Synonyms provide semantic preview benefit in English

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ABSTRACT

While orthographic and phonological preview benefits in reading are uncontroversial (see Schotter, Angele, & Rayner, 2012 for a review), researchers have debated the existence of semantic preview benefit with positive evidence in Chinese and German, but no support in English. Two experiments, using the *gaze-contingent boundary paradigm* (Rayner, 1975), show that semantic preview benefit can be observed in English when the preview and target are synonyms (share the same or highly similar meaning, e.g., *curlers-rollers*). However, no semantic preview benefit was observed for semantic associates (e.g., *curlers-styling*). These different preview conditions represent different degrees to which the meaning of the sentence changes when the preview is replaced by the target. When this continuous variable (determined by a norming procedure) was used as the predictor in the analyses, there was a significant relationship between it and all reading time measures, suggesting that similarity in meaning between what is accessed parafoveally and what is processed foveally may be an important influence on the presence of semantic preview benefit. Why synonyms provide semantic preview benefit in reading English is discussed in relation to (1) previous failures to find semantic preview benefit in English and (2) the fact that semantic preview benefit is observed in other languages even for non-synonymous words. Semantic preview benefit is argued to depend on several factors—attentional resources, depth of orthography, and degree of similarity between preview and target.

Introduction

One of the most debated topics over the past decade in the field of eye movements during reading is whether or not semantic information can be obtained from an upcoming word while still fixating a prior word (see Hohenstein & Kliegl, 2013; Rayner, 1998, 2009; Schotter et al., 2012 for reviews). The debate centers on cases when a target word is not skipped; when it is skipped, it can be reasonably assumed that it had been sufficiently identified prior to fixation (Drieghe, Rayner, & Pollatsek, 2005; Ehrlich & Rayner, 1981; Rayner & Well, 1996). Throughout this debate researchers have used various tasks and languages to examine whether readers can obtain such information.

The results of these studies have come to different conclusions: some claim positive evidence while others claim negative evidence. Some studies that have been used as evidence in the debate have not investigated the task of silent reading (e.g., "reading" lists of words, Dimigen, Kliegl, & Sommer, 2012) and, because the nature of the task is different from that of silent reading, will not be considered here. The perspective in the present paper is not to provide yet another piece of evidence to weigh on one side or another, but rather to attempt to reconcile various studies showing different results. I first discuss past studies on semantic preview benefit and develop a conceptual framework in which to reconcile them. A prediction of this framework was tested in two experiments showing that semantic preview benefit may be observed in English, but only if the preview and target are very similar in meaning—i.e., are synonyms of each other.

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To test what information about upcoming words readers can access and use while reading, researchers use the *gaze-contingent boundary paradigm* (Rayner, 1975). In this paradigm, a preview word is changed to a target word during the saccade to it (see Experiment 1 Method; Fig. 1). Reading time measures on the target are compared between various related preview conditions and an unrelated control condition. Faster processing in a related condition compared to the unrelated condition suggests *preview benefit*—that information was obtained from the preview word parafoveally and used to facilitate processing of the target. The evidence is clear that orthographically (e.g., Balota, Pollatsek, & Rayner, 1985; Drieghe et al., 2005; Johnson, Perea, & Rayner, 2007; McConkie & Zola, 1979; Rayner, 1975) and phonologically related previews (e.g. Ashby & Rayner, 2004; Miellet & Sparrow, 2004; Pollatsek, Lesch, Morris, & Rayner, 1992; Pollatsek, Tan, & Rayner, 2000) provide preview benefit, while preview benefits from other relationships (e.g., morphologically or semantically related previews) have mixed evidence and may depend on the language being considered (see Hohenstein & Kliegl, 2013; Rayner, 1998, 2009; Schotter et al., 2012 for reviews). Preview benefit is defined as facilitated processing of a target word (e.g., *beer*) when the reader had access to a related preview word/nonword (e.g., an orthographically similar letter string, *becn*) in that location compared to an unrelated preview condition (e.g., *rope*; Rayner, Balota, & Pollatsek, 1986). Rayner et al. did not find preview benefit for semantically related previews (e.g., *wine*, see below). Semantic preview benefit is one of a few effects that researchers believe distinguishes the two most prominent models of eye movement control in reading: E–Z Reader (Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Pollatsek, & Rayner, 2006; Reichle, Rayner, & Pollatsek, 2003; Reichle, Warren, & McConnell, 2009) and SWIFT (Engbert, Longtin, & Kliegl, 2002; Engbert, Nuthmann, Richter, & Kliegl, 2005; Schad & Engbert, 2012). Because of this, the presence of semantic preview benefit is of particular interest to the field.

