

**Prediction in Narrative Reading:
A Brief Review**

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Introduction

Reading comprehension has been considered an important aspect of reading (Gough & Tunmer, 1986; Scarborough, 2001). Researchers frame the process of comprehension as a process of constructing situation models, that is, an abstract representation that reflects the meaning of what's being read (Locke, 1948). To construct such a representation by processing through discrete sentences, researchers suggest humans are continuously generating inferences to maintain the coherence of the situation model (Graesser et al., 1994; Zwaan & Radvansky, 1998; Kintsch, 1988)

In narrative (or story) comprehension, a core element is event. People perceive plots in narratives as events and use their knowledge of events to construct situation models. Different from expository text (or non-fiction), the events in narrative text demonstrate stronger reliance on sequential relationships, such as causal relationships and temporal relationships, perhaps because people perceive events in order in real life.

Causal inferences are considered essential for capturing this sequential relationship and establishing situation models during narrative reading. Researchers typically emphasize two types of causal inferences, bridging inferences and predictive inferences. Bridging inferences, or backward inferences, describe the process of connecting the information stated in the currently read sentence and previously read sentences. For instance, after reading the sentence "the man threw the delicate porcelain vase against the wall" and "it cost him well over one hundred dollars to replace the vase", readers could infer that the vase is broken. Predictive inferences, or forward inferences, are the process of generating expectations about possible future outcomes after reading one or more sentences. For example, simply reading the sentence "the man threw the

"delicate porcelain vase against the wall" itself might be able to lead to the expectation of breaking the vase.

The two examples demonstrated above lead to several questions. If bridging is not prediction by definition, how can they lead to the same inference? Are they two different observations of the same process? What is the relationship between bridging and prediction? These questions highlight the complexities surrounding causal inferences in narrative comprehension. To resolve the questions, a deep understanding of both types of causal inferences is required. While it is well established and emphasized that bridging happens during reading and is essential for people to understand the narratives, the role and mechanisms of predictive inferences remain debated in the field (McKoon & Ratcliff, 1992; Singer et al., 1994; Potts et al., 1988). In the last decades, prediction has been emphasized in many other areas such as neuroscience and event cognition (de-Wit et al., 2010; Zacks et al., 2007). It is worth reevaluating the role of predictive inferences in narrative reading.

This paper presents a brief literature review of 8 empirical studies with a discourse psychology background on predictive inference in narrative reading (Asiala et al., 2019; Fincher-Kiefer, 1993; Keefe & McDaniel, 1993; Klin et al., 1999; Magliano et al., 1993; McKoon & Ratcliff, 1986; Murray et al., 1993; Potts et al., 1988). First, we will summarize theoretical perspectives on predictive inferences from the 8 studies (see Table 1). Second, we will introduce the task and measurements used in the studies. Third, we will evaluate the results of the experiments done in each study and try to address the inconsistency.

Table 1

8 representative empirical studies on predictive inferences

Title	Author	Year
Assessing the occurrence of elaborative inferences: Lexical decision versus naming	Potts, G. R., Keenan, J. M., & Golding, J. M.	1988
The time course of generating causal antecedent and causal consequence inferences	Magliano, J. P., Baggett, W. B., Johnson, B. K., & Graesser, A. C.	1993
Inferences about predictable events	McKoon, G., & Ratcliff, R.	1986
The time course and durability of predictive inferences	Keefe, D. E., & McDaniel, M. A.	1993
Prevalence and persistence of predictive inferences	Klin, C. M., Guzmán, A. E., & Levine, W. H.	1999
The role of predictive inferences in situation model construction	Fincher-Kiefer, R.	1993
Forward Inferences in Narrative Text	Murray J.D., Klin C.M., Myers J.L.	1993
The role of goals and goal barriers in predicting	Asiala, L. K. E., Chan, G. C., Kurby, C. A., & Magliano, J. P.	2019

Main Body

Theoretical view on prediction

Many theoretical perspectives have been mentioned in the 8 representative empirical studies on predictive inferences. We summarize them into three types: the online prediction view, the conditional online prediction view, and the offline prediction view.

