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Perceptual specificity effects in rereading: Evidence from eye movements

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ABSTRACT

The present experiments examined perceptual specificity effects using a rereading paradigm. Eye movements were monitored while participants read the same target word twice, in two different low-constraint sentence frames. The congruency of perceptual processing was manipulated by either presenting the target word in the same distortion typography (i.e., font) during the first and second presentations (i.e., the congruent condition), or changing the distortion typography of the word across the two presentations (i.e., the incongruent condition). Fixation times for the second presentation of the target word were shorter for the congruent condition compared to the incongruent condition, and did not differ across the incongruent condition and an additional baseline condition that employed a normal (i.e., non-distorted) typography during the first presentation and a distortion typography during the second presentation. In Experiment 1, we employed both unusual and subtle distortion typographies, and we demonstrated that the typography congruency effect (i.e., the congruent < incongruent difference) was significant for low frequency but not for high frequency target words. In Experiment 2, the congruency effect persisted across a 1 week lag between the first and second presentations of the target words. Overall, the present demonstration of the long-term retention of superficial perceptual details (i.e., typography) supports the existence of perceptually specific memory representations.

Introduction

When text is read twice, readers display a variety of processing advantages during their second encounter with the text, including decreases in overall reading times (e.g., Collins & Levy, 2007; Hyönä, 1995; Kolers, 1975; Raney & Rayner, 1995; Raney, Therriault, & Minkoff, 2000; for reviews see Levy, 1993; Raney, 2003), fewer and longer saccades (Hyönä, 1995; Inhoff, Topolski, Vitu, & O'Regan, 1993; Raney & Rayner, 1995), shorter fixations (Hyönä, 1995; Hyönä & Niemi, 1990; Inhoff, Topolski, Vitu, & O'Regan, 1993; Kaakinen & Hyönä, 2007; Raney & Rayner, 1995; Raney et al., 2000), and fewer regressions (Hyönä, 1995; Hyönä & Niemi, 1990; Kaakinen & Hyönä, 2007; Raney & Rayner, 1995; Raney et al., 2000; Schnitzer & Kowler, 2006). Because rereading benefits (also referred to as text repetition effects, or priming effects) are assessed without explicitly instructing participants to refer back to their previous encounter with the text, the rereading task constitutes an implicit, or indirect, measure of readers' memory for their prior encounter with the text (Rayner, Raney, & Pollatsek, 1995). Consequently, researchers have examined the impact of a variety of experimental variables on the magnitude of rereading benefits, in order to gain insights into the nature of memory representations for text (for reviews, see Levy, 1993; Raney, 2003).

Of particular relevance to the present study, the rereading paradigm has been used to study the perceptual specificity of memory representations. Perceptually specific representations are contrasted with representations which contain conceptual information concerning the meaning of the text but do not preserve information concerning the perceptual processes that were involved in the encoding

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of the text, and/or the perceptual surface features (e.g., the type, orientation, size, or color of the font) of the text. In the rereading literature, research concerning the perceptual specificity of memory representations is of theoretical interest to ongoing debates over competing accounts of text repetition effects (for reviews, see Bowers, 2000; Tenpenny, 1995). Furthermore, as discussed by Reingold (2002), the memory literature has undergone a shift from a primary focus on conceptual and semantic influences on memory performance in the 1970s, towards a growing acknowledgment of the role of both conceptual and perceptual influences, and this shift is reflected in both processing views of memory (e.g., Jacoby, 1983; Roediger & Blaxton, 1987; Roediger & Srinivas, 1993; Roediger, Weldon, & Challis, 1989) and multiple memory systems views (e.g., Moscovitch, 1992; Schacter, 1994; Schacter & Tulving, 1994; Schacter, Wagner, & Buckner, 2000; Squire, 1992; Tulving & Schacter, 1990).

In the rereading literature, a common method of testing for perceptually specific memory representations (i.e., long term retention of perceptual details) is to use surface variables, such as typography, to manipulate the congruency of perceptual details during the first and second presentations of the text. This approach was used by Kolers (1975, 1976, 1979) in a seminal series of studies that pioneered the study of perceptual specificity effects during rereading. In these studies, participants were asked to read transformed text that had been derived from normal text by applying certain geometrical transformations, such as rotation about axes, inversion, and mirror reflection (Kolers, 1968). Kolers' logic for introducing these transformations was that normal text is processed so fluently as to render difficult the task of isolating the components of language processing. Employing transformed typographies, Kolers felt, could disentangle the relative contributions to reading of graphemic and semantic analyses. Using this approach, Kolers (1975) demonstrated that readers were faster at rereading inverted text if they had previously read the text in the same inverted text transformation, relative to text that was previously read in a normal typography. Furthermore, Kolers (1976) showed that readers were faster at rereading inverted text 1 year after the first presentation of the inverted text, even if they did not remember previously reading the text. In interpreting such findings, Kolers argued strongly that readers retain highly specific visual pattern-analyzing operations for over 1 year.

