# Discourse updating: Acquiring and revising knowledge through discourse

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## 1.Introduction

When readers comprehend a text, they continuously build a representation of the situations and events termed a situation model. This cognitive activity involves the encoding of new information from the text and its integration with the existing representation and prior knowledge. However, in many cases, new information does not simply add another aspect or element to the existing representation but rather necessitates this representation to be altered in some way or another. This cognitive operation has been called *updating* (e.g., Albrecht & O'Brien, 1993). Consider, for example, a story describing a protagonist's activity followed by a sentence starting with the phrase *Three days later*. This phrase signals a temporal break to readers, prompting them to shift to a new representational structure, in this case a new event in the situation model of the story (Zwaan & Radvansky, 1998). Updating can also be necessitated by conflicting information, such as a character in a story performing an action (*Mary orders a cheeseburger*) that is at odds with a trait ascribed previously to that character (*Mary is a vegetarian*, Albrecht & O'Brien, 1993). Evolving news reports that include some piece of information that is corrected or discredited by later information also require readers to update their situation model of the reported events (Johnson & Seifert, 1994). Finally, text information can conflict with previously held knowledge and beliefs of the reader, potentially causing a more drastic *revision* of this knowledge. The attempt to change students' misconceptions in science education through appropriately designed texts is a case in point (Sinatra & Broughton, 2011).

For comprehension to be successful, readers need to update their mental representations in the appropriate way. Likewise, they need to revise their prior knowledge when new

information renders it inaccurate or unreliable. At the same time, there is evidence that readers often do not engage in updating and revision even when they should do so. This chapter examines different instances of updating and knowledge revision from the integrative perspective of an extended construction-integration model (Kintsch, 1988), which involves the component processes of activation, integration, and validation of information. Starting from an overview of relevant theoretical assumptions, we will discuss the available empirical evidence for when and how readers update or revise existing representations, and when they fail to do so. This discussion will prepare the ground for an outline of basic principles and cognitive processes that contribute to discourse updating and the revision of existing knowledge structures.

## *2.* Theoretical Frameworks of Comprehension, Updating, and Revision

A thorough treatment of discourse updating must address the scientific methods for evaluating it and must rely on general theories of comprehension. Methods of studying discourse receive thorough treatment by Albert et al. (this volume). Of particular relevance is the section about on-line methods. Other methodological issues will be considered when necessary. Here, we provide an overview of the frameworks that advance theories of updating.

### *Multiple Levels of Representation*

Discourse representation is considered to comprise a verbatim or surface representation of the message, a "proposition" network of the idea units directly expressed in the message, and a representation of the situation to which the message refers (Johnson-Laird, 1983; van Dijk & Kintsch, 1983). This latter situation model integrates discourse information and world knowledge. Furthermore, it bears numerous dimensions, including but not restricted to temporal

and spatial information, causation, and characters and their motivations (Zwaan, Magliano, & Graesser, 1995).

Evidence supporting multiple levels of representations converges from many sources. To cite just one example, consider a story with the sentences, *The bear was older than the hawk* and *The hawk was older than the wolf*. After reading, people are faster and more accurate to verify *The bear was older than the wolf* than the explicitly stated sentences. Because only the explicit sentences exactly match the story's surface form (Kintsch & Bates, 1977) and propositional content (Ratcliff & McKoon, 1978), this result must be explained in terms of a situation model representation of the story. Specifically, the more different the animals' ages in that model, the easier it is to distinguish them (Potts, 1972). It is considered that text comprehension results in verbatim, propositional, and situational encoding (van Dijk & Kintsch, 1983).

In addition, the representation levels have different qualities. For example, surface representations decay rapidly whereas situation models are enduring (Kintsch, Welsch, Schmalhofer, & Zimny, 1990; Sachs, 1967). Our treatment of discourse updating will address the different levels, with particular emphasis on the situation model.

*The Construction-Integration Model (CI)*

This influential model (Kintsch, 1988, 1998) posits two stages of processing of each successive discourse segment. Processing initially involves the *construction* of a network of the propositions stated in the message. Upon reading *The turtle ate lettuce*, its underlying ideas are extracted. However, the construction network is an enriched one: It includes generalizations, such as THE TURTLE WAS FEEDING, as well as ideas linking the current segment to the preceding discourse. The network also includes associated ideas both relevant (e.g., turtles are

herbivores) and even irrelevant (turtles walk slowly) to the message.

Then, during *integration*, activation accumulates in the most highly interconnected message elements, effectively eliminating ideas less relevant to the message. A subset of highly activated ideas are retained in working memory as the comprehender proceeds to the next message constituent (Fletcher 1981; Kintsch & van Dijk 1978). These processes optimize the coherence of the representation.

The integration phase of CI is increasingly considered to itself comprise multiple phases, including validation and updating. *Validation* refers to the reader's continuous assessment of the accuracy, consistency, and congruence of the evolving message (Nieuwland & Kuperberg, 2008; Schroeder, Richter, & Hoever, 2008; Singer, Halldorson, Lear, & Andrusiak, 1992). Successful validation of novel discourse ideas with reference to the existing message representation and world knowledge enables the updating of the representation (Ferretti, Singer, & Harwood, 2013).

*Structure Building*

During comprehension, the reader continually initiates and completes structures at all levels of representation (Gernsbacher, 1990; Zwaan & Radvansky, 1998). At the syntactic level, for example, the word *the* routinely initiates a noun phrase. At the other end of the continuum, messages situate their circumstances in terms of specific places and times, and the traits and goals of their participants. Transitions on these dimensions may be signalled by explicit or subtle verbal expressions. Detecting that a narrative character has jumped ahead in time or has achieved an important goal is central to comprehension (Zwaan, Magliano, et al., 1995). Completing one structure and initiating a new one comprise a central aspect of discourse updating.

*Relationship to Basic Memory Processes*

Comprehension is widely considered to be based on general cognitive mechanisms rather than uniquely linguistic processes (e.g., Kintsch et al., 1990). Regarding updating, it is especially important to distinguish between mechanisms of working memory and long-term memory (LTM). Working memory comprises the active contents of cognition. It coordinates both storage and processing demands and is limited in its total capacity (Baddeley, 1986; Just & Carpenter, 1992; Miller, 1956). In comprehension processing, working memory is updated after every processing cycle to retain a few recent and highly relevant propositions (Fletcher, 1981; Kintsch & van Dijk, 1978).

