

Effects of thematic and lexical priming on readers' eye movements

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The study was inspired by Ehrlich & Rayner (1981). In the study semantic context effects were investigated during on-line discourse processing. Readers' eye movements were registered to see whether words that were semantically closely related to the global theme of the text were read faster than words that did not have any apparent semantic link to the discourse theme. In addition, lexical priming was examined by presenting an identity prime earlier in the text. The results showed that non-thematic words were regressed to more often than thematic words. Regressions were typically initiated after reaching a clause or sentence boundary. Regressions were thus assumed to be made in order to integrate non-thematic words into the previous context. Modest negative correlations were found between word's fixation time and its relative predictability. No effects of lexical priming were observed. It was concluded that moderately constraining discourse contexts produce negligible effects on word recognition.

Key words: Eye movements in reading, semantic context effects, lexical priming.

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INTRODUCTION

A number of studies has been conducted to examine how semantic context influences the process of identifying and comprehending individual words. These studies have indicated that semantic context can facilitate, and possibly also inhibit, word recognition. Thus, for instance, in the sentence "Since the wedding was today, the baker rushed the wedding . . ." the word 'cake' is more congruous continuation for the sentence than, say, the word 'pie', and thus easier to identify and integrate into the preceding context (see Balota *et al.*, 1985).

That semantic context can potentially affect word recognition is indisputable. It is questionable, however, what the necessary conditions are for the semantic context to exert its effect. In other words, how predictable should the semantic context be in order to facilitate word recognition? Or to put it in the other way, how incongruous should the preceding context be in order to inhibit the identification of a target word? Moreover, how do context effects generalize to on-line discourse processing?

In designing stimulus materials for context experiments, a common procedure has been to use single sentence contexts with the target word occupying the sentence-final position. Secondly, rather massive context manipulations are often employed. Take an example from the Stanovich and West (1981) study. The target word 'dog' was preceded either by a congruous context "The boy was bitten by the . . ." or an incongruous context "The awards were presented after the . . .". Obviously, the incongruous condition is rather anomalous, in fact, to the extent that it is uninterpretable. Given the strong context manipulation, the generalizability of the effect to a more natural discourse can thus be challenged.

Typically, context effects on word recognition are studied by employing either the naming or the lexical decision task. In the naming task, the critical measure is the vocalization latency, i.e., the time elapsed between the onset of stimulus and that of vocalization. In the lexical decision task, the subject is to decide as fast as possible whether or not a given letter

string is acceptable as a word in the language studied. Both tasks are based on the principle of mental chronometry (see Posner, 1978), according to which the time needed to trigger a response to a stimulus reflects the relative ease of the performed mental task.

Recently, studies have also been carried out that have employed readers' eye fixations as the dependent measure. The eye movement method rests on the mental chronometry assumption as well, the typical variables being individual fixation durations and summed fixation times on a given word. In eye movement experiments, subjects are not required to carry out any subsidiary tasks alien to normal reading, such as rapid naming of words or making decisions upon the lexical status of letter strings, but are free to progress through the text in a desired speed. On the other hand, it should be added that naming and lexical decision tasks do share at least some of the same cognitive processes with natural reading (see Kerr & Underwood, 1985; Schustack *et al.*, 1987).

Eye movement studies concerning semantic context effects are quite scarce. A few studies have examined lexical priming effects in reading. Zola (1984) constructed pairs of paragraphs in which the target noun was immediately preceded either by a high-associate adjective or non-associate adjective. Thus, in a paragraph about movie business, the target noun 'popcorn' was preceded either by 'battered' (high-associate) or 'adequate' (non-associate). As predicted, the target word reading was facilitated by presenting a high-associate lexical prime. The context effect was reflected in shorter fixation durations on the target word and in the lower probability of regressing back to the target, if it was preceded by a high-associate adjective than by a non-associate adjective. However, the size of the effect was very modest.

Analogously, Carroll & Slowiaczek (1986) were able to show that when the target noun ('rum') was primed by its category name ('alcoholic beverages') in the previous sentence, the processing was facilitated, compared to the case when the target was unprimed ('that stuff' instead of 'alcoholic beverages'). A similar effect was reported by Kerr & Underwood (1985). Balota *et al.* (1985), on the other hand, used single sentence frames where the target word occurred towards the end of the sentence. The target word was either highly predicted by the sentence context or not predictable from the prior context. The results showed that gaze duration on non-predictable targets was longer than on predictable targets.