Because, according to SWIFT, attention is allocated to multiple words in parallel (distributed as a gradient related to distance from fixation location) it is believed that semantic pre-activation of words naturally falls out of the model. In contrast, because attention is allocated serially in E–Z Reader, it is thought that the model is unable to account for lexical (and consequently, semantic) preprocessing of the upcoming word. However, according to the model, there is nothing barring lexical preprocessing of the upcoming word; it is just very unlikely, given that attention is only allocated to the upcoming word during a brief amount of time, after the current word has been identified but before the saccade to the upcoming word has been triggered. The robustly observed orthographic and phonological preview benefits reported throughout the literature are due to these features of words being processed parafoveally quickly during that brief attention shift. Thus, in E–Z Reader, if the preview duration is longer more time would allow for semantic pre-processing.

Semantic preview benefit likely arises because of a mechanism similar to that thought to cause *semantic priming* (e.g., spreading activation throughout a semantic network; Collins & Loftus, 1975; Quillian, 1967; but see Hutchinson, 2003; Lucas, 2000; and Neely, 1991 for reviews with other accounts, as well). Semantic priming is the finding that subjects respond faster to target words (generally presented in isolation) when a prime word (that was presented in its location briefly before the target) was semantically related to the target compared to when the prime was unrelated (see Neely, 1991). Semantic priming is generally assessed within a *lexical decision task* (where the response to the target is a decision about whether the target letter string is or is not a word), a *naming task* (where the response to the target is pronunciation of the word aloud) or a *categorization task* (where the response to the target is a decision about whether it belongs in a certain category (e.g., "animals")). In general in all of these tasks, subjects are facilitated by semantically related primes (as well as orthographically and/or phonologically related primes). In essence, semantic priming is generally accepted as being due to the prime providing a head-start on processing the target (e.g., Balota, Yap, Cortese, & Watson, 2008; Voss, Rothermund, Gast, & Wentura, 2013).

However, there are important differences between semantic priming and preview benefit; most notably, the fact that target words in sentences benefit from the sentence context putting constraints on (and making it easier to process) the meaning and syntactic class of the word (Hale, 2001; Levy, 2008). Furthermore, parafoveal preview allows for access to the visual form of the word before it is fixated (see Schotter et al., 2012). Regardless of which

Condition	Sentence
Identical	Sarah tried using **curlers** on her stubborn straight hair before prom.
Synonym	Sarah tried using **rollers** on her stubborn straight hair before prom.
Unrelated	Sarah tried using **suffice** on her stubborn straight hair before prom.
Semantically related (Experiment 2 only)	Sarah tried using **styling** on her stubborn straight hair before prom.
Target	Sarah tried using **curlers** on her stubborn straight hair before prom.

Fig. 1. Example sentences used in the experiments. Asterisks represent the location of the word being fixated. The first three lines represent the sentence during preview (i.e., before the display change) in the three conditions presented in both experiments, the fourth line represents the sentence during the preview in the semantically related condition (presented in Experiment 2 only), and the last line represents the sentence after the display change for all conditions in both experiments. For clarity, preview and target words are represented in boldface in the figure (but were presented normally in the experiments).