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Task effects reveal cognitive flexibility responding to frequency and predictability: Evidence from eye movements in reading and proofreading ☆

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ABSTRACT

It is well-known that word frequency and predictability affect processing time. These effects change magnitude across tasks, but studies testing this use tasks with different response types (e.g., lexical decision, naming, and fixation time during reading; Schilling, Rayner, & Chumbley, 1998), preventing direct comparison. Recently, Kaakinen and Hyönä (2010) overcame this problem, comparing fixation times in reading for comprehension and proofreading, showing that the frequency effect was larger in proofreading than in reading. This result could be explained by readers exhibiting substantial cognitive flexibility, and qualitatively changing how they process words in the proofreading task in a way that magnifies effects of word frequency. Alternatively, readers may not change word processing so dramatically, and instead may perform more careful identification generally, increasing the magnitude of many word processing effects (e.g., both frequency and predictability). We tested these possibilities with two experiments: subjects read for comprehension and then proofread for spelling errors (letter transpositions) that produce nonwords (e.g., *trcak* for *track* as in Kaakinen & Hyönä) or that produce real but unintended words (e.g., *trial* for *trail*) to compare how the task changes these effects. Replicating Kaakinen and Hyönä, frequency effects increased during proofreading. However, predictability effects only increased when integration with the sentence context was necessary to detect errors (i.e., when spelling errors produced words that were inappropriate in the sentence; *trial* for *trail*). The results suggest that readers adopt sophisticated word processing strategies to accommodate task demands.

1. Introduction

The processing of a word in a sentence is affected by a range of linguistic properties, across many tasks and experimental paradigms, but how does the cognitive system change the way it responds to these properties in different tasks? Two hallmark effects derive from the frequency of a word to be processed (high frequency words are processed more quickly than low frequency words) and the predictability of a word in its sentence context (more predictable words are processed more quickly than less predictable words; see Kutas & Federmeier, 2011; Rayner, 1998, 2009

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for reviews). While frequency and predictability effects are robust and well documented, the magnitudes of these effects vary across tasks and paradigms (even when equating the magnitude of the frequency or predictability manipulation). The fact that these effects change across tasks suggests that the way in which people approach a task can modulate the extent to which they are sensitive to specific linguistic properties of the words they read (even when held constant across tasks). In the present study, we investigated this cognitive flexibility in reading for comprehension and proofreading. While still poorly understood, proofreading is a useful task for elucidating how cognitive processing changes along with task demands because of its similarity to reading for comprehension in terms of stimuli and response measure. The only differences in experimental design between these two tasks are the instructions and the inclusion of sentences that contain an error. Thus, we can study how processing of sentences without errors changes when people are asked to process them in different ways: checking for errors or reading for understanding. In the remainder of this introduction, we briefly discuss frequency effects and predictability effects and existing evidence regarding how they change magnitude across tasks, then turn to theoretical and empirical aspects of proofreading and discuss the goals and design of the present study.

1.1. Frequency effects

Word frequency is one of the strongest linguistic aspects of a word that affects how easily it is processed, across many tasks (*lexical decision*, Stanners, Jastrzembski, & Westbrook, 1975; *word naming*, Berry, 1971; Forster & Chambers, 1973; reading a sentence, as indexed by *eye fixation times*, Inhoff & Rayner, 1986; Rayner & Duffy, 1986; see Rayner, 1998, 2009 for reviews; and *event related potentials*, King & Kutas, 1998; Polich & Donchin, 1988; see Kutas & Federmeier, 2011 for a review). In general, cross-experiment comparisons cannot convincingly test whether frequency effects change size across tasks because they use different stimuli (the magnitude of the effect on the response variable depends on the magnitude of the frequency manipulation) and different subjects (more skilled readers show smaller frequency effects than average readers; Ashby, Rayner, & Clifton, 2005).

The most direct indication that frequency effects change across tasks comes from studies by Schilling, Rayner, and Chumbley (1998; for a more recent similar study, see Kuperman, Drieghe, Keuleers, & Brysbaert, 2013) and Rayner and Raney (1996; see also Rayner & Fischer, 1996, as well as Murray & Forster, 2008). Schilling et al. used the same materials and subjects and compared frequency effects between word naming, lexical decision, and *gaze duration*[1] (how long the eyes remain on a word before leaving it) during reading. The sizes of the frequency effect on naming latencies, lexical decision latencies, and gaze durations were highly correlated (though Kuperman et al. (2013) reported generally lower correlations), but more importantly, were not equal across tasks (64 ms in naming, 149 ms in lexical decision, and 67 ms in gaze durations during reading). These tasks differ in the type of processing required (Schilling et al., 1998): naming emphasizes producing the sounds of the word (although this can be greatly facilitated by lexical and semantic access), lexical decision emphasizes how familiar the word is (Gernsbacher, 1984; which is highly related to word frequency), and reading emphasizes accessing the meaning of the word (but obviously involves processing the word's sounds and familiarity, as well). Rayner and Raney (1996); see also Rayner & Fischer, 1996) found that the frequency effect (which was 53 ms when subjects read for comprehension) went away (i.e., was only 1 ms) when subjects searched for a particular word in a passage (and responded when they had found it). Rayner and Raney suggested that reading for comprehension requires accessing meaning (dependent on lexical access) and searching for a word in a text can be performed by more surface-level matching and may not be sensitive to frequency. In a similar vein, during mindless reading (e.g., when the reader "zones out" and stops understanding the sentence but their eyes continue to move along the text) frequency effects are absent (Reichle, Rennenberg, & Schooler, 2010) or attenuated (Schad & Engbert, 2012).

Taken together, data on frequency effects across tasks suggest that when word identification does not occur (either because it is not necessary, as in word search, or shuts off, as in mindless reading) subjects are insensitive or minimally sensitive to word frequency, whereas when word identification is required or emphasized (as in reading and lexical decision) frequency influences how long it takes to do so, although the precise way in which it does so in these cases also depends on the particular requirements of the task.

1.2. Predictability effects

When a word is encountered in a sentence (as opposed to in isolation) the meaning of the other words in the sentence can help constrain and identify the target word. In fact, the predictability of a word (i.e., how expected the word is, given the prior context) has an effect on reading times and fixation probabilities (Balota, Pollatsek, & Rayner, 1985; Drieghe, Rayner, & Pollatsek, 2005; Ehrlich & Rayner, 1981; Kliegl, Grabner, Rolfs, & Engbert, 2004; Rayner, Slattery, Drieghe, & Liversedge, 2011; Rayner & Well, 1996; Zola, 1984; see Rayner, 1998, 2009 for reviews) as well as ERPs (Kutas & Hillyard, 1984; see Kutas & Federmeier, 2011 for a review).

Tests for predictability effects in isolated word processing tasks are rare. However, some studies have recorded response times to target words presented after a sentence context (in word naming: Stanovich & West, 1979, 1981; West & Stanovich, 1982; and lexical decision: Schuberth & Eimas, 1977) or when the target word is preceded by a single prime word (in naming: de Groot, 1985; Meyer & Schvaneveldt, 1971; and lexical decision: Schuberth & Eimas, 1977). Here, cross task comparisons reveal that the predictability effect for primed lexical decision (65 ms) is larger than for primed naming (38 ms; de Groot,

[1] Schilling et al. (1998) also analyzed first fixation duration and single fixation duration.