For the present purpose, the most relevant study is that of Ehrlich & Rayner (1981). Instead of using single sentences or single lexical items for the context manipulation, they varied whole text passages. For each target word, Ehrlich & Rayner created a high-constraint and a low-constraint passage. In the following, an example is given of the type of stories they used.

High constraint

He saw the black fin slice through the water and the image of sharks' teeth came quickly to his mind. He turned quickly toward the shore and swam for his life. The coast guard had warned that someone had seen a *shark* off the north shore of the island. As usual, not everyone listened to the warning.

Low constraint

The young couple were delighted by the special attention they were getting. The zoo keeper explained that the life span of a *shark* is much longer than those of the other animals they had talked about. The scientists decided that this man would make a great ally.

In the high-constraint passage, the target word 'shark' is strongly associated with the theme of the text, which is something like "Sharks seen on the coastal area". This is clearly not the case in the low-constraint passage, the theme of which is something like "A couple visiting a zoo". In other words, in the Ehrlich & Rayner study, high-constraint targets were strongly associated with the discourse theme, which was not true for the low-constraint targets.

The results showed reliable context effects: High-constraint words were fixated less often than low-constraint targets (51% vs. 62%), and when they were fixated, the total fixation

durations were shorter for the high-constraint targets (248 ms vs. 305 ms). As apparent from the above example, in many of the high-constraint passages the target word also occurred earlier in the text. In other words, there was an identity prime present in the high-constraint but not in the low-constraint passages. Consequently, the results could be accounted for as a word repetition effect and not as a thematic priming effect. This problem was partly solved by Ehrlich & Rayner (1981) in their experiment 2, in which no identity primes were present. However, in both experiments the unpredictable target words tended to be somewhat surprising completions to the text passage. Thus, the context effect may not be so much due to thematicity as due to semantic incongruity.

The present study was designed to further investigate the issues raised in Ehrlich & Rayner (1981). In particular, answers were sought to two questions: (1) Does the thematic status of a word affect its processing during on-line discourse processing? More specifically, are thematic words read faster than non-thematic words? (2) Is word recognition facilitated by presenting an identity prime earlier in the text? In other words, does an earlier occurrence of a word facilitate its later recognition? Moreover, does the lexical priming effect restrict to thematic words only?

By definition, a thematic word is one which is closely associated with the global theme of the text, whereas a non-thematic word does not have any apparent association with it. In other words, a thematic word could easily be incorporated in a summarizing statement of the text passage expressing what the text is primarily about (see the pretest in Method). However, this would not be the case for non-thematic words. Previously, Guindon & Kintsch (1984) have shown that after reading a text, words incorporated in a summarizing statement are recognized faster than some other words that also appeared in the text. It is not clear, however, whether this would happen also during on-line discourse comprehension. The present study may shed some light on the issue.

The present study differs from the usual procedure used in naming and lexical decision experiments in four respects: (1) Readers' eye movements were used to measure the process of word identification. (2) Single sentence contexts were substituted by a discourse context. (3) Care was taken that semantic incongruity did not mean incomprehensibility. (4) Target words occupied various sentential positions, instead of restricting the analysis to the sentence-final position only.

The eye movement method affords several measures to explore context effects during reading. These include durations of individual fixations and summed fixation durations on a word, as well as probabilities of fixating and refixating a word. Inhoff's (1984) two-stage model suggests that the initial fixation would primarily reflect lexical access, and effects of contextual constraints would show up only when fixations for the first-pass reading are summed up in gaze duration. Furthermore, regressive fixations are assumed to reflect post-access checking and integration processes (see e.g., Carpenter & Daneman, 1981; Frazier & Rayner, 1982), so they may also be sensitive to semantic context effects. In the following, all the different eye movement parameters were employed. Gaze durations and regressions were expected to reveal context effects most reliably.

METHOD

Subjects

Forty-eight undergraduate students served as subjects as a part of their course requirement. All had normal, or corrected to normal vision. The subjects were naive with respect to the purpose of the study. One subject was discarded from the analysis due to equipment failure.

Materials

There were 20 target words (all nouns), the length of which ranged between 6 and 13 characters (mean = 8.8, SD = 1.8). For each target word, two text passages were written: one in which the target word was semantically closely related to the discourse theme (thematic version), and another where there was no obvious semantic relation between the target word and the discourse theme (non-thematic version). Thus, when the passage was about "Learning to read", the target word 'letter' was a close-associate with the theme, while this was not the case when the passage dealt with "Advertisements" (see Appendix A for the complete list of the passage themes and the respective target words, and Appendix B for an example story-pair).