These working memory updates reflect transitions both of surface and gist representations. Regarding surface structures, for example, people take less time to recognize a test word from the current clause than preceding clauses (Caplan, 1972; Jarvella, 1971). This indicates that when the reader proceeds to a new clause, the words of the preceding clause are purged from working memory (Kintsch & van Dijk, 1978). Accessibility is likewise affected by subtle situational cues. It takes less time to recognize a text word if it is associated with versus dissociated from a character (e.g., *the sweatshirt was pulled-on/taken-off*, respectively; Glenberg, Meyer, & Lindem, 1987). Likewise, it takes less time to verify that a phrase (*FIX FLAT*) accurately describes a text episode if the *aspect* of the relevant verb suggests that the activity was ongoing versus completed (*she was-changing/changed the flat tire*; Magliano & Schleich, 2000). Discourse events such as a character walking through a doorway diminish the accessibility of objects associated with the abandoned location (Radvansky, 2012). These phenomena reflect the continual updating of working memory contents.

The long-term memory system, in contrast, is characterized by features such as a great if not unlimited capacity, effortful and slow retrieval, and the spread of activation among related concepts (e.g., Anderson, 2005). Memories may reside in long-term memory effectively for a lifetime (Bahrick, 1984). These qualities apply as much to long-term discourse representations as other memories (Ratcliff & McKoon, 1978).

Three fundamental qualities of memory clarify the relation between working memory and long-term memory, and bear special significance for discourse comprehension and updating. First, encoding information to long-term memory is promoted by *elaborative processing*; that is, detecting meaning relationships among ideas. For example, people exhibit better memory for *The fat man read the sign that warned of thin ice* than for *The fat man read the sign that was two feet tall* (Stein & Bransford, 1979). In discourse comprehension, enduring memory is superior when the reader's task emphasizes the consideration of meaning rather than a focus on surface qualities (e.g., proofreading; Mayer & Cook, 1981).

Second, the retrieval of relevant memories is promoted by mental models known as *long-term working memories* (*LT-WM*; Ericsson & Kintsch, 1995). LT-WMs bridge the gap between the very limited capacity of working memory and the need for efficient access to prior discourse ideas. In the language domain, LT-WMs comprise the situation model of the discourse up to the current segment. Effective LT-WMs are promoted by strong reading skills, which foster the construction of integrated situation models (Gernsbacher, Varner, & Faust, 1990; Radvansky & Copeland, 2001; Singer & Ritchot, 1996).

Third, all stimuli function as memory cues for the passive, nonstrategic retrieval of related ideas. The retrieved information is said to resonate to the cues, and it becomes available

for integration with the current stimuli. In the comprehension domain, this analysis is called *memory-based text processing*. The elements of each text segment provide retrieval cues for antecedent discourse ideas and relevant world knowledge (Greene, Gerrig, McKoon, & Ratcliff 1994; O'Brien, Lorch, & Myers 1998). As such, both the antecedent discourse representation and *all other memories* are, in principle, eligible to be incorporated in the evolving representation (Hintzman, 1988; Murdock, 1982). Thus, the full contents of working memory guide the continuous *updating* of all levels of text representation. In conclusion, the theoretical analysis of discourse updating draws heavily upon thoroughly evaluated formulations. The present treatment will refer extensively to those formulations.

## 3. Situation model updating during comprehension

Surface, propositional, and situation representations must be continuously updated during reading. Two influential research approaches to discourse updating have focused on (a) the construction and refinement of these representational structures during comprehension and (b) the impact on encoding of detecting discourse inconsistencies. Both approaches bear on all representational levels but we will emphasize the situation model.

### *Constructing and Shifting Among Discourse Structures*

Advances in this realm are captured by several complementary accounts: namely, the structure building framework (Gernsbacher, 1990); the event-indexing model (Zwaan, Langston, & Graesser, 1995; Zwaan & Radvansky, 1998); the event segmentation theory (Zacks, Speer, Swallow, Braver, & Reynolds, 2007); and the event horizon model (Radvansky, 2012). These accounts hold, first, that understanders strive to map new information onto existing mental

structures (Gernsbacher, 1990). Mapping is facilitated by syntactic cohesion, in the form of lexical repetition and transparent referential devices. Mapping is also promoted by coherence on situational dimensions such as cause, location, and time.

Conversely, disruptions and deficiencies in referential, causal, temporal, and spatial coherence initiate *shifts* to new structures (Gernsbacher, 1990; Radvansky, 2012). Shifting is cognitively demanding: It requires wrapping up the prior structure (Haberlandt & Graesser, 1985), a form of updating that resolves ambiguities in that structure and consolidates it in the discourse representation. Shifting also entails the initiation of a new structure.

One index of the cognitive demands of structure shifting is text reading time. Shifts can be signaled explicitly. For example, with reference to a lifeguard noticing a struggling child, reading time for *he jumped into the water* is inflated if it is preceded by the adverb, *Next* (Gernsbacher, 1990). This suggests that the adverb initiates a new structure. However, shifts are also routinely signalled semantically or implicitly. If a text describes the start of a marathon, for example, it takes less time to next read *Half an hour later, it began to rain*, which falls within the time frame of a marathon, than *Three days later, it began to rain*, which does not (Gernsbacher, 1990; Zwaan, Magliano, et al., 1995). In this example, *Three days later* requires a shift to a new time frame.

*Structure building and memory updating.*

Constructing and shifting among structures continuously updates the contents both of working memory and long-term memory. As discussed earlier, superior word memory for the most recent clause indicates that the wording of prior clauses has been deleted from *working memory* (Jarvella, 1971). It is important that, in these studies, test words in the recent- versus

prior-clause conditions were separated from their antecedent by exactly the same string of words. Gernsbacher (1985) observed that these findings therefore favored a structure-shift explanation over a memory-limitation hypothesis. Further evidence extended these phenomena to the comprehension of picture-stories and to transitions not only among syntactic structures but also between story episodes and between entire stories.

Other studies document pervasive and qualitatively varied effects of *situational shifts* on the contents of working memory. In one study, people made faster recognition judgments about objects (e.g., a lamp) in a protagonist's present story location, the reception room, than objects in a previous location, the library (Morrow, Greenspan, & Bower, 1987). Likewise, memory is worse for objects left behind in a different room (a spatial transition) than for those in the current room when people move among real and virtual spaces, holding the distance from the object constant (Radvansky & Copeland, 2006; Radvansky, Krawietz, & Tamplin, 2011).

A perhaps surprising claim is that working memory structures exhibit resistance to updating. Kurby and Zacks (2012) explained that such resistance protects the evolving structure from the impact of transient interruptions and distractions. Consistent with this proposal, when people read a narrative that interweaves two episodes, they spontaneously recall the episodes separately (Gernsbacher, 1990; Mandler, 1978). It would be counterproductive to update an episode in a manner that contaminated its features with those of a different episode.

