konzentrieren und erweitern sie. Aus praktischer Sicht stellt die Ausbreitung von Unsicherheit eine Herausforderung bei der Vermittlung von bestätigten Nachrichten dar. Spekulationen sollten daher mit Bedacht berichtet werden.

Chapter 1: General Introduction

Undoubtedly, the Internet has broadened the scope of ones' experiences and impact power. It allows traveling virtually to places far away, even when stuck at home, and to access different cultures and ways of living that governments may repress. By being online, one can receive the latest news in a matter of seconds and can contribute one's own point of view instantly, reaching people one never met or does not even know to exist. What Carey (2007) called "a particularly modern hunger for experience" (p. 6), a hunger for the new, seems to be difficult to circumvent since news appears ever-present in most peoples' daily lives. Consider the many moments one is accompanied by news via technical devices carried along, apps routinely used, or via screens in public places, for instance, while waiting for the train.

This flood of information brings freedoms but also risks, which became apparent during a number of past events: The U.S. presidential election 2016, the "Brexit" campaign, and the pandemic spreading of the novel coronavirus Sars-Cov-2 are just some happenings in the course of which false and uncertain information circulated and were considered a common threat (e.g., Scheufele & Krause, 2019). Following this, psychological research around the impact of news has experienced a tremendous upswing in the past six years, asking how false or withdrawn contents could propagate and developing and extending models on how the human mind represents the categories of true and false. Although these studies addressed diverse aspects of news reception, ranging from ideological beliefs to mere repetition (see Pennycook & Rand, 2021 for an overview), they still share one perspective that the present work aims to transcend. They conceptualize contents as either true or false – but they neglect that a considerable portion of information fits neither into one nor the other category. The headline "Did Covid-19 escape from Wuhan lab? […]" (Washington Post, Feith, 22th of March 2021) illustrates this, which poses a question to indicate that the expressed content is merely speculative and therefore could turn out to be wrong in the end. But even if speculative contents are disclosed by uncertainty expressions (e.g., questions or words such as "could" or "might"), it remains unclear how recipients consider such cues and what memory consequences their presence could hold.

This dissertation investigates the effects of reading speculative news at multiple levels of observation, ranging from the memory of single articles to potential cross-item effects when reading a conglomerate of pieces of news. As psychological models on the mental processing and memory of speculative language are scarce, I will consider findings from adjoining fields, such as negation research (e.g., "X did not cause Y."), to inspire initial

hypotheses. But can such models, grounded in a dichotomous distinction between true and false, be applied to uncertainty expressions, or are new models needed as uncertain language could represent a special case? In this dissertation, I address this question and identify two kinds of potential effects uncertain language (as evident in speculations) could evoke: On the one hand, people could neglect uncertainty expressions just as they tend to forget negations after some time. This would mean that people are biased to remember and treat speculations *as if* they were confirmed facts later on – even though the speculation may still end up being incorrect. On the other hand, instead of getting lost in memory, uncertainty could also *spread*. From this perspective, the presence of speculations in the news could diminish the remembered certainty of jointly reported facts. In other words, uncertainty cues concerning single messages might sow doubt in a general sense, leading people to remember (confirmed) facts as mere speculation.

Understanding which of these possible paths takes place is relevant from both a theoretical and applied point of view. On the theoretical side, discerning both effects could help develop models on how the human mind represents speculation and extend and challenge existing approaches rooted in a binary conception of true and false. On the practical side, this work could inform news reporting and eventually help to find communication strategies that counteract false memories and a blurring of certain and uncertain contents.

In the following, I will first give an overview of the previous work on uncertainty expressions in language, originating mainly from psycholinguistics. Extending these considerations, I will derive two theoretical perspectives from related research fields, supporting either the possibility that uncertainty is forgotten or spreads across memories. Following this, I describe three experimental series in the form of independent manuscripts: Chapter 2, "In Case of Doubt for the Speculation", addresses the first perspective and tests whether uncertainty might decay in memory over time. Chapter 3, "When Uncertainty Spreads Across Pieces of Information", targeted the second perspective and potential cross-item effects. Chapter 4, "Shadow of a Doubt", combines both views by comparing the effects speculations and negations could evoke regarding the memory of other news. Finally, in the last part of this thesis (Chapter 5), the results are summarized, and their implications are discussed.

The Language of Uncertainty

The Multiple Functions of Uncertainty Expressions in Speech

Thus far, psychological research has focused primarily on the distinction between true and false, or between factual (e.g., "X did cause Y") and negated formulations (e.g., "X did not cause Y"). Accordingly, uncertainty expressions are barely present as a subject of investigation yet. This priority might be due to negation constituting a universal operator that appears and is used consistently across human languages (De Haan, 2013). In contrast, linguistic cues of uncertainty seem to be more challenging to grasp. On the one hand, the term "linguistic uncertainty" itself subsumes numerous forms of expression, including, for instance, the posing of a question or the adding of different words such as "likely", "possibly", or "might", to give just a few examples. On the other hand, such language cues are also associated with multiple overarching concepts, leading these cues to be the subject of several seemingly unrelated research fields. Accordingly, as Van der Bles et al. (2019) stated, the few empirical works on uncertain formulations are "widely scattered across many disciplines" (p. 1). For instance, prior work examined uncertainty expressions as part of the concept of "powerless speech" (Hosman, 1989), as a mirror of "gender inequalities" (e.g., Coates, 2003), as a form of politeness (e.g., Brown & Levinson, 1987; Holtgraves & Perdew, 2016), but also of scientificness (Meyer, 1997), or as a means of innuendo (Wegner et al., 1981), to name a few.

The multiple meanings of uncertainty expressions are also reflected in the many incidents in which they are used and the different interpretations associated with them. Consider, for example, that a stranger asking for the way could sound friendly if adding the word "may" to his question for help. An applicant for a job, in comparison, could appear unconvincing if he uses many uncertain terms (Russell et al., 2008). Factettes of uncertainty expressions are, thus, manifold and their meaning changes considerably, depending on the context of their occurrence. Therefore, defining this *context* has been considered critical to study uncertainty expressions in a sensible way (Dodd & Bradshaw, 1980).

For the present thesis, one contextual distinction is of particular relevance: In many cases, people spontaneously add words such as "might" or "could" during oral communication, mainly as mere filler words, which has been associated with subjective impressions of the speakers' character, such as politeness or a lack of power, as noted above (e.g., Brown and Levinson, 1987; Hosman, 1989). However, these studies leave out that

uncertain phrases can also serve essential *substantive* functions in other contexts, such as when they are used to point out that a matter is still subject to speculation and therefore unconfirmed. This latter context is the focus of the present work. That is, I will address uncertainty expressions as a means to index speculation and not in terms of any other context. Note that to ease the reading flow, I will use the terms "speculative formulation" and "speculation" interchangeably, always referring to uncertainty cues in language as a means to express speculation that is yet unconfirmed.

Since systematic studies on speculative formulations are lacking in psychology so far, I will consider conceptions and models from neighboring fields of research inside and outside psychology, which repeatedly show points of contact with initial psychological studies in this domain. As a starting point, I will explain the linguistic concept of *modality* from which various properties and functions of speculative formulations can be derived. These functions, in turn, could provide the first basis for models on their mental representation.

The Concept of Modality – Speculative Language from a Linguistic Point of View

To understand how recipients process speculative formulations, linguistic research may prove the first vital clue. As already argued in earlier works, linguistic structures and their function could mirror general patterns of human thought (Clark & Clark, 1977; Gilbert, 1991). Thus, these functions might allow inferences on how distinct concepts, such as facticity or uncertainty, are represented in the mind.

From a linguistic point of view, a speculative formulation such as "Arson could have caused the fire" can be subdivided into two components that are crucial for the present work: first, the entailed proposition, referring to the content of a sentence (here: "Arson caused the fire."), and second, its modality. The latter is marked by the word "might" in this example, yet it can be expressed in many different ways, for instance, also by posing a question (e.g., "Did Arson cause the fire?").

Modality, etymologically from "mode", refers to the specific way in which something exists, is experienced, or expressed (Dudenredaktion, o. D.). The study of modality spans a long history, tracing back to ancient Greece and Aristotle's reflections on logic (De Haan, 2013). It also takes a central place in later philosophical writings, such as Kant's "Critique of

pure reason" (1781/2020), in which modality forms a judgment function serving to structure phenomena of the world. However, it wasn't until the middle of the 20th century that the concept of modality was adopted and broadened by linguists placing the *expressions* of possibility and necessity in *natural* language at its center (Portner, 2009).

Likewise, as in philosophy, various subforms of modality have been distinguished in linguistic work, all referring to the language structures "whereby grammar allows us to say things about or on the basis of situations which need not be real" (Portner, 2009). Jespersen (1924/2013) juxtaposed two basic types of modal expressions: The first contains an element of volition, as present in sentences such as "The door *should* be closed", whereas the second type, that comprises speculative formulations (e.g., "The door could be closed"), does not. Although research has since moved on from this dual structure, both categories, nowadays termed deontic and epistemic modality, still play a crucial role. The latter category – named *epistemic modality* – has several defining functions that might provide a starting point for developing psychological models on the mental structures representing uncertainty compared to facticity, as I aim for in the present work.

First, Chung and Timberlake (1985) stated that the epistemic modality serves to indicate the "actuality of an event in terms of alternative possible situations, or worlds" (p. 242). According to this definition, speculative formulations differ from factual ones since they indicate the existence of *alternatives* beyond the one that was explicitly named. In contrast, factual formulations describe a single situation. Second, several researchers have emphasized that the epistemic modality points not only toward alternatives but also refers to the speaker himself (e. g., Lyons, 1977; Palmer, 1986/2001). Thus, while factual formulations express that a statement follows the speaker's stance, speculative formulations indicate a speaker's distancing from it, for instance, due to doubts. Third, since language may express different levels of uncertainty, the epistemic modality has been conceptualized as spanning a spectrum between two extremes (Nuyts, 2001): the certainty that a state of affairs is true and the certainty that it is not. Speculations and facts should therefore differ in their position upon this mental spectrum. Further, different kinds of uncertainty expressions (e.g., "unlikely", "possibly", "probably", "likely") as present in speculative language should differ in their position upon this mental spectrum as well. In this dissertation, speculations are conceived as statements characterized in terms of the preceding three functions: the pointing to alternatives, the distancing of the speaker, and the reference to a continuum between true and false. Are these functions mirrored in a readers' mental representation?

Notably, the continuum aspect has been formative for most psychological studies on this question so far. They addressed whether verbal phrases such as "may", "possibly", or "likely" carry an inherent *probabilistic meaning* and are, therefore, identifiable with specific numbers or ranges of numbers between zero and one. However, prior attempts to quantify verbal uncertainty expressions were rather inconclusive: Studies showed that the spectra of probabilities that participants assigned to these expressions were broad and varied largely between subjects and situations (Beyth-Marom, 1982; Budescu & Wallsten, 1985; Lichtenstein & Newman, 1967). Accordingly, later work questioned this approach and argued that linguistic uncertainty carries a *distinct* function compared to probabilities represented by numbers (Druzdzel, 1989 & Teigen, 1988). As Druzdzel (1989) and Teigen (1988) explained, probabilities suggest an often-misleading certainty about opportunities and risks, whereas language can express *vagueness* and the absence of any knowledge. Moreover, Druzdzel (1989) pointed out that cognitive psychologists have a broad consensus that humans cannot reliably handle, discriminate, or convey information that involves too many categories. Also, from this perspective, a discriminatory power of the whole vocabulary could prove to be obsolete.

The above studies are relevant for this dissertation project as they suggest that verbal uncertainty expressions carry a *function* that numeric probabilities cannot provide. As verbal phrases seemed hardly identifiable with a reasonably precise spectrum of numbers, the question of alternative conceptions on how uncertain content is represented in the mind arises. The present work addressed this question by developing and contrasting new theoretical models on how humans process and remember speculative formulations and by empirically testing these models' predictions in the applied context of news. At first, it might be worth taking a closer look at the two other linguistic functions of speculative formulations, the *distancing of the speaker* and the *pointing toward alternatives,* as described above. The *first approach* proposed in this thesis is closely tied to these two linguistic functions (with a particular emphasis on the latter one). It supposes that uncertainty, as present in speculation, might be particularly complex to process, which could foster memory errors concerning speculative news (but not factual ones).

Contrasting this approach, the second account outlined below considers speculative language in its *broader* effects. Accordingly, this latter account breaks away from the narrow conception inspired by linguistic work that conceives the *individual* message and its memory structures as the central unit of investigation. In contrast, this perspective addresses potential

cross-item effects that the presence of speculation could evoke and builds on a distinct theoretical frame. Both approaches arrive at opposing hypotheses: Uncertainty as present in speculation could either be forgotten *or* it could spread in memory, leading facts to be remembered as uncertain information as well. Empirical studies and theoretical models supporting one or the other position will be presented in the following.

The Forgetting Perspective: Does Uncertainty Decay in Memory Over Time?

As outlined above, the mental representation and memory of speculations have hardly been explored in previous psychological work. Therefore, the memory structures representing uncertain content and resulting memory tendencies remain to be unknown. Yet, initial evidence for the human mind striving to *reduce* uncertainty is present in some neighboring fields. In particular, research on the handling of alternatives and the negation operator that shares essential linguistic functions with speculative formulations might be relevant here. Notably, both fields put forward specific models on how speculative content is mentally processed, providing initial hints toward a tendency to *neglect* uncertainty cues.

Initial Evidence that Uncertainty is Reduced from Studies on Handling Alternatives

To begin with, as indicated before, one central function of speculations is their reference to *alternatives*. Accordingly, theories and studies that address how people handle alternatives could offer a starting point to understand how people receive and remember speculative language. Aspects of uncertainty reduction for deciding between alternatives are already prevalent at comparatively low levels of processing, for instance, in the visual system (Kersten et al., 2004; Knill & Richards, 1996). Although the visual system can switch between distinct alternatives under some circumstances, it does not seem to integrate across them. This property can be illustrated by ambiguous figures, such as the Necker cube (Attneave, 1971) or the drawing depicted in Figure 1.

Figure 1. This drawing was publicized in the U.S. satirical magazine Puck in 1915 (Colman, 2015).

Some people might recognize a young woman peeking over her shoulder in this picture. Others might see an elderly, hook-nosed woman facing left or even alternate between both percepts. However, the image will never appear to the viewer as a mixture of both faces. As Johnson et al. (2020) explained, "The visual system must adopt one or another belief at a time, rather than delivering both percepts simultaneously" (p. 1418). Perceptual uncertainty is reduced in this way.

Several theorists have proposed that such a principle could also shape higher cognition, namely more abstract ideas (e.g., Gilbert, 1991; Johnson et al., 2020). This assumption is rooted in several observations: For instance, people often find it difficult to contemplate multiple categorizations of an object simultaneously (Murphy & Ross, 1994) and rely on a single, plausible hypothesis when making predictions, even though another relevant hypothesis exists (Johnson et al., 2020; Lagnado & Shanks, 2003). Consistent with these findings, Evans et al. (2003) supposed a *singularity principle* of hypothetical thinking, suggesting that "people represent only one relevant possible world at a time as a mental model" (p. 7). In this view, the human mind chooses between different alternatives to form predictions. Similarly, Johnson et al. (2020) conceptualized inferential reasoning as "a digital one" (p. 1418). They proposed that people often simplify the likelihood of different hypotheses similar to digital bits with the values zero and one to use them in downward

inferences. Thus, the assumption of focusing on a single possibility is also posited in this latter approach.

The above theories and findings are relevant for this dissertation project, as they suggest that people *reduce* uncertainty and the inherent ambiguity to derive predictions. But do people tend to neglect *uncertainty expressions* as present in speculative news in a similar way? Note that the above examples addressed the use of alternatives that were explicitly given as such. For instance, in the case of the picture, two distinct faces can be discerned, and in the study on inferential reasoning, differing alternatives were presented (Johnson et al., 2020). Conversely, the linguistic expression of speculation represents a particular case: Words such as "might" allow pointing to alternatives, though only *one* possibility is expressly named. For example, the speculation "The door might be open" designates only the possibility of an open door though it implies that the door could be closed just as well.

In this capacity, uncertainty expressions closely resemble *negations*. For example, the negation "The door is not open" also expresses the alternative (here factual) scenario that the door is closed only implicitly, meaning that it does not require this scenario to be named. In addition to this property, negations share other essential features with uncertainty expressions. As outlined below, this set of commonalities provides further hints supporting the perspective that uncertainty might decay in memory over time – just as negations do.

Some Similarities to Negations – Potential Implications for Speculative Language

Another rationale for why linguistic uncertainty might be neglected or forgotten is found in research on negation. Several *similarities* that negations and speculations share argue in favor of models on the former being potentially relevant to understand how speculation is remembered: First, negations and uncertainty expressions constitute linguistic operators that modify the meaning of an otherwise factual statement. Accordingly, negations like speculative formulations are linguistically marked by words such as "not" or "might", whereas factual formulations are not. In addition to this structural correspondence, two of the previously described linguistic functions of speculative formulations also apply to negations: As stated above, both kinds of formulations posit *alternatives* (see also Dudschig & Kaup, 2018; Hasson & Glucksberg, 2006; Wirth et al., 2019 for a similar argumentation). For

instance, the negation "The door is not closed" and the parallel speculation "The door might be closed", both point to the implicitly suggested or potential alternative that the door is open. Further, both negations and speculations express a *speakers' distancing* from a content: The speaker either denies (negates) or questions (speculates about) a contents' truth.

These similarities suggest that models of negation research could also be informative for the case of speculative formulations. Notably, compared to the previous approach concerning the handling of alternatives, these models allow more specific predictions on how speculations are mentally represented and remembered.

From a psychological point of view, negation can be defined as the mental operation of rejecting the truth of a statement (Gilbert, 1991). The cognitive structures that characterize rejection and acceptance have been the subject of extensive discussion in psychological work. Two kinds of positions can be distinguished here: In earlier models, several researchers proposed that mental representations emerge from two subsequent processes: The first is directed at understanding a statement, whereas the second serves to form a position on this statement's truth, resulting in its acceptance or rejection (e.g., Zimbardo & Leippe, 1991).

Later models, however, disputed this assumption by supposing that "understanding" and "believing", albeit being distinct words, refer to the same mental operation. In parallel to the above-described models on the handling of alternatives, Gilbert et al. (1990; see also Gilbert, 1991; Gilbert et al., 1993) supposed a first process functionally related to perception: It operates fast, upstream, and solely in agreement. Consequently, thinking should appear valid here as a matter of course – just as the table at which we work intuitively seems to us as existent. This "experiential mode" of processing precedes more complex reflective considerations that are capable of distancing one's own thinking from its object and are therefore able to question or negate. Thus, according to this model, *believing* should be "easy and inexorable" (p. 231), as represented by the first process. In contrast, as part of the second process, "*doubt*" and thinking of alternatives is considered as "retrospective, difficult, and only occasionally successful" (p. 231) and therefore carries the risk of failure. Although this model might have an intuitive appeal, it contains a strong assumption relevant for the present work: In contrast to most of the earlier psychological accounts, it *opposes* the possibility of a neutral mental representation of ideas without any reference to their validity. Instead, it supposes "initial acceptance" to be the basic mode of thinking.

Notably, the assumption of "initial acceptance" is also prevalent in many models on processing explicit negation that could be transferred to speculative language (Clark & Chase, 1972; Fiedler et al., 1996; Hasson & Glucksberg, 2006; Loftus, 1975; Mayo et al., 2004). One of them is the "schema plus tag model" (Mayo et al., 2004). It supposes that in order to process or comprehend a negated statement, one needs to represent the enclosed *affirmation* first. For instance, if one is told, "Arson did not cause the fire" the concept of "arson" would be activated first, along with congruent associations to this word (such as ideas about possible perpetrators). Only thereafter, a *negation tag* can be mentally attached. In contrast, understanding a factual formulation should not require this two-step procedure, as no validity tag is needed in this case. This model implies a specific memory distortion crucial for the present work: Negation tags might be *detached* over time, leading to memories representing a negated content as if it had been affirmed. Conversely, the memory of factual formulations should be less susceptible to error.

Several studies support this prediction in a broader sense. For instance, in one study, participants saw a videotape of an apartment and were asked to indicate which of a list of objects were present and which were not (Fiedler et al., 1996). While the participants gave correct answers in this immediate task, they had false affirmative intrusions after a period of time had passed, meaning that they did remember negated objects (e.g., "there was no hat rack in the apartment") as having been *present* before (more often than they falsely recognized objects they were not asked about; see also Maciuszek & Polczyk, 2017 for a replication). Mayo et al. (2004) extended this finding to written descriptions of a persons' character that were either expressed by affirmative or negated sentences. They showed that while affirmative descriptions were reproduced correctly in most cases, negated descriptions were prone to error and led to memories reflecting the *opposite* of what was actually read. In addition, Skurnik et al. (2005) found that similar effects can arise even for materials on which prior knowledge potentially exists. In this study, the participants remembered that "the side effects of the flu vaccine are more dangerous than the flu itself", although this statement was flagged as *false* in the first place. The opposite mistake of misidentifying facts as myths, in contrast, did rarely occur.

In sum, it appears that providing or reading a negative statement can create *false affirmative* memories in line with the predictions of the schema plus tag model. This indicates that a negation operator can get lost or is less accessible in memory than the entailed proposition, which might be due to the abstract nature of the former and the comparably

higher salience of the proposition itself (e.g., Wegner et al., 1981). But could a similar distortion arise when being confronted with *speculative* language that arguably resembles negations in crucial ways? This would imply that people tend to forget uncertainty expressions (e.g., the "might" or "could" in a speculative statement) – which would ultimately lead them to misremember mere speculation as being a confirmed fact later on. In other words, this perspective would support the idea that *uncertainty does decay in memory*.

Indeed, theoretical considerations and first experiments could provide initial evidence for this presumption. A first and indirect hint could be that the schema plus tag model particularly applies to those negations that imply uncertainty themselves and, thus, are most similar to speculative formulations (Mayo et al., 2004). In detail, studies show that specifically those negations that lack a *well-defined opposite* seem to be mentally represented via abstract tags. "Arson did not cause the fire" is an example for this negation type, which simply rules out Arson as the cause, but fails to suggest an alternative one. However, as soon as a negation implies an unambiguous affirmation (as in case of "the door is not closed", which means it is open), the prevalence of negation forgetting appears to decline (Hasson et al., 2005; Mayo et al., 2004). As findings suggest, negations are represented via their translation into an affirmative fact in this latter case. Notably, speculations cannot be transformed into a single fact by definition (just as negations lacking a well-defined opposite); otherwise, the entailed uncertainty would be lost. Consequently, for the case of speculations, a fundamental prerequisite of the schema plus tag model is necessarily met. It, therefore, appears reasonable that uncertainty cues are mentally treated similarly as negations without an affirmative translation, suggesting a tendency to forget these cues over time.

More direct evidence stems from a few experiments that studied the handling and memory of uncertainty expressions themselves. Although these studies have several constraints, they provide initial hints toward people *neglecting* uncertainty cues – which conforms to the schema plus tag model. To begin with, initial empirical evidence indicates that people tend to neglect the *difference* between a factual and a speculative formulation (Wegner et al., 1981). For instance, incriminating questions in headlines about political candidates (e.g., "Is Bob Talbert Linked With Mafia?") can influence the negative assessment of their character to an equal extent as the corresponding factual formulation. Following this result, researchers concluded that the recipients of speculations in news "seem apt to go far beyond the information given." (Wegner et al., p. 825). However, on closer inspection, it remains unclear whether this conclusion is right: Did the participants indeed *overrate* the

certainty of the speculative formulation? In principle, it would also be possible that they underrated or doubted the validity of the factual one used as a comparison standard.

A phenomenon called *statement bias* arguably favors the former option (Pandelaere & Dewitte, 2006). It denotes the tendency to remember previously read trivia questions (e.g., "Do fresh-water snakes swim upside down for about half of the time?") as statements more often than to remember statements as questions. At first glance, this bias could indicate the predicted loss of uncertainty cues, here represented through a question. However, one should not disregard that a statement bias was demonstrated so far only for relatively artificial material that lacked any context specifying what exactly a question or statement meant and what intentions it involved. Thus, the question is raised whether the statement bias can inform the memory of content-enriched materials, such as speculations and facts in the context of news.

In this regard, Dodd and Bradshaw (1980) formulated a profound critique. They stated that "the *pragmatics* of language in the psychological laboratory is decidedly odd and bears little resemblance to most ordinary speaker-listener communications. In experiments of the kind described above, it is not clear what intentions the speaker has in asking a leading question since it is not clear who the speaker is nor what purposes that speaker might have. Therefore, the influence of presuppositions on memory may be restricted to these unusual pragmatic conditions". (p. 696) With these words, Dodd and Bradshaw referred to the problem of *ecological validity*: It remains unclear whether memory tendencies arising for context-lacking material can inform the memory of meaningful uncertainty – such as present in speculative news – in any way.