Kolers' conclusions generated a great deal of controversy (Craik, 1989; Graf, 1981; Graf & Levy, 1984; Horton, 1985, 1989; Masson, 1984, 1986; Masson & Sala, 1978; Tardif & Craik, 1989; for a review, see Levy, 1993), and several researchers have advanced the alternative explanation that Kolers' findings were due to conceptual rather than perceptual influences (e.g., Graf & Levy, 1984; Horton, 1985; Masson & Sala, 1978; Tardif & Craik, 1989). According to these critics, transformed text receives more extensive conceptual (or semantic) processing than normal text, and this enhanced conceptual processing produces the superior rereading benefits in the transformed text conditions used by Kolers. A key reason for why it is difficult to refute this criticism is that Kolers' use of identical sentences and passages during both readings makes it is difficult to rule out the possibility that readers were using their memory for the gist, or meaning, of the passages to assist them during rereading. One way to further isolate perceptual influences would be to prevent readers from using their memory for the meaning of passages by examining repetition effects for the same word in two different sentence frames or passages. Previous rereading studies have already investigated the impact of semantic contextual changes during normal reading (i.e., for normal typographies). Specifically, it was shown that repeating the same word or phrase in two different contexts, such as two different stories, usually eliminates or strongly attenuates text repetition effects (e.g., Besson & Kutas, 1993; Levy & Burns, 1990; Levy, Barnes, & Martin, 1993; Levy et al., 1995; Oliphant, 1983; Raney et al., 2000; but see Klin, Drumm, & Ralano, 2009; Klin, Ralano, & Weingartner, 2007). However, Kolers' approach of using unusual or difficult typographies has not yet been implemented within a rereading paradigm that examined repeated words in two different sentence contexts.

Thus, the main goal of the present study is to further investigate perceptual specificity effects by exploring cross-context rereading benefits for target words that were presented using a range of unusual typographies. Specifically, individual target words were read twice in two different sentence frames, and eye movements monitoring was used to measure fixation times on target words in order to quantify cross-context repetition effects. Eye tracking methodology has been previously demonstrated to be an effective technique for measuring rereading benefits for individual target words (see Raney, 2003; Raney & Rayner, 1995; Raney et al., 2000). Thus, in order to further explore the perceptual specificity of memory representations of text, the present study employed a novel application of eye tracking methodology to study cross-context rereading benefits for individual target words that were presented in unusual typographies. Accordingly, we begin with a brief review of prior work concerning perceptual specificity effects in rereading with a focus on prior eye tracking research, and we then outline the rationale and predictions for the present study.

Previous eye tracking investigations have used synonyms with monolingual readers, and translations with bilingual readers, in order to vary the perceptual form of the word while maintaining a similar semantic content. For example, in support of the role of perceptual contributions to rereading benefits, less skilled bilinguals (but not fluent bilinguals) show larger repetition effects for same word repetitions, relative to conditions in which the word is changed to a translation with a similar meaning but a different orthographic form (Friesen & Jared, 2007; Raney, Atilano, & Gomez, 1996). Similarly, Raney et al. (2000) reported that text repetition effects are greater when the same words are repeated during the second reading of a passage, relative to conditions in which some of the words are changed to a synonym. However, an earlier eye tracking study by Raney and Rayner (1995) reported similar fixation times when a single target word in a passage was either repeated or changed to a synonym. As pointed out by Raney (2003), one caveat concerning the use of synonyms in repeated passages is that readers may become

Table 1
An illustration of the typographies used in the present studies. Sample target words are shown by distortion difficulty (subtle, unusual), typography type (normal, Distortion A, Distortion B), and word frequency condition (high frequency, low frequency).

Typography	High frequency	Low frequency
Subtle distortions		
Normal text	street	duplex
Distortion A	STREET	DUPLEX
Distortion B	street	duplex
Unusual distortions		
Normal text	success	tequila
Distortion A		
Distortion B		

aware of the wording changes across readings. Moreover, it is difficult to exactly match synonyms and repeated words for meaning, and other variables such as word frequency.