After a shift, the former structure, although abandoned, becomes part of the evolving *long-term memory* (LTM) representation of the full discourse. In this regard, people can, of course, retrieve many details of messages even at great delays (Kintsch & van Dijk, 1978). The integration of the current segment with discourse information that has largely been backgrounded

in LTM is at least partly accommodated by two of the basic memory processes discussed earlier. First, the contents of the current segment cue the full contents of memory (global matching). As a result, LTM antecedents that match this segment resonate to those cues (O'Brien, Lorch, et al., 1998). They are restored to working memory and become integrated with the current segment. Second, complex but well-organized LTM structures such as situation models may reside in the long-term working memory discussed earlier (LT-WM; Ericsson & Kintsch, 1995). Although the individual elements of LT-WMs cannot all be simultaneously active, they are efficiently accessed by suitable cues from working memory (Zwaan & Radvansky, 1998). Kurby and Zacks's (2012) view that *event representations* have a larger capacity than that measured for verbal materials suggests that those representations reside in LT-WM.

It is noteworthy high-skill readers can construct and capitalize on the complex structures of long-term working memory more effectively than low-skill readers (Gernsbacher et al., 1990; Hannon & Daneman, 2001; Singer & Ritchot, 1996). In this regard, recall that people tend to read more quickly and make judgments more accurately about objects still associated with story characters (*sweatshirt - pulled on*) than dissociated from them (*sweatshirt - took off*) (Glenberg et al., 1987). However, this effect is largely restricted to readers diagnosed in a pre-test to be highest in the ability to identify sentences compatible with a prior discourse situation model (Radvansky & Copeland, 2001). These individuals apparently make suitable updates to discourse structures in a manner that optimizes their comprehension of and memory for discourse.

To summarize, several event-oriented theories converge on the view that comprehension involves the continual construction of representational structures and that transitions among these structures require that they be suitably updated. Despite their similarities, these theories

exhibit several subtle differences. For example, Radvansky (2012) noted that the event horizon model is inconsistent with some tenets of memory-based text processing. According to the latter view, access to antecedent text ideas is regulated by factors such as the degree of elaboration and distinctiveness of those ideas, and their text distance from the current segment. Beyond the current scope of memory-based processing, however, accessibility is also affected by text signals of a shift in events, even when all text-based variables are held constant. For example, readers exhibit worse memory for an object when they have left its room than when they are the same distance from that object but in a larger room that contains the object (Radvansky & Copeland, 2006). The possible incompatibility between the event horizon model and text-based processing merits further scrutiny.

Another example of differences among the structural theories is that Kurby and Zacks (2012) observed that Zwaan and Radvansky's (1998) event-indexing model demands continual, "incremental" updating on all situational dimensions, whereas the event segmentation theory (Zacks et al., 2007) emphasizes only global updating at major structural transitions. Kurby and Zacks used a variation of the think-aloud method (Albert et al., this volume) to distinguish these alternatives: They instructed the readers of an extended narrative to record instances of changes on situational dimensions and to segment the narrative into episodes. Their data indicated that readers are sensitive to dimensional changes, beyond those signalled by major episodic changes. They judged that Gernsbacher's (1990) structure building framework accommodates both incremental and global updating.

*Detecting Discourse Inconsistency and Situational Updating*

Informational inconsistency pervades language communication. In answering a press conference question about Russian involvement in conflicts in Syria, President Barack Obama stated that steps were being taken *so that we're not seeing U.S. AND AMERICAN firefights in the air* (an attentive listener might wonder why U.S. and American pilots might fight one another). As another case, a speaker might erroneously characterize a teenager as exhibiting *"autopsy*" rather than *"autism."* Or a story character might perform incongruent or impossible actions, such as making sandwiches in the absence of bread (Cohen, 1979). When understanders detect these kinds of inconsistencies, what impact does it have on the evolving discourse representation?

The role of inconsistency detection in representational updating has received extensive attention. At a general level, evidence is highly consistent across situational dimensions. In a seminal study documenting the consistency effect (O'Brien & Albrecht, 1992), readers encountered, toward the outset of a text, *Jane waited outside the door of her health club, waiting for the instructor*. Later, they read the target, *The instructor came in*, a statement inconsistent with Jane's location. Target reading times were greater in this condition than when Jane had been described as being inside the club. Likewise, in the temporal domain, it takes longer to read that Claudia was waiting for Markus on the railway platform when Claudia's train was set to arrive after Markus' rather than earlier (Rinck, Hahnel, & Becker, 2001). Regarding character traits, it takes longer to read about Mary ordering a cheeseburger when the text has previously described her as a vegetarian than a junk food fanatic (Albrecht & O'Brien, 1993).

These results confirm that readers monitor discourse congruence, but the findings also bear on knowledge updating in at least two distinct ways. First, detecting text inconsistencies and refutations enables the possible updating both of the message representation and world

knowledge. Second, inconsistency detection diagnoses whether prior discourse ideas have been previously updated. We focus on the latter issue here, and the former issue later.

*Diagnosing prior updating*.

Researchers have asked whether novel text information completely displaces prior inconsistent information or whether the outdated information continues to influence comprehension. In one familiar paradigm, critical sentences are either consistent or inconsistent with prior ideas: For example, ordering a cheeseburger is consistent with loving junk food but not healthier food. In an additional, crucial condition, ordering a cheeseburger invokes previously *qualified* information. Such qualifications include describing a character as a vegetarian who eats meat in restaurants or even as a *former* vegetarian (Albrecht & O'Brien, 1993). In the extreme, the qualification could be that the crucial information ("vegetarian") was a joke or a lie (O'Brien, Rizzella, Albrecht, & Halleran, 1998).

In these studies, reading times for the target sentence about ordering a cheeseburger have regularly been longer in the inconsistent than the qualified condition. However, the critical comparison is between the qualified and consistent conditions. According to the full-updating view posited by a *here-and-now* analysis, those reading times should be approximately equal (Morrow et al., 1987; Zwaan & Radvansky, 1998). That is, were it unequivocally encoded that Mary is no longer a vegetarian, then ordering a cheeseburger would be no more inconsistent with the reader's knowledge than if she had never been one. In contrast, a *memory-based text processing* view predicts that reading times in the qualified condition will exceed consistent ones, on the rationale that even outdated information continues to reside in long-term memory to influence comprehension.

Typically, evidence has supported the memory-based prediction: That is, reading is slowed when a former vegetarian orders a cheeseburger, relative to when the character never was one (Albrecht & O'Brien, 1993; O'Brien, Cook, & Gueraud, 2010; O'Brien et al., 1998). In contrast, evidence from Zwaan and Madden (2004) favored the here-and-now view. However, O'Brien et al. (2010) observed that some of Zwaan and Madden's critical concepts appeared at the end of their sentences, a position at which wrap-up processing might obscure differences between the consistent and qualified reading times. Using materials that avoided this problem, O'Brien et al. (2010) again documented greater qualified than consistent reading times.