The sentence containing the target word was almost identical in both passage versions. If needed, minor changes were made in the wording in order to fit the sentence in the passage. However, the words immediately preceding and succeeding the target word were always kept intact. This was done to ensure that parafoveal processing of the neighboring words did not confound the target word processing. The syntactic structure of the sentences containing the targets was also identical in both versions.

The passage length varied from 5 to 8 sentences. The target sentence occurred towards the end of the passage, usually immediately preceding the final sentence. This was to increase the likelihood that internal representations associated with the theme of the passage would be activated in the reader's working memory. The target word never occupied the initial or final position in a sentence or in a line. Within these limits, the targets took various positions. The intention was to avoid the typical procedure in which context effects are measured for the sentence final words only.

For each thematic and non-thematic passage, two versions were prepared: one with identity prime present, the other without identity prime. Identity prime denotes an explicit mention of the target word previously in the text. In the case of the identity prime not being present, the identity prime was substituted by a synonymous expression preserving the overall meaning of that sentence. There was one filler sentence intervening between the sentence including the identity prime and the target sentence.

In sum, for each target word, four passage versions were prepared: (1) thematic-primed, (2) thematic-unprimed, (3) non-thematic-primed, (4) non-thematic-unprimed. Each subject read 20 passages, one for each target word, so that the subject only read one of the four possible passage versions. Subjects read 10 thematic and 10 non-thematic passages, half of them being primed versions, the other half unprimed versions. Four separate sets consisting of 20 passages were formed. Each subject was randomly assigned to one of the four passage sets. Thus, across subjects, each passage version was read an equal number of times.

Pretesting the predictability of the stimulus material

The predictability of the target words was judged by a modified cloze procedure. Thirty-eight university students who did not participate in the eye movement experiment gave completions to the 40 target passages. Each passage was presented up to the point where the target word would have appeared. The subjects were asked to fill in a word that provides a smooth continuation for the text passage. The subjects were further informed that only content words were accepted, and that the filled-in word does not need to complete the sentence.

Two 20-passage lists were prepared for the cloze task. Both lists contained 10 thematic and 10 non-thematic versions. The thematic and non-thematic version of a given text always appeared in separate passage lists. The cloze task was performed as a paper-and-pencil test, and the two passage lists were completed by an equal number of subjects (i.e., 19 subjects for both lists). For the cloze procedure, only those versions in which the identity prime was present were chosen. In addition to presenting the preceding context up to the target word, the initial letter of the target word was also given (see Jarvella & Kalliokoski, 1991). The idea was to roughly mimic the parafoveal preview that the reader is afforded in continuous reading prior to fixating on a word (see e.g., Lima & Inhoff, 1985).

The completions were analyzed using a scale adopted from Marslen-Wilson & Welsh (1978). On this scale, a response identical to a target word is awarded 1 point, a synonym 2 points, a semantically related completion 3 points, and a fully unrelated word 4 points. The cloze task yielded average scores of 1.84 and 2.86 for the thematic and non-thematic targets, respectively. Moreover, totally correct completions were given for 65.0% of the thematic and for 31.8% of the non-thematic targets.

The cloze task thus confirmed that thematic targets were contextually more predictable than non-thematic targets. The difference was not as pronounced as in the Ehrlich & Rayner (1981) study. In particular, even the non-thematic targets were occasionally guessed correctly, which was seldom the case in Ehrlich & Rayner (1981). In the Ehrlich & Rayner study, the probabilities of giving a correct completion were 93% and 15% in the experiment 1, and 60% and 0% in the experiment 2. However, the

predictability scores are not perfectly comparable, because the procedure adopted in the present study where the initial letter of the target word was given may have slightly increased the probability of giving a correct completion.

In addition to perform the cloze task, subjects were also asked to give a short title for each text. A target word was explicitly mentioned in 43.4% of the titles for thematic versions, whereas with non-thematic passages this was the case only for 2.1% of the targets. This analysis further confirmed the differential thematic status of the target words in the two text versions.