The online prediction view suggests that people are generating predictions routinely while reading. Magliano and colleagues proposed a prediction-substantiation model that reflects this view (1993). In this view, people utilize their knowledge structures such as frames, scripts, or schemas to generate expectations of future outcomes immediately after a sentence is

processed (DeJong, 1979; Dyer, 1983; Schank & Abelson, 1977; Bower et al., 1979; Magliano et al., 1993; Sharkey, 1986). For instance, after reading the sentence "the man threw the delicate porcelain vase against the wall", activation of a schema of collapse may immediately lead to the expectation of a broken state of the vase.

The conditional online prediction view acknowledges that prediction happens during reading, but emphasizes it happens only when certain conditions are met. This view is supported by Minimalist Theory, Constructionist Theory, and the Causal Inference Maker Model. The Minimalist Theory suggests that prediction is online only when it is beneficial to coherence maintenance and is easily available in memory (Fincher-Kiefer, 1996; Graesser et al., 1994; McKoon & Ratcliff, 1992). It suggests online predictions are less likely to happen unless the context constrains a highly possible outcome. The Constructionist Theory has a similar view to the Minimalist Theory. In addition, it suggests that prediction is less likely to happen with more alternative consequences available (Graesser et al., 1994). The Causal Inference Maker Model suggests that the reader expects novel information to be presented with some continuity to the previous sentences. They generate expectations with different specificities depending on the sufficiency of the causal relation provided in the text (van den Broek, 1990).

In contrast, the offline prediction view suggests online prediction does not happen and considers it a purely offline process. Magliano and colleagues (1993) contrasted and tested a bridging model, suggesting that comprehension involves coherence-based inferences, and predictions are elaborative inferences and therefore are not typically online (Graesser & Clark, 1985; Kintsch, 1988; Magliano et al., 1993; McKoon & Ratcliff, 1986, 1989, 1992; Singer et al., 1992; van Dijk & Kintsch, 1983). For instance, the Construction-Integration Model considers that comprehension involves the process of mental model construction at the surficial, textbase,

and situation level. Coherence is primarily established through anaphoric references that utilize argument overlapping at the textbase level at the moment of reading. Prediction, on the other hand, is considered an elaborative inference and happens at the situation level, which does not happen online. A simple table demonstrating different views and their assumptions is shown in Table 2.

Table 2

Summary of theoretical views on prediction

View	Online prediction	Representative theories
Online Prediction View	Online	Script Theory, Schema Theory
Conditional Prediction View	Conditional Online	Constructionist Theory, Minimalist Theory, Causal Inference Maker Model
Offline Prediction View	Offline	Construction-Integration Model

Methodologies

To understand the mechanism of prediction during narrative reading, empirical studies are essential. Multiple tasks have been used in empirical research on inferences. In the following paragraph, we introduce 8 tasks and their corresponding measurements applied in the empirical studies.

The Lexical Decision task is one of the most frequently used tasks in online inference research. In this task, participants read the materials, typically one or multiple sentences describing an event, the process is self-paced, line by line. After reading the materials, the participants see a target word on the screen and decide whether it is a real word. The manipulation is on the relation between the target word and the material. For instance, in the prediction condition, the target word would be a word related to the causal consequence of the

event described by the material. Whereas the controlled condition would use an unrelated or related word that is not associated with the consequence word as the target word. Reaction time and accuracy on the real words are generally used as measurements for lexical decision tasks.

With shorter reaction time and higher accuracy associated with stronger activation. If the consequence is activated during reading, participants are expected to respond faster and more accurately compared to the control group. Researchers suggest that the lexical decision task can assess the activation of representations at the conceptual level and is not disrupted by the processes at the surface or textbase level (Fincher-Kiefer, 1993; Lucas et al., 1990; Masson & Freedman, 1990). However, some researchers argue that the lexical decision task, as a binary choice task, could not capture the online process since the binary choice task is assessing the post-reading decision-making processes (Balota & Chumbley, 1984; Potts et al., 1986).