Other rereading studies, including the present study, have avoided the methodological challenges associated with synonyms by using Kolers' approach of repeating the same text twice while varying the congruency of surface features. In reviewing this literature, Levy (1993) concluded that it is possible to show modality specificity such that repetition effects are greater for text that was previously read rather than text that was previously listened to (e.g., Jacoby, Levy, & Steinbach, 1992), but it has proven more difficult to show that repetition effects are sensitive to more subtle changes in visual details, such as changes in typography. Although the rereading literature does contain some examples of typography effects (Jacoby et al., 1992; Levy, Di Persio, & Hollingshead, 1992), these effects tend to be stronger when more difficult and unfamiliar typographies are used (Brown & Carr, 1993; Carr, Brown, & Charalambous, 1989; Graf & Ryan, 1990; Horton & McKenzie, 1995; Jacoby & Hayman, 1987).

In light of the above evidence that difficult-to-read or unusual typographies are required for demonstrating perceptual specificity effects, the present study employs a variety of typographies. Specifically, as summarized in Table 1, we contrasted a pair of distortion typographies that were slightly more difficult than normal typographies (i.e., the subtle distortion condition), with a pair of distortion typographies that were much more difficult and unusual than normal typographies (i.e., the unusual distortion condition). By using a pair of distortions in each condition, we were able to vary whether the target occurred in the same typography twice (i.e., the congruent condition) or whether the target word was shown in two different typographies (i.e., the incongruent condition). Importantly, the use of a pair of distortions eliminates the potential confounds inherent to Kolers (1975)'s inverted versus normal text manipulation, because both the congruent and incongruent conditions employ equally difficult distortion typographies during both readings (for a similar approach, see Horton, 1985; Tardif & Craik, 1989). Moreover, as explained previously, we further isolated perceptual processing by embedding the target words in two different sentence frames (i.e., at study versus test), that were shown in a normal (i.e., non-distorted) typography. The use of two different contexts prevents participants from using their memory for the meaning of the sentence to help them to decipher the target words. Thus, a demonstration of shorter fixation times for the second reading of the target words in the congruent condition, relative to the incongruent condition, would constitute strong evidence in support of the existence of perceptually specific memory representations.

In addition to the incongruent and congruent conditions, the present study also included a baseline condition in which the target words were read in a normal typography during the first reading, and in a distortion typography during the second reading. By including the baseline condition, we were able to examine first reading times for both the normal and distortion typographies, in order to confirm that the distortion typographies were in fact more difficult to read than normal text. Moreover, by comparing second reading times across the baseline and incongruent conditions, we were able to test whether the distortion typographies produced any perceptually non-specific rereading benefits. Since both the incongruent and the baseline conditions involve a change in typography, shorter processing times in the incongruent condition relative to the baseline condition would constitute evidence for a perceptually non-specific benefit from initially reading the distortion typography rather than the normal typography.

Thus, to test for perceptual specificity effects, we contrasted the congruent and incongruent conditions, and to test whether the distortions produce perceptually non-specific rereading benefits, we contrasted the incongruent and baseline conditions. In the experiments reported below, we test for these two types of effects under a variety of conditions, by varying the difficulty of the distortion typographies (Experiment 1), manipulating target word frequency (Experiment 1), and examining the impact of a 1 week lag between the first and second presentations of the target words (Experiment 2).

Experiment 1

The goal of Experiment 1 was to explore whether the present study's rereading and eye movements paradigm could provide evidence for perceptual specificity effects, and to examine whether several different familiarity manipulations could impact the magnitude of the perceptual specificity effects. Specifically, in addition to the paradigm's typography manipulation (i.e., congruent, incongruent, baseline), we manipulated the level of difficulty of the distortion typographies (subtle, unusual) as well as word frequency (high frequency, low frequency). We predicted that the less familiar stimuli (i.e., low frequency target words and unusual distortions) would produce the largest typography congruency effects (i.e., congruent < incongruent differences). This prediction was motivated by previous findings that unusual or difficult-to-read typographies seem to be more effective at producing perceptual specificity effects (for a review, see Levy, 1993). In addition, long-term

repetition priming effects are stronger for low frequency than for high frequency words (e.g., Coane & Balota, 2010; Forster & Davis, 1984; Jacoby & Dallas, 1981; Jacoby & Hayman, 1987), and for unfamiliar relative to familiar pictures (e.g., Srinivas, 1993). Given that unfamiliar visual stimuli benefit more from repetition, we expected that the present study's low frequency and unusual distortion conditions might provide the greatest scope for showing perceptual specificity effects.

As an additional topic of interest, we tested if reading text in a distortion typography produces any perceptually non-specific rereading benefits relative to a baseline condition in which the text that was initially read in a normal typography. To the extent that difficult typographies produce more extensive semantic processing than normal text (see e.g., Horton, 1985), it is possible that the distortion typographies in Experiment 1 will produce perceptually non-specific rereading benefits, such that second reading fixation times will be shorter for the incongruent condition relative to the baseline condition.