*Situational dimensions of consistency and updating*.

Ostensively, updating ought to proceed similarly for different dimensions of the situation model. However, the dimensions might differ in their relative importance to a message. Causal and motivational structures are particularly essential to message meaning (e.g., Schank & Abelson, 1977; Trabasso, Secco, & van den Broek, 1984), whereas spatial details, for example, may be more tangential (e.g., Zwaan & van Oostendorp, 1994). Dimensional differences might thus influence the degree to which revisions and inconsistencies impact updating.

In this regard, researchers have documented informative relations between character-trait information and *causes* pertaining to these traits. Consider a character named Albert whose shoes are buried under magazines and laundry, suggesting that he is messy. Participants in Rapp and Kendeou (2009) read about such situations. In one condition, called a "causal refutation," the text explained this circumstance by stating that Albert had just moved into his apartment. Immediately after the refutation, participants had to make a lexical decision about the relevant trait word, *messy*. Response time was greater in the presence than in the absence of a prior causal

refutation. This suggested that causal refutations relatively deactivate the trait, inflating lexical decision time. This represents an instance of updating. Equally important, reading times for a subsequent sentence which portrayed Albert as behaving messily were *greater* with the prior refutation of Albert's messiness than without it. That is, an early refutation of Albert's messiness made subsequent sloppy behavior seem incongruent with the message meaning. The early updating of his character had a continued impact later in the text. It is noteworthy that a simple, noncausal refutation did not have this effect, such as the assertion that Albert was usually neat and that this circumstance was an exception (Rapp & Kendeou, 2009, Experiment 2; also see Mensink & Rapp, 2011).

Likewise, reading the causal explanation that Mary abandoned vegetarianism *because of her doctor's advice* resulted in participants needing no more time to subsequently read that she ordered a cheeseburger than in a *consistent* condition in which she is a junk food fanatic (Kendeou, Smith, & O'Brien, 2013; cf. O'Brien et al., 2010).

*Conclusion*

Updating is an essential, ongoing process of text comprehension. As a reader proceeds through a text, representational structures at the syntactic, propositional, and situational levels are continually initiated and completed. These transitions regulate the updating of the contents of both working memory and long-term memory in a manner that optimizes comprehension.

Detection of text inconsistencies constitute an important, special aspect of updating. Inconsistencies may appear at the syntactic level, such as when the reader must reanalyze a "garden-path" sentence such as S*ally ate up the street*. Alternatively, they may comprise

situational inconsistencies or blatant contradictions of meaning. In either event, processes are initiated either to correct the inconsistency or to reconcile the contradictory facts.

### 4. Revision of established memories through learning from text

Encountering new information in a text can lead both to an updating of the current situation model and to a revision of knowledge stored in long-term memory. Such representations need to meet two seemingly antithetic criteria in order to be functional: They need to be stable over time, but also to be updated flexibly when new information challenges their validity (Ecker, Swire, & Lewandowsky, 2014; Schroeder, Richter, & Hoever, 2008). Research on the continued influence of misinformation (Johnson & Seifert, 1994) and on conceptual change (Vosniadou, 2004) describes situations in which stability wins over flexible updating: Readers often stick to acquired information even if this information has been discredited or corrected explicitly. In contrast, research on the impact of narrative texts on world knowledge and beliefs suggests that stories are particularly effective in changing mental representations, including the creation of misconceptions (Marsh, Meade, & Roediger, 2003).

*Continued Influence of Misinformation*

In a series of insightful experiments, Wilkes and Leatherbarrow (1988) had participants read a series of news messages about a warehouse fire that mentioned cans of paint and gas cylinders in the room where the fire started and other details inviting an inference that the paint and the gas had caused the fire. However, for one group of participants, the original information was explicitly corrected by a later message stating that the closet where the paint and the gas was usually kept was empty on that day. Interestingly, when asked open questions about the event

described in the messages, participants who had received the correction were as likely to mention the paint and the gas as possible causes of the fire as were participants who had not received it, despite the fact that they accurately recalled the corrective message as well. This is reminiscent of the finding that readers of the garden-path (i.e., temporarily ambiguous) sentence, *While **Anna dressed the baby** spit up on the bed*, may misinterpret the sentence as meaning that Anna dressed the baby rather than herself (Ferreira, Christianson, & Hollingworth, 2001).

The participants in Wilkes and Leatherbarrow (1988) also based inferences about other aspects of the event on the misinformation. Several experiments based on variants of this paradigm have yielded highly similar results (e.g., Ecker et al.,, 2010; Johnson & Seifert, 1994). In addition, experiments in social psychology on the perseverance of beliefs despite the presence of invalidating information support the continued influence of misinformation (e.g., Anderson, Lepper, & Ross, 1980; Ross, Lepper, Strack, & Steinmetz, 1977). For example, Ross et al. found that participants continue to embrace information from clinical case studies even if they learned later that this information was unsubstantiated.

Why and when do readers fail to revise mental representations in the light of correcting information? Interpreting their own results, Wilkes and Leatherbarrow (1988) suggested that despite the fact that readers recognized and remembered the correction, they were unable to alter the inferences they had made based on the original misinformation. However, Johnson and Seifert (1994) found that the misinformation showed a continued influence even if the correction was given immediately after the misinformation, which makes an influence on later inferences unlikely. Instead, they proposed that the central role of the misinformation in an explanation of the described events is crucial for the misinformation effect to occur. As long as no plausible

alternative to the potential cause of the warehouse fire is available, the cans and gas cylinders keep their position on top of the causal chain organizing the situation model, even though their existence is denied by the corrective message. In fact, when Johnson and Seifert provided their participants with the potential alternative explanation that arson might have led to the warehouse fire, the correction was more effective in reducing inferences based on the misinformation.

Experiments on belief perseverance provide additional evidence that misinformation continues to be influential if it is integrated in a causal situation model of the described events. For example, Anderson et al. (1980) gave their participants case studies on the relationship between risk-taking and professional performance of firefighters. One group of participants provided written explanations of why such a relationship might occur. Later on, participants were debriefed that the case studies were purely fictitious. The instruction to generate explanations increased the degree to which participants still endorsed the belief that risk-taking and the performance of firefighters were related in the way described in the case studies (for similar results, see Anderson, 1983; Ross et al., 1977). Self-generated explanations for discredited information, which promote situation model construction through elaborative processing, seem to be even more effective in creating continued influence of misinformation than explanations provided by others (Davies, 1997). In contrast, generating explanations for alternative states of affairs can reduce misinformation effects (Anderson & Sechler, 1986).