The Word Naming task is another popular task applied in online inference research. Participants are asked to read aloud the target word after reading the materials. Similar to the lexical decision task, the manipulation is on the relation between the target word and the material. Reaction time is the typical measurement used for this task. Shorter reaction times are assumed to indicate stronger activation of representations related to the target word. Some researchers suggest that the word naming task captures the online process better than tasks that involve a binary choice task (Potts et al., 1986; Seidenberg et al., 1984; West & Stanovich, 1982). In opposite, other researchers claim that word naming tasks can be affected by the surface level activation and may not assess the conceptual level representation (Fincher-Kiefer, 1993).

Word recognition tasks have participants read through the materials, see the target word, and then decide if it has been seen in the materials. The manipulation is also on the relation between the target word and the materials. The measurement of the word recognition task

involves both reaction time and accuracy on the critical items, which are words that are not shown in the materials. It is expected to have higher difficulty when the target word is activated but not shown in the materials. Therefore, if prediction is online, participants should react more slowly with higher errors on those target words related to the consequences. Similar to the lexical decision task, the word recognition task involves a binary choice task and a potential active retrieval process in addition. This implies it may not provide direct access to the online process. On the other hand, it assesses conceptual level representation just like lexical decision task, therefore is considered a proper task for assessing activation of causal consequences.

The cued recall task has participants read the materials first, then perform an unexpected recall task with some words as a cue after a gap of a few minutes. Manipulation is the relation between the cue words and the materials. For example, the prediction condition may use words related to the causal consequence as cue while the controlled condition uses an unrelated or related but not causally related word as cue. Recall tasks generally use the recall rates as the measurement. With higher recall rates, the stronger the cue word is related to the representation of the materials. An issue with cued recall is that it is generally applied after a delay of reading, which indicates it does not directly assess the online processes. However, it does assess the memory encoded during reading and therefore, can be used to assist researchers in understanding the online encoding processes.

The reading time task is simply monitoring the speed of sentence reading during self-paced reading. The manipulation is on the content of the materials. For instance, whether the later sentences violate the possible outcome set up by previous sentences. Researchers generally measure the reading time on the target sentences. A longer reading time on the contradictory line suggests stronger activation of the possible outcome. Therefore, if there's no difference in

reading time on the later sentences in the contradictory condition versus the controlled condition, it suggests no prediction has been made. An advantage of reading time is that it measures the reading process naturally without interruption. However, this would require further manipulation of the materials, which can add some complexity when analyzing the results.

Word prediction tasks have participants perform binary choice tasks during reading. After reading sentences, a target word is displayed on the screen and the participants need to decide whether it will appear in the future sentences. Researchers use reaction time and accuracy to evaluate the activation of causal consequences. With predictive inferences made online, it is expected to have shorter reaction times and higher accuracy on words associated with possible consequences than controlled words such as those associated with the theme but not the consequences. Due to the involvement of the binary choice task, it is debatable whether the task assesses the online processes properly. An advantage of this task is the flexibility of the location of assessment. The researchers could locate the task at any place in the materials.

Thinking aloud is a common method of accessing participants' thoughts. The type of think aloud method used for prediction generally asks participants to respond to prompts of "What Happens Next". In the 8 empirical studies, only Asiala et al. (2019) used this method. In their case, the research question is the relation between prediction and character goals. Therefore, they used the ratio of mentioning of goal completion in responses as the measurement to compare the level of predictive inferences at different locations of the material. Locations with higher frequency of mentioning of goal completion, which is a possible outcome, suggest a higher chance of prediction. Similar to cued recall, the task is performed after reading is completed. Therefore, it may not directly measure online processes. However, it could still reflect memory encoded during reading.