Thus, in Experiment 1, we tested for two types of rereading effects (i.e., perceptually specific and perceptually non-specific) under a wide range of typography and word frequency conditions. Both of these effects are tested for by examining second reading fixation times on target words that were read twice in two different sentence frames, in order to prevent readers from using their prior memory for the meaning of the sentence while deciphering the target words.

Method

Participants

All 96 participants were undergraduate students at the University of Toronto. The participants were all native English speakers and were given either one course credit, or $10.00 (Canadian) per hour. All participants had normal or corrected to normal vision.

Materials and design

The target words consisted of 108 low frequency nouns and 108 high frequency nouns, which ranged in word length from 5 to 9 letters ($M = 6.4$). The mean word frequency was 2.9 occurrences per million for the low frequency targets, and 106.1 occurrences per million for the high frequency targets, according to the SUBTLex corpus of American English subtitles (Brysbaert & New, 2009). For each participant, a total of 108 target words (54 high frequency words and 54 low frequency words) were each presented twice in two different low-constraint sentence frames (see the Appendix for the complete list of sentences). To give an example, the target word *table* was presented in the two sentences (A and B) that are shown below:

(A) John decided to sell the *table* in the garage sale.
(B) I was told that the *table* was made out of expensive wood.

Target word predictability in these sentence frames was assessed by providing an additional group of 10 participants with the beginning of each sentence frame and asking them to write a word that could fit as the next word in the sentence. Average predictability was extremely low, amounting to 1.3% for the high frequency target words and 0.1% for low frequency target words.[1]

In addition to the word frequency manipulation, target words were presented in a variety of typographies (see Table 1 for examples) that ranged from normal text (i.e., a mono-spaced Courier font) to a pair of distortion typographies that were selected to be slightly more difficult to read than normal text (i.e., the subtle distortion condition), and a pair of distortion typographies that were much more unusual and difficult to read than normal text (i.e., the unusual distortion condition). As can be seen from Table 1, the distortion typographies within each pair were selected to be roughly equivalent in difficulty, and to be visually distinct from one another.

The typographies in Table 1 were used to setup three typography conditions (i.e., congruent, incongruent, baseline). For the congruent condition (one third of trials), the target word was presented in the same distortion typography for both the first and second readings (50% of trials = Distortion A was used for both presentations, 50% of trials = Distortion B was used for both presentations). For the incongruent condition (one third of targets), the type of distortion changed across the two readings (50% of trials = Distortion A was followed by Distortion B, 50% of trials = Distortion B was followed by Distortion A). Finally, for the baseline condition (one third of trials), the target was shown in the normal typography during the first reading, and in a distortion typography during the second reading (50% of trials = the second presentation was Distortion A, and 50% of trials = the second presentation was Distortion B). For all of the above typography conditions, the sentence frames surrounding the target words were presented in the normal typography.

Thus, a total of twelve experimental conditions resulted from crossing typography condition (congruent, incongruent, baseline), distortion difficulty (subtle, unusual), and word frequency (high frequency, low frequency). The typography condition and word frequency variables were manipulated within subjects, and the distortion difficulty variable was manipulated between subjects such that 60 participants were shown only the subtle distortion condition, and the remaining 36 participants were shown only the unusual distortion condition. Each participant read each target word twice, but they saw a given sentence frame only once, and the assignment of target words and sentence frames to conditions was counterbalanced across participants. Participants read five practice sentences followed by 274 sentences (108 first presentation sentences, 108 second presentation sentences, and 58 non-experimental filler sentences). To ensure that participants could not distinguish the filler sentences from the experimental sentences, some of the filler sentences contained a single word shown in the same distortion typographies as the

[1] This small difference in the predictability of high versus low frequency words was not expected to be a factor in the results because predictability was extremely low. In fact, for 90% of the sentence frames, predictability was at 0% for both the high and low frequency targets.

target words (none of the filler sentences contained repetitions of the target words). The order of trials was randomized, with the constraint that the first and second presentations of the target words occurred in separate blocks, and these two blocks were separated by 20 filler sentences that served as buffer trials.

Apparatus and procedure

Eye movements were measured with an SR Research EyeLink 1000 system with high spatial resolution and a sampling rate of 1000 Hz. Viewing was binocular, but only the right eye was monitored. A chin rest and forehead rest were used to minimize head movements. Following calibration, gaze-position error was less than 0.5°. The sentences were displayed on a 21 in. ViewSonic monitor with a refresh rate of 150 Hz and a screen resolution of 1024 × 768 pixels. All letters were lowercase unless capitals were appropriate, with the exception that one of the distortion typographies employed only capital letters (i.e., Distortion A typography in the subtle condition). The text was presented in black (4.7 cd/m^2) on a white background (56 cd/m^2). Participants were seated 60 cm from the monitor, and 2.4 characters equaled approximately 1° of visual angle.