In summary, integration of misinformation as a cause or an outcome in a causal situation model makes it more resistant to correction, whereas helping readers to construct an alternative causal situation model seems to be an effective way to counter the continued influence of misinformation. The latter conclusion converges with the findings by Rapp and Kendeou (2009)

that causal refutations are particularly effective for updating during comprehension (Section 4). However, a problem arises when no simple alternative explanation is available, as it is often the case when scientific accounts of complex phenomena compete with simple but incorrect pseudo-explanations. In such cases, the misinformation is likely to prevail even when readers know in principle that it is wrong.

What are the cognitive processes that mediate the continued influence of misinformation? Ecker et al. (2014) sketched a dual process model positing that misinformation effects occur when readers rely on passive memory processes to assess the plausibility of information but fail to apply strategic processes to monitor the accuracy of this assessment. The model is based on observations that individuals use metacognitive experiences such as the familiarity of information or the ease of retrieval as a heuristic to assess its plausibility (e.g., Schwarz, 2004). For example, when some piece of misinformation is tightly integrated in a causal situation model or in a network of a reader's beliefs, it is likely to be easily accessible and will be activated automatically by associated concepts, which will increase its subjective plausibility. Likewise, statements that have been encountered repeatedly are perceived as more plausible (truth effect, Dechene, Stahl, Hansen, & Wänke, 2010). The positive effects of repetition on plausibility can occur even if the repetition is coupled with an explicit retraction of the information (e.g., Skurnik, Yoon, Park, & Schwarz, 2005). One way to explain these backfire effects for retractions is that the retracted information might be tagged as "false" in memory but activated later on without the "false" tag. In this case, comprehenders tend to accept false information as being true, especially when they lack the cognitive resources to process the information strategically. Supporting this assumption, Gilbert, Krull, and Malone (1990) demonstrated a confirmation bias

when readers verified fantasy facts (e.g., *A Twyrin is a doctor*) that they had learned earlier together with a "true" or "false" label and under cognitive load. However, it should be noted that the confirmation bias occurs only for information that readers cannot validate based on their prior knowledge (Richter, Schroeder, & Wöhrmann, 2009) and when they are unable to establish a plausible alternative situation model of the negated state of affairs (Hasson, Simmons, & Todorov, 2005).

*Conceptual change*

In educational and developmental psychology, problems similar to the continued influence of misinformation have been studied under the label of conceptual change. Conceptual change is a kind of learning that involves the revision or restructuring of existing preconceptions or misconceptions rather than enriching it or creating completely new knowledge. Most of the research in the area focuses on conceptual change in science learning. The preconceptions studied in conceptual change research are typically not experimentally induced but more or less deeply rooted in an individual's learning history (such as naïve physical concepts acquired in infancy; Vosniadou, 1994). Despite this difference in study topic from work on the continued-influence-of-misinformation effect, there are interesting parallels between the two lines of research. First, preconceptions can often be resistant to change. Second, this resistance to change depends in part on whether these preconceptions form more complex knowledge structures or are embedded in such structures. Third, a plausible and intelligible alternative needs to be presented to correct misconceptions (Posner, Strike, Hewson, & Gertzog, 1982).

Regarding the complexity of the underlying knowledge structures, Chi (2008) distinguished three different types of misconceptions. (1) When a misconception is based on

single false beliefs, it can often be changed quite easily by direct refutation (e.g., Chi & Roscoe, 2002)**.** (2) However, when the misconception is based on schema-like knowledge structures or a flawed mental model, a greater number of beliefs need to be changed to replace the mental model with an adequate one. For example, many children hold inadequate mental models about the shape of the earth, including conceptions that the earth is flat or a hollow sphere (Vosniadou & Brewer, 1992). To correct such models, it is insufficient to refute one single belief. Rather, a large number of beliefs that involve related concepts such as gravity, seasonal changes, and the day/night cycle need to be addressed as well. (3) Finally, the misconceptions most difficult to change are those that are based on category mistakes. Such mistakes occur when readers mistakenly think that a central concept belongs to a different branch in a conceptual hierarchy (lateral category) and, therefore, shares few features with the correct category. For example, in learning physics, misconceptions based on the category mistake that heat is an entity rather than a process cannot be corrected by simply refuting it (Chi, 2008).

Both typical expository texts and also persuasive texts that promote the correct alternative often fail to induce conceptual change, in particular if misconceptions are based on flawed mental models or category mistakes. In contrast, refutation texts are more effective in this regard (Guzetti, Snyder, Glass, & Gamas, 1993; Tippett, 2010). Refutation texts explicitly state a misconception, refute it, and provide an elaborate presentation of the correct alternative. For example, a refutation text aimed at correcting the misconception that global warming is caused only by natural causes could first introduce this view, then state that it is based on a misconception and explain why this is the case, and continue with presenting the alternative view about man-made causes of global warming along with scientific evidence. In terms of the

comprehension processes outlined earlier in this chapter (Section 2), refutation texts support conceptual change in several ways (Sinatra & Broughton, 2011). First, they activate the misconception through a resonance-like mechanism, without requiring the reader to engage in any kind of strategic and effortful memory retrieval. The co-activation of the misconception and the correct information in working memory makes it likely that readers will notice that the two pieces of information are inconsistent, creating a cognitive conflict. Refutation texts facilitate resolving this conflict by making a plausible and intelligible alternative to the misconception available to the reader. In this regard, a refutation text on Newtonian mechanics promoted longer reading times and more knowledge-based inferences for critical sentences in readers who held misconceptions compared to readers without misconceptions, whereas a comparable non-refutation expository text did not produce these effects (Kendeou & van den Broek, 2007).

*Acquiring misinformation and belief change through narrative texts*

Texts not only can be used to convey knowledge and help correct inadequate knowledge and beliefs. Sometimes, people also acquire false information and inadequate beliefs from texts. Social psychologists have a long-standing interest in the impact of persuasive texts that present arguments in favor or against certain claims on recipients' beliefs and attitudes. One tenet of this research is that strong and durable persuasive effects of such texts are quite limited and largely restricted to favorable conditions that include high-quality arguments and knowledgeable and motivated recipients (e.g., Petty & Wegener, 1999). Perhaps surprisingly, fictional stories seem to be more effective for conveying false information and changing recipients' beliefs, despite the fact that the authors of these texts do not claim to communicate true information. In one of the first experiments on this issue, Gerrig and Prentice (1991) presented participants with a story

about a mock kidnapping that included false statements embedded in conversations between the story characters (e.g., *Most forms of mental illness are contagious*). In a subsequent verification task, participants were slower to reject the false statements. These results indicate that some information was learned from the story that interfered with real-world knowledge in the verification judgments.