Apparatus

Eye movements were collected by an Applied Science Laboratories eye-tracker Model 200, which is a spectacle-mounted photoelectric recorder. For measuring horizontal movements, it makes use of the differential reflectivity of the iris and the sclera, while vertical eye movement recording is accomplished by monitoring eyelid movement. The measurement accuracy of the apparatus is 1 degree horizontally and 2 degrees vertically. Eye positions were sampled every 10 ms by an Apple IIe microcomputer. A chin rest and a head band was used to restrict head movements. Fixations less than 100 ms were excluded from the analysis.

The texts were displayed on a monochrome TV screen and were seen as white against dark background. There were two lines of text per page. With the viewing distance of 100 cm, one character space subtended a visual angle of 0.5 degrees. Uppercase letters were used. One could argue that the use of uppercase letters may slow down the general reading speed. However, Hyönä *et al.* (1989) obtained comparable fixation durations for uppercase and lowercase texts (see experiments 2 and 3), so the argument may not be warranted.

Procedure

The experimental session was initiated by a calibration procedure. For the calibration, three numerals were used for both stimulus lines, one numeral in the place of the first character of a line, one in the center, and one in the end of a line. The subject was asked to fixate each of the numerals, while the experimenter adjusted the accuracy of the eyetracker. There was a brief calibration check before each passage.

Reading was self-paced with the restriction that returning to a previous page was prevented. Subjects pressed the space bar in the computer keyboard to change the page. They were instructed to read the passages for meaning, but not for detailed memorization. To ensure that the texts were read for meaning, the subject responded, after each text, to a statement concerning some aspect of text's content. The subject pressed the 'Yes' key on the computer keyboard if she felt the statement was in accordance with the text, and the 'No' key if it seemed to contradict the sense of the text. These responses were not analysed further.

RESULTS

An analysis of variance was performed using a 2 (thematicity) \times 2 (prime) repeated measures design. If not stated otherwise, the analyses were computed treating subjects as the random factor.

The following eye movement measures associated with the target word reading were used: (1) *first-fixation duration*, (2) *gaze duration*, (3) *total fixation time*, and (4) *fixation frequencies* associated with gaze duration and summed fixation time. First-fixation duration is the duration of the initial fixation landing on a target word. Gaze duration is the sum of all fixations falling on a target word before moving away from it to another word. In total fixation time the regressions back to the target word are added to gaze duration. When only one fixation falls on a word, gaze duration parallels first-fixation duration. Analogously, when there are no regressive fixations, gaze duration equals total fixation time.

In addition to the above measures, the fixation immediately prior to and after the target word reading was also considered. The idea was to see if there were any signs of parafoveal preprocessing of targets being influenced by the manipulations (i.e. the fixation prior to fixating the target), or if lagged an/or spill-over effects were observed (i.e., the first fixation after leaving the target) (see Ehrlich & Rayner, 1981, experiment 2).

(a) First-fixation duration

ANOVA revealed no reliable effects. Thematicity did not affect first fixation durations on target words ($F < 1$), the means being 233 ms (SD = 50) for the thematic targets and 238 ms (SD = 55) for the non-thematic targets. Neither did the identity prime have an effect ($F < 1$): the average initial fixation on the primed targets was 237 ms (SD = 51) and on the unprimed targets 234 ms (SD = 54).

(b) Gaze duration

There were no reliable effects associated with the gaze duration (all F 's < 1). The mean gaze durations were 329 ms (SD = 113) and 339 ms (SD = 109) for the thematic and non-thematic targets, and 335 ms (SD = 100) and 332 ms (SD = 122) for the primed and unprimed targets, respectively.

(c) Total fixation time

There was a slight hint that total fixation time may have been affected by thematicity (the means were 418 ms (SD = 166) and 441 ms (SD = 162) for the thematic and non-thematic targets, respectively), although this trend was not reliable ($F(1,46) = 2.40$, $p = 0.13$, by subjects), and ($F(1,19) = 3.18$, $p = 0.09$, by items). The means show a tendency toward the predicted direction, that is, the non-thematic targets attracting slightly more visual attention than the thematic targets. The main effect of identity prime was non-significant ($F(1,46) = 1.19$, $p = 0.28$); the respective means were 439 ms (SD = 166) and 420 ms (SD = 162) for the primed and unprimed targets.