Prior to the experiment, participants were informed that they would occasionally encounter words written in an unusual font, but they were not told about the occurrence of repeated targets. Participants were told to focus on reading the sentences for comprehension. After reading each sentence, they pressed a button to end the trial and proceed to the next sentence. To ensure that participants were reading for comprehension, about 15% of the sentences (all were filler sentences) were followed by multiple-choice comprehension questions. The average accuracy rate was 95.4% for participants in the subtle distortions condition, and 94.8% for participants in the unusual distortions condition.

Results and discussion

In the analyses reported below, we used the following variables, which are standard for eye movement studies (for a review, see Rayner, 1998), to examine processing times for the second reading of the target words: (1) first-fixation duration (i.e., the duration of the first forward fixation on the target, regardless of the number of subsequent fixations on the target); (2) single-fixation duration (i.e., the first-fixation value for the subset of trials in which there was only one first-pass fixation on the target); (3) gaze duration (i.e., the sum of all the consecutive first-pass fixations on the target word, before a saccade to another word); (4) total time (i.e., the sum of all the fixations on the target, including regressions back to the target); (5) the probability of skipping (i.e., trials in which there was no first-pass fixation on the target regardless of whether or not the target was fixated later in the trial); (6) the probability of a single first-pass fixation. However, prior to reporting the results for the second reading of the target words, we will first briefly examine processing times during the first reading of the target words, using the gaze duration and total time measures.

For the first reading analyses, 4.8% of trials were removed due to skipping of the target. Table 2 contains the means and standard errors for the first reading of the target words in Experiment 1, by distortion difficulty (subtle, unusual), typography type (normal, Distortion A, Distortion B), and word frequency condition (high frequency, low frequency). To confirm that the distortion typographies were read more slowly than normal text, we conducted 2 × 2 analyses of variance (*ANOVA*s) that were carried out on the mean fixation time data via both participants (F_1) and items (F_2), and with typography type (normal, distortion) and frequency (high frequency, low frequency) as independent variables. These ANOVAs were carried out separately for each measure (i.e., gaze duration, total time) and for each of the four distortion conditions in Experiment 1 (i.e., subtle Distortion A, subtle Distortion B, unusual Distortion A, unusual Distortion B). As can be seen from Table 2, all four of the distortion conditions consistently produced longer fixation times than normal text (all Fs > 60, all ps < .001) and this effect tended to be numerically larger for the unusual distortions relative to the subtle distortions. In addition, the low frequency targets consistently produced longer fixation times than the

Table 2
Gaze duration and total time (ms), for the first reading of the target word in Experiments 1 and 2. Standard errors are shown in parentheses.

Variable	High frequency			Low frequency		
	Normal	Distortion A	Distortion B	Normal	Distortion A	Distortion B
Experiment 1						
Subtle distortions						
Gaze duration	251 (6.5)	308 (8.3)	344 (9.3)	299 (8.9)	419 (16.3)	499 (21.7)
Total time	328 (11.0)	471 (14.4)	512 (19.5)	408 (15.6)	680 (31.1)	810 (39.9)
Unusual distortions						
Gaze duration	246 (8.3)	464 (22.0)	358 (16.8)	302 (12.5)	622 (40.6)	468 (26.1)
Total time	332 (15.3)	710 (41.2)	581 (34.0)	451 (25.7)	1049 (80.0)	745 (52.7)
Experiment 2						
Unusual distortions						
Gaze duration	–	–	–	324 (19.2)	660 (47.6)	478 (26.9)
Total time	–	–	–	435 (26.9)	983 (67.7)	668 (37.0)

Note: The means and standard errors shown in the table are based on the by-participant analyses.

high frequency targets (all Fs > 30, all ps < .001). This word frequency effect was larger in magnitude for the distortion conditions relative to the normal text condition as indicated by significant interactions for all of the analyses (all Fs > 9, all ps < .01) except for the total time measure in the unusual Distortion B condition ($F_1(1,35) = 2.71$, $p = .109$; $F_2(1,107) = 1.41$, $p = .238$). Overall, this pattern of results replicates prior findings that difficult-to-read typography conditions typically produce longer fixation times and larger word frequency effects relative to normal text (Barnhart & Goldinger, 2010; Paterson & Tinker, 1947; Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006; Slattery & Rayner, 2010; Tinker & Paterson, 1955).