In sum, there are theoretical reasons to assume that people tend to *neglect* (forget) uncertainty cues in language – derived from research on hypothetical thinking, negation models, and the "statement bias". Still, profound empirical work addressing this hypothesis is lacking or suffering from constraints. As outlined above, the only two studies existing are either ambivalent with regard to the conclusions to be drawn or did not specify what uncertainty expressions exactly meant as no well-defined context was given.

With this dissertation, I aimed to tie into this critique in two ways: First, I address the processing and memory of uncertainty cues in a specific, meaningful and relevant application context, namely speculative explanations in the domain of news. Second, I investigate the influence of the broader context of a message *explicitly* by manipulating the *composition* of

the short news articles presented and considering its impact on the memory of individual pieces of news. Note that the schema plus tag model only considers the memory of uncertainty expressions in terms of the specific content to which these expressions refer. Accordingly, the unit of inquiry is a *single* speculative formulation that is considered *apart* from its context of appearance, which parallels the methodological approach used in the few existing studies in this field (Pandelaere & Dewitte, 2006). However, speculative formulations in the news could also elicit effects that reach far beyond the memory of the speculative content itself: They could impact how people receive other articles that are presented *in their context*. This is the point from which the second perspective of this thesis begins.

An Alternative Perspective: Does Uncertainty Spread to Unrelated Information?

The above perspective suggested that people might tend to forget uncertainty expressions, just as they tend to forget negations over time. The memory of facticity, in contrast, should prove to be less prone to error, which is supported by some prior studies (Mayo et al., 2004). Yet, reading speculations in short news stories could also evoke other, more far-reaching consequences that the preceding perspective did not address. An alternative perspective taken in this thesis builds upon this potential constraint. From this perspective, uncertainty as present in news stories is not necessarily remembered at the level of an individual statement, headline, or article but can also provoke cross-item effects. That is, it can affect the reception and memory of other pieces of news that are presented along with speculative ones, for instance, as part of the same headline overview. Indeed, *mindset* studies and applied research on *news reception* provide initial evidence in support of this alternative view. Compared with negation studies, they suggest an opposite conclusion: Instead of getting lost, uncertainty as present in speculative news might also *spread* by reducing the remembered certainty of jointly presented but otherwise unrelated *facts*. Approaches and evidence in line with this spreading perspective shall be outlined below.

The Tendency to Overestimate Uncertainty

Although a huge body of research focuses on people's credulity, on believing in "fake news", neglecting alternatives, or forgetting corrections and negations (Mayo, 2015), some

studies also center on the opposite case of doubting the *fact*. This work suggests that uncertainty is by no means always neglected.

On the contrary, several phenomena concerning news and science communication indicate that people sometimes *overestimate* uncertainty just as well (Dixon & Clarke, 2013). A striking example for this tendency is anthropogenic climate change. While more than 90 percent of the researchers in this field agree that this phenomenon exists, segments of the general population understate the scientific consensus and remain unconvinced (Anderegg et al., 2010; Ding et al., 2011; Doran & Zimmerman, 2009). Researchers have put forward several factors which could lead people to consider knowledge as more uncertain than it actually is, reaching from an incompatible worldview of the recipient (Dunlap & McCright, 2008; Feygina et al., 2010; Heath & Gifford, 2006; Kahan et al., 2011; Lewandowsky et al., 2013) to a falsely balanced reporting of opposing perspectives in the news (Cook et al., 2017; Dixon & Clarke, 2013).

These studies are important for the present thesis as they indicate that people overestimate uncertainty concerning confirmed information under some circumstances, showing that more factors are necessary to understand the processing of facticity and uncertainty beyond linguistic structures. What the reported studies have in common, however, is that they conceptualize "false" uncertainty as a *substantive* phenomenon, which differs from the focus of this thesis. For example, these studies see uncertainty as rooted in preconceptions that *oppose* measures to mitigate climate change (e.g., Lewandowsky et al., 2013) or as driven by contradictory reports addressing *one* issue, such as a vaccine-autism link (e.g., Dixon & Clarke, 2013). Accordingly, opposing views, by which uncertainty is created, always center around a specific content here. The following section will discuss studies and theories that go beyond these content-bound effects and thus approach my research question even more closely. These studies might serve as initial hints supporting the hypotheses that uncertainty expressions in some reports could evoke uncertainty concerning *other* articles, even though their contents are not related in any kind.

Initial Evidence for Cross-Item Effects of Uncertainty

To the best of my knowledge, cross-item effects triggered by reading speculations have neither been studied empirically nor targeted by current theoretical accounts. Still, two

separate strands of studies might yield first indications in line with the proposed effect that uncertainty may spread across memories.

One of them is *mindset research*. Studies from this domain show that specific forms of uncertainty, namely distrust, and skepticism, can evoke effects that reach far beyond the concrete items that triggered these states (e.g., Mayo, 2015; Schul et al., 2004, 2008;). For instance, seeing faces associated with false information before changed the way participants processed other information unrelated to the trust issue and led them to consider alternatives to the contents they read (Schul et al., 2004). Accordingly, single items appeared to trigger a more general state of scepticism which extended to contents not related to the source of this scepticism in any meaningful way.

Can such findings be transferred to the domain of (speculations on the) news? Initial evidence for cross-item effects in news reception stems from research on "fake news" warnings. Essentially, findings from this domain indicate that recipients represent news articles of differing credibility (i.e., those with and those without a "fake news" flag) in an interconnected network in their minds if these news articles had been read together, for instance, as part of a headline overview. Yet, observed phenomena resulting from these interconnections appear to be partly contradictory.

On the one hand, some prior work describes what I refer to as "*contrast effects*". Findings here suggest that the mere presence of some questionable contents in the news (i.e., some news tagged with fake news warnings) can reinforce the salience and perceived accuracy of the other, unrelated pieces of news that are framed to be certain information (Pennycook et al., 2020). Indeed, speculative news could cause factual formulations to "stand out" similarly, fostering a correct memory of the latter. Notably, the effect proposed here – albeit hinting at the role of contextual headlines – contradicts the idea of uncertainty spreading to factual news.

This perspective, however, can be contrasted with findings that point out a reverse effect, namely, a potential *spreading* of cues toward doubt if a more extended period of time is considered: Indeed, being exposed to "fake news" warnings can also evoke a general sense of skepticism towards subsequently read, unrelated "fake news" that one was not warned about (Pennycook et al., 2018). This means that warnings did not exclusively affect the specific contents to which they were attached but also reduced the credibility of unrelated pieces of "news" presented later. In other words, these warnings seemed to cause "spreading

effects", rather than strengthen the other statements' credibility (as a contrast effect would propose).

This latter finding is relevant for the present work as it provides initial support for the potential spreading of cues toward doubt in the news domain. Still, it is a point outstanding whether intermingling speculations could provoke a similar spreading effect as "fake news" tags on the reception of factual news. On the one hand, one might argue that "fake news" tags resemble uncertainty expressions since both indicate questionable content. Considering this, it seems reasonable to assume that speculations could also trigger spreading effects. On the other hand, however, unlike "fake news" tags, speculations do not imply any attempt to defraud, but represent the state-of-the-art that an assumption is currently being examined instead. Moreover, previous studies on cross-item effects have exclusively focused on immediate perceptions of the *accuracy* of a news content but not on memory distortions concerning its reported certainty. It, therefore, remains to be tested whether uncertainty as present in speculative news could spread similarly in memory as skepticism evoked by "fake news" warnings does.

Dissertation Overview

As argued in the previous sections, the question of how speculations in the news affect memory biases is essential yet still unanswered. In this regard, different theoretical and empirical backgrounds inspire two opposing hypotheses. On the one hand, people may tend to neglect uncertainty expressions. An overwhelming amount of prior research favors this first perspective. Indeed, the tendency toward remembering negations as affirmations has been highlighted as one of the most robust memory phenomena in earlier work (Mayo, 2015), and could suggest that uncertainty cues could get lost in memory just as well.

On the other hand, instead of being forgotten, uncertainty could also *spread*, causing facts to be remembered as uncertain information (second perspective). A handful of studies taking a more applied approach suggest this contrasting pattern. This latter work has in common that uncertainty is not conceptualized as being tied to individual items here but understood in terms of potential cross-item effects. Consequently, the question of which memory tendencies arise when encountering speculations in the news mirrors the theoretical question of how broadly the unit of inquiry should be defined.

To the best of my knowledge, no prior work exists that empirically compared these opposing theoretical accounts concerning the mental processing of speculative formulations in the news (or in any other clearly defined domain). This is surprising since both proposed effects, a forgetting or spreading of uncertainty in memory, would be informative not only in terms of different theoretical accounts but also for news practices.

Following these considerations, this dissertation aimed to systematically study and contrast both perspectives in the highly relevant domain of news using a range of different indicators. Three empirical chapters comprising a total of 13 experiments and 3265 subjects provide the empirical basis for this. **Chapter 2** addresses the possibility that uncertainty might be neglected over time as supposed by the **forgetting perspective**. It followed the logic of negation studies by considering the memory for and belief in individual pieces of news. In detail, in the first two studies of this chapter, I asked participants how likely they judged previously read explanations for different events to be true. These explanations had either been presented in a short news article framed as speculation, fact or were not presented before. In line with the first perspective and findings from the related case of negation, I expected that participants would *neglect* the difference between both formulations in their later judgments. Accordingly, reading facts and speculations should increase the participants' beliefs in the presented explanations to an equal extent.

To more explicitly address the predictions of the schema plus tag model, I conducted four additional memory experiments. These tested the hypothesis that people tend to *neglect* uncertainty cues, meaning they should remember speculations as facts more often than falling for the inverse mistake (of remembering facts as speculations). Memories were assessed either via recognition or cued recall, and uncertainty was manipulated by using different kinds of expressions (i.e., questions or statements qualified by the modal axillary "might") in order to be able to draw method-independent conclusions on the processing of speculation in the news.

In **Chapter 3**, I took a broader perspective by investigating what effects uncertainty expressions in the news could hold *beyond* their intended scope, that is, how they could affect memories of factual news presented among them. I addressed this by manipulating the *composition* of the presented short news articles. The participants read either articles reporting exclusively speculative news, exclusively factual news, or a mixture of both. The main hypothesis was that having read speculations would *decrease* the remembered certainty of jointly presented facts. In contrast, the effect of having read facts on the memory of speculations should be less pronounced. This pattern would be in line with the second

theoretical approach, the **spreading perspective**. In two additional experiments, I manipulated the presentation order of both types of news and the number of speculations intermingled. The aim was to draw conclusions on whether the presence of speculations can change the encoding of other news articles or impact their memory representations in retrospect. Further, I sought to study whether the effect of interspersing speculations grows in size with their number.

The final empirical chapter, **Chapter 4**, consisting of three experiments, combined the two perspectives of the previous ones by directly comparing the influence of reading *speculations* on remembering facticity with the potential effect of reading *negations*, which build one starting point of this thesis. In three experiments, participants read factual pieces of news ("X caused Y") interspersed with speculations, negations, or other facts. These experiments aimed to investigate whether speculations and negations are processed similarly or do entail different memory consequences. In my third experiment, I applied a signal detection framework to directly compare the discriminability of facts and negations versus facts and speculations. The goal was to understand the mental structures representing negations versus speculations that were read among factual news.

In sum, this thesis combined and tested two distinct theoretical approaches concerning the memory of speculation. In doing so, all my experiments centered around one question, relevant also from an applied perspective: Do people tend to neglect uncertainty expressions in the news, or do they rather doubt the facts presented among speculation? My results are described in the following three empirical chapters (Chapter 2, 3 & 4), and their overall theoretical and practical implications are outlined in Chapter 5, the General Discussion. Please note that the empirical chapters were written as independent manuscripts that are partly publicized. Thus, their contents can overlap with each other and with the General Introduction and Discussion.

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Declaration according to § 5 Abs. 2 No. 8 of the PhD regulations of the Faculty of Science
-Collaborative Publications-

The following chapter (Chapter 2) consists of a manuscript that is published and was co-authored by Annika Scholl and Hauke S. Meyerhoff. The proportional contributions to this manuscript are presented in the subsequent table.

Author	Author position	Scientific ideas	Data generation	Analysis & interpretation	Paper writing
Ann-Kathrin Brand	First author	80 %	100 %	80 %	70 %
Annika Scholl	Second author	10 %	0 %	10 %	15 %
Hauke S. Meyerhoff	Third author	10 %	0 %	10 %	15 %

Title of paper: In case of doubt for the speculation? When people falsely remember facts in the news as being uncertain.

Status in publication process: Published. Brand, A. K., Scholl, A., & Meyerhoff, H. S. (2021). In case of doubt for the speculation? When people falsely remember facts in the news as being uncertain. *Journal of Experimental Psychology: General*.

Chapter 2: In Case of Doubt for the Speculation?

Negation Models Cannot Explain How Recipients Remember Speculative Language

"[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 [...]" (Sanger & Edmondson), whereas according to the Washington Post, this was only "probably" the case (Demirjian & Itkowitz). However, even if news reports correctly expose insufficiently confirmed information as speculative rather than factual, for instance, by using adverbs such as "probably", 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*.

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 linguistic 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 & Perdew, 2016). Yet, one adjoining field of psychological research 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 that 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, 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 a separate cognitive unit that 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). In contrast, 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 various alternatives and, thus, provoke uncertainty themselves.

Still, it is crucial 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 remembering isolated

questions is representative for remembering 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 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 recall[1]). 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 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/).

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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).

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 (α = .05, (1- β) > .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 reliably 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_{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 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 2.1).

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 2.1. 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 minute[2].

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 Tsfati & 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).

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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).

Results

As Figure 2.2 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 2.2).
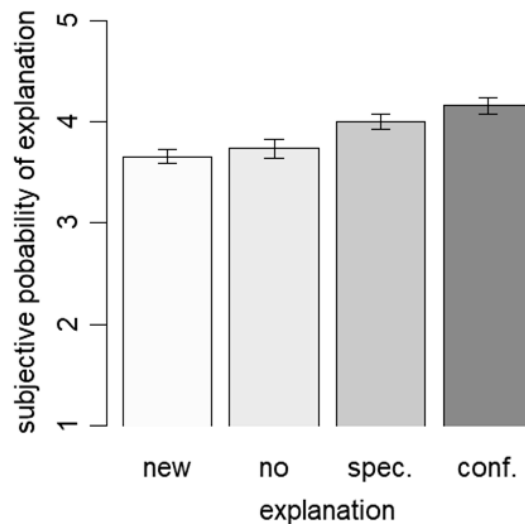

Figure 2.2. Results of Experiment 1A. Mean probability ratings of explanations for the conditions "new", "no", "speculative", and "confirmed explanation" with 95%-confidence intervals for within-participants comparisons (method: Cousineau-Morey intervals with adaption by Baguley, 2012). Note: spec. = 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 2.3 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.
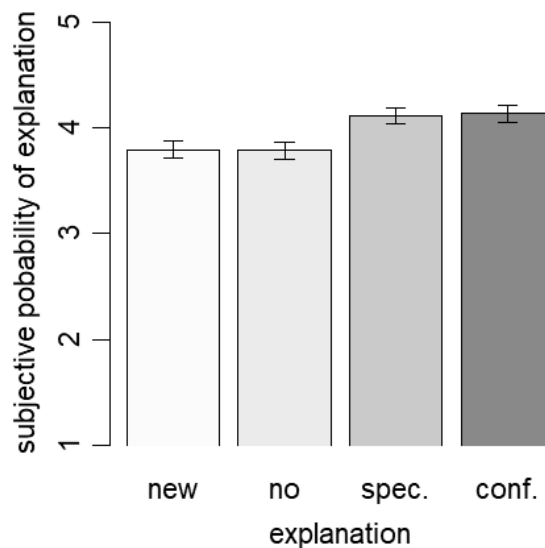

Figure 2.3. Results of Experiment 1B. Mean probability ratings of explanations for the conditions "new", "no", "speculative" and "confirmed explanation" with 95%-confidence intervals for within-participants comparisons. Note: spec. = speculative explanation; conf. = confirmed explanation.

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, $t(89) = 0.27$, $p_{orrected} > .999$. Instead, speculative and confirmed explanations had almost identical effects on subjective probability ratings as depicted in Figure 2.3.

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_{age}=36.4 years; SD_{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 2.1). 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 2.1; see Appendix 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 2.4 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, $X^2(1) = 43.07$, $p < .001$, $R^2_m = .10$, $R^2_c = .23$. As depicted in Figure 2.4, 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.
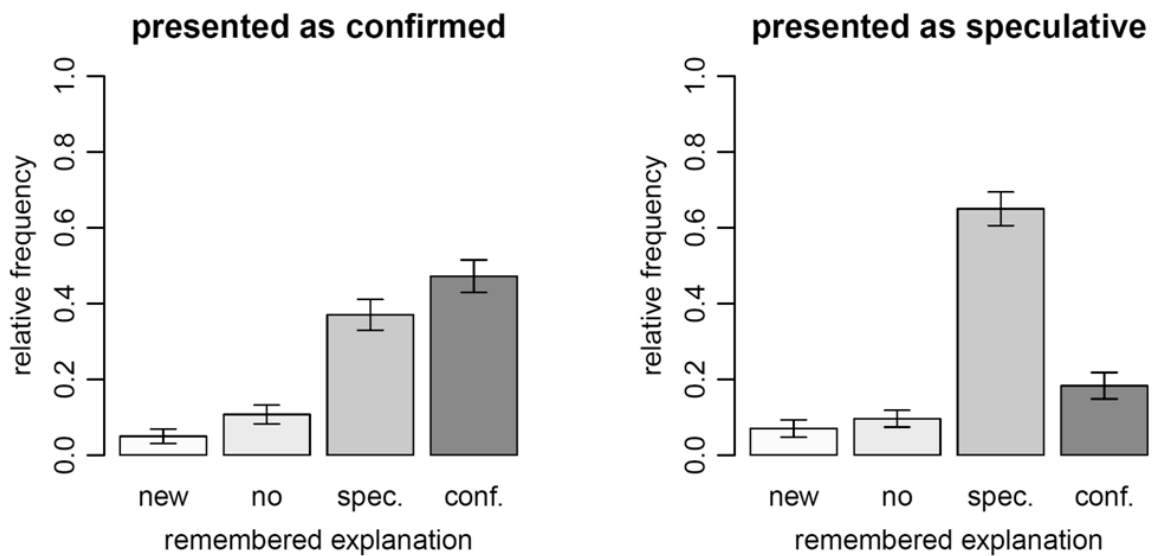
Figure 2.4. Results of Experiment 2A: Memory for headlines depending on whether they were previously presented as 'confirmed' (left graph) and 'speculative' (right graph); bars indicate the relative frequency with which the respective event and explanation were remembered as being new vs. not explained 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.

Table 2.1

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".

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]

Method

Participants. Following the previous studies, participants were recruited online from Prolific Academic. The participants who took part in our prior studies[4] 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; $M_{age}=35.2$ years; $SD_{age}=11.7$ 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

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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.

[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.

afternoon", see Figure 2.1 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 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]

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

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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".

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 2.5 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", $X^2(1) = 11.54$, $p < .001$, $R_m^2 = .04$, $R_c^2 = .23$. Although, on average, 13 % of the speculative explanations presented first were falsely reproduced as being certain (Figure 2.5), 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.
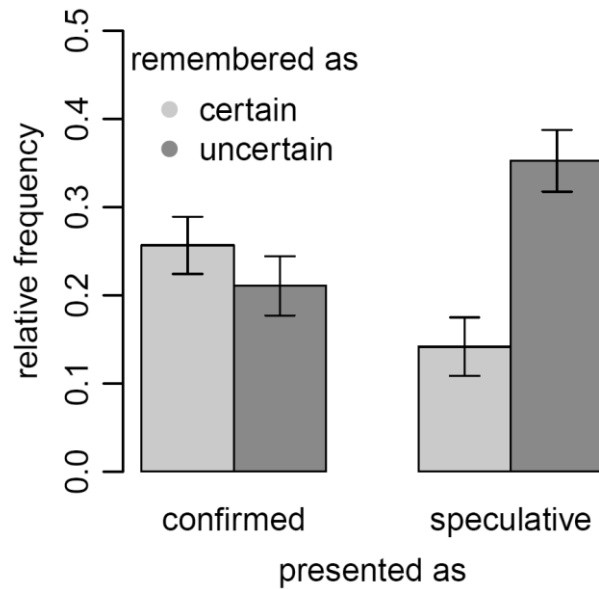
Figure 2.5. Results of Experiment 2B. Relative frequency of remembering explanations either as certain or uncertain depending on whether they were initially presented as confirmed (left pair of bars) vs. speculative (right pair of bars) with 95%-confidence intervals for within-participants comparisons. 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_{age}=37.24 years; SD_{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 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 2.6, the participants rated both speculative and confirmed explanations as *more probable* after explicit recollection

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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.

(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.
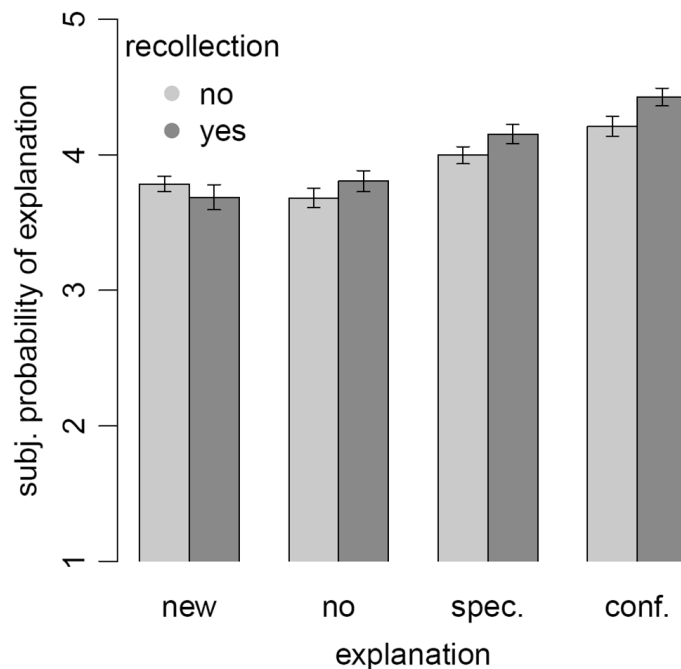
Figure 2.6. Results of Experiment 3: Subjective probability of an explanation depending on the type of previously presented headline (new / no / spec. = speculative; conf. = confirmed) as well as on explicit recollection of the headline's content (yes / no) with SEM.