(d) Fixation frequencies

The number of fixations associated with gaze duration was not affected by thematicity ($F < 1$), the mean being 1.44 for both thematic and non-thematic targets (the respective SD's were 0.4 and 0.3). Neither did identity prime affect the fixation frequency ($F < 1$), the means were 1.44 (SD = 0.3) and 1.43 (SD = 0.4) for primed and unprimed targets, respectively.

Similarly, the number of fixations associated with total fixation time was not affected by the manipulations (all p 's > 0.1). The means were 1.81 (SD = 0.7) and 1.86 (SD = 0.6) for the thematic and non-thematic targets, and 1.86 (SD = 0.6) and 1.81 (SD = 0.7) for the primed and unprimed targets, respectively.

Typically there was at least one fixation falling on the targets. In other words, the target words were skipped very seldom (in 2.1 % of the cases). Interestingly, once skipping occurred, it was as a rule a thematic (18 occurrences) rather than a non-thematic word (2 occurrences) that was skipped.

(e) Duration of the previous and the following fixation

The durations of fixations immediately preceding or succeeding the fixations on target words were examined to see if there were any signs of parafoveal processing being influenced by the manipulations (preceding fixation), or if lagged effects could be found (following fixation). The duration of the previous fixation was not affected by the manipulations (all F 's < 1). The respective means were 232 ms (SD = 58) and 229 ms (SD = 45) for the thematic and non-thematic targets, and 229 ms (SD = 54) and 232 ms (SD = 48) for the primed and unprimed targets. Neither were any reliable effects observed in the duration of the following fixation. There was a tendency for the duration being slightly longer in the thematic (i.e., 269 ms, SD = 82) than in the non-thematic version (i.e., 251 ms, SD = 70), but the effect was again non-significant ($F(1,46) = 2.42$, $p = 0.13$). Moreover, even if reliable, it would have gone

against the prediction. That is, if there were a lagged effect of thematicity, it should mean, according to the prediction, longer fixation durations in the non-thematic versions.

(f) Regressions

As apparent from above, the only effect that approached significance was the main effect of thematicity using total fixation time as the dependent measure. Total fixation time differs from gaze duration in that it also includes regressions back to a target word. Thus, an analysis was carried out to explore the nature and frequency of these regressive fixations. The analysis indicated that there was at least one regressive fixation back to the target in 24.9% of the cases. In other words, 75.1% of the targets were not reread after first passing through them. There were more thematic words that were not refixated (40.4%) than non-thematic words (34.7%). The reliability of this difference was tested using the nonparametric Wilcoxon test. The test value was computed over items, because there was insufficient amount of data points for an analysis by subjects. The Wilcoxon T value proved significant ($p = 0.01$).

To further qualify the nature of refixations on the targets, regressions were grouped into three categories: (1) regressions taking place immediately *after reaching the end of a sentence or a clause* and before beginning to read the following sentence, (2) regressions made *after reading through the 2-line page* and before turning to the next one, and (3) regressions initiated *before reaching the end of a sentence/clause or the 2-line page*. The frequency of the regressions falling into these three categories are given in Table 1.

As apparent from Table 1, a regression back to the target was frequently made after completing reading the currently processed clause/sentence or page (i.e., 73% of the regressions). Pairwise comparisons (by items) over thematic and non-thematic passage versions were carried out using the Wilcoxon test. The test was carried out to see whether the type of regressions varied as a function of thematicity. The test revealed that the Wilcoxon

T value was non-significant for the type 2 and 3 regressions. On the other hand, the T value just barely failed to reach significance ($T = 18$; the T value of 17 would have been needed for $p = 0.05$) for the type 1 regressions. That is, there was a trend that the incidence of regressions initiated after reaching the clause/sentence boundary was more frequent for non-thematic than thematic words. This finding suggests that a post-access check for non-thematic words takes place after the meaning of a clause/sentence is uncovered. This can also be considered as evidence for the integrative nature of the regressions, under the assumption that non-thematic words are more difficult to integrate into the previous text.

Table 1. *The frequency of regressions (in percentages) to the target word, as a function of thematicity and timing of regressions*

Timing	Text version	
	Thematic	Non-thematic
Clause	12.6	26.5
Page	13.5	20.5
Before	12.6	14.4

Note: 'Clause' = regressions shot immediately afterreaching a clause/sentence boundary and before beginning to read the next sentence, 'Page' = regressions shot after finished reading a 2-line page, 'Before' = regressions shot before reaching a clause/sentence boundary or the end of page.