Goal verification is another method applied in Asiala et al. (2019). Instead of asking participants to respond to a prompt, the participants are asked a question about the goal of the character. For example, "Did Jimmy want a bike?". The measurement utilized is the reaction time of responses. However, the measurement is not assessing prediction, but the activation of character goal, which is considered a factor related to prediction. Table 3 briefly summarizes the features of these methods.

Table 3

Empirical methods used for predictive inferences

Task	Measurement	Target of evaluation
Lexical Decision	Reaction Time, Accuracy	Debatable
Word Naming	Reaction Time	Online
Word Recognition	Reaction Time, Accuracy	Debatable
Cued Recall	Recall Rates	Offline
Reading Time	Reading Time	Online
Word Prediction	Reaction Time, Accuracy	Debatable
Think Aloud	Frequency of mentioning	Offline
Goal Verification	Reaction Time	-

Note. Goal verification was used to evaluate the relation between goal and prediction, but did not directly test on prediction.

Empirical Evidence

Across the 8 empirical studies, 24 experiments have been conducted. In these experiments, 4 used a lexical decision task, 10 used a word naming task, 4 used a word recognition test, 1 used cued recall, 1 used reading time, and 1 used word prediction, 2 used think aloud, and 1 used goal verification. Overall, 17 out of 24 detected predictions and 7 did not show significant differences between the prediction condition and the controlled condition.

Details of the results for each experiment are listed in Table 4.

Table 4*Results of experiments*

Study	Experiment	Method	Manipulation	Result
Potts et al., 1988	1	Lexical Decision		+
	2	Lexical Decision		+
	3	Word Naming		-
	4	Word Naming		-
Magliano et al., 1993	1	Lexical Decision		-
McKoon & Ratcliff, 1986	1	Word Recognition		+
	2	Cued Recall		+
	3	Word Recognition	Added priming words before target words	+ (prime words from paragraph) - (neutral prime words)
	4	Word Recognition	Added priming words before target words and with time limit	+ (prime words from paragraph) - (neutral prime words)
Keefe & McDaniel, 1993	1	Word Naming		+
	2	Word Naming	Added second sentence	+ (letter deleted version) - (normal version)
	3	Word Naming	Added second sentence or a delay	+ (1 sentence material) - (with sentence added) - (with delay)
Klin et al., 1999	1	Word Naming		+
	2	Reading		+
	3	Word Naming	Added intro material adding possible outcomes	-
	4	Word Naming	Added neutral intro material	+
Fincher-Kiefer, 1993	1	Word Recognition		+
	2	Word Prediction		+

	3	Lexical Decision	+
Murray et al., 1993	1	Word Naming	+
	2	Word Naming	Used different materials
Asiala et al., 2019	1	Think Aloud	+
	2	Think Aloud	
	3	Goal verification	

Note. + indicates significant predictive effects, - indicates absence of predictive effects

The 17 experiments that have detected prediction include all kinds of tasks described above. Suggesting that prediction happens at some level. In the worst case, representation related to the possible outcome has been temporally encoded in readers' memory. It is worth taking a deeper look at the 7 experiments with negative results. Among these experiments, 1 used a lexical decision task, 4 used a word naming task, and 2 used a word recognition task. Results of 2 experiments from Potts et al., 1993 and 1 experiment from Magliano et al., 1993 were interpreted as evidence of prediction not being an online process.

Potts and colleagues first conducted two experiments with lexical decision tasks, which led to positive results (1993). However, they argued that lexical decision tasks involve a binary choice, which makes the measurement inappropriate for online processes. Therefore, they conducted experiments 3 and 4 with word naming tasks and got two negative results. Based on these results, the authors suggest that prediction happens when the participants are tested after reading, but does not take place at the moment of reading. Magliano and colleagues, on the other hand, did not find predictive effects using a lexical decision task (1993). They manipulated the word rate of displaying (RSVP: Rapid Serial Visual Presentation) and the interval between task and display of the last word (SOA: Stimulus Onset Asynchrony). The results show no facilitation on responses toward predictive words with any RSVP and SOA.