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 2.7). 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 $X^2(1) = 31.09$, $p < .001$, $R^2_m = .07$, $R^2_c = .19$. As depicted in Figure 2.7, 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.
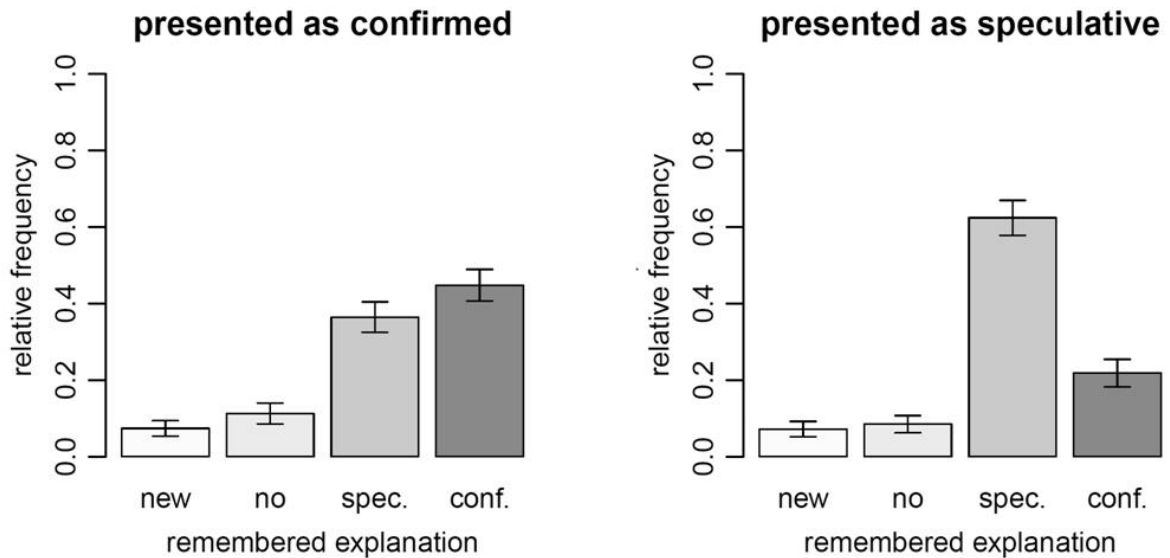
Figure 2.7. Results of the *Recollection* Condition of Experiment 3: Relative frequency of remembering a headline as new vs. including no vs. a spec.=speculative vs. a conf.=confirmed explanation, depending on whether the headline was previously presented as confirmed (left graph) or as speculative (right 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.", Chang, Oct. 16, 2020, or "*Can* an *air purifier help protect* you *against* the *coronavirus*?", Daily, Oct. 19, 2020, both published 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 $N = 94$ participants (65 females, 27 males, and 2 indicated "other"; $M_{age}=37.76$ years; $SD_{age}=14.62$ 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

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

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 human remains that might be from Tulsa's 1921 race massacre", Brown, published in Oct 21, 2020, or "Laker fans' parties, celebrations might have fueled L.A. coronavirus spike, official says", Boren, 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 $X^2(1) = 97.39$, $p < .001$, $R^2_m = .22$, $R^2_c = .32$. As Figure 2.8 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.
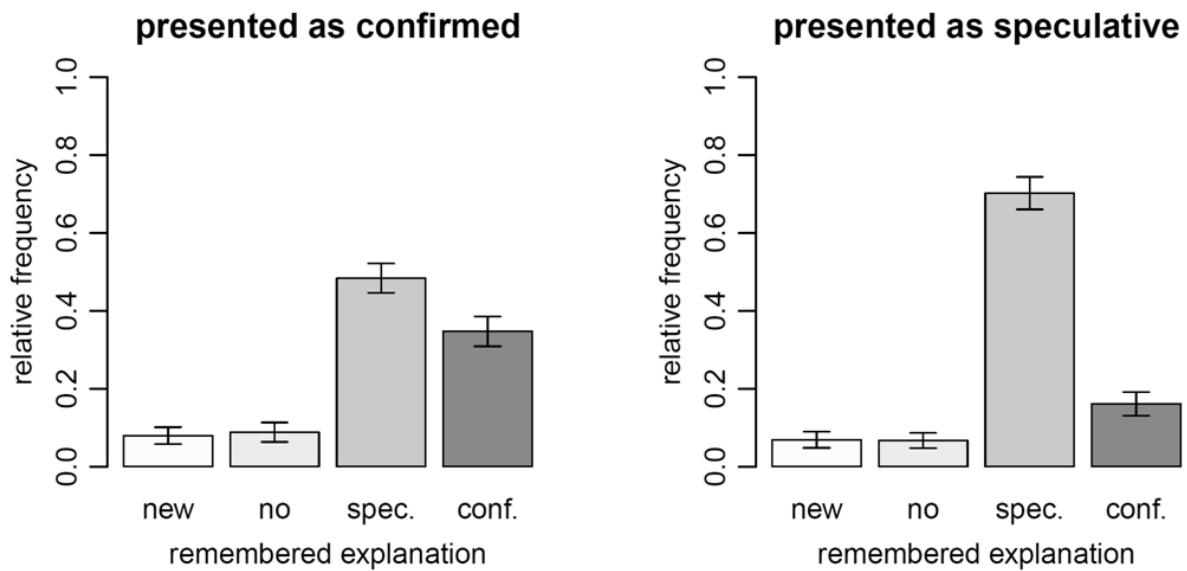
Figure 2.8. Results of Experiment 4: Relative frequency of remembered headline types (new vs. no vs. spec.=speculative vs. conf.=confirmed explanation) depending on whether a headline was previously presented as confirmed (left graph) or speculative (right graph) with 95%-confidence intervals for within-participants 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 *broader 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, 1991; Gilbert et al., 1990, 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 (Nadarevic & Erdfelder, 2013, 2019; Street & Richardson, 2015). 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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Declaration according to § 5 Abs. 2 No. 8 of the PhD regulations of the Faculty of Science
-Collaborative Publications-

The following chapter (Chapter 3) consists of a manuscript that is published and was co-authored by Hauke S. Meyerhoff, Florian Holl and Annika Scholl. The proportional contributions to this manuscript are presented in the subsequent table.

Author	Author position	Scientific ideas	Data generation	Analysis & interpretation	Paper writing
Ann-Kathrin Brand	First author	70 %	90 %	70 %	70 %
Hauke S. Meyerhoff	Second author	10 %	0 %	10 %	15 %
Florian Holl	Third author	10 %	10 %	10 %	0 %
Annika Scholl	Fourth author	10 %	0 %	10 %	15 %

Title of paper: When Linguistic Uncertainty Spreads Across Pieces of Information: Remembering Facts on the News as Speculation

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Chapter 3: When Linguistic Uncertainty Spreads Across Pieces of Information

Remembering Facts on the News as Speculation

Providing people with timely information based on independent reports is an integral part of democratic societal orders. With the rise of modern online media, however, access to news covering the latest worldwide events has been changing profoundly. This holds true not only for the speed and diversity of reporting but also for the *way* distinct pieces of news are presented. Online articles consisting of either *facts* or *unconfirmed speculations* first and foremost appear in a concise and abridged, frequently also intermingled form as a headline overview (e.g., via news pages on the internet or various social media channels). This observation suggests that, for recipients, it might prove difficult to distinguish between factual and unconfirmed contents while reading, as well as in retrospect.

Indeed, over the past fifty years, a vast body of research has accrued, revealing the many ways in which unconfirmed contents might propagate. Examples are phenomena such as illusory truth (e.g., Hasher et al., 1977; Pennycook et al., 2018) or the continued influence of corrected misinformation (e.g., Johnson & Seifert, 1994). Yet, the potential memory effects of an *intertwined* presentation of unconfirmed and factual contents on the news (as is typically the case in an applied setting) have remained widely neglected so far. How could the presence of speculation impact the recollection of reported facts embedded among the former?

The present work sought to address this question with regard to a widespread but barely studied language phenomenon on the news: Pieces of news can vary with respect to the *presence* or *absence* of subtle but decisive linguistic uncertainty expressions, as in the headline "[…] snowstorms might be to blame for lag in coronavirus vaccine allocation" (30th of December, 2020). Notably, this headline includes the word "might" to index mere speculation (here, snowstorms may or may not be the reason) instead of facticity.

A news context providing such uncertainty expressions could impact how people remember unrelated factual news in several ways. On the one hand, embedding facts among speculations could allow facts to *stand out,* which might improve their credence and memorization. On the other hand, uncertainty cues could also *spread onto* memories of reported facts, causing these facts to appear less certain in retrospect. The present work

examined both possibilities by bringing together language and memory psychology models with applied research on news processing.

In doing so, we extend existing work that has so far conceptualized and understood cues of (un)certainty in language mainly with regard to the specific content these cues referred to (e.g., Pandelaere & Dewitte, 2006), but not in terms of potential contrast or spreading effects *across* different items – such as individual pieces of news. This broader perspective could inform theories on mental structures representing (un)certainty, and have implications for practical matters. Notably, from an applied perspective, studying potential, unwanted side effects of reporting facts among speculations is critical for news reporting and eventually serves as a starting point to develop new communication forms that support readers in remembering information correctly.

The Language of Uncertainty: How Speculations Differ from Facts

Speculation can be expressed through various means, for instance, through explicitly stating a lack of confirmation, posing a question, or using modal auxiliary verbs such as "might" or "could". From a linguistic perspective, a speculative formulation (e.g., "snowstorms might be to blame for a lag in coronavirus vaccine allocation") shares the same proposition with its corresponding factual version (e.g., "snowstorms are to blame…"). Crucially, however, both types of formulations differ in their *epistemic modality* – that is, in the level of linguistic (un)certainty that they express. According to Coates (1987), epistemic modality is "concerned with the speaker's assumptions, or assessment of possibilities, and, in most cases, it indicates the speaker's confidence or lack of confidence in the truth of the proposition expressed". Two core differences of speculative and factual formulations can be derived from this definition. First, speculations differ from facts as the former convey that a claim does not inevitably refer to the actual state of affairs but exposes one *possibility* alongside others (Chung & Timberlake, 1985). Speculations, therefore, point toward alternatives whereas factual formulations do not. Second, speculations and facts indicate a different relationship of a speaker to what is said: Framing content as factual implies agreement of the speaker's stance on the uttered proposition. In contrast, formulating the same content as speculative indicates that the speaker *detaches from* this proposition, for instance, due to doubt, a lack of knowledge, or missing evidence (Druzdzel, 1989; Lyons, 1977; Palmer, 1986/2001; Teigen, 1988).

Both functional differences suggest that the complexity of speculative formulations exceeds that of factual ones. Yet, it remains unclear what memory consequences these differences could imply. In the following, we outline two perspectives on remembering (un)certainty expressions in the news: First, we outline a 'narrow' view that conceptualizes (un)certainty cues in isolation by defining *single* speculations versus facts as units of investigation; this view formed the basis of prior work. We then introduce a 'broader' approach that considers the *context* in which speculations appear. This latter perspective argues that uncertainty cues might impact the recollection of other news *beyond* their intended scope. Both perspectives can be subsumed under two questions: Do people forget uncertainty cues? Or could uncertainty also spread onto other memories such as those of jointly presented facts?

(Un)certainty Cues in Isolation: Do People Forget Uncertainty Cues?

Thus far, the mental processing and recollection of speculations have hardly been studied from a psychological point of view. Moreover, the scarce research existing to date has focused solely on memories of single speculations as a unit of investigation. Accordingly, potential interferences that might emerge while remembering a *mixture* of speculations and facts (as often reported in the news) have not been subject to previous work. In the following, we argue why this perspective needs to be broadened.

Previous work on speculations was mainly inspired by research on *negations* and by the models present in this field, as negations (e.g., "X did not cause Y") resemble speculations (e.g., "X might have caused Y") in many ways. First, both message types indicate that speakers 'distance' themselves from the uttered proposition – either by questioning its correctness (in case of speculations) or in its most extreme way by denying its truth (in case of negations). Second, both speculations and negations refer to the existence of alternatives (here, alternative causes for Y). Particularly, negations point to both the supposedly factual and the counterfactual state of affairs that the utterance disclaims (see Dudschig & Kaup, 2018; Hasson & Glucksberg, 2006; Winter et al., 2020; Wirth et al., 2019, for a similar argumentation).

Regarding the effects on memory (that we target in the present work), studies have shown that people tend to forget negations (Fiedler et al., 1996; Maciuszek & Polczyk, 2017; Mayo et al., 2004), meaning that they misremember a negated message (e.g., "He is not guilty") as if it had been affirmed ("He is guilty"). The *schema plus tag model* explains such

errors (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975; Mayo et al., 2004). It assumes that a negated statement is represented via two cognitive units, the core supposition (e.g., "He is guilty") and the negation tag ("not"). Due to this representation structure, the negation tag might be detached over time, leading to memories that express the opposite of the original meaning. Essentially, this model predicts memories of *factual* formulations to be less error-prone, as they do not require a tagged representation.

As speculations share crucial commonalities with negations, some researchers have suggested that similar memory errors could arise when reading a mixture of uncertain formulations (i.e., speculations) and facts (Brand et al., 2021; Pandelaere & Dewitte, 2006). Applied to speculations, the schema plus tag model would forecast a specific, testable distortion: Recipients should tend to forget uncertainty cues (e.g., "might") included in speculations, meaning that they misremember speculations as facts later, just as people are known to forget negations. In contrast, the reverse mistake of remembering facts as speculations should rarely occur according to this model.

Surprisingly, however, the one series of experiments that explicitly tested this prediction found a *reverse* pattern of results, namely, the tendency to misremember facts as speculative later on (Brand et al., 2021). This finding is central to our further argumentation. In these experiments, participants read a mixture of explanations in short news articles consisting of an equal number of speculations (that were under investigation yet unconfirmed) and facts. The participants then recollected the presented contents after a temporal delay, either by recognition or cued recall. Findings indicated that a previously read speculative explanation doubled the overall frequency of falsely recognizing this explanation as a fact later (relative to receiving no explanation at all). However, the experiments also revealed that the *opposite mistake* was much more likely: Participants *misremembered facts* as having been mere speculation (e.g., as being not yet confirmed) almost twice as often as they did misremember speculations as facts. This memory tendency (bias) toward uncertainty contradicts the predictions one would draw from the schema plus tag model, which would forecast a memory bias toward *facticity* instead (i.e., uncertainty being forgotten).

The project at hand set out to explain this surprising result. To do so, we went beyond previous work by taking a broader perspective that exceeds single items as the units of investigation. Instead, we considered the *context* in which uncertainty cues appear: Could the presence of speculations decrease the remembered certainty of unrelated, but jointly presented facts? We tested this in the domain of news.

Uncertainty Cues in Context: Does Uncertainty Spread Across Memories?

As the preceding remarks show, previous models on processing *single* speculations and facts seem to have little predictive power for the memory of a *mixture* of both message types. Still, the question remains how a bias to misremember and reproduce facts as mere speculation (Brand et al., 2021) could be explained. The present work examined a potential mechanism that might have provoked this effect: We propose that uncertainty cues (e.g., "might", "could", or the framing as a question) as present in speculations may *spread onto* the memory of unrelated, factual news. This mechanism, in turn, could explain why facts that were read among speculations in prior work did appear to be more uncertain in retrospect than initially communicated. Phrased differently, we suggest that a memory bias toward uncertainty is *context-driven* and therefore elicited by the *presence* of speculations (as a context) – instead of occurring independently of other intermixed news.

Demonstrating such a *spreading* of uncertainty cues would be of practical and theoretical relevance: On the practical side, this effect would suggest that the mere presence of speculative contents on the news could disguise or discredit information that is actually very much confirmed – an effect that reporters need to be aware of.

On the theoretical side, such a context effect would question or at least expand assumptions of the schema plus tag model, which implicitly assumes the processing and recollection of facts to be robust and hardly error-prone (as compared to the processing of negations, falsehood, or doubt; e.g., Clark & Chase, 1972; Fiedler et al., 1996; Gilbert, 1991; Loftus, 1975; Mayo et al., 2004). Conversely, we suggest that how previously read facts are remembered crucially depends on whether speculative contents were initially presented among these facts or not. This contrasts sharply with previous theorizing and empirical work that conceptualized and understood cues of (un)certainty in language mainly with respect to the specific content to which these cues referred (e.g., Pandelaere & Dewitte, 2006).

To the best of our knowledge, context effects concerning the processing of linguistic (un)certainty cues have neither been researched to date nor explicitly addressed in current theoretical accounts. Nonetheless, seemingly related context effects have been reported in empirical studies on "fake news" warnings. Essentially, findings from this domain indicate that different types of news articles (i.e., those with and those without an explicit "fake news" tag) are represented in an interconnected manner when read together as part of a headline overview. In detail, these studies show that the mixture of presented news can influence how accurate readers consider individual articles to be, even in the absence of any content-wise

relation between these articles. Yet, the evidence regarding the *direction* of such interferences is mixed, supporting either contrasting effects (i.e., the presence of tagged fake news *increased* the perceived accuracy of untagged news; Pennycook et al., 2020) or spreading effects (i.e., the presence of tagged fake news *disguised* the credibility of unrelated news; Pennycook et al., 2018).

Irrespective of this mixture of findings, however, the general result pattern shows that it is necessary to investigate news processing beyond the boundaries of single articles and supports our supposition of context effects when reading facts among speculations in a broader sense. Could a spreading of uncertainty cues, thus, account for the tendency to misremember facts as speculations found in recent studies (Brand et al., 2021)? The present work investigated this possibility by manipulating which composition of speculative and factual pieces of news the participants read.

The Current Work

We conducted four preregistered experiments to investigate the possibility that uncertainty spreads towards the memory for unrelated facts and its potential mechanisms. The setups of Experiment 5A and 5B followed the same basic structure, which was slightly adapted for Experiment 6 and 7: In (1) the presentation stage, participants consecutively read several target articles (consisting of a headline plus a short teaser) that addressed distinct events (e.g., a disappeared plane, the shrinkage of a penguin colony, or an explosion) each with one explanation. Participants were later asked to recollect these target articles without prior announcement. The target articles were presented among several topically unrelated "context" articles (which had the same structure as the target articles but were not tested later). Note that the distinction between target and context articles was predetermined by us as a feature of the experimental design – it was, however, not apparent to the participants. We orthogonally manipulated two between-participant factors in a 2 (targets speculations vs. targets facts) x 2 (context consistent vs. inconsistent) design.

First, we manipulated whether all *target* articles were formulated as speculations (i.e., they presented an explanation that was currently under investigation but not yet confirmed) or facts (i.e., they presented an explanation that was confirmed through investigations). Second, we manipulated which kind of *context* articles were intermingled. The certainty of all context articles was either *consistent* or *inconsistent* with that of the target articles. In the consistent context condition, the participants from the target speculations condition read exclusively

speculations, and the participants from the target facts condition read exclusively facts. Conversely, in the inconsistent context condition, the participants read a mixture of speculations and facts in both target conditions. This structure resulted in four distinct experimental groups, as depicted in Figure 3.1.

After (2) a short distraction of about five minutes, the participants continued with (3) the assessment stage in which they were asked to recollect their memories of the *target* articles, either on the basis of short prompts (naming the events to be explained; cued recall; Experiment 5A) or through a recognition task (identifying which version of a presented set of short articles they had seen; Experiments 5B).

	Context *consistent*	Context *inconsistent*
Targets: *Speculations*	Exclusively speculations (in target and context articles)	A mixture of speculations (target articles) and facts (context articles)
Targets: *Facts*	Exclusively facts (in target and context articles)	A mixture of facts (target articles) and speculations (context articles)

Figure 3.1. Experimental groups implemented in Experiments 5A and 5B. We orthogonally manipulated the target and context articles. Information in the table indicates which types of articles participants read in the respective condition.

Experiments 5A and *5B* tested and confirmed the proposed spreading effect of uncertainty cues in memory. Two further experiments sought to extend this primary effect by drawing out its theoretical and practical implications. *Experiment 6* addressed whether an uncertain context specifically affects the way recipients *encode* unrelated news or whether such a context can also alter memories *in retrospect*. To test these two possibilities, we manipulated whether a context of speculations was encountered before or after unrelated facts were presented and then compared memory distortions concerning the latter after a temporal delay. This experimental setup also allowed us to test a potential intervention to eliminate spreading effects: Can the separation of contents that are reported to be speculations versus

facts (via a block-by-block presentation) facilitate the recollection of (un-)certainty cues compared to an intertwined presentation of both kinds of messages? Further, with *Experiment 7,* we investigated whether uncertainty spreading increases in an approximately linear manner, depending on the number of speculations presented among unrelated facts, or whether only a few speculations are all it takes to elicit uncertain memories.

Transparency and Openness: Data, Analytic Methods, and Materials

Please note that data, analytic codes, preregistrations, and materials for all studies are made available online, as indicated in the respective methods section of each experiment.

Experiment 5A: Does Uncertainty Spread from Speculations to Facts? (Cued Recall)

Experiment 5A sought to investigate whether linguistic uncertainty cues (such as using a question, presenting an explanation as investigated yet unconfirmed, and including qualifiers such as "may" or "might") as present in speculations could affect the memory of factual news. Specifically, we tested the hypothesis of *uncertainty spreading*: A context of speculative articles (inconsistent context) should lead recipients to misremember unrelated pieces of news that were initially framed as facts as more uncertain (e.g., as unconfirmed, speculative) than a context consisting of factual articles (consistent context). We addressed this question via cued recall – that is, by asking the participants to reproduce the central message of each of the target articles based on short prompts on the respective topic (these prompts contained neither the reported explanations nor any reference to their certainty). We chose this memory measure as it is unaffected by response or guessing biases (because no response options are displayed in this task).

Note that a context-induced *spreading* of uncertainty cues would imply that the effect of (a context of) speculations on recollecting facts is *larger* than the reverse effect (i.e., the effect of reported facts on the recollection of speculations). Accordingly, we tested the interaction of the (un)certainty that the target articles express and the specific context that these articles appear in (consistent vs. inconsistent) against the possibility of comparable context effects for both target conditions. We preregistered our hypothesis, analyses, exclusion criteria, and sample size for the conducted studies (https://aspredicted.org/h4h9b.pdf). The local ethics board approved all studies. The data, scripts, and materials of all experiments are available online (https://osf.io/2b79q/).

Method

Participants. Our initial sample consisted of N=440 people from Prolific and was set by the following considerations: A power simulation that was based on previous findings (Brand et al., 2021) suggested $N = 400$ participants to detect the proposed interaction with a power of 87 % (for further details see ESM or preregistration). To compensate for potential exclusions based on preregistered criteria, we collected data from 40 further participants (as we expected an exclusion rate of roughly 10%).

The data was obtained on the 16th of December 2019. Across all experiments, we only invited those participants who fulfilled the following criteria: (1) high response rate (above 85 percent), (2) native language English (due to our language-sensitive materials), and (3) age between 18 and 75. Following our preregistered criteria, we excluded participants from further analysis who failed the attention check (n=39) or indicated that they had searched for the headlines online during the experiment (n=4). Additional 22 participants were excluded due to missing data (either because they did not remember any of the previously presented explanations, or because all their answers were ambiguous concerning the certainty they expressed, e.g., because they were not formulated in full sentences). The final sample comprised data of N=375 participants (246 females, 128 males, one person indicated "other"; $M_{age} = 35.9$ years; SD_{age}=12.2 years; range 18 - 68 years).

Materials. As articles, we used a list of headlines, each with a teaser, to investigate our hypotheses. These headlines concerned 16 possible explanations for different events (such as toxic waste as a potential cause of the dead fish that were found in a river). Each headline had two versions: An event's respective explanation was formulated as either speculation or fact (Figure 3.2). In the former case, the headline named a potential explanation for the respective event via a question (e.g., "Was … caused by …?"), and the teaser indicated that this explanation was currently uncertain (i.e., under investigation but unconfirmed). In the latter case, the item was identical, except that the headline was a factual statement (e.g., "… was caused by …."), and the teaser below indicated that investigations confirmed the posed explanation. Doing so allowed us to keep the amount of provided information (on the event and the explanation) constant across both types of articles and thus across the experimental conditions. With these items, we created four different conditions to which the participants were randomly assigned, meaning that participant went through *one* of these conditions as part of a between-participants design. All materials are available online (https://osf.io/2b79q/).

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.

Figure 3.2. Examples of the Different Headline Types with (A) "Speculative explanation" and
(B) "Factual explanation".

Procedure. In the *presentation stage*, every participant read 16 topically unrelated
headlines concerning all 16 explanations. A predetermined, fixed subset of eight of these
headlines served as *target* articles that the participants had to recollect in a later stage of the
experiment (this, however, was not previously announced). The remaining eight articles were
predetermined to serve as *context* articles and were not queried later.

First, we manipulated whether all eight targets were presented as speculations versus
facts (target condition). Second, we varied the context in which the targets appeared; that is,
whether the certainty of all eight context articles was *consistent* with that of the target articles
(participants read factual targets among factual context articles or speculative targets among
speculative context articles) or *inconsistent* (participants read either factual targets among
speculative context articles or speculative targets among factual context articles). Both factors
were manipulated between participants. This structure resulted in one group of participants
that read exclusively speculations, one group that read exclusively facts, and two groups that
read a mixture of both types of articles (see Table 3.1).

Each headline was presented one per page in random order with the restriction that
two fixed context headlines were always given first (to ensure that participants would always
encounter some context headlines before reading the targets). For each headline, the
participants were asked to indicate whether they would consider reading the corresponding
article in full length by selecting one of three response options ("no", "maybe", and "yes").
This filler task served to ensure that the participants would engage themselves with the items
without disclosing that their memory for some of them would be tested later.

Table 3.1

Four experimental conditions (manipulated between participants via different item lists)

Item	Type of item	Condition target fact, context consistent (list A)	Condition target fact, context inconsistent (list B)	Condition target fact, context consistent (list C)	Condition target fact, context inconsistent (list D)
		Item presented as…	Item presented as…	Item presented as…	Item presented as…
1	*Target*	Fact	Fact	Speculation	Speculation
2	*Target*	Fact	Fact	Speculation	Speculation
3	*Target*	Fact	Fact	Speculation	Speculation
4	*Target*	Fact	Fact	Speculation	Speculation
5	*Target*	Fact	Fact	Speculation	Speculation
6	*Target*	Fact	Fact	Speculation	Speculation
7	*Target*	Fact	Fact	Speculation	Speculation
8	*Target*	Fact	Fact	Speculation	Speculation
9	*Context*	Fact	Speculation	Speculation	Fact
10	*Context*	Fact	Speculation	Speculation	Fact
11	*Context*	Fact	Speculation	Speculation	Fact
12	*Context*	Fact	Speculation	Speculation	Fact
13	*Context*	Fact	Speculation	Speculation	Fact
14	*Context*	Fact	Speculation	Speculation	Fact
15	*Context*	Fact	Speculation	Speculation	Fact
16	*Context*	Fact	Speculation	Speculation	Fact

Note. Each participant received one list of items. Two context items were presented in a fixed position in the beginning of the experiment; then, all remaining items were presented in random order. Context items are highlighted in grey. In contrast to the target items, context items were not requested in the subsequent memory task (without this being previously announced to the participants).

In the next step, the participants entered the *distraction stage* (five minutes) in which they indicated their demographic information, completed several filler questionnaires (e.g., need for structure, Neuberg & Newsom, 1993) and riddles (such as the "lost at sea" task in which they had to rank order several items with regard to their usefulness for survival).