(g) Correlating fixation times with predictability scores

Although the target words in the thematic versions were generally more predictable than in the non-thematic versions, some of the non-thematic versions obtained higher predictability scores than the least predictable thematic versions in the cloze task that was used as a pretest. In the final analysis, total fixation times for target words were correlated with the corresponding predictability score to look for a possible linear trend between fixation times and contextual predictability. The analysis was performed using the 40 stimulus texts as cases. Two predictability scores were used: the probability of correct completion in the cloze task and the predictability score on the Marslen-Wilson & Welsh (1978) scale (see above). A stepwise regression analysis was computed. Since the length of the target words varied somewhat, the length of the target words in syllables was also entered as a variable together with the two predictability scores.

The regression analysis revealed that total fixation time was significantly predicted by the probability of correct completion, after first entering syllable length in the equation. The two factors predicted 53% of the variance in total fixation time, syllable length predicting 47% and predictability the rest 6%. The partial correlation between total fixation time and predictability was -0.33 .

An analogous trend was observed when gaze duration was used as the dependent measure. The partial correlation between gaze duration and the probability of correct completion was -0.29 . Similarly, a modest negative correlation (-0.30) was found between the frequency of making at least one regressive fixation back to the target and the probability of correct completion. However, in both cases the independent contribution of predictability just barely failed to reach statistical significance.

In sum, fixation times for words and words' contextual predictability are negatively correlated, although the correlations are quite modest. Yet, there is a tendency for less predictable words to attract longer fixation times during reading.

DISCUSSION

Contrary to what was expected, no effects of contextual constraints were observed in the first-pass reading of target words. Words that were closely associated with the discourse theme were not read with shorter gaze durations than words having no apparent semantic association with the global theme of the text. Neither did the presence of an identity prime earlier in the text aid in recognizing the same word later in the text. However, there was evidence suggesting that non-thematic words are regressed to more often than thematic words. This was especially true for regressions initiated immediately after reaching a clause or sentence boundary. Moreover, thematic words were left unfixated more often than non-thematic words, although the skipping itself was rare. Modest negative correlations were also found between fixation times for target words and their relative contextual predictability. That is, less predictable words seemed to receive longer fixation times.

The study failed to replicate the Ehrlich & Rayner (1981) study in that it did not find a semantic context effect for word's initial reading. On the other hand, the increase in regressive fixation for less predictable words was also observed by Ehrlich & Rayner (see also Inhoff, 1984). The obvious difference between these studies is that the variation in predictability between contextually constrained and less constrained words was much more pronounced in Ehrlich & Rayner than in the present study. Thus, it seems likely that strong contextual manipulations are needed to produce a reliable context effect for the first-pass reading of a word, while with weaker constraints the effect is seen only in a later integration stage.

In the eye movement literature, it is proposed that readers' regressive fixations reflect post-access checking and integration processes. Frazier & Rayner (1982) and Ferreira & Clifton (1986) showed that misanalyzed syntactic structures are reanalyzed, and thus disambiguated, by making a regression back to the critical text locations. Carpenter & Daneman (1981) found that the occurrence of regressions increased when a homograph was given an interpretation not matching the semantic context. Thus, a regression served the function of recovering from the erroneous interpretation. The present study suggests that regressive fixations may also assist in integrating less predictable non-thematic words into the reader's mental representation of the text.

Regressions were typically initiated after completing reading a clause or a sentence. This was particularly the case with non-thematic targets. That is, readers tended to postpone the execution of regressions until a structural boundary was reached. A similar finding was also observed by Carpenter & Daneman (1981). It agrees well with the notion that the integration phase is carried out at sentence boundaries. According to Jarvella's (1979) buffer-integrate-purge model (see also Sharkey & Sharkey, 1987), the lexical entry for each processed word is deposited to a temporary buffer until a clause or sentence boundary provides an occasion to integrate the meanings of words with the previous text. After executing the integration phase the buffer is purged, and the processing of the next sentence is initiated. The present study suggests that occasional reinspections of non-thematic words are needed in order to integrate them into the emerging internal text representation.

Ehrlich & Rayner (1981) reported evidence favoring the idea that skipping over individual words, i.e. leave words unfixated, is at least partly dependent on word's contextual predictability. There was some minor evidence in the present data pointing at the same direction. When the target word was skipped, it was almost always a thematic word. This suggests that a thematically predictable word can be identified parafoveally without directly fixating on it. It should be born in mind, however, that in the present study the incidence of skipping was very rare. This is nothing unexpected, considering the length of the target words used (i.e., 8.8 character spaces). Rayner & McConkie (1976) have shown that the longer the word, the more probably it receives at least one fixation. In other words, choosing shorter 5-letter words, as Ehrlich & Rayner (1981) did, yields more opportunities for the skipping to occur.