For the second reading analyses, 9.6% of trials were removed because the target word was skipped during the first and/or the second reading. Table 3 shows the means and standard errors for the second reading of the target words, by distortion difficulty (subtle, unusual), typography condition (congruent, incongruent, baseline) and word frequency condition (high frequency, low frequency). To test for perceptual specificity effects, we used 2 × 2 analyses of variance (*ANOVA*s) that were carried out on the data via both participants (F_1) and items (F_2), and with distortion difficulty (subtle, unusual) and typography condition (congruent, incongruent) as independent variables. These ANOVAs were carried out separately for high and low frequency target words, and for each of the eye movement measures (i.e., first-fixation, single-fixation, gaze duration, total time, probability of skipping, and probability of single fixation). However, since the high frequency *ANOVA*s did not yield any significant congruent versus incongruent differences (all Fs < 3, all ps > .15), we will only discuss the results for the low frequency target words below. Moreover, we also tested for perceptually non-specific effects by contrasting the incongruent and baseline typography conditions, but this effect will also not be discussed further because there were no significant differences between the incongruent and baseline conditions (all Fs < 4, all ps > .07).

Most importantly, as can be seen from Table 3, Experiment 1 demonstrated perceptual specificity effects by showing shorter fixation times on low frequency targets in the congruent relative to the incongruent condition, for both total time and gaze duration (all Fs > 5, all ps < .05). In addition, for both gaze duration and total time, fixation times were longer in the unusual distortion condition than in the subtle distortion condition (all Fs > 4, all ps < .05). Although there was a numerical trend towards a larger congruency effect for the unusual distortions relative to the subtle distortions (see Table 3), none of the interactions were significant (all Fs < 3, all ps > .1). In the reading and eye movements literature (for a review, see Rayner, 1998), gaze duration is the most commonly used index of processing time during a reader's initial encounter with a word, and total time is a commonly used measure of later processing. To provide further time-course information, we also examined early eye movement measures (i.e., first-fixation, single-fixation) and several probability measures (i.e., probability of skipping, probability of single fixation). However, as can be seen from Table 3, these additional measures did not show any significant congruent versus incongruent differences (all Fs < 1).

Overall, Experiment 1 provided strong evidence for perceptual specificity effects, by demonstrating shorter fixation times in the congruent than in the incongruent condition, using a novel paradigm that examined cross-context rereading effects for individual target words. Interestingly, the present study's perceptual specificity effect was significant for low frequency but not for high frequency words. This difference in the pattern of results for low versus high frequency words may not be surprising, because long-term repetition priming effects are often larger for low frequency than for high frequency words (e.g., Coane & Balota, 2010; Forster & Davis, 1984; Jacoby & Dallas, 1981; Jacoby & Hayman, 1987). It is possible that since low frequency words benefit more from repetition, they provide more scope for revealing perceptual specificity effects. Furthermore, it is possible that less familiar stimuli in general are more conducive to showing perceptual specificity effects, because typography congruency effects in the rereading literature were stronger for less familiar and difficult-to-read typographies relative to normal typographies (for a review, see Levy, 1993). As discussed above, the present study did show a numerical trend towards larger perceptual specificity effects for the unusual than for the subtle distortions, but this interaction was not significant.

Experiment 2

Our main goal in Experiment 2 was to test whether the perceptual specificity effects from Experiment 1 would still occur when a 1 week lag was introduced between the first and second presentations of the target words. Previous rereading and memory studies have demonstrated that memory for surface details, such as typography, can be remarkably long lasting (for reviews see Levy, 1993; Roediger & McDermott, 1993). For example, Kolers (1976) showed that inverted text is reread faster even if there is a 1 year delay between the first and second presentations of the text. Consequently, we predict that the perceptual specificity effects (i.e., the congruent < incongruent difference in second reading fixation times) will still persist under conditions in which there is a 1 week lag between the first and second readings. Given that Experiment 1 showed the largest numerical congruent < incongruent differences for the low frequency condition and the unusual distortions condition (see Table 3), in Experiment 2 we examined the impact of a 1 week lag using only the low frequency words and only unusual distortion typographies (see Table 1 for examples).

Method

Participants

All 24 participants were undergraduate students at the University of Toronto. The participants were all native English speakers and were given either one course credit, or

Table 3
First-fixation, single-fixation, gaze duration, total time (ms), and the probability (proportion) of skipping and single fixation for the second reading of the target word in Experiment 1. Standard errors are shown in parentheses.