Lastly, in the *assessment stage*, the participants were asked to freely reproduce the main message of each of the eight target headlines as completely and as accurately as they they could remember them. To that end, they consecutively read a short prompt on each headline's topic that was identical to the event description of the respective teasers that they had seen in the presentation stage (e.g., "Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon"). These prompts neither entailed any hints at potential explanations nor at their certainty and were therefore uninformative regarding the experimental conditions. To prevent potential ambiguities regarding the (un)certainty expressed in the recalled information, we instructed the participants to imagine that they were talking to a friend of theirs about the content of the headlines that they had read before and to write down their memories in full sentences.

Coding. Following our preregistration, two independent raters blind to the experimental conditions first coded all answers regarding the correctness of the reproduced explanations. Only correctly reproduced explanations were included in the subsequent analysis (56 % of all trials).[8] With the objective to classify all correctly remembered explanations in terms of the certainty or uncertainty that they expressed, we applied the following coding scheme (for a similar procedure see Bonyadi, 2011; Brand et al., 2021; Rubin, 2007): Answers qualified by words such as "presumably", "probably", "potentially", "could", "may" or "might" or other expressions of uncertainty (e.g., "researchers investigate / presume / suspect / believe", "there was a theory that" or "the article discussed whether") were assigned to the category "remembered *speculative* explanation". In contrast, answers that (a) expressed a definite causal relationship (instead of correlation) and (b) did not include qualifiers (as, for example factual formulations such as "this was caused by …" or "investigations confirmed that…") were classified as "remembered *factual* explanation". Expressions that referred to doubts of the participant but not remembered uncertainty in the news coverage (e.g., "apparently this was caused by") were also assigned to the latter category.

Some memories were inconclusive in terms of the certainty that they expressed and were therefore excluded from analyses. Those cases encompassed factually formulated memories that expressed a correlation instead of causation (e.g., "… was related to") or

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[8] A Glme analysis revealed no significant differences in the number of correct trials depending on the target condition (facts vs. speculations), $X^2 (1) = 2.50$, $p = .114$, the context type (consistent vs. inconsistent), $X^2 (1) = 0.16$, $p = .687$, and no interaction effect between both factors, $X^2 (1) = 0.02$, $p = .876$.

factually formulated memories which, albeit containing the correct content of a previously read explanation (e.g., "They found aluminium particles in the bee keepers' dwellings"), did not explicitly name its causal relation to the respective event (e.g., bees dying).

With respect to the correctness of a reproduced explanation, the interrater reliability was Kappa = .88. Regarding the certainty or uncertainty expressed by the participants, we obtained an interrater reliability of Kappa = .88. Both ratings did not differ with respect to the statistical test results. For the sake of brevity, we report only the results based on Rater 1 (but all data and ratings are accessible online).

Analytic Methods. We compared generalized linear mixed effects (GLME) models with a logit link function to test the impact of target certainty ("speculative" vs. "factual explanation") and context (consistent vs. inconsistent) on the probability of confusion errors, as well as a potential interaction between both factors. *Confusion errors* were defined as (a) previously read facts that were misremembered as speculative, or as (b) previously read speculations that were misremembered as facts. Both between-participant factors, target certainty and context, were conceptualized as fixed effects in the models. Additionally, we included a random intercept for both participant and item in accordance with the structure of our experimental design. Our baseline model included exclusively random effects. In three further models, we successively added both fixed effects, as well as their interaction. We compared these nested models using likelihood ratio tests to determine which model best fits the data.

Notably, GLME models have several advantages over ANOVA models: First, they can deal with dichotomous dependent variables as is necessary for our study (confusion error: Yes vs. No). Second, GLME models allow us to analyze participants' memories for a set of items, meaning that they can account for repeated measures of one condition within one participant via *different* items, as is the case in our study (although the fixed effects all represent between-participants factors). This is possible by modelling random effects for both participants and items. Third, GLME models can easily handle missing data, whereas ANOVA models cannot. Fourth, GLME models have greater statistical power (see also Jaeger, 2008, for more details on these arguments). Following these considerations, we decided to analyze all data via GLME models. Note that, similar to ANOVA models, this analysis includes the main effects of target and context and their interaction (represented by the fixed effects). It is, therefore, interpretable in a similar way.

In all experiments, as is common for GLME models, we report marginal and conditional R^2 as a measure of effect size; marginal R^2 (R^2_m) expresses the variance explained by fixed effects in the respective model (i.e., our manipulations). In contrast, conditional R^2 (R^2_c) indicates the variance explained by both fixed and random effects. The analytic code needed to reproduce the analyses of all the reported experiments is available online (https://osf.io/2b79q/).

Results

Confusion mistakes. As outlined above, a spreading of uncertainty cues would be indicated by a target headline (fact vs. speculation) x context (consistent vs. inconsistent) interaction on confusion errors. The GLME analysis revealed a main effect of target certainty, $X^2(1) = 24.15$, $p < .001$, $R^2_m = .05$, $R^2_c = .41$, and a main effect of context, $X^2(1) = 32.27$, $p < .001$, $R^2_m = .10$, $R^2_c = .41$, on confusion errors. Contrary to our hypothesis, however, there was no target certainty x context interaction, $X^2(1) = 1.53$, $p = .227$, $R^2_m = .10$, $R^2_c = .41$. As depicted in Figure 3.3, a context of *speculations* increased the relative frequency of remembering previously read facts as speculations (i.e., as not being confirmed yet) by about 23 % (targets fact, context inconsistent condition) as compared to a context consisting of other *facts* (targets facts, context consistent condition). Conversely, a context of *facts* increased the relative frequency of recalling previously read speculations as facts by about 9 % (targets speculation, context inconsistent condition), as compared to a context consisting of speculations (targets speculation, context consistent condition). Numerically, the effect of an *inconsistent* context on recalling facts was larger than its effect on recalling speculations. This interaction, however, was not significant.
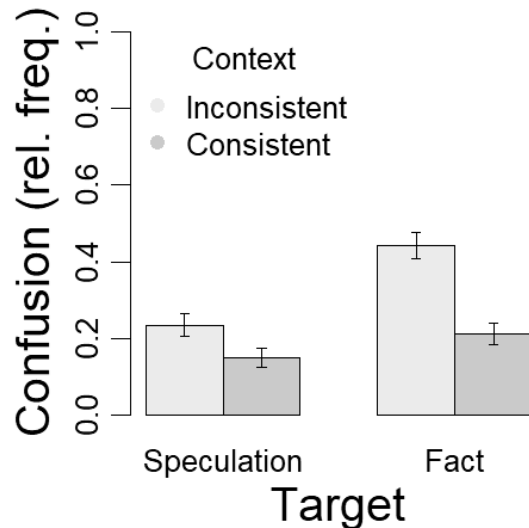
Figure 3.3. Results of Experiment 5A. Average frequency of confusion errors depending on whether a target was previously presented as speculation vs. fact and on whether it appeared in an inconsistent (mixture of speculations and facts) vs. consistent context (either speculations or facts). Confusion errors are defined as facts that were remembered as speculations or speculations that were remembered as facts. Error bars indicate the SEM.

Discussion

The results of Experiment 5A confirmed the hypothesis that a context of *speculations* impacts the recollection of unrelated facts in the news, leading the latter to be misremembered as more uncertain than these facts were initially reported to be (e.g., as being mere possibilities, speculative, suspected, or yet unconfirmed instead of confirmed). Conversely, however, the certainty of *facts* as a context also tainted the way in which unrelated speculations were remembered. Specifically, speculations were more often mistakenly remembered as being facts if they had appeared among unrelated facts (as compared to a context consisting exclusively of speculations). Contrary to our expectations and the hypothesis of uncertainty spreading, our results indicate no significant difference in the size of both kinds of context effects. Yet, numerically, the effect of a context of speculations on the memory for reported facts exceeded the reverse effect of a context of facts on the memory for speculations.

In our view, this experiment provided initial support for context effects via cued recall (which has the advantage of being unaffected by guessing biases, as no response options are displayed here). Yet, potentially due to the open response format of this task, we had more missing data than initially expected (leading to a decreased power of the statistical tests).

Therefore, we decided to conduct a further experiment in which we replaced the cued recall with a recognition task which is less prone to missing data. This was done in order increase the statistical power to detect a potential interaction and to replicate and clarify the findings of Experiment 5A.

Experiment 5B: Does Uncertainty Spread from Speculations to Facts? (Recognition Task)

Experiment 5B was identical to Experiment 5A except that we changed the cued recall paradigm to a recognition task which included further filler items. Again, our hypothesis, analysis, exclusion criteria and sample size were preregistered (https://aspredicted.org/vq288.pdf). Again, all data, scripts, and materials are available online (https://osf.io/2b79q/).

Method

Participants. We determined our initial sample size by the following considerations: First, we conducted a power simulation based on Experiment 5A and previous work using a recognition task (Brand et al., 2021). We assumed confusion errors for facts to be approximately 20 % higher than those for speculations in the inconsistent context condition (in which participants read a mixture of speculations and factual formulations in news headlines). Furthermore, we assumed no such difference in confusion errors in the consistent context condition (in which participants read either exclusively speculations or exclusively factual formulations; for further assumptions see ESM or preregistration). The simulation suggested 400 participants to detect the proposed interaction effect with a power of .83. To compensate for potential data exclusions due to our preregistered criteria (which led to the exclusion of roughly 10% of participants in previous studies), we collected data from 444 participants in total.

Data collection took place on 15th of May 2020 via Prolific. In line with our preregistration, we removed data from participants who failed the attention check ($n=22$) or reported searching for the headlines on the internet during the experiment ($n=3$). Further three data sets were incomplete and were therefore not part of the analyses. The final sample consisted of N=416 participants (299 females, 116 males, one person indicated "other"; $M_{age} = 34.3$ years; $SD_{age}=12.0$ years; range 18 - 74 years).

Materials and Procedure. The materials and procedure were identical to Experiment 5A except that we replaced the cued recall procedure in the assessment stage by a recognition task. For this recognition task, the participants could choose between three given response options (see Figure 3.2) for each of the (predetermined) eight target items and for eight additional fillers that were not previously presented; the items used to manipulate the context were not queried. The first two presented options comprised two almost identical headlines, one being framed as fact and one being framed as speculation. The third response option indicated that the participants did not recognize either of both headline versions from before. The filler items followed the same basic structure as our target and context items consisting of a short event description and a corresponding explanation.

Analytic Methods. In line with Experiment 5A and as specified in our preregistration, we excluded from our main analysis those trials in which targets were not recognized as having been presented before. As intended, the percentage of included trials was considerably higher (96 %) compared to Experiment 5A. Again, we specified GLME models with a logit link function to compare the probability of confusion errors in our four experimental conditions. Target certainty ("speculative" vs. "factual explanation") and context (consistent vs. inconsistent) were represented as fixed effects in these models (both factors were manipulated between participants). Following Experiment 5A, we again included a random intercept for both participant and item to account for the structure of our experimental design.

Results

Confusion errors. Once again, a target x context interaction on confusion errors would indicate support for our hypothesis. A GLME analyses confirmed this interaction effect, $X^2(1) = 4.22$, $p = .0399$, $R_m^2 = .09$, $R_c^2 = .33$. As depicted in Figure 3.4, a context of *speculations* led participants to (falsely) recognize previously read facts more often as *speculations* (as being investigated but not yet confirmed; target fact, context inconsistent condition) in comparison to a context of facts (target fact, context consistent condition). The frequency of recollecting facts as speculations was increased by about 25 %. This reflects two additional misremembered articles per participant due to the context manipulation. Conversely, a context of *facts* led participants to misremember formerly presented speculations more often as being *facts* (target speculation, context inconsistent condition) than a context of speculations (target speculation, context consistent condition). As indexed by the significant interaction, context effects were particularly pronounced for the (confused)

recognition of *facts* (more so than for the confused recognition of speculations), indicating a (stronger) spreading of uncertainty cues in memory.
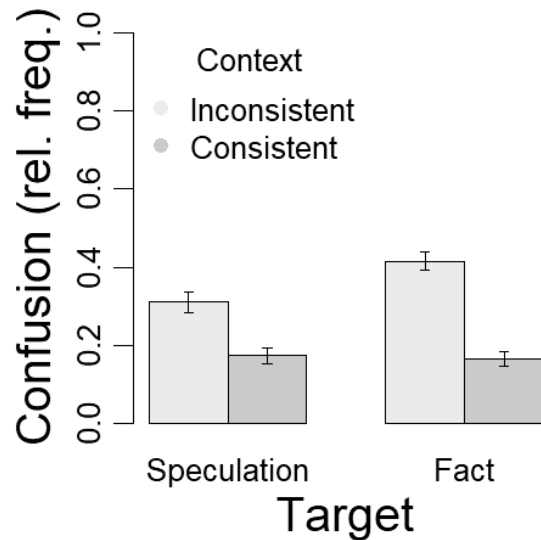

Figure 3.4. Results of Experiment 5B. Average frequency of confusion errors in the recognition task, depending on whether an explanation was previously presented as speculation vs. fact and on whether it appeared in an inconsistent (mixture of speculations and facts) vs. consistent context (either speculations or facts); error bars depict SEM.

Discussion

As expected, and in accordance with Experiment 5A, a context of speculations (compared to a context of facts) resulted in a stronger tendency to misremember reported facts as being mere speculations (i.e., as being yet unconfirmed). As in Experiment 5A, we also found the reverse effect, namely, an impact of a context of reported facts on the recognition of speculations, leading to a stronger tendency to falsely remember the latter as being facts as well (as compared to reading exclusively speculations). This tendency, however, was less pronounced. Particularly, and in distinction to Experiment 5A, the tendency to misremember news that were framed to be facts as speculations only arose when participants were confronted with a *mixture* of both types of articles (as was the case in the inconsistent context condition). In contrast, when participants had read either exclusively facts or speculations (consistent context), the frequency of confusion errors did not differ for both kinds of article types. Together, this pattern suggests that uncertainty was not merely redistributed across recollected articles but *increased even after a short period of time* once speculative pieces of

news were intermingled. Accordingly, our data confirm the hypothesis of a spreading of uncertainty cues in memory and thus clarify the ambivalent findings from Experiment 5A.

Experiment 6: Altered Encoding Versus Overshadowing of Memories as Mechanism?

Following this initial demonstration of uncertainty spreading to the memory of facts, one might ask about the underlying mechanisms on which such an effect could operate. Does being confronted with speculations on the news affect the way and structure in which unrelated factual information is *encoded* (encoding account)? This view would imply that spreading effects only arise when speculations were encountered before – but not after – further messages were presented. Or can uncertainty spread even *after* encoding as speculations might overshadow memories of already stored facts (overshadowing account)? The following considerations might support the latter view.

Note that linguistic theories suggest that understanding the uncertainty of a speculative formulation should require more cognitive effort than understanding the certainty of a factual one (and potentially also a negation)— because in the case of speculations, alternative possibilities must be kept in mind (and cannot be dissolved, as is the case for negations). This property could imply memory distortions toward facticity (as the schema plus tag conception supposes, which however was not empirically supported; Brand et al., 2021). Conversely, such mechanisms could also give rise to a higher *salience* of uncertain formulations in memory, as they are more complex to process. A speculative formulation could thus overshadow a factual one, leading the former to appear less certain in retrospect. Notably, and in contrast to the above-proposed effect on encoding, this *overshadowing account* predicts altered memories for factual news *regardless* of the order in which those facts and speculations are presented.

Experiment 6 sought to distinguish between encoding versus overshadowing effects by manipulating the *presentation order* of speculations and facts. In the case of encoding effects, we expected that context-induced false memories of facts mainly arise if those facts are encountered *after* (as compared to *before*) the uncertain context was induced. In contrast, assuming overshadowing effects, we expected that context-induced false memories of factual formulations occur independently of whether those factual formulations are encoded before or after the context manipulation. Investigating the proposed effects might also inform practical matters such as *how* to communicate news in a way that counteracts a blurring of speculative and confirmed contents in memory. Again, we preregistered our hypothesis, sample size,

exclusion criteria, and analyses (https://aspredicted.org/un46h.pdf) and provide data, scripts, and materials online (www.osf.io/2b79q).

Method

Participants. Again, we conducted an a priori power simulation to determine our minimum sample size based on the findings of Experiment 5B (see ESM or preregistration for further assumptions). This simulation proposed 420 participants to detect potential differences between all three comparisons of interest with a power of .83. To compensate for possible data exclusions according to our preregistered criteria, we increased this sample size to 460.

We collected data via Prolific on the 16th of July 2020. We again excluded data from those participants who failed the attention check ($n=31$) or reported searching for the headlines on the internet ($n=1$) or incomplete data sets ($n=1$). The final sample comprised $N=427$ participants (261 females, 163 males, three persons indicated "other"; $M_{age} = 34.7$ years; $SD_{age}=12.5$ years; range 18 - 74 years).

Materials and Procedure. The methods were similar to those of Experiment 5B with the following exceptions: First, the target items presented in the presentation phase and then queried in the recognition task exclusively covered *factual* formulations; these were identical to the ones we used in Experiments 5A and 5B.

Second, we implemented four context conditions (between participants) in which these targets appeared: In a *baseline* condition (facts only condition), the participants read the eight target items in the context of eight other, unrelated facts in news headlines (each with a short teaser). The three further conditions involved the same eight context headlines, which, however, were all formulated as speculations. In two conditions, the speculations (as context) and the targets were presented in a block-by-block order: Participants read the speculations as context items either before (blocked: *speculations first*) or after (blocked: *speculations after*) the target items. In the fourth condition, speculations as context items and the target items were presented in a randomly determined order (*mixed* context). Every participant underwent one of these conditions as part of a between-participants design.

Third, we included ten additional *filler* headlines. Three were presented at the beginning of the presentation stage, three in the end (to prevent primacy or recency effects), and the remaining four were randomly mixed among the target and context items presented in-between. These fillers were selected from news pages on the internet, such as the German SPIEGEL online. Importantly, fillers did not adhere to the structure of the target and context

articles and therefore did not refer to any speculative or factual explanations of occurrences (e.g., "The world's first floating farm making waves in Rotterdam" or "Europe to ban halogen light bulbs").

Analytic Methods. Again, our main dependent variable was *confusion errors,* defined as presented facts (targets) that were misremembered to be speculations. As preregistered, we excluded all trials in which targets were not recognized as having been presented before (5 % of all trials). In accordance with our previous studies, we specified GLME models with a logit link function to test for potential differences between the four context conditions regarding this variable. Context was thus represented as a fixed effect in the models. We again included a random intercept for participant and item.

Results

In the case of encoding effects, we expected that a context of speculations does only change the way facts are remembered if this (inconsistent) context is presented before, not after the facts. In the case of overshadowing effects, in contrast, we expected that speculations impact the memory of facts regardless of the order in which the participants read both message types. The GLME analysis revealed a main effect of *context* on the frequency of misremembering a previously presented fact as speculation, $X^2(3) = 92.64$, $p < .001$, $R^2_m = .09$, $R^2_c = .27$. As depicted in Figure 3.5, the frequency of misremembering facts as speculations was lower if participants had read *only facts*, compared to the three other context conditions (blocked: speculations first, $\beta = -1.45$, $se = 0.18$, $z = 7.95$, $p < .001$; blocked: speculations after, $\beta = 1.46$, $se = 0.18$, $z = 8.00$, $p < .001$; and mixed, $\beta = 1.55$, $se = 0.18$, $z = 8.50$, $p < .001$). There was, however, neither a difference between the two block-by-block conditions, $\beta = -0.01$, $se = 0.16$, $z = -0.07$, $p = .943$, nor between the conditions mixed and blocked: speculations first, $\beta = -0.10$, $se = 0.16$, $z = -0.63$, $p = .529$, or blocked: speculations after, $\beta = -0.09$, $se = 0.16$, $z = -0.56$, $p = .578$. This is in line with the overshadowing account.
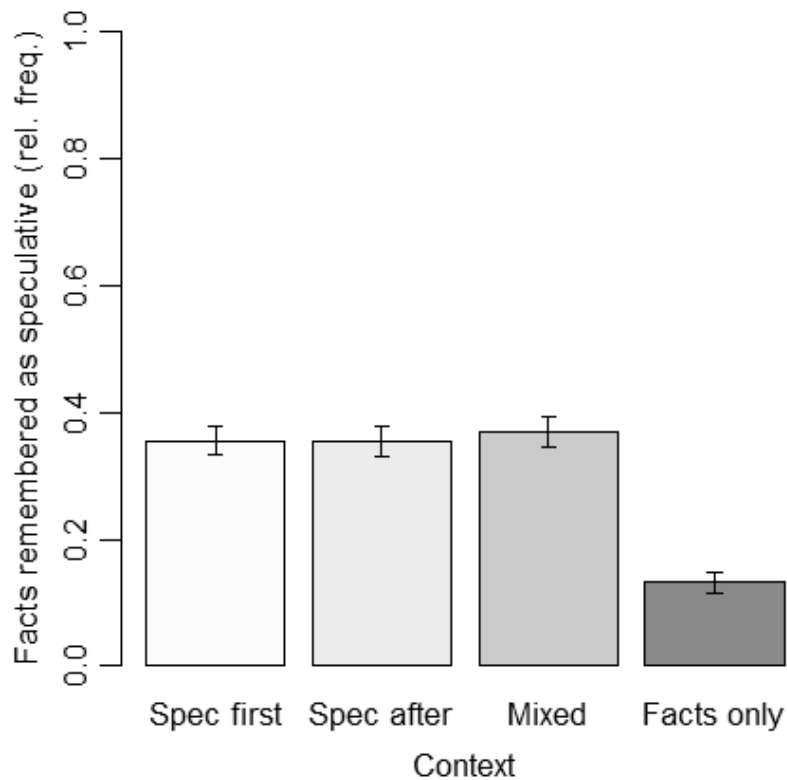
Figure 3.5. Results of Experiment 6. Average frequency of misremembering a previously read
fact (target) as speculation, depending on the four different context conditions (spec first:
context of speculations presented before the target items vs. spec after: context of
speculations presented after the target items vs. mixed: intertwined presentation of
speculations and facts vs. facts only) with SEM.

Discussion

As Experiment 6 indicates, a spreading of uncertainty occurred *regardless* of the order
in which speculations and facts were presented. This finding suggests that a news context
expressing uncertainty does not specifically affect the way and structure in which unrelated
factual formulations are *processed* and *encoded.* Instead, uncertainty seems to spread because
speculations bear the potential to overshadow existing memory representations by changing,
for instance, the way missing memories are reconstructed. Such backward effects could be
explained by a higher salience of uncertainty cues in memory, which leads factual news to
appear uncertain as well. Furthermore, our results point out that a mere blockwise separation
of speculative from factual contents in the news does not improve their distinctiveness in
memory by providing an external grouping structure.

Experiment 7: All-Or-Nothing Principle Versus Linear Growth of Uncertainty

In all the experiments carried out thus far, uncertainty was treated as either present or absent in a dichotomous way. In a realistic news context, however, speculations and facts may not be evenly distributed but vary in their relative proportion. This poses the question of which role the *number* of speculations presented among reported facts could play in the dispersion of uncertainty in memory.

One possibility is that uncertainty spreads according to the all-or-nothing principle. This means that once a minimum threshold of speculations (still to be determined) is met, the number of reported facts is misremembered as speculations should increase sharply irrespective of their initial proportion ("all-or-nothing" hypothesis). Alternatively, uncertainty might expand on unrelated memories in an approximately linear way. This, in turn, would imply that the higher the initial proportion of speculations among the presented headlines, the more often reported facts are misremembered as being mere speculations (linear growth hypothesis).

Experiment 7 aimed to decide between both hypotheses. As in our previous experiments, we preregistered our (competing) hypotheses, sample size, exclusion criteria, and analyses (https://aspredicted.org/jp4xk.pdf), and made data, scripts, and materials available online (www.osf.io/2b79q).

Method

Participants. Based on our previous results, an a-priori power simulation suggested a sample size of 312 participants to detect potential differences between all conditions of interest (see ESM or preregistration for further assumptions). Since the simulations did not include exclusions according to our standard protocol, we collected data from additional 32 participants (N=344).

As in our previous experiments, data collection was implemented via Prolific (2nd of November 2020). One person did not finish the survey; therefore, his or her data could not be analysed. Participants who failed the attention check (n=20) or reported searching for the headlines online (n=0) were excluded from our final data set, which comprised N=323 participants (196 females, 127 males, three persons indicated "other"; M_{age} = 36.5 years; SD_{age}=13.5 years; range 18 - 73 years).

Materials and Procedure. Again, we used the same materials as in Experiment 5B, but varied the number of speculations and facts depending on the implemented conditions

(four conditions, manipulated between participants). All participants were presented with a total of 24 headlines in the presentation stage. In detail, the participants read six *target* articles ,which had to be remembered later (in the assessment stage without prior announcement as part of a recognition task); all targets were formulated as *facts*.