Later research extended these results by showing that stories can even influence readers' responses to knowledge questions and belief ratings (Wheeler, Green, & Brock, 1999). In experiments by Marsh et al. (2003), participants read a number of short fictional stories that contained statements that either appeared in a true or false version (e.g., *A sextant/compass is the main tool used at sea to navigate via the stars*). After reading all stories, participants answered general knowledge questions in a cued recall format and indicated whether they knew the answer based on their general world knowledge. For correct story statements, more participants indicated that they had known the correct answer before the experiment, as compared to participants who did not read the story. This illusion of knowing was most pronounced after reading the story twice. More strikingly, however, participants who had read the story with false statements accepted a greater proportion of such statements as being true as compared to participants who had not read the same false statements. Furthermore, a considerable portion of these participants indicated that they had "known" the false answer before. At the same time, participants remembered quite well that they had read the false statement in the story. Thus, it seems that readers acquire correct information from fictional stories but that they also acquire false information to some degree. Moreover, the results for participants' source attributions militate against the view that information acquired from stories is stored in a completely

compartmentalized way in memory, i.e. separate from general world knowledge. Rather, they suggest a hybrid view according to which both true and false information acquired from stories is integrated in readers' general world knowledge even though the source of the information seems to be retained as well (see also Potts & Peterson, 1985).

One limitation of Marsh et al.'s (2003) experiments is that they did not allow diagnosing misinformation effects on an individual basis. Subsequent work overcame this limitation by measuring prior knowledge in a pretest together with confidence ratings (Fazio, Barber, Rajaram, Ornstein, & Marsh, 2013). Two weeks later, participants read two stories that contained false information such as *Newton invented the theory of relativity* and responded to a knowledge test again. Participants used misinformation acquired from the stories on one fifth of the knowledge questions they had answered correctly in the pretest. Even for knowledge questions that were answered correctly and with high confidence in the pretest, misinformation effects occurred in one tenth of the answers given after reading the stories. In line with Marsh et al.'s (2003) aforementioned hybrid view, Fazio et al. interpreted these effects as intrusions of the misinformation from the stories into the knowledge tests rather than complete revisions of the original knowledge.

Again, for misinformation effects to occur, it may be crucial for the misinformation to have been processed recently and appear familiar to the reader. This interpretation is backed up by findings that misinformation effects decline when the knowledge test is applied after a delay of several weeks, which should reduce the recency of misinformation (Marsh et al., 2003, Experiment 3; but see Appel & Richter, 2007, for contrary results). Regarding the moderating role of familiarity, research by Rapp, Hinze, Slaten, and Horton (2014) is informative. These

authors varied the familiarity of misinformation by presenting inaccurate statements either in a realistic or unrealistic (fantasy) story context. The unrealistic context greatly reduced the use of misinformation on a later knowledge test. Similarly, the plausibility of misinformation matters with respect to readers' uptake of false information (Hinze, Slaten, Horton, Jenkins, & Rapp, 2014).

While the misinformation effect through stories is well-established, research on the cognitive processes during reading that might explain these effects is still scarce. Experiments by Rapp (2008, Experiments 1 and 2) shed light on the question of whether readers' acquisition of misinformation from stories might be a result of a failure to detect them while reading the story. In these experiments, participants read short stories that described historical events either in a way that conformed to readers' expectations, or in a way that suggested that the historical events might also have taken another turn, creating a suspenseful context. For example, one suspenseful story indicated that George Washington had doubts as to whether he should accept the offer to become president of the United States and seriously thought about retiring. A target sentence then described the historically correct outcome (*George Washington was elected First President of the United States*) or a counterfactual, historically incorrect outcome (*George Washington was not elected First President of the United States*). Reading times were longer for the historically incorrect than correct outcomes, indicating that readers detected the inconsistency given their prior knowledge. However, the suspenseful context reduced the penalty for inconsistent sentences, suggesting that stories may modulate the way readers use their world knowledge in validating the information communicated by the story. Importantly, reading tasks that promote the retrieval of accurate world knowledge when people read a story (such as the

task to correct false information, Rapp, Hinze, Kohlhepp, & Ryskin, 2014) can greatly reduce the use of incorrect information in a later knowledge test. Thus, in principle, readers are able to protect themselves against the impact of misinformation by strategically recruiting their world knowledge for scrutinizing the veracity of story information.

Overall, these findings suggest that stories induce a kind of "suspension of disbelief" (Coleridge, 1817/1907) that might explain their power to shape readers' view of the world. To describe the psychological state that brings about this suspension of disbelief while reading stories, Gerrig (1993) proposed the metaphorical concept of transportation, which means that readers undertake a mental journey into the world of a narrative, with the result that "all mental systems and capacities become focused on the events occurring in the narrative" (Green & Brock, 2000, p. 701). The state of transportation is conceived of as a rather broad experiential state of being lost in a story (Nell, 1988), incorporating attentional and cognitive processes, imagery, and emotional reactions (e.g., Green, 2004; Green & Brock, 2000). Transportation is typically measured with a self-report scale developed by Green and Brock (2000). This scale captures cognitive-attentional processes ("I was mentally involved in the narrative while reading it"), emotional reactions ("The narrative affected me emotionally"), and visual imagery ("I had a vivid image of [character name]"). Psychometrically, items capturing these different types of processes form separable facets of the construct but nevertheless load on a common transportation factor, which supports the notion of transportation as a holistic experience (Appel, Gnambs, Richter, & Green, 2015). A number of experiments have used this scale to show that transportation is related to or even mediates the impact of stories on readers' beliefs (e.g., Appel & Richter, 2010; Green, 2004; Green & Brock, 2000; Vaughn et al., 2009). However, relatively

few studies have employed objective measures of the cognitive and emotional processes that supposedly constitute transportation. Regarding cognitive processes, evidence based on retrospective measures such as thought-listing procedures suggest that readers rely less on their world knowledge to counter information in a narrative when they are transported in the story world (Green & Brock, 2000). In an fMRI-experiment by Bezdek et al. (2015), participants watched an excerpt of a narrative movie while flashing checkerboards were presented in peripheral visual regions. During suspenseful parts of the movie, neural activity increased in the posterior calcarine sulcus of the primary visual cortex (associated with central vision) and decreased in the anterior calcarine sulcus (associated with peripheral vision), suggesting that higher transportation during the suspenseful sequences narrowed the focus of visual attention. Regarding emotional processes, one experiment measured physiological indicators of emotional arousal (electro-dermal and cardiac activity) while participants watched a video of a father telling a sad story of his son's illness (Barraza, Alexander, Beavin, Terris, & Zak, 2015). The more that participants were aroused during story reception, the more they were willing to donate money to a charity after the experiment. These findings complement other studies showing that the intensity of subjective feelings during story processing is correlated with story-consistent beliefs after reading (e.g., Busselle & Bilandzic, 2009).