The present experiment did not find any evidence supporting the idea that prior explicit mention of a word in text would facilitate its processing when encountered for the second time. At first glance, the finding seems to be at odds with what is known of lexical priming. However, the prime-target distance may play a relevant role here. Namely, Schustack *et al.* (1987) showed that identity prime produced a more pronounced facilitation effect if mentioned in the immediately preceding sentence (recent prior mention), in comparison to the case that there was a filler sentence in between the prime and the target (distant prior mention). Carroll and Slowiaczek (1986) were also able to show a recency effect in their eye movement study: the priming effect was greater when the lexical prime and the target were in the same clause than when they were separated by a clause boundary.

The recency effect may well explain why, in the current study, prior mention of a word did not produce a priming effect. The priming condition in the present study resembles the distant mention condition of the Schustack *et al.* (1987) study. It can thus be concluded that a single lexical prime may facilitate word recognition primarily if mentioned very recently in text, the priming effect decaying as the time elapses and/or the lexical prime being purged from the working memory by incoming novel stimuli.

In conclusion, the present study suggests that with moderately constraining text passages semantic context has a very modest effect on reading individual words during on-line discourse

processing. Considering the fact that average predictability of words in natural discourse is even lower (see Gough, 1983; Jarvella & Kalliokoski, 1991) than what was found here, it seems likely that the role of semantic context for word recognition in discourse is quite negligible. However, global discourse structure may play a significant role in determining the identification of less predictable non-thematic words (see Hyönä & Jarvella, in press).

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APPENDIX A

The following list gives the English translations of the target words and the respective themes of the two text versions (thematic and non-thematic).

Targets	Discourse theme	
	Thematic	Nothematic
1. Horse	Horse-race	Returning home from work
2. Resignation	Resigning from job	Egocentric people
3. Style	Architecture	On holidays
4. Stroke	Playing tennis	Bicycling
5. Letter	Learning to read	Advertisement
6. Station	Awaiting a train	Policemen on duty
7. Analysis	Psychoanalysis	Tennis in Finland
8. Traffic	Transportation	Housewife's day
9. Axe	Chopping wood	Members of the parliament
10. Terrorism	Bomb attack	Reading newspapers
11. News	Finnish newspapers	Visiting relatives
12. Music	Becoming a musician	Sailing as a hobby
13. Lecture	Professor giving a lecture	Nature of wisdom
14. Fairy-tale	Reading to children	Christmas presents
15. Photograph	Photographing	Hiking in nature
16. Computer	Computer applications	People with good memory
17. Sawing	Working at a sawmill	Painting a drawer
18. Mother tongue	Finnish in schools	Sexual equality
19. Judge	Studying law	Having a divorce
20. Library	Visiting a library	Computer programming

APPENDIX B

An English translation of the thematic and non-thematic text for the target word 'fairy-tale' (target word underlined). In the (a)-version, an identity prime is included, whereas in the (b)-version it is replaced with a synonymous expression.

Thematic version

Sometimes it can be very tiring to get children to go to sleep. The best way to handle the situation is to read a story that interests the child. Even when very young, children love to hear (a) a fairy-tale (identity prime)/(b) a fantasy story (not primed) before going to sleep. This becomes a habit that pleases both the reader and the listener. You must only make sure to choose such a *fairy-tale* that would not make the child too excited. Otherwise reading won't have the desired effect, that is, the child falling asleep.

Non-thematic version

This Christmas one of the most desired Christmas presents was definitely a video recorder. Many of the music lovers probably wished to get a CD player for Christmas. Christmas sale is thus a good forum to introduce new household technology to the consumers. The more traditional Christmas presents, such as clothing, (a) books of fairy-tales (identity prime)/(b) children's books (not primed), thrillers, toys, etc. nevertheless maintain their popularity. Buying presents is an inseparable part of the present-day Christmas tradition. However, no more do we tell such *fairy-tales* that would deal with the activities that the Christmas dwarfs are occupied with during the Christmas time. This reflects a general cultural change: We have moved from a story-telling tradition to a consumer culture.