These targets appeared among 18 *context* articles, all presented in random order. The context articles consisted either of exclusively facts (18 facts; *baseline condition*), a mixture of facts and speculations (*6 versus 12* speculations out of the total 24 headlines) or exclusively speculations (*18 speculations* out of 24 headlines).

Analytic Methods. As before, confusion errors regarding the target items served as the main dependent variable. Trials in which targets were not recognized as having been presented before were not part of our analysis (5 % of all trials). To examine whether confusion errors vary depending on the number of speculations presented among the context items, we specified GLME models with a logit link function. Accordingly, context was defined as a fixed effect in these models. Again, the models included a random intercept for participant and item.

Results

We had two competing hypotheses: According to the "linear growth" hypothesis, we expected that the number of confusion errors would change linearly, depending on the number of speculations intermingled. Alternatively, and according to the "all-or-nothing" hypothesis, confusion errors should increase sharply if a minimum threshold of speculations is met.

Model comparisons revealed a main effect of *context* on confusion errors, $X^2 (3) = 139.59$, $p < .001$, $R^2_m = .21$, $R^2_c = .39$. As Figure 3.6 indicates, the number of facts (falsely) remembered as speculations increased with the number of speculations initially presented as part of the contextarticles. In the condition in which the participants read *exclusively facts* (0 out of 24 headlines were speculations), the frequency of confusion errors was lowest compared to all other conditions; $\beta = 1.72$, $se = 0.25$, $z = 6.89$, $p < .001$ for the comparison between the conditions including 0 versus 6 speculations. Both conditions in the medium range including *6 or 12 speculations* did not differ significantly regarding confusion errors, $\beta = 0.37$, $se = 0.22$, $z = 1.72$; $p = .085$. However, confusions increased if the context items included a maximum of *18 speculations* (compared to 12): $\beta = 0.80$, $se = 0.22$, $z = 3.70$, $p < .001$. This pattern supports the hypothesis that uncertainty expands approximately linearly, depending on the number of intermingled speculations (linear growth hypothesis).
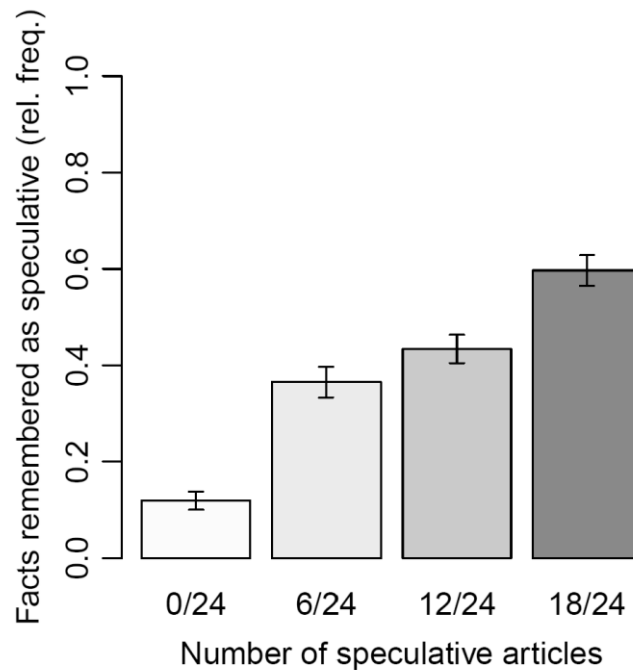
Figure 3.6. Results of Experiment 7. Relative frequency of misremembering a previously read fact (target) as speculation, depending on context (i.e., the number of speculative headlines which were presented among the factual ones, ranging from 0 out of 24 to 18 out of 24 headlines). Error bars indicate the SEM.

Discussion

The results of Experiment 7 show that the number of facts misremembered as speculation increases in an approximately linear manner with the number of speculative articles that were initially presented as context (among the reported facts to be called to mind later). Importantly, a spreading of uncertainty was clearly evident even when only a few speculations (6 out of 24) were interspersed. Indeed, intermingling only six speculations magnified the frequency of recalling facts as uncertain by 25 %. This finding further highlights the practical relevance of the spreading effect we found: Very few speculative contents seem sufficient to systematically diminish the remembered certainty of unrelated, jointly reported facts on the news.

General Discussion

The modern media landscape allows for rapid reporting that does not refer to facts alone but is often interspersed with (still) purely speculative content. While previous research has primarily defined individual pieces of news as units of investigation (e.g., in the study of so-called "fake news"; Bago et al., 2020; Pennycook et al., 2018; Pennycook & Rand, 2019), the present work took a broader perspective: In a series of four experiments, we examined potential memory effects of an *intertwined* presentation of unrelated short news articles that differed with respect to the presence or absence of linguistic uncertainty cues. On the one hand, the presence of speculative news (as indexed by words such as "might" or "could") could overshadow the recollection of jointly reported facts, thereby *lowering* their remembered certainty (i.e., such that people misremember facts as speculations). Alternatively, cues toward certainty (i.e., a factual formulation) might appear more salient once contrasted with mere speculations, which could *enhance* the recollection of such cues instead.

Our results clarify this ambiguity by providing evidence in support of the first option: They indicate that uncertainty (as present in speculations) spreads onto the retention of facts, causing the latter to appear uncertain as well. This tendency was evident across different measures of memory, including a series of recognition experiments (Exp. 5B, 6, 7) and a cued recall task that required a free reproduction of the news read beforehand (Experiment 5A). One important aspect of our study is that we combined these two memory measures so that each can compensate for the possible disadvantages of the other. On the one hand, recognition provides high experimental control and reduces data loss, leading to a higher statistical power. On the other hand, a cued recall task rules out potential guessing biases triggered by the response format (because no response options are displayed in this approach). Therefore, similar results for both measures support the conclusion that the context effects that we found reflect a memory phenomenon and not an artifact of the experimental procedure.

In addition, Experiment 5B revealed that speculations exerted a stronger influence on remembering facticity than, conversely, facts on remembering speculations. This asymmetry points out that cues on the certainty or uncertainty of a content were not evenly redistributed across the remembered articles. Instead, after having read a mixture of speculations and facts, the participants remembered more uncertainty than was initially present in the news read before, indicating the proposed spreading of uncertainty in memory.

Additionally, this experiment shows that the frequency of recognizing facts as speculation did not differ from the frequency of recognizing speculations as facts once *exclusively facts* or *exclusively speculations* were presented. Accordingly, no uncertainty bias occurred in these conditions. This finding is of particular importance, also from a methodological point of view. It underlines that a bias to misremember facts as speculations does not solely reflect the participants' tendency to "play it safe" or answer with tentativeness if they cannot recall the exact wording of the original message. Instead, it shows that a bias to misremember facts as speculations is context-induced (i.e., triggered by the presence of speculations) and does not reflect a context-independent response strategy.

Two follow-up experiments were designed to investigate more deeply the mechanisms underlying the observed propagation of uncertainty cues: These showed, first, that a context of speculations not specifically altered the *encoding* structures of unrelated news but also *retroactively* modified their representation. Moreover, the frequency of recalling facts as speculations seemed to *increase* in an approximately linear fashion depending on the number of uncertain pieces of news that were intermingled. Yet, despite this linear relation, a spreading of uncertainty was manifest even when only a few speculations were encountered (6 out of 24 articles), denoting the impact of this bias. These findings have important theoretical as well as practical implications.

Theoretical Implications

Referring to Previous Findings on (Un)Certainty and Negation Processing. Our results replicate the tendency to misremember facts as speculation (more often than falling for the reverse mistake) that has been demonstrated in prior work (Brand et al., 2021). Going *beyond* previous work, however, our findings provide an explanation for this memory distortion: They suggest that it does not occur independently of a message's broader context but is instead *context-driven*. This conclusion stems from the finding that a bias to misremember facts as speculative (more so than remembering speculations as facts) only did occur if facts were initially read among speculations—but not if exclusively facts (or exclusively speculations) were encountered.

First, this finding indicates that the processing of uncertainty expressions seems to differ from that of negations (with the latter having been studied more in prior work) in a crucial way. Whereas previous research shows that people tend to *forget* negations (which is

assumed to occur regardless of other items; Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975; Mayo et al., 2004), our findings revealed that uncertainty seems to *increase* by spreading onto other memory units, such as those representing facts. This finding contradicts the idea that uncertainty may be represented as an abstract tag of the propositional core of a sentence so that the former might be dissociated and forgotten after a while (as the schema plus tag model suggests; Mayo et al., 2004). On the contrary, linguistic uncertainty seems to unfold an impact that *exceeds* its intended meaning.

Second, our findings seem to conflict with the idea that *facts* prove stable in memory—a widely spread notion in models and experiments on negation processing (Gilbert, 1991; Gilbert et al., 1990, 1993; Mayo et al., 2004). In that work, memories of negations were classically contrasted with those of affirmations (or true statements), whereby the latter were usually found or assumed to be less error prone. In contrast, however, our results indicate that the recall and reconstruction of facts can change once they have been read in the context of speculation (instead of other facts or negations), signifying that whether or not facticity is reproduced might be substantially context-dependent.

Potential Mechanisms of Uncertainty Spreading. How can such dependencies in the memory of distinct pieces of news be explained? On the one hand, intermingling speculations could change very early stages of processing, such as the way other pieces of news are *encoded*. Such encoding effects have been shown for a mindset of distrust that arguably reflects uncertainty as well (Mayo, 2015; Richter et al., 2009; Schul et al., 2004, 1996). Specifically, studies suggest that mental representations become more complex under distrust because it leads to new information being understood and stored in the context of potential alternatives that come to mind. Such references could serve as a protection against accepting and integrating information in dispute.

Yet, going beyond previous findings from mindset research, our results illustrate that speculations do not specifically elicit encoding effects but hold the potential to *retroactively* alter the recollection of already stored facts. This conclusion stems from the observation that a speculative context was effective even when all factual pieces of news were encoded first. Such backward effects could be explained by facts and speculations being represented in an interconnected network in memory—if they were read together in temporal proximity. Note that this account extends previous network models such as those assumed in multiple document theory (Britt et al., 1999; Perfetti et al., 1999), as no content-wise relation between the items is presupposed in the former case. There are several ways of conceptualizing

spreading effects in the scope of this network approach. In particular, it is unclear whether uncertainty might spread in an undirected manner onto various kinds of jointly stored information or whether such spreading effects are also shaped, at least in part, by the *plausibility* of a content. The former process might be explained by uncertainty expressions appearing particularly salient to the reader due to entailing a potentially higher processing effort compared to negations and facts (as alternative possibilities cannot be resolved in the case of speculations). By this means, facticity might fade into the background, leading recipients to overestimate the proportion of uncertain statements they had previously read.

Yet, beyond undirected or "neutral" spreading effects, retrieving facts stored in the context of speculation might also encourage recipients to question and elaborate a remembered content more deeply. In this case, uncertainty might spread in a *directed* manner, affecting precisely such information that is questionable itself or related to little prior knowledge. Indeed, theoretical and empirical considerations could speak for this position: First, considering alternatives by engaging in hypothetical and conjectural thinking are essential parts of the concept of deliberation, which is classically contrasted with intuition-based judgment (Evans & Stanovich, 2013; Kahneman, 2011). Indeed, this conception is mirrored in models of language processing that characterize the comprehension of a speculation to be more elaborate as compared to comprehending a fact since the former refers to and involves mental detachment. In contrast, the latter does not (e.g., Gilbert, 1991). Second, prior research shows that deliberate compared to intuitive thinking leads to a better distinction between true and false (Bago et al., 2020; Martel et al., 2020), suggesting that the presence of speculative news might provoke similar effects. Note that we chose to study "reported facts" about which little prior knowledge should exist, which might be consistent with this idea. Still, it is a task for future research to further explore the interplay between jointly presented pieces of news by considering both their form and *content.*

Practical Implications

Although our findings clearly point out a context-driven change in the recall of factual news, one can derive different practical implications from them. On the one hand, our results emphasize *problems* arising from reporting speculations – not exclusively, however, because uncertainty cues could be forgotten and neglected, as earlier research might suggest (and as shown by our study). Conversely, speculations appear also to lower the remembered certainty of jointly reported *facts* and thus the potential persuasiveness of these facts. Interestingly, this

was the case even when only a few speculations were intermingled, which exposes the impact and practical relevance of this effect.

On the other hand, however, reporting speculations could also be accompanied by a positive effect. Thus, although the formulation of a fact lays *claim* to truth, it does not necessarily have to be true. People might be wrong or deceive others – and even "fake news" is presented as fact per definition because, only in this way, can one expose it as being false (see Allcott & Gentzkow, 2017, for a definition of fake news). Especially when confronted with a multitude of unverified news, as is often the case in social networks that create some kind of "filter bubbles" around their recipients, explicitly reporting speculations could encourage a more cautious approach among readers toward reported facts that are actually untrue or controversial. It is a task for future research to investigate both proposed effects further. In sum, however, the present findings can draw both readers' and reporters' awareness to the special nature of processing speculations on the news and encourage future research to identify best practices on how these pieces of information may be communicated and received in a more conscious manner.

Future Directions

Besides its theoretical and practical implications, the current study also opens new questions for future avenues. First, one might ask which *boundary conditions* underlie a spreading of uncertainty cues. Note that we found spreading effects for distinct pieces of news whose content was not related in any way. Yet, all short articles were structurally similar, as they all involved potential explanations for events (as a feature of our experimental design). Such similarities could have enhanced retrieval interferences (e.g., by creating additional loose associations between the presented articles, similar to mush representations, Perfetti et al., 1999). Accordingly, future studies should investigate spreading effects also for other materials such as less structured or longer articles. Related to this, it would be interesting to study whether our findings generalize to other ways of expressing uncertainty (beyond the leading questions in headlines we used). Although prior work clearly supports this generalizability (e.g., to the uncertainty expression "X may have caused Y"; Brand et al., 2021), future research should further examine the memory effects of other kinds of uncertain language (such as *open* questions or other words indicating doubt).

Second, it is relevant what other *consequences* may result from intermingling speculations and factual news beyond the memory effects that we found. For instance, we

ruled out mere encoding effects only in an indirect way (by manipulating the presentation order of speculations and facts). Yet, the consequences of intermingling speculations on more *direct* encoding measures such as reading times or eye tracking remain unknown and should be addressed in future studies.

Third, it is unclear what *moderating role* other factors, such as source information or personal epistemic beliefs (Schommer, 1990), might play in the memory bias that we found. For instance, people can differ in their ideas of how simple and certain knowledge is, which could influence how they remember facticity and uncertainty in the news. Although our study shows that interspersing speculations can change how facticity is retained on a general level, considering person-related aspects could be a fruitful addition to our work.

Conclusion

To conclude, our experiments show that reporting speculative among factual (confirmed) pieces of news can decrease the remembered (and reconstructed) certainty of the latter. This finding highlights the recollection of facticity to be crucially context-dependent and more error-prone than assumed by the previous theorizing in this field. On the practical side, our study hints at the challenge of spreading confirmed contents (facts) as such—even in the absence of any attempt to defraud.

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Declaration according to § 5 Abs. 2 No. 8 of the PhD regulations of the Faculty of Science

-Collaborative Publications-

The following chapter (Chapter 4) consists of a manuscript that is in preparation for submission and was co-authored by Annika Scholl and Hauke S. Meyerhoff. The proportional contributions to this manuscript are presented in the subsequent table.

Author	Author position	Scientific ideas	Data generation	Analysis & interpretation	Paper writing
Ann-Kathrin Brand	First author	80 %	100 %	80 %	70 %
Annika Scholl	Second author	10 %	0 %	10 %	15 %
Hauke S. Meyerhoff	Third author	10 %	0 %	10 %	15 %

Title of paper: Shadow of a Doubt: Comparing the Effects of Negated and Speculative Contents on Recollecting Facts in the News

Status in publication process: In preparation for submission.

Chapter 4: Shadow of a Doubt

Comparing the Effects of Negated and Speculative Contents on Recollecting Facts in the News

The internet has expanded our world by allowing us to receive and spread an ever-growing number of pieces of news. Via modern media, all kinds of reports can be publicized in a matter of seconds – however trustworthy or uncertain they are – and through various technical aids, they are omnipresent in most people's everyday lives. In such information environments, discerning fact from myth, that is, true from false information, seems critical. Accordingly, prior work extensively studied how "fake" or retracted contents could propagate (e.g., Hasher et al., 1977; Johnson & Seifert, 1994; Pennycook et al., 2018) and developed detailed models on how truth and falsity (i.e., negations) are represented in mind (e.g., Gilbert, 1991; Gilbert et al., 1990, 1993; Nadarevic & Erdfelder, 2013).

Not all pieces of news, however, are distinctively true or false. News can comprise *speculations* that eventually may or may not prove to be true. This can be illustrated by the headline "Vaccine demand could soon surge again in the U.S." (Washington Post, Roubein, 21th of Oct. 2021), which uses the word "could" as a means of uncertainty expression. Prior theories suppose that speculations might be processed similarly as *negations (e.g.,* "Vaccine demand will not soon surge…"), suggesting similar memory processes and errors concerning both types of messages. In this work, we sought to investigate this theoretical assumption empirically.

To build upon and go beyond previous studies that focused primarily on memory errors concerning a negated or speculative message *itself* (e.g., Fiedler et al., 1996; Gilbert et al., 1990; Maciuszek & Polczyk, 2017; Mayo et al., 2004), we here considered *broader* consequences of reading both message types. We contrasted the effects of reporting negations versus speculations in the news on representing and reconstructing *other* messages. Does being confronted with speculative or negated contents (for example, when ruling out a previously spread but false explanation) impact the memory of jointly reported but unrelated facts similarly? Or are the effects of negations and speculations on remembering facts divergent? As we argue in the following, answers to these questions will allow inferences

about mental structures representing different language cues indexing the truth, falsity, or uncertainty of presented information.

Negations and Speculations Versus Facts: Structural and Functional Similarities Between the Former Two

The ability to reflect our knowledge and reasoning and to use language to express doubt or to discard a once-believed assumption are among the most distinctive features of humankind. What Portner (2009) described as "the linguistic phenomenon whereby grammar allows us to say things about, or on the basis of, situations which need not be real" (p. 1), can be illustrated by the following sentences (italics used for emphasis only) that share the same propositional core but differ in their *epistemic modality* and, thus, express distinct meanings.

(1) The fire *was* caused by a defective cable.

(2) The fire *was not* caused by a defective cable.

(3) The fire *might have been* caused by a defective cable.

According to Palmer (1986/2001), the epistemic modality of a sentence indicates the speaker's position on the truth value of an expressed matter. It thus refers to the evidential status or reality reference of an uttered proposition (Palmer, 1986/2001) that is affirmed by a *factual* formulation (1), discarded through a *negation* (2), and questioned through *speculative* language (3).

It is clear from the above examples that negations and speculations exhibit a crucial structural difference compared to a factual formulation. The reality reference of negations and speculations is explicitly *marked* by words such as "not" or "might". In contrast, a factual formulation does not need any marking to indicate evidentiality (hereafter also referred to as "epistemic marking"). This phenomenon is observable in almost all languages of the world, however old they are (one exception is the language Tuyuca, see Barnes, 1984). Accordingly, it seems reasonable that such linguistic structures could allow inferences about general structures of human thought, building on the classic idea that higher linguistic complexity could mirror more complex representations in the mind (Clark & Clark, 1977).

In line with this argument, several theories assume that marked information requires *more mental effort* to be understood in comparison to unmarked information (Chomsky, 1957; Clark & Clark, 1977, p. 523; Gilbert, 1991; Gilbert et al., 1990, 1993; Mayo et al., 2004). In detail, these approaches hold that understanding marked information presupposes understanding the entailed proposition (e.g., "The fire was caused by a defective cable") that

was negated or the subject of speculation first. According to this view, the negation operator (e.g., "not") or uncertainty expression (e.g., "might") can only be represented in a second step. Such two-step models are consistent with the function of negations and speculations to contrast two alternatives, such as a factual and a negated situation or two possible states of affairs (e.g., that a defective cable may or may not have caused a fire). In contrast, factual formulations refer to a single given and are, therefore, assumed to require no additional processing step (see Dudschig & Kaup, 2018; Hasson & Glucksberg, 2006; Wirth et al., 2019 for a similar argumentation).

Further complexity in processing speculations and negations might arise because both expressed alternatives usually differ in terms of *concreteness* (Mayo et al., 2004). For instance, the first alternative that a defective cable caused the fire is highly specified and imaginable. In contrast, the second alternative – the negation of this cause – is abstract, as it points out the possibility of multiple alternative explanations (be it a hot stovetop, arson, a glowing cigarette, or many more). Accordingly, this negation is abstract – it lacks a single affirmative translation (as compared to the negation "the door is not open", which can be translated into the affirmation "the door is closed"). Similarly, resolving the proposed alternatives is impossible for any speculation (e.g., "A defective cable might have caused the fire") without changing its meaning and omitting the uncertainty it initially expressed. Uncertainty, therefore, is abstract just as most negations are. This property is crucial for a first theoretical perspective on remembering epistemically marked information, as outlined in the following.

Two Perspectives on Remembering Epistemically Marked versus Unmarked Information

As outlined before, epistemically marked information (i.e., negations and speculations) could require a higher processing effort than unmarked information (i.e., facts). Although there is widespread agreement on this general idea of processing differences between both message types, divergent theoretical perspectives on the memory consequences of these differences exist. According to a first perspective, epistemic markings might be lost in memory, whereas a second view supposes that such markings could "spread".

The *first perspective* is grounded in the *schema plus tag model*. It was initially developed to describe the mental structures representing negation and particularly applies to those negations that cannot be translated into a factual given (Hasson et al., 2005; Mayo et al.,

2004). According to this model, negations that lack a clear affirmative translation can only be represented by two cognitive units, proposition (e.g., "fire was caused by defective cable") and abstract negation tag (+ "not"), whose connection can decay with time. This conception is consistent with the phenomenon that people tend to forget negations, and thus sometimes recall the *opposite* of the original meaning of a negated message (such as that a defective cable started a fire, although this was explicitly ruled out; Fiedler et al., 1996; Maciuszek & Polczyk, 2017; Mayo et al., 2004). In contrast, according to this model, memory traces on *factual* messages should prove to be robust.

However, this latter assumption has hardly been explicitly examined yet (one exception is an experiment of Mayo et al., 2004). Furthermore, the question arises to what extent the schema plus tag model is also valid for other cases of epistemically marked information, such as *speculative* language, and thus is applicable beyond the dichotomy of true and false. On the one hand, one might argue that speculations are very similar to those negations whose memory errors can be predicted by the schema plus tag model. Thus, precisely those negations that lack an affirmative translation open up several alternatives – they are underspecified (Street & Richardson, 2015) – and thus arguably express some uncertainty, similar to speculative language.

On the other hand, recent experiments show that typical memory biases toward facticity known for negations did *not* emerge for the case of speculative language (Brand et al., 2021). On the contrary, when reading a mixture of speculative and factual short news articles, participants misremembered facts as speculations more often than falling for the reverse mistake (Brand et al., 2021; Brand et al., in press). Specifically, being confronted with speculative news exerted a more substantial impact on recollecting facticity than being confronted with facts on recollecting the speculative character of other news. Reading speculations thus seemed to trigger an uncertainty that exceeded their intended scope, causing unrelated facts to be misremembered as uncertain (speculative) information as well. Accordingly, instead of getting lost in memory, uncertainty seemed to spread onto factual news. It should be emphasized here that this finding seems to *contradict* both the idea that epistemic markings in language generally tend to be forgotten and that the memory of unmarked information (e.g., facts) is hardly liable to error.

Interestingly, these latter results are consistent with a *second perspective* partly expressed in some recent work (Nadarevic & Erdfelder, 2013; Bell et al., 2021; Brand et al., in press). It shall be referred to as the *explicit marking account* in the following. This account

assumes that the epistemic modality of a sentence is actually *better* remembered when it is explicitly marked (vs. unmarked). Thus, the epistemic modality could be particularly salient when expressed by additional words (such as "not" or "might") instead of their absence and could, therefore, interfere with recollecting other information that lacks such a marking. Following the explicit marking account, it stands to reason that it is the memory of *facticity* (classically unmarked in language) that proves to be error-prone and susceptible to external influence.

Although the proposed perspectives may both appear plausible, they still draw opposite conclusions with regard to one and the same linguistic structure: The presence of epistemic markings (e.g., "not" or "might") could either suggest that these markings are *forgotten* or that they *spread* onto memories of initially unmarked information, with the latter expressing cross item effects. The present work aims to resolve this discrepancy. In the following, we will outline two ways to explain the different patterns of results, supporting either one or the other view.