Variable	Subtle distortions			Unusual distortions			Perceptual specificity effect	
	C	I	B	C	I	B	Mean	Significance
High frequency targets								
First-fixation	240 (4.2)	241 (4.1)	241 (3.7)	240 (8.7)	242 (7.9)	243 (5.4)	2 (2.6)	$F_1 < 1$ $F_2 < 1$
Single-fixation	249 (4.9)	253 (5.0)	256 (5.1)	272 (12.6)	267 (10.9)	266 (8.5)	1 (3.3)	$F_1 < 1$ $F_2 < 1$
Gaze duration	289 (7.4)	292 (6.9)	294 (8.2)	335 (14.5)	345 (17.4)	348 (13.9)	6 (4.7)	$F_1 = 1.85$, $p = .177$ $F_2 = 2.04$, $p = .156$
Total time	370 (10.8)	377 (12.0)	386 (14.6)	458 (23.6)	467 (29.0)	467 (21.8)	8 (8.1)	$F_1 < 1$ $F_2 = 1.45$, $p = .231$
Prob. of skipping	.07 (.01)	.08 (.01)	.06 (.01)	.05 (.01)	.03 (.01)	.04 (.01)	0 (.01)	$F_1 < 1$ $F_2 < 1$
Prob. of single fixation	.69 (.02)	.68 (.02)	.70 (.02)	.55 (.03)	.54 (.03)	.52 (.03)	.01 (.01)	$F_1 = 1.02$, $p = .315$ $F_2 < 1$
Low frequency targets								
First-fixation	262 (5.4)	266 (5.9)	268 (6.2)	258 (9.4)	259 (8.2)	258 (7.5)	3 (3.8)	$F_1 < 1$ $F_2 < 1$
Single-fixation	279 (6.7)	282 (6.9)	291 (8.1)	297 (15.0)	297 (12.6)	294 (11.1)	2 (5.9)	$F_1 < 1$ $F_2 < 1$
Gaze duration	354 (11.0)	363 (12.5)	385 (16.1)	397 (19.0)	420 (21.5)	430 (20.9)	14 (6.7)	$F_1 = 5.24$, $p < .05$ $F_2 = 7.16$, $p < .01$
Total time	467 (21.6)	502 (23.6)	510 (25.3)	550 (38.5)	590 (37.7)	607 (39.5)	37 (12.9)	$F_1 = 8.07$, $p < .01$ $F_2 = 10.93$, $p < .01$
Prob. of skipping	.06 (.01)	.06 (.01)	.06 (.01)	.04 (.01)	.05 (.02)	.03 (.01)	0 (.01)	$F_1 < 1$ $F_2 < 1$
Prob. of single fixation	.61 (.02)	.63 (.02)	.59 (.03)	.47 (.03)	.47 (.03)	.44 (.03)	− .01 (.01)	$F_1 < 1$ $F_2 < 1$

Note: For F tests, df for $F_1 = (1,94)$, and df for $F_2 = (1, 107)$. C = Congruent, I = Incongruent, B = Baseline. For the fixation time variables, the perceptual specificity effect = I − C. For the probability variables, the perceptual specificity effect = C − I. The means and standard errors shown in the table are based on the by-participant analyses.

$10.00 (Canadian) per hour. All participants had normal or corrected to normal vision.

Materials and design

The stimuli for Experiment 2 consisted of only the low frequency words from Experiment 1, and only the unusual distortion condition (see Table 1 for examples). For each participant, a total of 108 low frequency target words were each presented twice in two different low-constraint sentence frames (see the Appendix for the complete list of sentences). Similar to Experiment 1, we manipulated typography condition (i.e., congruent, incongruent, baseline) as a within subject variable. In addition, in Experiment 2, we manipulated the amount of time between the first and second presentations of the target word. Specifically, in the immediate condition, the second presentation of the target words occurred in the same session as the first presentation (similar to Experiment 1, the first and second presentations of the target words occurred in separate blocks, and these two blocks were separated by 20 buffer trials). In contrast, in the 1 week lag condition, the first and second presentations of the target words occurred in two different sessions that were scheduled a minimum of 7 days apart. The lag condition variable (immediate, 1 week lag) was manipulated within subjects (50% of trials were in the immediate condition, and 50% of trials were in the 1 week lag condition). Thus, a total of six experimental conditions resulted from crossing typography condition (congruent, incongruent, baseline), and lag condition (immediate, 1 week lag).

Apparatus and procedure

As in Experiment 1, participants were informed that they would occasionally encounter words written in an unusual font, but they were not told about the occurrence of repeated targets. Participants were told to focus on reading the sentences for comprehension, and about 15% of trials (all fillers) were followed by multiple-choice comprehension questions. The average accuracy rate was 95.2%. All other aspects of the experiment were the same as Experiment 1.