*Conclusion*

The revision of existing knowledge and beliefs in long-term memory through text information is overall more difficult to achieve than the updating of episodic text representations. This resistance to change contributes to the stability of knowledge and beliefs but it can also cause readers to hold fast to misinformation and misconceptions. This section also reviewed

research on the remarkable potential of narratives to change readers' beliefs and communicate false information, and discussed this research in terms of the cognitive/attentional and emotional processes that constitute an immersive reception of the narrative (transportation, Gerrig, 1993). In the next section, we will adopt an integrative perspective on the cognitive processes underlying discourse updating and knowledge revision and discuss these phenomena in terms of memory access, integration, and validation.

## 5. Contexts of updating: Validation and revision

It was discussed at the outset that discourse updating and knowledge revision, like all facets of comprehension, depend on general cognitive processes. Theoretical advances have increasingly converged on mechanisms that support updating. One important trend can be explicated using Kintsch's (1988, 1998) construction-integration framework. In particular, theorists have proposed that construction and integration can be further analyzed to comprise memory-access (the basis of construction); and integration, validation, and updating (Cook & O'Brien, 2014; Ferretti et al., 2013).

### *Memory Access*

Memory access in reading appreciably reflects the operation of the resonance processes of memory-based comprehension. As discussed earlier, the effectiveness of a discourse memory cue depends on its similarity to and text-distance from its antecedent; and by the typicality, distinctiveness, and degree of elaboration of those antecedents (Albrecht & Myers, 1995, 1998; O'Brien & Albrecht, 1991; O'Brien, Albrecht, Hakala, & Rizzella, 1995; McKoon & Ratcliff, 1992). In this regard, consider that the target sentence, *Susan was tired and decided to go to bed*,

is inconsistent with the fact that she needed to complete booking a flight before midnight. Albrecht and Myers (1995) reported that target reading times were greater when Susan had not previously booked the flight than when she had. However, the effect was detected only when Susan was in the same location, such as on a sofa, that she had occupied when previously thinking about the flight. As stipulated by memory-based processing, mentioning the sofa provided memory access to her prior intention to book a flight: This increase in cue similarity enhanced the salience of Susan's inconsistent action.

Another study that highlights the influence of access on possible updating scrutinized the joint impact of cue-antecedent distances and causal explanations (Blanc, Kendeou, van den Broek, & Brouillet, 2008). News report texts (similar to those used in the experiments on the continued influence of misinformation described in Section 4) presented one explanation of an event, followed by a different, conflicting explanation. For example, a factory explosion was attributed to (1) the volatility of materials and then (2) human negligence. Later, a target sentence favored either explanation 1 or 2. In subsequent testing, participants strongly preferred explanation 2 over explanation 1 when the target had supported explanation 2. The two explanations were about equally preferred when the target had supported explanation 1. This suggests that text distance influenced the relative preference for two explanations. That is, across the two versions of the target, explanation 2 was closer to the target sentence than was explanation 1. According to memory-based processing, explanation 2 would therefore be more eligible to be integrated with the target sentence than explanation 1. This accounts for why the closer explanation (viz. #2) was, on average, more preferred by the readers. Studies of this sort can expose the basic mechanisms contributing to the updating phenomena.

Memory access also plays a role in persisting effects of misinformation. When misinformation stored in long-term memory can be retrieved easily, it appears to be familiar, increasing the likelihood that the information will be used in later inferences and judgments (Ecker et al., 2014). Difficulties in correcting misconceptions often arise when the correct information is less accessible than the misinformation, for example because the misinformation is embedded in a causal situation model whereas the correcting information is stored separately or only loosely linked to other information. Causal links are effective retrieval structures that will lead to the passive activation of information when other elements of the causal chain are presented (O'Brien & Myers, 1987). As a result, the misinformation but not the correcting information may be passively activated when relevant cues are available in later judgments and inferences. And even if both the misinformation and the correcting information are retrieved from long-term memory, the misinformation might still persist because its familiarity and relative ease-of-retrieval make it appear as more plausible than the correcting information (Schwarz, 2004). In contrast, adding a sufficient amount of causal information that supports updating can effectively prevent activation of the outdated information (Kendeou et al., 2013).

*Integration, Validation, and Updating*

The processes of discourse integration and validation were introduced earlier, in the framework of the construction-integration model. Cook and O'Brien (2014; O'Brien, 2015) characterized integration, validation, and updating as parallel and asynchronous components of discourse comprehension. The chronological relations among them were clarified in an event-related potential (ERP) study of Ferretti et al. (2013). ERPs are fast electrophysiological responses to "events," such as a word in a sentence (Jones et al., this volume). Early in stories,

people read one of three versions of sentences like *Ken ate oranges/apples/<null> as he cycled to practice*. Later, all participants encountered the target sentence, *The coach knew that it was oranges that Ken had eaten.* This sentence was true, false, or of indeterminate truth, respectively, depending on which earlier version the subject had read. Comparing the false and the indeterminate conditions was especially revealing. Around 750 ms after the onset of *oranges*, ERPs were more negative in the false than in the indeterminate condition. This was interpreted as an extension of a familiar ERP response, the N400 (negative 400 ms after an event), reflecting a detection of the *apples-oranges* contradiction by validation processes. Importantly, this pattern was accompanied by *positive* deflections that were *greater* for the indeterminate than the false condition in the 800-1000 ms window. This late positivity is proposed to reflect representation updating (Burkhardt, 2006), an interpretation consistent with Ferretti et al.'s data. Their findings suggest that the indeterminate target is first successfully validated with respect to its antecedent because there is no incongruence between Ken having previously eaten something and the coach knowing that it was oranges. Then, assuming confidence in the author by the reader, the story representation should be updated to include the concept *oranges*.

Eye-tracking studies contrasting the processing of plausible and implausible sentences provide additional evidence for early effects of validation. For example, Staub, Rayner, Pollatsek, Hyönä, and Majewski (2007) manipulated plausibility in sentences with compound nouns such as *The new principal (talked to/visited) the cafeteria manager at the end of the school day.* In the implausible version of the sentence, the head noun *cafeteria* creates an implausible scenario (because one cannot talk to a cafeteria) but plausibility is restored when readers encounter the second noun. Staub et al. found longer first eye fixations on the head noun in

implausible compared to plausible sentences, suggesting that implausibilities of this type exert rapid and local effects even on non-strategic comprehension processes. Moreover, the size of the effect was correlated with off-line plausibility ratings. Early effects of plausibility have also been found in eye-tracking experiments with typical versus atypical verb-instrument-patient combinations (e.g., *Donna used the shampoo/hose to wash her filthy hair/car*; Matsuki et al., 2011, Experiment 3; see Patson & Warren, 2011, Experiment 2, for similar results). However, when readers process less strong implausibilities and no strong cues are available that could activate validity-relevant prior knowledge, the detection of implausible information may be delayed and plausibility effects appear only in eye-tracking measures that are indicative of integration processes. For example, Patson and Warren (2011, Experiment 1) used sentences such as *After illustrating the research results in a poster/mosaic, David asked for help*. They found no effects on first fixations to the target region where the implausibility became apparent but longer fixations on the sentence region following this region (*mosaic*) and more and longer regressive fixations to the implausibility. This suggested that readers detected the implausibility only when they tried to integrate the information in the sentence into a coherent sentence meaning.