The other 4 experiments are follow-ups of experiments that show positive results by adding a manipulation. In Keefe & McDaniel (1993), the authors have detected predictive inference using a word naming task in experiment 1. In experiment 2, they added one sentence after the final sentence, which implies a possible outcome. This manipulation led to the disappearance of the prediction effect. However, in the same experiment, by using a letter-deleted version of the same materials to strengthen the encoding of events, the predictive effects were still detected. Adding this manipulation creates an identical design to experiments 3 and 4 of Potts et al., 1993, and replicates their negative results. With experiment 1 and the letter deleted condition, Keefe & McDaniel (1993) addressed the negative results by showing that online prediction exists but fades out rapidly after reading the sentence, implying the possible outcome. This is once again confirmed in their experiment 3. This fading effect is also supported by experiment 3 and 4 of McKoon & Ratcliff, 1986. In their first two experiments, they detected predictive effects using lexical decision tasks and cued recall. In experiment 3, they added a prime word for 200 ms before the target word. The authors argued that this prime word paradigm could assess the representation encoded in memory during reading through an automatic process. Two types of prime words were used, one is neutral words like "ready", and the other is a word from the materials. The results showed no significant difference in reaction times with neutral prime words, but did show a significant predictive effect with the prime word from the read paragraphs. The same pattern was found in experiment 4, in which the researchers added a temporal deadline for the task. The author concluded that participants may minimally encode the prediction with multiple non-specific representations related to the possible consequence, which won't be able to be triggered by an unrelated prime. In the first two experiments of Klin et al. (1999), the researchers demonstrated that people respond faster to words associated with possible

outcomes in lexical decision tasks and read more slowly when confronted with sentences contradicting the implied outcomes. In their experiment 3, an introductory paragraph was added at the beginning of the material to provide an alternative outcome. The results demonstrated that participants no longer showed significant differences in reaction times in the lexical decision task between the prediction condition and the controlled condition. This suggests multiple possible outcomes could reduce or eliminate predictive inferences.

Therefore, except for Magliano et al (1993), the results of experiments from all 7 other studies are consistent. We propose one possibility why Magliano et al. (1993) did not detect predictive effects is due to the property of the material used. In Table 5, we compare the example materials provided by the studies. For all 7 studies, the materials involve human characters, and the causal relationships are established based on events that are frequently observed in real life, such as breaking fragile items, humans falling from high positions, sitting down when tired, etc. In contrast, the example materials provided by Magliano et al. (1993) involve a non-human character with a less common event carried away by a stream. While this event may appear to be like falling from a high position, the latter has stronger restrictions on the consequences, whereas the former has less clear consequences. This idea is supported by the results of experiment 1 in Fincher-Kiefer (1993). In the experiment, the researcher performed a word recognition task at different locations of a paragraph, and prediction was not detected at the beginning of the paragraph, but after the situation was set up. Similarly, Asiala et al. (2019) have shown that predictions are more likely to be made when an unsatisfied character's goal is set up.