Possibility 1: Negations Might Elicit Spreading Effects Just as Speculations Do

A first possibility to explain the divergent result patterns described above might be that negations can also trigger spreading effects (just as speculations do) but these had not been documented to date. In this case, spreading effects would not be specific to speculative language but could also be induced by other forms of epistemically marked information. Two arguments could support this view. First, in negation studies, the unit of observation is classically the negated statement itself (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975; Mayo et al., 2004). The interplay of different items, such as negated and factual statements and associated cross item effects could thus not be considered in these studies. Second, studies from the related field of "fake news" showed that falsehood tags on some particular news could lower the perceived accuracy of other news that were themselves not accompanied by tags (Pennycook et al., 2018) – indicating a kind of spreading effect caused by cues toward doubt. Under the assumption that negations are comparable to falsehood tags, negations could trigger similar cross item effects, and might lead confirmed facts to be remembered as having been negated or uncertain instead.

Possibility 2: Spreading Effects Might Depend on the Type of Epistemic Marking

A second possibility is that whether epistemic markings are forgotten or spread onto other information depends on *which type* of epistemic marking (negation vs. uncertainty cue) is considered. According to this view, negations and speculations should *differ* in their scope of influence on recollecting jointly presented facts. Note that this would suggest that the way epistemic modality is represented in mind is not mainly tied to linguistic structures (such as the presence or absence of epistemic markings), as it was proposed by both of the above approaches, the schema plus tag model and the explicit marking account. Indeed, more pronounced memory interferences caused by intermingling *speculations* (vs. negations) with facts could have several reasons that are not mutually exclusive but rather involve distinct components of remembering.

First, *negations* and facts could be *better differentiated* in memory than *speculations* and facts since their epistemic modality expresses opposite extremes (i.e., facticity vs. denial). Negations, thus, reverse a statement into its opposite, whereas speculations and facts are each formulated affirmatively, albeit to varying degrees. This contrast, in turn, might imply that facts that were read among negations are more explicitly encoded as such (relative to facts read among speculations) or more distinctly represented – as the epistemic modality of each statement is particularly important here. Accordingly, facts might be obscured by the presence of speculation but less so by negated news.

Second, above and beyond differences in the memory structures itself, a context of speculations (compared to negations) could also heighten the memory strength needed to remember facts as such. This means that the inferences that people draw based on a given memory representation of previously read factual messages could change to a more conservative mode if speculations were read among these facts. For instance, speculative language could be more *salient* than negations and, thus, interfere more strongly with reconstructing other memories. This possibility is supported by the argument that negations ("X was not responsible for Y") are typically more conclusive than speculations ("X may have caused Y"), as conflicting alternatives cannot be resolved in the latter case. Accordingly, due to speculations being potentially more complex to process, recipients could overestimate the number of speculations they had previously read, leading to a higher memory threshold to remember facts as such.

In sum, two distinct processes could suggest more substantial spreading effects for speculations than for negations. The present work aims to test this possibility.

The Current Work

Inspired by the outlined theoretical tension, the current work had two aims: First, we tested the basic hypothesis that spreading effects differ depending on whether speculations or negations were presented among factual news. This served to connect and resolve the discrepant findings from prior studies. In detail, we propose that speculations influence the memory of jointly presented (unrelated) facts to a more substantial extent than negations, causing facts to be remembered as uncertain information (Experiment 8 and 9). In contrast, the effect of reading negations on the memory of facts should be smaller or not present at all (i.e., negations should neither lead facts to be remembered as negated not as uncertain).

Second, we aimed to disentangle the potential memory mechanisms (strength of memory traces vs. inferences) that could underly such an effect (Experiment 10). Although we conducted a laboratory study with full experimental control, we framed our experiments as a study in the domain of news, as this seems to be the most relevant application field.

Experiments 8 and 9 had a similar design that was slightly modified for Experiment 10. Across all conditions, the participants read a mixture of short news articles that were subdivided into an equal number of target and context articles, presented in random order. All target articles reported factual explanations and had to be remembered later (without this being previously announced). Depending on the experimental condition, the context articles differed in the epistemic modality they expressed. In a first group, the participants read factual targets among context articles each including negated explanations (e.g. "Defective cable was not the cause of fire in immigration office", context type: Negations), whereas in a second group, the intermingled context articles presented exclusively speculative explanations (e.g. "Defective cable might be the cause of fire in immigration office", context type: speculations). After a short distraction, we assessed confusion errors, defined as facts that were misremembered to be speculative or negated (and thus to be reported as ruled out), respectively. These errors were contrasted against errors occurring in *two baseline conditions* for each type of context (negations vs. speculations) in which exclusively facts were presented (meaning that the target and context articles were formulated as facts; context absent condition). The increase of confusion errors for both context types (speculations vs. negations) served to indicate the extent of spreading effects. We tested this by implementing

different memory measures: a recognition task in Experiment 8 and a cued recall task in Experiment 9 (by which guessing biases can be ruled-out). Figure 4.1 depicts the between participants design of Experiments 8 and 9 with the factors context type and context presence.

	Context *present*	Context *absent*
Context type: *Speculations*	Mixture or facts (targets) and speculations (context)	Exclusively facts (in target and context articles)
Context type: *Negations*	Mixture of facts (targets) and negations (context)	Exclusively facts (in target and context articles)

Figure 4.1. Experimental groups implemented in Experiments 8 and 9. Information in the table indicates which types of articles participants read in the respective condition.

Both experiments consistently showed that spreading effects only occurred if *speculations* were intermingled with the facts; *negations*, in contrast, only lead to spreading effects on a negligible level. Following on from this, Experiment 10 sought to investigate the underlying processes explaining these divergent effects of both context types by using a signal detection framework. In this framework, memories of target and context articles were assessed, respectively. Derived from the theory presented above, we compared memory performance (i.e., the discriminability of target and context articles) and the response criterium depending on whether facts were presented within a context of negations versus speculations. The first dependent variable indicates the strength of memory traces for representing the difference between facts and context items. The second refers to the memory strength needed to recognize facts as facts.

Experiment 8: Recognition

Method

Participants. Five-hundred participants took part in this experiment. They were recruited via prolific academic on 8th of December 2020. This initial sample size was

determined by two considerations: First, an a-priory power simulation based on previous studies suggested 460 participants to reach a power of .80 (for further details, see preregistration or the ESM). Second, to compensate for potential data exclusions due to our preregistered criteria, we collected data from 40 additional participants (since we expected a data outage of approximately 5-10 %).

In line with our preregistered protocol, we excluded data from participants who did not pass the attention check (n=38), indicated they did not answer the questions honestly (n=1) or searched the presented headlines on the internet during the experiment (n=2). One person was excluded due to missing data. The final sample consisted of $N = 458$ participants (289 females, 156 males, four persons indicated "other"; $M_{age} = 38.03$ years; SD_{age}=12.0; range 18 - 74). The experiment was approved by the local ethics board. All participants provided informed consent prior to testing.

Materials. We used 16 short news articles about distinct events (such as the dying of fish in Hamburg waters) each with one explanation (e.g., toxic waste as the cause of fish deaths). Eight previously determined articles served as *target* items that were later queried (without this being announced beforehand). All targets presented explanations as being facts. In detail, each target consisted of a headline that presented a specific explanation for an event in statement form (e.g., "Dead fish in Hamburg's waters are due to toxic waste") and a teaser that indicated that the respective explanation was confirmed through investigations.

The remaining eight articles were defined as *context* items. Importantly, these items differed in the epistemic modality they expressed: Depending on the experimental conditions that were manipulated between participants, all eight context items were either formulated as referring to *factual* (baseline), *speculative* or *negated* information (Figure 4.2). In the case of factual information, headline and teaser followed the same basic structure as the target items. Speculative and negated items differed from this structure in two ways: In the case of speculations, the headline was qualified by the modal auxiliary verb "might" (e.g., "Defective cable might be the cause of fire in immigration office") and the teaser described the respective explanation as being currently investigated but *not* (yet) confirmed. In the case of negations, the headline was negated (e.g., "Defective cable was not the cause of fire in immigration office") and the teaser described the named explanation as being ruled out through investigations.

To obscure the purpose of the experiment to the participants, we included eight additional filler items that did not adhere to the structure of the target and context items. Most

importantly, the fillers did not include any causal explanations for events. These fillers were taken form or inspired by online news pages such as the German SPIEGEL Online or the Washington Post (e.g., "Getting it out of the bin: Students are offering courses for dumpster diving: Salvaging food from supermarket's trash cans is illegal, but popular. While some shops try to prevent dumpster diving, a group of students is offering courses for beginners.")

A)
Defective cable was the cause of fire in immigration office
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.

B)
Defective cable might be the cause of fire in immigration office
Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon. Specialists investigate whether the fire might have been caused by a defective cable.

C)
Defective cable was not the cause of fire in immigration office
Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon. Specialists rule out that the fire was caused by a defective cable.

Figure 4.2. Example for the different types of context items with (A) "Factual explanation" and (B) "Speculative explanation" and (C) "Negated Explanation".

Procedure. The experiment began with the *presentation stage* in which the participants read the target, context and filler items in random order and one per page. They indicated whether they would consider reading the respective article in full length by choosing between three response options ("yes", "maybe", or "no"). This filler task should lead the participants to engage with each headline and teaser and served to obscure the purpose of our study (i.e., the subsequent memory test). Across all experimental conditions, the participants were presented with a fixed set of eight target and eight filler items. However, the *type of context* differed according to the experimental condition: All context items were either presented as speculations or as negations. Furthermore, we included one baseline for each context type in which all context items were presented as facts. This resulted a two factorial between participants design including the factor context type with the levels speculations versus negations and the factor context presence with the levels present versus absent.

After finishing the presentation stage, the participants entered a *distraction stage* in which they answered some filler questionnaires and completed other tasks (e.g. the "lost in sea" task in which they had to rank order 15 items with regard to their importance for survival). These tasks took about five minutes.

Finally, the participants continued with the *assessment stage* in which they had to indicate which version of a previously read target item had been presented to them initially. In detail, they had to choose between four distinct response options for each target item, indicating whether it had been presented as being factual, speculative or negated in the first stage of the experiment or whether this item had not been presented to them at all. This recognition task included eight additional distractor items that were new to the participants. Memories for the items were tested in random order.

Design and Analysis. Confusion errors served as our main dependent variable. They were defined as target items that were later recognized as having been merely speculative in a context consisting of speculative articles or target items that were recognized as having been initially presented as negated in a context consisting of articles including negations. We fitted nested generalized linear mixed effects models (GLME) with a logit link function in order to test for differential context effects on confusion errors for speculations versus negations. Therefore, context type (negations versus speculations) and context presence (absent versus present) were defined as fixed effects. Additionally, the models included a random intercept for participant and for item in order to represent our experimental structure with measurement repetitions through distinct items. We compared a model including an interaction between context presence and type with a model including both factors as main effects in order to test our hypothesis. We calculated marginal and conditional R^2 as effect size for the model that best described our data. Marginal R^2 (R^2_m) indicates the variance explained by the fixed effects and conditional R^2 (R^2_c) refers to the variance explained by both fixed and random effects. We preregistered our sample size, exclusion criteria, hypothesis and main analysis (https://aspredicted.org/m68xc.pdf).

Results

Main analysis. We tested the hypothesis that speculations would have a stronger effect on remembering facts (indicated by more confusion errors) than negations. Confirming this hypothesis, the preregistered model comparisons revealed an interaction effect for the factor context type and context presence on confusion errors, $X^2(1) = 18.15$, $p < .001$, $R^2_m =$

.41, $R_c^2 = .55$. As depicted in Figure 4.3, a context of *speculations* exerted a (quantitatively) stronger influence on confusion errors concerning factual (target) headlines as compared to a context consisting of *negations*. In detail, after having read a mixture of facts (targets) and speculations, the frequency of facts being misremembered as speculative information increased by about 16 %. In contrast, after reading a mixture of facts and negations, the frequency of misremembering facts as negated increased by about 7 %.
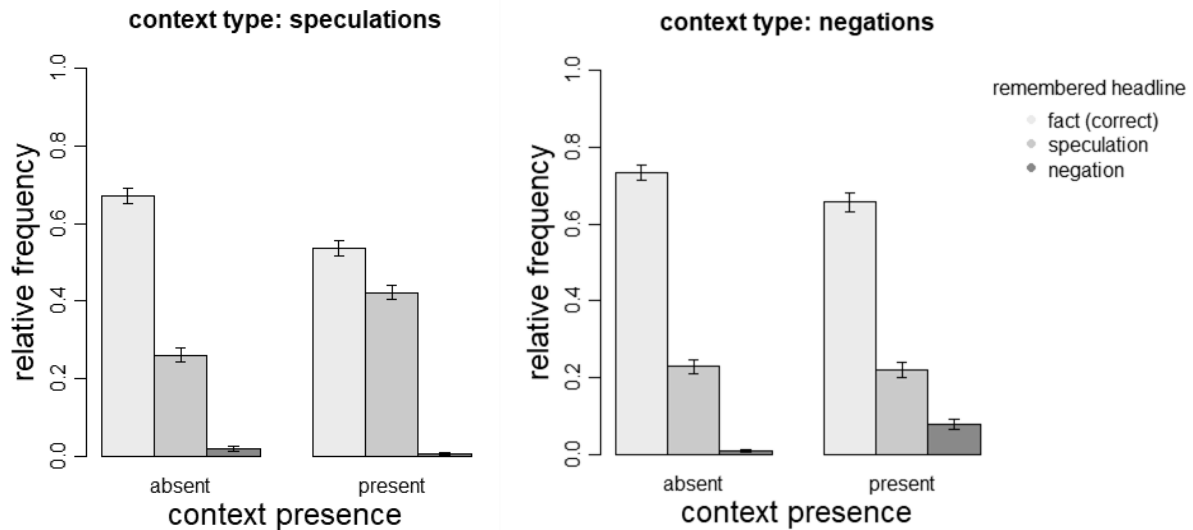

Figure 4.3. Results of Experiment 8. Relative frequency of remembering a previously read article as either fact, negation or speculation, depending on the context type with standard errors.

Exploratory analysis. In order to examine whether both context types might increase other kinds of confusion errors, such as facts being remembered as speculative (negated) information after having read these facts among negations (speculations), we fitted two further GLME models. They were identical to the models used for our main analysis, except that we changed the dependent variable. With the "Speculation Model" we compared the relative frequency of falsely remembering facts as speculations depending on the fixed effects context type and context presence. Again, this analysis revealed a significant interaction, $X^2(1) = 15.33$, $p < .001$, $R_m^2 = .05$, $R_c^2 = .21$. As Figure 4.3 indicates, the frequency of remembering facts as speculations selectively increased in the case in which these facts were presented among speculations relative to being presented among negations (negations context) or other facts (context absent).

Conversely, with the "Negation Model", we compared the relative frequency of falsely remembering facts as negated information depending on context type and presence. As before, a GLME analysis indicated a significant interaction between both factors, $X^2(1) =$ 19.22, $p < .001$, $R^2_m = .16$, $R^2_c = .65$. In this case, the frequency of misremembering facts as negated did only increase if these facts had been presented among negations (context type negation), but not if these facts had been presented among speculations (Figure 4.3). Taken together, these result patterns indicate that confusion errors were specific for the type of context (negations vs. speculations) that was induced.

Discussion

The results of Experiment 8 indicate that a context consisting of speculations exerted a (quantitatively) stronger impact on the memory of facts than a context of negations. This finding confirms the hypothesis that uncertainty cues as present in speculations spread to a larger extent onto other memories than is the case for negations, indicating that spreading effects depend on the *type* of epistemic marking. In addition, our exploratory analyses showed that confusion errors seemed to be specific for the particular context involved. For instance, even though it might seem plausible, negations did not increase participants' tendency to misremember reported facts as uncertain.

Still, there is one constraint regarding these results. It is unclear whether the observed pattern of results partly arose due to confronting participants with predefined response options in order to record their memories. This might have elicited guessing or response biases not evident in other methods of memory acquisition. This is a general critique of recognition tasks. To rule out the possibility that methodological artefacts triggered our results, we conducted Experiment 9. Most importantly, we here replaced the recognition with a *cued recall* task. As this task does not confront participants with any predefined response options, task-dependent guessing strategies are not possible here.

Experiment 9: Ruling out Guessing Biases

Method

Participants. Again, we collected data from $N = 500$ participants via prolific. Data acquisition was finished on 15th of December 2020. In line with our previous experiment, we excluded data from participants who failed the attention check ($n=36$), or searched the

presented headlines on the internet during the experiment (*n*=7). One person was excluded due to missing data. The final sample included $N = 456$ participants (293 females, 160 males, three persons indicated "other"; $M_{age} = 38.0$ years; $SD_{age} = 14.2$ years; range 18 - 74 years).

Procedure. The materials and procedure were identical to Experiment 8 except that we assessed the participants' memories on the presented articles via a cued recall task. In this task, the participants were asked to freely reproduce the substance of each of the presented target articles from the presentation stage as completely and as accurately as they were able to remember. We instructed the participants to respond as if they would do when talking to a friend. As a retrieval cue, they received short prompts which consisted of the first sentence of the teaser of the respective article that described the event (e.g., "Two employees were injured and numerous documents destroyed by fire in Munich's immigration authority on Monday afternoon."). Importantly, this cue did not include the corresponding explanation and its epistemic modality whose memory we aimed to capture. Accordingly, the presented cues were uninformative regarding the experimental conditions. They were presented one by page and in random order.

Coding. Answers were coded by two independent raters who were blind to the experimental conditions. As preregistered, they first coded whether an answer correctly reproduced a previously read explanation. Trials in which an explanation was not or falsely remembered were excluded from further analysis. In a second step, correctly remembered explanations were classified in terms of the certainty or uncertainty, or negation they contained.

For coding, we applied the following scheme (for a similar procedure, see Bonyadi, 2011; Brand et al., 2021, in press; Rubin, 2007): If answers included expressions of uncertainty such as "presumably", "probably", "potentially", "could", "may" or "might" or formations such as "researchers investigate / presume / suspect / believe", "there was a theory that" or "the article discussed whether", we classified them as "remembered *speculative* explanation". Explanations that were reproduced as having been negated (e.g. "aluminium particles did not cause dying of bees"; as indicated by expressions such as "not", "it was ruled-out that", "was unrelated to" etc .) were classified as "remembered negation".

In contrast, answers that expressed a definite causal relationship (instead of correlation) and did not contain uncertainty expressions or negations (as, for example factual formulations such as "this was caused by …" or "investigations confirmed that…") were assigned to the category "remembered *factual* explanation". Answers that expressed doubts of

the participant but not uncertainty in the news coverage itself (e.g., "apparently this was caused by") were also coded to belong to this category.

Some cases were neither classified as remembered fact or speculation (or negation), as they were ambivalent in terms of the certainty they expressed. These cases include factually formulated memories that expressed a correlation instead of causation (e.g., "… was related to") or factually formulated memories which, although expressing the correct content of an explanation (e.g., "They found aluminium particles in the bee keepers' dwellings"), did not explicitly name its causal relation to the respective event (e.g., bees dying).

Regarding the correctness of a recollected *explanation*, the interrater reliability was Kappa = .85. Regarding the certainty, uncertainty or negation an answer expressed, we obtained an interrater reliability of Kappa = .92. Both ratings did not differ with respect to the statistical test results. For the sake of brevity, we report only the results based on Rater 1 (but all data and ratings are accessible online).

Design and Analysis. As in Experiment 8, we were interested in participants' confusion errors depending on context condition. Confusion errors were defined as target items (facts) that were falsely reproduced as speculative information in the condition context type *speculations*, or target items (facts) that were falsely reproduced as negated in the condition context type *negations*. Again, we used nested GLME models with a logit link function in order to compare the context effects on confusion errors evoked by intermingling speculations versus negations in the presentation stage. Accordingly, context type (negations versus speculations) and context presence (absent versus present) served as fixed effects. Additionally, the models contained a random intercept for participants and for items. The procedure was identical to that of Experiment 8: We tested a model including an interaction between context presence and type against a more parsimonious model including both factors as main effects. We preregistered our sample size, exclusion criteria, hypothesis and main analysis and coding scheme (https://aspredicted.org/6fb8n.pdf).

Results

Main Analysis. As in Experiment 8, we hypothesized that speculations would impact the memory of facts to a stronger extent (indicated by more confusion errors) than negations. Accordingly, we expected an interaction effect between context presence and context type again. The preregistered model comparisons revealed a main effect for the factor context type, $X^2(1) = 125.88$, $p < .001$, $R_m^2 = .46$, $R_c^2 = .75$, and context presence on confusion errors, $X^2(1) = $

8.95, $p < .01$, $R^2_m = .49$, $R^2_c = .76$. As depicted in Figure 4.4, there were rarely any confusion errors in the condition with *negations* as context type (with zero cases in the associated context absent condition). Due to this extreme result, it was impossible to fit the planned GLME model that includes an additional interaction term. Nevertheless, the absence of substantial confusion errors in the case of confronting participants with negations is in line with our hypothesis of a stronger context effect due to reading speculations as compared to reading negations.

Figure 4.4 shows that a context of *speculations* increased the frequency of facts being remembered as speculative information by about 10 %. In contrast, a context of *negations* increased the frequency of facts being remembered as negated numerically by about 1 % (which reflects five single cases in the whole dataset). This replicates the general result pattern of Experiment 8. Extending the findings of Experiment 8, Experiment 9 thus indicates that the effect of reading negations on the recollection of facticity is negligible.
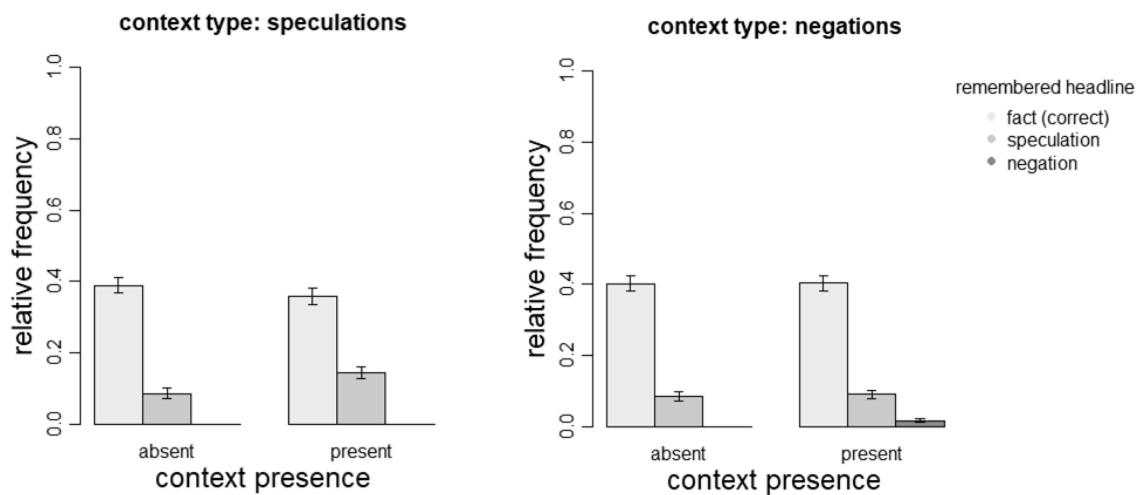

Figure 4.4. Results of Experiment 9. Relative frequency of reproducing a previously read article as either fact, speculation, or negation, depending on the context type with standard errors. The relative frequency of misremembering facts as negated is represented by the third bar, respectively. Yet, due to (almost) no cases of this mistake, these bars are not visible for most conditions in this figure.
.

Exploratory Analysis. Similar to Experiment 8, we conducted an explanatory analysis in order to examine the possible effects of reading negations on other kinds of confusion errors (note that the Negation Model could not be fitted due to zero confusion errors in three out of four conditions). The Speculation Model served to test the relative

frequency of recollecting facts as uncertain information depending on context type and context presence. In contrast to Experiment 8, this analysis yielded a main effect of context presence, $X^2(1) = 7.10$, $p < .01$, $R_m^2 = .02$, $R_c^2 = .43$, but no significant interaction between context presence and context type, $X^2(1) = 1.2$, $p = .272$, $R_m^2 = .02$, $R_c^2 = .43$. As Figure 4.4 indicates, the frequency of remembering facts as speculative information slightly increased (by about five percent) if these facts were initially presented among negations as compared to being presented among other facts. Since this effect is numerically very small, it should be interpreted with caution.

Discussion

The results of Experiment 9 replicate those of Experiment 8 with an even clearer pattern of findings: Whereas speculative articles lead to spreading effects, negated ones did not. In other words, intermingling speculations among facts increased the frequency of recollecting those facts as speculations – but intermingling negations rarely, if at all, lead to facts being misremembered as negated information. Memories on facts were, thus, (almost) unaffected by the presence of negations.

Overall, Experiments 8 and 9 support the conclusion that *speculations* exert a stronger influence on remembering facticity than negations, using different memory measures. Still, the question arises of *how* these divergent effects of being confronted with both context types might be explained. Experiment 10 addressed this question using a framework building upon signal detection theory. The aim was to investigate which aspects of remembering a context of speculations (compared with a context of negations) might change. Could intermingling speculations (versus negations) differentially impact participants' memory performance (i.e., the discrimination between target and context items)? A signal detection framework allows us to separate this aspect of remembering from reconstruction tendencies, namely the strength of memory evidence needed to recognize previously read facts as facts. It, therefore, seems suitable to disentangle both potential constituents of the divergent spreading effects we found.