A self-paced experiment by Cook and O'Brien (2014) using the inconsistency paradigm further specifies the conditions when effects of implausible or inconsistent information may be delayed. Their participants read that Mary was either a junk food fanatic (consistent) or vegetarian (high inconsistent) and ordered a cheeseburger; or else that she was a vegetarian and ordered a tuna salad sandwich (low inconsistent). At the target sentence (*she ordered a cheeseburger/tuna salad sandwich*), reading time in the low inconsistent condition was

intermediate to the other two. This suggested that validation against world knowledge revealed greater incongruence for high- than low-inconsistent information. However, one sentence after the target, the high-low reading time pattern reversed. The authors suggested that low-inconsistent information engages relevant knowledge later than does high-inconsistent information, leading the reader to grapple with the incongruence subsequent to the target sentence.

Reading times, eye-tracking, and ERP data provide broad support for the assumption of routine validation during comprehension but they leave open the question of how readers react to implausible or inconsistent information. Experiments with the epistemic Stroop paradigm inform this issue by showing that information that is inconsistent with prior knowledge does indeed evoke a negative response tendency, indicating that readers routinely monitor plausibility and passively reject implausible information (Richter et al., 2009). In a typical epistemic Stroop experiment, participants see words appearing on the computer screen in rapid succession (e.g., for 300 milliseconds [ms]). These words progressively form sentences. At specific words, the presentation stops and participants are prompted to give a response that is unrelated to the content of the sentence. For example, they are prompted to respond to the word TRUE and the word FALSE with different keys (e.g., Isberner & Richter, 2013). When the prompt appears after words forming a false sentence (*Computers have emotions*), a negative response tendency occurs and interferes with responses to the word TRUE, leading to slower responses. Importantly, similar effects occur for information that is inconsistent with the discourse context. Isberner and Richter (2013) manipulated plausibility through a context sentence (e.g., *Frank has a broken pipe/leg*. *He called the plumber*). These mini-stories were combined with the task to respond

with *yes* when the color of the critical word (*plumber*) changed from black to blue and *no* when it remained black. The *yes* responses were longer in the implausible version of the mini-story compared to the plausible version. Considering that the semantic content and the plausibility of the mini-story is completely irrelevant for the task of reacting to a change in font color, the slower yes responses indicate an involuntary, passive monitoring of discourse consistency.

Validation may be regarded as a precondition for updating because diagnosing an inconsistency may be seen as a precondition for a shift to a new structure (Gernsbacher, 1990). Examples include opening a new event node in reaction to situational inconsistencies in a story (Zwaan & Radvansky, 1998) or constructing a new situation model when novel information cannot be integrated into the existing one (Johnson-Laird, Girotto, & Legrenzi, 2004). Likewise, validation may be regarded as a precondition for revising existing knowledge structures in long-term memory. Conditions that enable validation, most notably the co-activation of inconsistent information (van den Broek & Kendeou, 2008), coincide with those that seem to be crucial for the correction of misconceptions. Moreover, there is a strong link between plausibility and comprehension, with information that is deemed as plausible being more likely to be integrated into the situation model of the text content (Schroeder, Richter, & Hoever, 2008).

Such findings suggest that validation can protect readers' mental representations from acquiring false information to some degree (e.g., Hinze et al., 2014). Sperber et al. (2010) proposed that language users possess a basic capacity called *epistemic vigilance* that capitalizes on a protective function of validation when acquiring knowledge from texts. However, it is important to note that this protection seems to be limited in two respects. First, if readers hold misconceptions or strong subjective beliefs, epistemic vigilance might backfire and hamper the

construction of an adequate mental representation during text comprehension (e.g., Maier & Richter, 2013). One could speculate that in such cases, validation even contributes to the persistence of misinformation and misconceptions (Richter, 2011). Second, specific discourse contexts, most notably stories that create a fictional story world, seem to modulate validation to some degree. An eye-tracking experiment by Filik (2008) is instructive with regard to the underlying mechanism. She presented participants with pragmatically anomalous sentences (e.g., *He picked up the lorry and carried on down the road*) that were presented either in a realistic baseline context or in an established fictional context (e.g., the Incredible Hulk). In the realistic context, first fixation durations and first-pass reading times were prolonged for the region of the sentence immediately following the target word (*lorry*) in the implausible version as compared to a plausible version of the sentence (*He glared at the lorry …*). However, these effects did not occur when the same sentences were presented in an established fictional context. Apparently, knowledge about the fictional context (e.g. about the superior strength of the Incredible Hulk) was activated during reading and used for validating the critical sentence, rendering it plausible in the fictional world of the story (for ERP evidence suggesting a similar conclusion, see Nieuwland & van Berkum, 2006). It seems possible that this modulation of validation processes through story contexts contributes to the persuasive power of stories, although this hypothesis still needs to be tested.

## 6. Conclusion

To understand when and how readers update their mental representation of a text or revise their prior knowledge, it is important to consider the contributing cognitive processes. We

propose that an elaborated construction-integration framework (Kintsch, 1988) clarifies both the temporal relations among the constituent comprehension phases and the qualities of their contributing processes, i.e. memory access, validation, integration, and updating. Memory access, in particular the relative strength of new and outdated information, seems to be crucial for updating and knowledge revision. Misinformation continues to exert an influence on cognitive processes when it is easily activated through a resonance process. The ease of activation of the misinformation, in turn, depends on its degree of integration in a causal situation model (Kendeou et al., 2013). Likewise, the new information will outweigh the misinformation when it is presented together with a strong causal explanation that resolves the inconsistency. Moreover, for knowledge revision to occur, both the misinformation and the new information must be co-activated in working memory. Refutation texts are likely to be effective in correcting misconceptions because they are structured according to interdependencies between updating and memory access. A second type of process that seems to be particularly relevant for updating and knowledge revision is the validation of text information, as indicated by early consistency and plausibility effects. Of course, such effects do not inherently clarify discourse updating. However, it is a viable hypothesis that validation sets the stage for updating, although the relations between the two will necessarily be complex.

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