Table 5*Example materials from each study*

Study	Example Materials
Potts et al., 1988	No longer able to control his anger, the husband threw the delicate porcelain vase against the wall. He had been feeling angry for weeks, but had refused to seek help. <broke>
Magliano et al., 1993	A thirsty ant went to a river. <the ant fell into the river> It became carried away by the rush of the stream. <the ant drowned>
McKoon & Ratcliff, 1986	The director and the cameraman were ready to shoot closeups when suddenly the actress fell from the 14th story. <dead>
Keefe & McDaniel, 1993	After standing through the three-hour debate, the tired speaker walked over to his chair. <sit>
Klin et al., 1999	Today Steven was angry at his wife because she had left a mess in the kitchen. He tried to cool down, but felt his resentment building. No longer able to control his anger, he threw a delicate porcelain vase against the wall. <broke>
Fincher-Kiefer, 1993	Henry hated going to the dentist. This time he especially dreaded the trip because he knew he had several cavities. Sure enough, the dentist located the cavities and asked Henry to open his mouth wider. <drill> Henry knew he should have also been more careful about flossing. Every time he went to the dentist this procedure was mentioned to him, but he just hated to do it. The dentist warned him that gum disease was a lot worse than having cavities.
Murray et al., 1993	Carol was fed up with her job waiting on tables. Customers were rude, the chef was impossibly demanding, and the manager had made a pass at her just that day. The last straw came when a rude man at one of her tables complained that the spaghetti she had just served was cold. As he became louder and nastier, she felt herself losing control. Without thinking of the consequences, she picked up the plate of spaghetti, and raised it above the rude man's head. <pour>
Asiala et al., 2019	Once there was a boy named Jimmy. One day he saw his friend Mark riding a new bike. Jimmy wanted to buy a new bike. He spoke to his mother. His mother got a new bike for him/His mother refused to get a new bike for him. He was very happy/He was very sad. The next day, Jimmy's mother told him that he should have his own savings. Jimmy wanted to earn some money. He asked about a job at a nearby grocery store. He made deliveries for the grocery store. Jimmy earned a lot of money. He went to the department store. He walked to the second floor. <Jimmy bought a new bike.>

Note. <event> represents the possible outcome

In summary, after reviewing all 8 empirical studies on predictive inferences during reading. The results suggest online predictions do happen, but do not directly represent the

possible outcome in memory. As the experimental manipulations have shown, the encoded prediction could disappear after a delay or additional reading. In addition, when alternative consequences are implied or when the events described in the narrative are less common, the prediction may not appear. These results together support the conditional prediction view.

Discussion

Based on the 8 empirical studies, we have presented different theoretical views on online predictive inferences in discourse psychology, introduced 8 tasks to assess prediction in narrative reading, and evaluated the results of 24 experiments conducted with those methods. Although the results on predictive inferences were considered mixed, we found a consistency among the findings of these studies, which supports the conditional prediction view. Suggesting that while people are able to make predictions during reading, the prediction is restricted by the certainty of the outcome and time.

Moreover, the results and the interpretations of the results by the authors provided us with an insight into the more detailed mechanism of prediction generation during reading. This synthesis suggests a potential mechanism where readers activate multiple high-level representations that connect the current read event and future events; these high-level representations are briefly encoded in working memory, waiting for confirmation by later read sentences. When they subsequently read sentences that disconfirm or are unrelated to them, they rapidly fade out. With sentences implying an outcome with higher certainty, the combinations of the high-level representations are more consistent and therefore, may be able to last longer or even be encoded into long-term memory. This idea provides a possible window to unify the mechanisms of bridging inferences and predictive inferences. As the high-level representations, if they include order relationships, may encode the relation across more than two states or events.

In that case, activating one or multiple high-level representations could lead to both the activation of causal antecedents and causal consequences.

However, it is worth acknowledging that this review only evaluated 8 empirical studies, which do not represent the complete view on predictive inferences. Also, the review did not assess the full data and materials used in the studies, which may lead to some bias. Future reviews with a more comprehensive scope should be considered. The review provided us with a deeper understanding of the possible mechanisms behind prediction. The view of constructing causal consequences and causal antecedents via high-level representations is related to the modern view of mental representations and distributed encoding (Brewer, 2000; Moser & Moser, 1998). This suggests that empirical studies in the future should make a distinction between the effect of semantic memory and episodic memory on comprehension. More specifically, the event knowledge is in semantic memory. With a better understanding of the mechanisms behind predictive inferences and bridging inferences, we would be one step closer to a comprehensive understanding of narrative comprehension.

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