Experiment 10: Memory versus Reconstruction

Within a signal detection framework, the participants' responses are considered to consist of two components, the memory performance in discriminating targets (i.e. factual news) and distractor items (i.e., speculative or negated news) referred to as sensitivity and the

response criterium (i.e., the strength of memory evidence to be met to recognize previously read facts as such). By this conception, memory performance and reconstruction tendencies (response criterium) can be disentangled and estimated independently of each other. Applying this framework to our research question thus allows us to test whether the divergent context effects of speculations and negations observed Experiments 8 and 9 actually emerge from differences in the memory discriminability (i.e. more accurate memory performance for facts read among negations than for facts read among speculations) or whether the divergent context effects emerge from a more conservative response criterion if facts are intermingled with speculations (i.e. a general bias toward the speculation option) in contrast to negations.

On the one hand, *memory performance* might differ depending on whether facts were initially read in the context of speculative or negated news. For instance, negations and facts might be better discriminated in memory because their epistemic modality refers to opposing poles. In contrast, speculations and facts might be less distinctively represented, as both express affirmations, although to different degrees. Following on from this, we expected that the discriminability of facts and speculations, as indicated by the sensitivity d' (d-prime) scores as a measure of memory performance, is lower than the discriminability of facts and negations. This difference could serve as one potential explanation of speculations exerting a more substantial impact on how facticity is remembered (compared to negations).

Above and beyond memory performance, the *strength of memory evidence* needed to reconstruct facts as such might differ depending on the context type. As an additional hypothesis, we thus expected that the tendency to recognize a message as having been previously presented as a fact is less pronounced if participants initially read facts among speculations (as compared to negations), which would be reflected in a higher response criterion. This mechanism could alternatively explain that memories on facts are particularly affected by speculations.

Method

Participants. Two hundred and five participants took part in this study between the 16th and 17th of June 2021. The data was collected via prolific. As before, data from participants who did not pass the attention check ($n=16$), or searched the presented headlines online ($n=2$) were excluded. The final sample consisted of $N = 187$ participants (121 females, 63 males, three persons indicated "other"; $M_{age} = 32.8$ years; $SD=11.3$; range 18 – 70 years).

Materials and Procedure. The materials and procedure were identical to that of Experiment 8, except for three major changes that resulted from applying a signal detection framework as a new method of data analysis. First, we used an *extended set* of short news articles (60 items in total) to ensure enough datapoints to calculate sensitivity d' and response criteria beta for each participant. This set of items could be divided into four categories of equal size (15 items per category), referring either to accurate, uncertain, or false explanations of real events or to explanations of invented events (which were roughly inspired by real happenings). In order to avoid systematic item effects, we counterbalanced their allocation to the different experimental conditions (i.e., target, context or news article) across participants. To do so, we divided the whole set of 60 items into three subsets (A, B, C), each consisting of five items that referred to accurate, five that referred to uncertain, five that referred to false and five that referred to invented news. Based on these three subsets, the items were assigned to the three distinct article groups, namely target, context or new articles. Articles that served as targets (factual formulation) or context (speculative formulation vs. negation) were included in the presentation stage. In contrast, items assigned to the third group "new articles" were presented exclusively in the subsequent recognition task. For example, in a first item list, all items from subset A were presented as target articles (factual formulation), all items from subset B were presented as context articles (speculative vs. negated formulation), whereas the items from subset C were not included in the presentation stage (see Table 4.1 for a detailed description). This assignment resulted in three lists (with 40 items) for each context type (speculation versus negation). Every participant read *one* of these lists in the presentation stage (6 lists in total).

Second, we omitted the *context absent* condition because it is neither needed nor embeddable in the applied signal detection framework. Third, we adapted the recognition task. A) to record all frequencies (i.e., hits and false alarms) needed to calculate sensitivity d' and response criteria beta not only target, but also context items were queried later (again, without prior announcement). b) as the outcome measure, participants indicated whether they had previously read an item as i) factual, ii) speculative (context of speculations) *or* negated (context of negations), or iii) had not seen this item before. Accordingly, and in distinction to our prior experiments, the options of the recognition task differed depending on the context type (speculations vs. negations). As our previous studies showed that selecting the here omitted response options was not substantially influenced by the type of context, this simplification seemed reasonable to us.

Table 4.1

Counterbalanced presentation of item subsets (each consisting of 20 items) as either target, context (negated vs. speculative), or new. Note that each list consists of exclusively target and context articles as new articles were only presented in the succeeding recognition task.

Target articles	Context articles	New articles	Item List
Subset A	Subset B	Subset C	1
Subset B	Subset C	Subset A	2
Subset C	Subset A	Subset B	3

Data Analysis. The experiment was conducted as a between-participant design with the factor context type: speculations versus negations. As a first dependent variable, we calculated the sensitivity d' for each participant as a measure of her or his *discrimination performance* between target (factual formulations) and context items (speculations versus negations, depending on the context condition). It is defined as the z value of the hit rate minus that of the false alarm rate. In this framework, we conceptualized facts that were correctly recognized as such as "hits" and regarded speculations or negations falsely recognized as facts as "false alarms".

As a second dependent variable, we calculated a beta score for each participant to measure their tendency to recognize an item as *having been presented as fact* before – independently of the actual epistemic modality of this item. In our experimental setup, this parameter indicates the memory evidence needed to recognize information as having been presented as fact before. In this framework, an unbiased participant has a value of around 1.0. Beta approaches 0.0 the stronger a participant is biased to generally recognize items as *facts*, as indicated by a higher hit and false alarm rate. In contrast, if a participant is generally biased to recognize items as *speculations or negations*, as indicated by a lower hit and false alarm rate, beta grows larger than 1.0 (see Wixted, 2007 for a more detailed description of the applied model).

Trials in which an initially presented factual, speculative, or negated item was not correctly recognized as having been read before (i.e., falsely considered to be new) were excluded from our analysis (11 % of all trials). Again, we preregistered our sample size, exclusion criteria, hypothesis and analysis (https://aspredicted.org/kc2bv.pdf).

Results

Two preregistered *t*-tests revealed an effect of the type of context on both, memory performance, t(185) = 10.66, *p* < .001, *d* = 1.55, and the response criterium beta, t(185) = -3.55, *p* < .001, *d* = 0.52. As depicted in Figure 4.5, *memory performance* was lower when participants read facts in the context of speculations as compared to negations. Thus, as predicted, participants were less able to discriminate facts from speculations than from negations. In addition, participants *reconstructed* modality information differently depending on both context types. As can be seen in Figure 4.6, participants showed a bias toward remembering all types of information to be mere *speculation* in the case of an intertwined presentation of speculations and facts. This was indicated by an average response criterium larger than 1.0. If facts were intermingled with negations, however, this tendency was reversed. In the latter case, participants were biased toward remembering all previously read information as facts, as indicated by an average response criterium lower than 1.0.
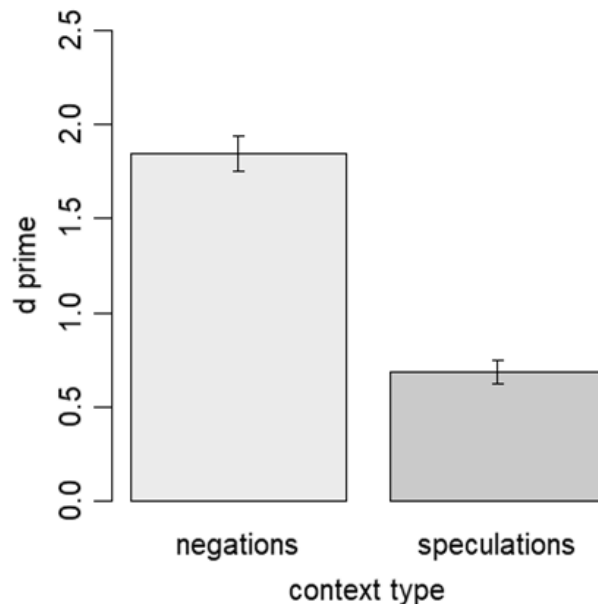

Figure 4.5. Results of Experiment 10. Memory performance as indicated by d prime scores depending on the type of context that was induced; error bars indicate Standard Errors.
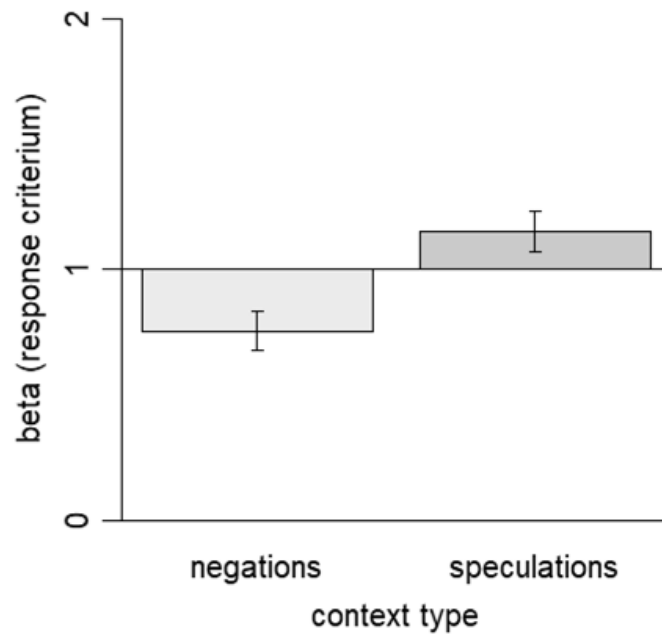
Figure 4.6. Results of Experiment 10. Tendencies of memory reconstruction as indicated by bias scores depending on the type of context that was induced; a value lower (vs. higher) than 1.0 indicates that participants were biased toward (not) recognizing facts. Error bars indicate Standard Errors.

Discussion

The results of Experiment 10 confirm that both aspects of remembering – memory performance and the response criterium – differed depending on the type of context in which pieces of factual news were initially presented. First, discrimination performance was considerably higher if facts were read among negations as compared to speculations. This suggests that the divergent effects of both context types can be partially explained by facts being better *remembered* and *discriminated* from other news if negations (instead of speculations) were intermingled.

Second, above and beyond memory performance, the response criterium differed depending on whether facts were initially read among negations or speculations. The memory evidence needed to remember facts as such was higher if participants read these facts among speculations before (compared to negations), suggesting a bias toward uncertainty if speculations were present and a bias toward facticity if negations were present. Together, both memory components explain why negations have almost no effect on how factual pieces of news are recollected, whereas speculations cause facts to be remembered as representing speculation as well.

General Discussion

This study aimed to gain a better understanding of how the human mind represents different language cues indicating the reality reference of information (which we refer to as its epistemic modality). This was studied in the domain of news articles. Our central question was whether and to what extent a context of epistemically marked information – namely negations ("not") and speculative formulations ("might") – can differentially impact the memory of factual formulations that lack such a marking. Albeit negations and speculations share not only structural but also crucial functional commonalities, three preregistered experiments consistently indicated that the impact of speculative language on remembering and reproducing facts is unique and distinctively *different* from that of negations. Participants who read facts among speculative news tended to misremember and reproduce these facts to be *uncertain* (speculative) information more often (compared to a baseline condition in which exclusively facts were presented). Accordingly, the uncertainty of speculations seemed to "spread" towards the memory of unrelated facts. In contrast, negations did not provoke such a spreading effect, neither causing facts to be remembered as negated nor as uncertain (or did so only at a negligible level). In other words, intermingling speculations changed the way facticity was remembered – whereas intermingling negations did not.

Notably, this pattern emerged across different measures of memory, including not only recognition but also a cued recall task in which participants received no predefined response options. Thus, guessing tendencies caused by response options can be ruled out as a methodological explanation of our results.

Building upon these findings, Experiment 10 served to clarify the memory processes that might underly these divergent effects of reading negations or speculative language. In principle, two independent aspects of remembering can be distinguished that could have produced our results (Wixted, 2007). These, in turn, might be relatable to functional differences between both message types. First, the *memory traces* for representing the difference between facts and context items could vary in strength depending on the mix of messages that the participants read. Second, the *response criterium,* namely the strength of memory evidence needed, to recognize facts as facts might differ depending on whether negations or speculations were intermingled with these facts before.

Experiment 10 separated both components of memory by applying a signal detection theory. Our findings revealed that the major difference between both context types concerned our first dependent variable: the strength of memory traces themselves. We observed the

memory performance in a context of negations exceeding that in a context of speculations with a very large effect size. This suggests that participants who read facts among negations were able to build a stronger memory trace for representing the difference between both message types. The difference between speculations and facts, in contrast, seemed to be less pronounced in memory.

On top of this difference in memory strength, we observed that also the response criterium differed significantly between both context types. While those participants who read facts among speculations generally tended to recognize all pieces of news as *speculations* rather than facts, this bias was reversed if negations were intermingled: Those who read facts among negations tended to recognize all information as being facts rather than negations. Taken together, both memory components explain why negations have only a negligible effect on recollecting factual news, while speculations provoke facts to appear as having been mere speculation as well. Our findings have theoretical and practical implications, which we now discuss along with both components of memory.

Memory Traces

The assumption that structures of language allow inferences about structures of thought enjoys high popularity, which might be due not least to its intuitive appeal (Chomsky, 1957; Clark & Clark, 1977; Gilbert, 1991; Gilbert et al., 1990, 1993; Mayo et al., 2004). Accordingly, many theories postulate that the memory of epistemically marked information (such as negations or speculative language) fundamentally differs from that of facticity that does not require to be highlighted through language. For instance, Gilbert et al. (1990) famously proposed that mentally representing the factual character of information should be "first, easy and inexorable" (p. 231), whereas representing unacceptance, our doubt is "difficult" (p. 231) and can be impaired by distraction.

Our study opposes this language-mind mapping assumption in two ways: First, although negations and speculations follow a similar language structure (both are epistemically marked by words such as "not" or "might"), their *memory consequences* differ fundamentally. Second, and relatedly, our experiments indicate that memories on facticity are not necessarily robust. Instead, they can be highly *context*-dependent, as they are impaired by reading speculative but not negated pieces of news that are intermingled.

How can these divergent effects of negations and speculations be explained? Building upon our results, we propose that whether facticity is correctly remembered or not is not

necessarily tied to its linguistic structures alone (i.e., the absence of epistemic markings). Instead, we argue that memory representations depend on the context-bound distinctiveness and relevance of a factual formulation. Since negations (e.g., "X did not cause Y") turn the meaning of a sentence into its opposite, they are most different from its corresponding factual version ("X caused Y"). Distinguishing different kinds of epistemic modality could thus be particularly important if facts are presented alongside negations, suggesting distinctive representations of both. In contrast, like facts, speculations are formulated affirmatively ("X may have caused Y"). This may result in less distinct memory traces of both message types so that they tend to be confused more easily at the moment of recall.

Interestingly, the assumption of context-bound memory structures for representing facticity is related to a model introduced by Nadarevic and Erdfelder (2019) that assumes a flexible coding system of epistemic information. These authors argued that "attaching true and false tags to encoded information should be optional and context-dependent rather than mandatory. More precisely, stored representations of statements might only be tagged as true or false, respectively, when the respective tag is informative in the context defined by the instructions." (p. 1397). A model that maps the memory structures of epistemic information should, therefore, "not rest on a mandatory tagging assumption" (p. 1397). Even though this model refers to a dichotomous conception of memories that are either tagged or not, and therefore differs from our approach, it agrees with the idea of *context-bound* representations of facts.

To our knowledge, our study is the first that explicitly addressed context-bound differences in the *strength* of memory traces for representing facticity and, by doing so, supports Nadarevic and Erdfelder's (2019) supposition in a broader sense. Still, additional studies are needed to further examine such context effects as well as the proposed model. It would be interesting to know, for instance, how and whether other context manipulations, such as the number of negations or speculations intermingled, can impact the way epistemic information is remembered.

The Strength of a Memory Signal Needed to Recognize Facts as Such

In addition to differences concerning memory strength, we found that the response criterium to correctly recognize facts differed qualitatively depending on whether these facts were presented in the context of negated (i.e., a bias toward facts) or speculative (i.e., a bias toward speculation) news. Distinguishing both aspects of remembering is grounded in the idea

that recollections are not solely shaped by phenomenal properties of a memory structure but are also based on inferences and decisions that operate on this structure (Wixted, 2007). How can we explain that such inferences turn out differently depending on the mixture of news that the participants read?

In principle, there are several explanations for this finding that should be considered in more detail. To begin with, differences in the response criterion potentially could be a methodological *artifact*, meaning that they were provoked by the methods used. For instance, the distinct response options displayed in both context conditions might have elicited distinct strategies of remembering. Yet, several observations speak against such a methodological explanation. *First,* we consistently found our basic pattern of results even if no response options were displayed at all (Experiment 9, cued recall). Notably, this pattern of results is consistent also with former studies (Brand et al., 2021; Brand et al., in press) which indicated that uncertainty spreading is not tied to guessing strategies caused by the response format.

Second, divergent effects of negations and speculations also emerged if all response options were included in the recognition task regardless of the context condition (Experiment 8). Crucially, selecting the in Experiment 10 dispensed options was not influenced by the context manipulation, suggesting that these options are negligible in terms of our effects.

How could the differences in the response criterion be explained beyond methodologically determined patterns? *One* possibility previously mentioned is, that the uncertainty in speculations appears particularly salient to the reader due to being less conclusive than negations and facts (as alternative possibilities cannot be resolved in the former case). Hence, while negations could stimulate a more distinctive encoding of facticity, having read speculations might change the threshold to remember facts as facts by causing recipients to overestimate the number of uncertain formulations previously read. *Another* possibility is that speculations might trigger a sceptical mindset and therefore increase the participants' uncertainty in a general way. Future studies should examine and disentangle these explanations in more depth.

Furthermore, the question arises why the tendency to recognize facts as such reversed in the case the participants read a mixture of facts and *negations* and thus differed not only quantitatively but also in a qualitative sense. One possibility for explaining the bias from negations to facts could be that assuming a memory to be affirmative is a basic mode of remembering. While this is principally in line with earlier research supporting the schema plus tag model (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975; Mayo et al., 2004), it

cannot explain why a reversed bias emerges if *speculations* are intermingled with facts. This leads to the conclusion that uncertainty might change basic ways and strategies of remembering and reconstructing the past. Therefore, the case of uncertainty challenges former models that were solely based on a dichotomous distinction of true and false. In this sense, it might be interesting to study whether the presence of uncertain messages can change not only memories on factual formulations but also memories on negations.

Practical Implications

We studied the processing of negation, speculation, and facticity in a specific application context, namely the news. This could be considered a limitation of our study as, strictly speaking, we do not know whether our findings will generalize to other application fields – particularly as we argue in favor of a context-sensitive memory model. Notwithstanding, studying the memory of epistemic modality in a highly meaningful domain allows us to draw inferences about this domain in an ecologically valid way. First, our study shows that recipients have difficulties especially with distinguishing factual from uncertain (speculative) content in the news. This suggests that news outlets should take extra care when reporting mere speculations and might withhold from intermingling them with facts (unless absolutely necessary). Second, we found that reporting negations in the news is less problematic with regard to remembering the factual news; however, our study ties in with earlier research showing that negations sometimes tend to be misremembered as having been affirmed. This suggests that negations should also be carefully reported and only when deemed necessary, such as in case of retractions or corrections of widely spread fake news.

Conclusions

To conclude, the way facts are remembered crucially depends on other pieces of news presented among them – with the presence of speculations eliciting a particular bias to misremember facts as uncertain information. Negations, in contrast, do not seem to substantially change how facts are reproduced, which can be explained by more distinct representations of both message types (facts and negations) and a lower memory strength needed to correctly remember facts as such if they were read among negations before. To the best of our knowledge, the present work is the first that explicitly contrasted the processing of negations and speculations and disentangled the memory consequences both message types provoke. In this way, it extends previous findings in theoretically relevant ways. Opposing

prior conceptions, the present work suggests that not the similarities but the *differences* between negations and speculations are crucial for theory development. From a practical perspective, our findings show that uncertainty can spread across different pieces of news and point out the unique and detrimental memory effects speculation can exert.

Chapter 5: General Discussion

Nowadays, digital media allow news to be shared and spread rapidly, often including contents that are merely speculative and whose confirmation is still pending. This thesis addressed how recipients consider and reproduce subtle but critical differences in wording, indicating whether an articles' content is merely speculative and yet unconfirmed or confirmed through investigations (this information is termed the epistemic modality of a sentence). As systematic work on the processing of speculative language rarely exists, I derived hypotheses from related research areas in and outside psychology. By building on distinct theoretical backgrounds, two perspectives emerged. On the one hand, negation models (i.e., the schema plus tag model) and the statement bias suggest that people could tend to forget uncertainty cues, producing a tendency to treat and remember speculations as if they were facts later on (which I will refer to as the "*forgetting perspective*" in the following). From this point of view, the memory of facticity (compared to uncertainty) should prove less prone to error. On the other hand, applied research on news processing suggests that uncertainty could also spread across memories, pointing to the reverse tendency of misremembering reported facts as uncertain information if these facts were presented among speculations before ("*spreading perspective*"). The goal of this thesis was to combine and contrast both perspectives to uncertainty processing empirically.

Despite prior work in harmony with the forgetting perspective (Clark & Chase, 1972; Fiedler et al., 1996; Gilbert, 1991; Gilbert et al., 1990, 1993; Loftus, 1975; Pandelaere & Dewitte, 2006), I found consistent empirical evidence supporting the alternative view across all three experimental series (Chapter 2 - 4). In essence, these studies showed that intermingling speculations could actually lower the remembered certainty of factual articles that were presented among the former – suggesting that uncertainty does not get lost but *spreads* in memory. In this final chapter, I will discuss the results on which this conclusion is based, relate them to existing literature, and outline how they can inform theoretical models concerning the cognitive architecture for representing true, false, or uncertain content. Thereafter, I will discuss the practical implications of my findings, the strengths and limitations of my studies, and possible future directions.

Summary of Findings and Their Relation to Both Theoretical Perspectives

The first experimental series, *Chapter 2,* aimed to study whether people neglect uncertainty cues in speculative articles just as they tend to neglect negations, in line with the forgetting perspective. Following this question, my first two experiments demonstrated that both speculative and factual formulations in the news fostered the participants' belief in the correctness of the presented content to a similar degree (compared with receiving no explanations at all). This suggests that participants neglected the difference between both information types, namely certain (factual) and uncertain (speculative) formulations. Crucially, however, these similar effects were not mainly driven by a tendency to *forget* uncertainty cues, as negation models would predict. Instead, four additional memory experiments (recognition and cued recall) revealed an inverse distortion: The participants showed a strong tendency to falsely recognize and reproduce a previously read "fact" as mere speculation later (rather than falling for the reverse mistake). This pattern clearly opposes the forgetting perspective.

The second experimental series, *Chapter 3*, strove to explain this surprising result by considering potential cross-item effects. Might the presence of speculations have decreased the remembered certainty of jointly reported facts? This would indicate that uncertainty spreads in memory. In line with this idea, my first two experiments of Chapter 3 showed that intermingling speculations caused factual news to be misremembered as uncertain information more often (compared to intermingling facts). This effect was evident for different memory measures, recognition, and cued recall (that I already used in my first study). Notably, the recognition experiment indicated that the presence of speculations exerted a more substantial impact on the way facticity was remembered than, conversely, the presence of facts on the memory of speculations. This asymmetry is essential, as it suggests that cues concerning the certainty or uncertainty of content were not simply reallocated across memories on the presented information. Instead, after having read a mixture of factual and speculative reports, participants recollected *more uncertain* contents than had been initially present. This pattern supports the proposed spreading perspective. It shows that an uncertainty bias is (at least partly) context-induced, meaning that it depends on whether speculations are presented next to factual pieces of news, instead of reflecting a context-independent tendency.

Two additional experiments were conducted in this study to investigate the underlying mechanisms of uncertainty spreading in more detail. They demonstrated, first, that speculations decreased the remembered certainty of factual reports even when both types of news were read one after another in separate blocks. Notably, the tendency to remember facts as speculations emerged even when all factual pieces of news were presented *first*. This pattern suggests that encountering speculations did not specifically change how recipients *encoded* other contents but also seemed to alter memories that had been previously stored. Second, the tendency to recall facts as uncertain information seemed to be fostered with the number of speculative reports interspersed. Yet, despite this relation, uncertainty did spread even if only a few speculations were present (6 out of 24 headlines), underscoring the force of this bias.

My last experimental series, *Chapter 4,* aimed to bring together both theoretical perspectives of the previous parts. This should be achieved by directly comparing the effects yielded by intermingling speculations with those of negations. Note that negation models served as a central starting point of this work. Although speculations and negations hold structural and functional commonalities, three experiments revealed that the detrimental influence of speculations on remembering facts is *unique* and differs fundamentally from that of negations. Unlike speculative news, intermingling negations did not evoke any spreading effects. Thus, intermingling negations neither led participants to remember facts as negated nor as uncertain information (or did so only in a negligible way), which was evident for both a recognition and cued recall measure. In my last experiment of this chapter, I applied a signal detection framework to the memory errors that arose, which revealed that two aspects of remembering could explain this pattern of results. On the one hand, facts and negations were better differentiated in memory than facts and speculations (indicated by d' scores), suggesting more distinct representations of the former message types. On the other hand, also the response criterium, namely the memory evidence needed to recognize facts as such, was lower if these facts were read among negations instead of speculations before. This indicates that participants were biased toward remembering *facticity* if negations were intermingled but biased toward remembering *uncertainty* if speculations were interspersed instead.

In sum, the reported experiments provide consistent evidence supporting the spreading and opposing the forgetting perspective. Further, they indicate that speculations ("X *might* have caused Y") represent a special case that appears to be remembered differently than the

functionally related negation operator ("X did *not* cause Y"). These findings make theoretical and practical contributions that I outline in the following sections. Before doing so, however, important methodological aspects of my studies shall be discussed that build the basis for my further arguments.

Methodological Considerations: Ruling Out Potential Constraints

Considering the reported results, one might ask whether they were influenced or partly influenced by the methods used, which reflects an essential question regarding all experimental work. Several properties of my studies speak against such methodological artifacts, which I will discuss in the following.

To begin with, one might argue that the tendency to remember reported facts as speculation could merely reflect a guessing or response bias triggered by the memory measures used. For instance, being confronted with predefined response options as part of the recognition task could have induced a tendency of "playing it safe", leading participants to select the uncertain option more often. In this case, the response format would have partly produced the uncertainty bias I found. This is a general critique of recognition tasks (e.g., Nadarevic & Erdfelder, 2013) that I aimed to counter via combining this measure with a *cued recall task* across all three experimental series. Importantly, this latter task did not include any given response options. Instead, the participants were asked to (freely) reproduce each article's content based on brief prompts that were uninformative regarding the (un)certainty an article had expressed. Notably, a response bias evoked by the response format cannot emerge in this latter task – as no response options have to be selected here. Accordingly, as my findings were consistent for *both* memory measures across all three experimental series, a response bias as defined above seems to be an unlikely explanation of my results.

At this point, it is essential to note that both recognition and cued recall tasks have *different* merits and weaknesses. For instance, besides having a low experimental demand (which renders method-induced response biases unlikely), a cued recall task represents a highly ecological valid measure. This means that cued recall better reflects how people retrieve their memories in a natural setting than a recognition task does. However, a recognition task ensures a higher experimental control and statistical power (due to less

missing data), whereas cued recall is comparably susceptible to data loss, which is also mirrored in the results of my studies. Therefore, I considered combining both measures as crucial, as *each* can compensate for the possible weaknesses of the other. Similar result patterns for both tasks, thus, favor the position that my results reflect no mere artifact of the implemented measures but a substantive memory phenomenon. This conclusion is corroborated, also, by my last experiment in which I found significant differences in d' scores depending on whether negations or speculations were intermingled with facts. These differences indicate that intermingling speculations has a detrimental effect on the *memory* component, *adjusted* for potential response biases.

Still, the question remains whether other elements of the methodology could have influenced the results. One crucial candidate is the way uncertainty was manipulated, namely the specific formulations to express speculative contents (compared to factual ones). Are my effects bound to a particular kind of uncertainty expression in the news, such as questions in headlines, which might evoke interest more so than other uncertain terms? Countering this potential critique, I found consistent results across different types of uncertain formulations in headlines, namely questions (Chapter 2 & 3) and statements qualified by the modal auxiliary verb "might" (Chapter 2 & 4). This supports the conclusion that the effects found are not tied, for instance, to leading questions but reflect a general way of how uncertain formulations in the news are handled.

An additional question might be whether the tendency to remember "factual" news as uncertain information can be generalized across different topics or forms of reporting or whether it occurs only for specific items. On the one hand, I used a set of diverse short news articles, in detail 12 to 60 different articles per experiment, which addressed a broad scope of topics in order to achieve generalizability. On the other hand, all articles had a similar structure: they always reported an event with explanation and consisted only of a few sentences. On this note, extending my studies to other materials, such as longer articles, would be desirable.

In sum, various details of my experiments underpin that the tendency to remember facts as uncertain information represents a substantive memory phenomenon produced by intermingling speculations and not by any aspects of the memory tasks nor the specific way uncertainty was expressed. This forms an essential basis for interpreting the results further.

Still, more work would be desirable to examine the generalizability of uncertainty spreading, for instance, to longer articles (see the section "Strength, Limitations and Future Directions" for a more detailed discussion of this subject).

Theoretical Implications

Implications for Existing Models on (Un-)certainty and Negation Processing

The prior discussion indicates that the tendency to remember facts in the news as uncertain information is a substantive memory phenomenon provoked by encountering speculation. Several theoretical implications arise from this result. First of all, my findings are informative for the question of to what extent existing models from related research areas can be transferred to the case of uncertain language in the news. Concerning this question, my studies have come to a clear conclusion. Albeit plausible from a theoretical point of view, the consideration and recollection of uncertainty expressions in language do not seem to be predictable in terms of negation models and a schema plus tag conception, that would suggest that recipients tend to forget uncertainty – just as they tend to forget negations over time (Fiedler et al., 1996; Gilbert, 1991; Gilbert et al., 1990, 1993; Maciuszek & Polczyk, 2017; Mayo et al., 2004). Instead, reading speculations in the news seems to trigger an opposite effect: Uncertainty cues present in speculations entail consequences that *transcend* their intended scope by lowering the remembered certainty of jointly presented facts. This result contradicts the idea that speculations are mentally represented as propositions and abstract tags so that the latter might be neglected and forgotten – a tendency assumed to arise irrespectively of the presence or absence of other items. Contrary to this, my results suggest that speculations can interfere with memories on factual news, even though their contents are unrelated.

In this vein, it is worth noting that my results on recollecting speculations and facts are diametrically different from the "statement bias" (Pandelaere & Dewitte, 2006) that denotes the tendency to misremember questions as statements later (rather than falling for the opposite mistake). To the best of my knowledge, the statement bias is the only prior finding that directly concerns the memory of uncertain and factual formulations, as I targeted in the present work. Unlike my results, however, the statement bias supports the schema plus tag

model's predictions, as it suggests that people tend to forget uncertainty cues, in this case, the framing as a question, leading them to remember a previously read question as a (factual) statement after some time (Pandelaere & Dewitte, 2006). Yet, one difference between experiments showing a statement bias and my studies might be essential: While the statement bias has so far been demonstrated exclusively for relatively artificial material, namely so-called trivia questions and statements (e.g., "Do fresh water snakes swim upside down for about half of the time" or the corresponding statement), I used *contextualized* sentences. That is, I investigated uncertainty expressions in a clearly defined and meaningful application domain: the report of speculative versus confirmed explanations in short news articles. Earlier work has questioned the study of uncertainty expressions without setting a specific context before, primarily because uncertain phrases can serve multiple functions and refer to numerous meanings, suggesting that they are meaningless if no clear context is given (Dodd & Bradshaw, 1980). In line with this argument, my results show how problematic broader inferences based on abstract and highly standardized materials can be and that theories that hold for such materials may not be of relevance "in the wild".

As already evident from the preceding remarks, my results concern not only the memory of uncertainty expressions but also that of *facticity* expressed by a factual formulation. The latter constitutes a critical comparative in negation research and for testing the schema plus tag model. According to this model, memories on facts should prove robust and unsusceptible to error since they do not require to be marked via abstract tags that potentially can become lost over time (Clark & Chase, 1972; Fiedler et al., 1996; Loftus, 1975; Mayo et al., 2004). Indeed, this assumption is widely shared across psychological accounts and is mirrored in the idea of "initial acceptance", meaning that believing in the truth of a statement forms a primary mode of thinking that occurs intuitively and is effortful to circumvent (Gilbert, 1991; Gilbert et al., 1990, 1993). Contrary to this assumption, my results show that the memory of facticity is by no means robust under all circumstances. Instead, the stability of memories on "facts" seems to depend on the context in which these "facts" did appear and is particularly biased if speculations were present – but *not* if other messages, such as negations, were intermingled. To conclude, my findings indicate that uncertainty might alter basic ways of remembering and that existing models based on a dichotomy between true and false need to be extended for this special case.

Suggestions for New Theoretical Perspectives on Speculative Language

As the preceding discussion indicated, the case of speculation in language calls into question former models that were merely grounded on a binary conception of true and false (such as those from negation research) or solely based on abstract materials (such as the statement bias). In contrast to the predictions of these approaches, uncertainty does not seem to be recalled necessarily at the level of individual items. Instead, it does generate cross-item effects by inducing uncertainty in a general way. But what exactly does an uncertainty bias reflect, and which cognitive processes are involved? Since the previously described approaches cannot explain my results, the question of alternative models arises.

Potential Encoding Effects. To begin with, one might ask which components of remembering speculations can affect. Could the encountering of speculations influence early processing stages, such as the way jointly presented contents are *encoded*? This would suggest that memories of factual news are only altered if they were read *after* but not before speculations were presented. Indeed, prior work has already demonstrated encoding effects if specific forms of uncertainty were given, encouraging this hypothesis. One example is a mindset of distrust which was shown to increase the complexity of mental representations by provoking that information is understood and stored in terms of potential alternatives (Mayo, 2015; Richter et al., 2009; Schul et al., 2004, 1996). However, my results rather speak against the idea that the tendency to remember facts as uncertain information is driven by encoding effects alone. Instead, speculations affected the way reported facts were remembered, even if these facts were presented before all speculative articles. This suggests that speculations can retroactively alter and blur memories on other articles that had been *already* encoded. Various explanations are conceivable for such a backward effect, some of which I directly or indirectly addressed in my studies.

The Distinctiveness of Mental Representations. Firstly, having read speculations could provoke retrieval interferences because their mental representations might *resemble* factual ones to a very high degree. Note that speculative and factual formulations express affirmations (although to different levels) – a similarity that could create confusion errors between both message types. In contrast, negations invert a statements' meaning into its opposite and are thus most different from the corresponding affirmation. This might be reflected in more distinct representations of facts read among negations before (compared to

speculations). The result of a higher discrimination performance between facts and negations compared to facts and speculations (characterized by the different d' scores in both conditions) supports this explanation. To the best of my knowledge, my studies are the first to show that the ability to remember factual formulations as such could depend strongly on their *contextual distinctiveness* instead of specific language structures such as the presence or absence of markings to indicate a contents' epistemic modality. After all, if the marking of a message was to be decisive, words like "maybe" and "not" should entail similar memory consequences – which was not the case in my studies.

    An Uncertainty Bias. However, beyond differences in discrimination performance, my studies also demonstrated that uncertainty seems to *spread* in memory, meaning that the participants remembered more reports as representing speculation than had been initially present. Notably, the distinctiveness of mental representations alone cannot explain this bias. Further, as argued in the section "Methodological Considerations: Ruling Out Potential Constraints", this bias does not appear to be a purely methodological artifact – primarily since it was found across different measures of memory (cued recall and recognition) and different uncertainty manipulations. Thus, the question is raised of how this bias could be explained theoretically.

    On the one hand, uncertainty spreading could reflect a rather mechanistic process, that is, for instance, *salience*-driven. From this perspective, participants might overestimate the number of previously read speculations compared to reported "facts" since the former appear more salient in memory which might cause some "facts" to be remembered as uncertain contents as well. A comparably higher salience of speculations could have several reasons. For instance, speculations could be particularly prominent as they are more complex to mentally process since alternative possibilities have to be represented and cannot be resolved (as is the case for negations that rule out one possibility, at least). Also, speculations could stand out due to being reported less frequently in the news than factual formulations and therefore could overshadow how "facts" are retrieved. Yet, this explanation would suggest that negations might elicit similar spreading effects since they too are arguably rather an exception in the news. However, such effects did not emerge in any of my studies.

    Beyond the proposed saliency effects, on the other hand, intermingling speculations could also entail less mechanistic and more deliberate consequences. For instance, having

read speculative formulations could provoke a stronger *questioning* of or deliberation on one's memories of jointly presented "facts". Indeed, the word "deliberation" can be defined as hypothetical or conjectural thinking (Evans & Stanovich, 2013; Kahneman, 2011) and, therefore, is closely tied to linguistic concepts of speculative language, with the latter being considered to prompt the thinking of alternatives as well (e.g., Chung & Timberlake, 1985). Furthermore, studies have shown that deliberation (compared to an intuitive mode of thinking) can enhance the distinction between fake and accurate news (Bago et al., 2020; Martel et al., 2020). Could the presence of speculation entail similar effects, leading people to question their memories more strongly? Note that in most of my studies, the reported explanations were merely invented and should therefore not be relatable to prior knowledge, which might give good reason to remember them as uncertain information – principally in line with the "deliberation" perspective. Thus, following on from my studies, future work could investigate the extent to which uncertainty spreading depends on the contents of the news presented, such as their plausibility or relation to prior knowledge.

Practical Implications

Is it problematic or even irresponsible to report speculations in the news? Given my findings, this question could have several answers. Regarding my initial hypothesis of a tendency to *forget* uncertainty cues, my results showed that some speculative reports were indeed reproduced as a fact later – on average, one out of eight articles, which can be considered a practically relevant number. Moreover, merely encountering a speculative explanation in a short news article did systematically heighten its believability after only a short temporal delay, which might be a problematic phenomenon if these speculations turn out to be wrong in the end.

Still, one should relate these results to the number of other memory errors I observed. When reading an equal mixture of speculations and facts, participants showed a clear bias to remember more information as uncertain than they had previously read, indicating that most memory errors concerned *factual* news. Moreover, my studies demonstrated that intermingling only a few speculations (6 out of 24 articles) increased the number of facts being remembered as speculative by about 25 % (on average, 1.5 out of 6 factual articles were

remembered as uncertain information in this case). This finding points to this effect's strength and practical relevance.

Both negative and positive aspects are attached to this result. On the *negative* side, this finding indicates that people might doubt evidence-based (i.e., factually formulated) reports if speculations are present. Particularly in times of massive circulations of uncertain information, such as during the current pandemic, communicating the few assured contents (such as the effectiveness of vaccination) is of major importance and might contribute to saving lives. Under such circumstances, speculation should be reported carefully and only when indispensable. This conclusion is reinforced by my finding that speculations and facts are particularly poorly distinguished in memory (compared to negations and facts), indicating a blurring of both message types.

Besides these negative aspects, however, uncertainty spreading might also carry a *positive* side. Although a factual formulation connotes the truth of an utterance, it may, of course, still be false, such as in the case of misinformation that is presented as fact as well. Furthermore, prior work has found that reporters tend to frequently skip uncertainties, for instance, when portraying scientific findings (Stocking, 1999). Reporting speculations *explicitly* could, therefore, be accompanied by a positive effect as well, as they might lead recipients to doubt questionable reports and encourage them to scrutinize news more closely.

Distinguishing these potential implications further could be a fruitful avenue for future work. In sum, however, my findings highlight the special role of speculative formulations in the news, relevant for both recipients and reporters, and stress the need of finding communication forms that counter that certain and uncertain contents become indistinctive.

Strengths, Limitations, and Future Directions

My studies entail several strengths and limitations, the latter emphasizing the relevance of more studies in this field. A first strength might lie in my *theoretical* approach that extends previous work in two aspects: First, my studies add a third category to earlier models that were mainly based on a binary distinction of true and false, namely, the case of uncertainty regarding a contents' truth. My results show that new models are needed to describe the mental processing of this particular case. Second, my studies extend existing

theories by considering not only the memory of (and belief in) individual statements or messages but also potential interconnections between memories. Although plenty of prior work already addressed how humans integrate different texts into one mental model, this work always presumes a content-wise relation between the presented texts (see Britt et al., 1999; Perfetti et al., 1999 for an overview), which was not given in my studies. Instead, my studies suggest that even unrelated items are represented and remembered in interconnection if received in the same context of appearance, for instance, as part of a conglomerate of different articles presented in temporal proximity.

In addition, my *methodological* approach holds various strengths. First, I preregistered the sample size, experimental design, hypotheses, and statistical analyses in 12 of my 13 experiments. Second, I conducted an a priori power simulation for most of my experiments. Third, I replicated my primary findings (uncertainty bias and uncertainty spreading) using different measures (recognition, cued recall, and beliefs in the accuracy of an explanation) and different materials (i.e., uncertainty expressions). All three aspects follow the most recent guidelines of transparency and reproducibility, which is of particular importance regarding the current replication crisis (Shrout & Rodgers, 2018).

A further strength of my studies is their high degree of *ecological validity* combined with high experimental control. As mentioned before, a major critique of existing work on uncertain language concerns their uncontextualized material (Dodd & Bradshaw, 1980). I aimed to overcome this constraint by embedding (un-)certain formulations in a specific application field, namely speculative reports in the news. In detail, each item consisted of a headline formulated either as speculation or fact plus an additional explanatory teaser clarifying that a proposed explanation was either confirmed through examinations or merely investigated. Thus, the meaning of (un-)certainty expressions was clearly defined in my studies. However, despite giving uncertainty expressions a specified context, my items were standardized, meaning that different forms of one item varied only with regard to the certainty they expressed in order to obtain experimental control. In this way, I aimed to draw conclusions for both theory and (news) practice.

Besides these strengths, however, this thesis also entails some limitations that point to the necessity and potential of further studies. Closely related to the preceding paragraph is the question of *generalizability*. My results are confined to the processing of speculative

formulations in news coverage. Thus, uncertainty expressions in other contexts, such as scientific reports, could be processed quite differently. A first indication pointing in this direction is already found in the existing literature. Glaser and Schwan (2019) showed that text information on architectural reconstructions is remembered worse if expressed by an uncertain formulation (compared to a certain one). The authors concluded that this might be due to valuing and attending to uncertain pieces of information less than to certain ones. This difference to my findings, again, points to the memory of (un)certain formulations being crucially context-sensitive. Future studies should examine how these divergent effects could be explained, for instance, by explicitly testing the role of the context-bound relevance of factual and speculative formulations.

However, the question of generalizability goes even further. My results concern *linguistic* ways of indexing speculation. Yet, news coverage alone entails many other means of expressing uncertain content beyond language, such as figures and numbers, for instance. Could these objects evoke similar effects as speculative formulations, inducing uncertainty on a general level? Or might this not be the case because figures, like numbers, suggest precise estimates of chances and risks and are, therefore, distinct from uncertain language that entails vagueness instead?

Related to these questions is another limitation of my experiments. I studied the expression of certainty by presenting a factually formulated explanation in the headline accompanied by a teaser stating that this explanation was confirmed through investigations. Accordingly, the certainty of a message was rather inconspicuous because, unlike speculative contents, certain contents were not explicitly marked by additional words (such as "might" or "not"), at least in the headline itself. On the one hand, this reflects a usual way of expressing certain contents, evident in almost all languages. On the other hand, one might ask whether effects of uncertainty spreading could be reduced if certain information would be reported *more explicitly* in the news, as is often the case in fact-checking sections (e.g., "*Yes*, there is data on the vaccination status of Covid 19 patients in intensive care units", headline published by correctiv.org, Jonas, 17th of Dec, 2021, English translation). Future studies should address this and other potential ways of supporting recipients to remember certain contents correctly.

In addition to the generalizability of my findings, a further limitation concerns the *scope of potential effects* uncertain formulations could evoke. I chose to study specific

dependent variables, namely memory distortions, and beliefs among readers. As part of an explanatory analysis, the participants rated additional variables, such as their trust in the news media in general, their subjective completeness, accuracy, and fairness. All these variables, however, were unaffected by the manipulation across the experiments (and did not affect memories or beliefs in a consistent way). Yet, previous work suggests that using speculative wording in news stories might have further consequences beyond the measures I considered. For instance, one study showed that uncertain wording could influence how *trustworthy* the source and scientists are judged to be (Jensen, 2008). The question how these appraisals, in turn, relate to spreading effects exceeds the boundaries of this dissertation and should be examined in further studies.

The previous point draws attention to a variable that has hardly been considered in my studies, namely the *source* of an article. What role could the source and its peculiarities play regarding the reported findings? Some effects might appear plausible in this regard: For instance, a low credibility source might exacerbate a bias toward remembering facts as uncertain information by creating uncertainty similarly as speculative language does. In contrast, a highly credible source might lead recipients to process and encode (un-)certainty expressions more deeply, as such cues could appear particularly relevant in this case. Note that no specific source was named in all experiments of this thesis, but the participants were told that they would receive "news articles" in the following, suggesting a relatively neutral source. In an additional experiment, conducted as part of a master's thesis, the influence of a source's credibility on the memory of speculative and factual formulations in the news was tested, but no consistent effects were found. Accordingly, additional studies are needed to investigate a source's influence further.

In addition, it should be taken into account that if considering a source or speaker, a *recipient* always stands on the other side. My studies addressed *general tendencies* that are systematically evident for a wide range of people, which could appear as the relevant perspective from a mass media point of view. Yet, this perspective also raises several questions. First, one might ask whether sample characteristics could have influenced the results. All my studies were conducted online with native English-speaking participants mostly living in the UK. Though this sample presumably shares a common culture, it is arguably more heterogeneous regarding gender, age, and education level than the classical student sample that forms the basis of most psychological studies, so far. Still, the

generalisability of my findings to other subgroups of the general population, different cultural backgrounds, and countries should be investigated further. Differences in the level of democracy of a country or state ownership of the media industry might be relevant factors in this regard.

Moreover, there is the question of individual differences among recipients that might moderate the memory biases found. Potential candidates are epistemic beliefs, namely an individual's conceptions about the "nature of knowing" (Schommer, 1990) or the consistency of an article's content with core beliefs and convictions on the recipient's side. The latter might be particularly relevant in the news domain since reported scientific findings often also suggest or entail consequences for personal lives (current examples are political decisions to curb the spread of the coronavirus SARS-CoV-2 or mitigate climate change). As prior studies showed, people tend to reject scientific findings that threaten their core convictions (Lewandowsky et al., 2013). This could suggest that these convictions might influence how people consider certainty or uncertainty expressions in the news as well. Understanding how such individual differences relate to the reported memory biases is a further task for future studies.

Conclusions

Theories about how the human mind represents uncertainty concerning a content's truth barely exist, as most models were grounded on a binary understanding of falsehood and truth so far. The present thesis had the aim to overcome this dichotomy by investigating which memory distortions might arise when reading a mixture of speculative and factual formulations, studied in the relevant domain of news. Inspired by adjoining research areas, I tested two opposing distortions: Do people tend to forget linguistic uncertainty expressions (e.g., "might"), just as negation studies suggest? Or does uncertainty spread in memory instead, causing factual information to be remembered as questionable content? My studies consistently support the *latter* possibility, showing that speculative formulations in the news decrease the remembered certainty of unrelated but jointly presented facts. In contrast, the presence of negations did not impact the memory of facts in any way. This led to the conclusion that speculations represent a particular case that is processed differently from the functionally related negation operator. Based on these results, I propose that not the

similarities, but the *disparities* of negations and speculations are vital for theory development. Moreover, my results indicate that remembering facticity is more error-prone than presumed by existing theories. Instead, whether facticity is correctly reproduced appears to be dependent on the context in which these facts were read, and biases specifically occur if *speculations* were intermingled. Accordingly, uncertainty seems to change basic ways of remembering, suggesting that models based on the binarity of falsehood and truth need to be adapted for this particular case. From a practical point of view, my findings point to the challenge of conveying confirmed content as such and preventing it from being obscured by mere speculation.

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Appendix

Additional Results of Study 1 (Chapter 2), 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, $X^2 (3) = 357.15$, $p < .001$, $R^2_m = .22$, $R^2_c = .34$. As depicted in Figure 2.9, 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, $\beta = -0.82$, $se = 0.13$, $z = -6.21$; $p < .001$).
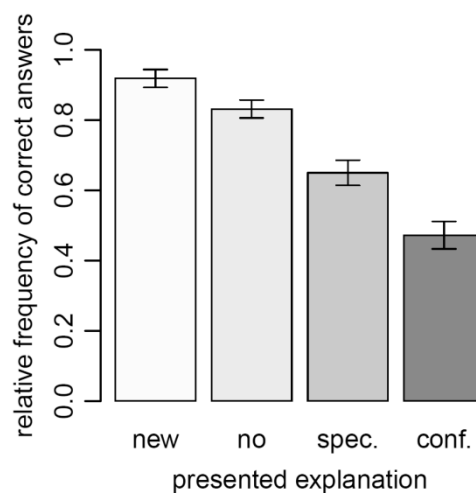

Figure 2.9. Results of Experiment 2A. Relative frequency of correct answers depending on the four explanation conditions with confidence intervals for within-participants comparisons. "New" expresses the relative frequency of *correct rejections* of new items (that had not been previously presented); 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.