Results and discussion

In the analyses below, we examined processing times for the first and second readings of the target words, using the same eye tracking variables as in Experiment 1 (see Experiment 1 for a description of these measures). For the first reading analyses, 2.0% of trials were removed due to skipping of the target. Table 2 contains the means and standard errors for the first reading of the target words in Experiment 2, by typography type (normal, Distortion A, Distortion B). To confirm that the distortion typographies were read more slowly than normal text, we separately contrasted the mean fixation times for each of the distortion conditions in Experiment 2 (i.e., unusual Distortion A, unusual Distortion B) with the normal typography condition, using planned comparisons that were performed based on subject variability (t_1) and on item variability (t_2). Similar to Experiment 1, the distortion typographies consistently produced longer fixation times than normal text (all ts > 9, all ps < .001).

For the second reading analyses, 4.0% of trials were removed because the target word was skipped during the first and/or the second reading. Table 4 contains the means and standard errors for the second reading of the target words, by typography condition (congruent, incongruent, baseline), and lag condition (immediate, 1 week lag). The analyses reported below tested for perceptual specificity effects by contrasting the congruent versus incongruent conditions. As in Experiment 1, we also tested if the distortions produce perceptually non-specific rereading benefits, by contrasting the incongruent and baseline typography conditions. However, similar to Experiment 1, the percep-

tually non-specific effect will not be discussed further because the incongruent versus baseline differences were not statistically reliable (all Fs < 1).

The second reading fixation times were analyzed using 2 × 2 analyses of variance (*ANOVA*s) that were carried out on the data via both participants (F_1) and items (F_2), and with typography condition (congruent, incongruent) and lag (immediate, 1 week lag) as independent variables. In replication of Experiment 1, fixation times were shorter in the congruent than in the incongruent condition, as indicated by a main effect of typography condition that was significant for the total time measure (all Fs > 4, all ps < .05) and for the gaze duration measure by participants, $F_1(1,23) = 5.04$, $p < .05$, and was marginally significant for the gaze duration measure by items $F_2(1,107) = 3.49$, $p = .064$. Most importantly, the congruent < incongruent difference was significant in the 1 week lag condition for both gaze duration and total time, as indicated by planned comparisons that were performed based on both subject (t_1) and item (t_2) variability (gaze duration: $t_1(23) = 2.45$, $p < .05$, $t_2(107) = 2.38$, $p < .05$; total time: $t_1(23) = 2.17$, $p < .05$, $t_2(107) = 2.33$, $p < .05$). Finally, as in Experiment 1, the early eye movement measures (i.e., first-fixation, single-fixation) and the probability measures (i.e., probability of skipping, probability of single fixation) did not show any significant congruent versus incongruent differences (all Fs < 3, all ps > .1). In addition, although there was a numerical trend towards larger congruent < incongruent differences in the 1 week lag condition relative to the immediate condition, there were no significant interactions between typography condition and lag condition (all Fs < 3, all ps > .1). Overall, Experiment 2 demonstrated that perceptual specificity effects can persist across a 1 week lag, which is consistent with prior demonstrations of the long term retention of perceptual details (e.g., Kolers, 1976; for reviews see Levy, 1993; Roediger & McDermott, 1993).

General discussion

Building on the approach introduced by Kolers (1975, 1976, 1979), we used a rereading paradigm to provide strong evidence for perceptual specificity effects by demonstrating shorter fixation times on target words that were previously read in the same typography (i.e., the congruent condition), relative to target words that were previously read in a different typography (i.e., the incongruent condition). This typography congruency effect was significant for low but not for high frequency target words (Experiment 1), and it persisted across a 1 week lag between the first and second presentations of the targets (Experiment 2). Finally, the present study did not find any evidence that reading the distortion typographies at study produced additional perceptually non-specific rereading benefits relative to normal text, as there were no significant differences between the incongruent condition and an additional baseline condition that employed a normal (i.e., non-distorted) typography during the first reading and a distortion typography during the second reading.

Consistent with the present findings, perceptual specificity effects have been previously shown with a variety of rereading and memory tasks (for reviews, see e.g., Levy, 1993; Roediger & McDermott, 1993; Roediger & Srinivas, 1993; Roediger et al., 1989; Schacter, 1987; Tenpenny, 1995), and in many cases these effects were remarkably long lasting (e.g., Goldinger, 1996; Kolers, 1976; Ray & Reingold, 2003; Roediger & Blaxton, 1987; for reviews see Levy, 1993; Roediger & McDermott, 1993). In the memory literature, perceptual specificity effects have most commonly been demonstrated using perceptual implicit (or indirect) tasks that employed a variety of physically degraded (i.e., data-limited) retrieval cues (e.g., masked words, word stems, word fragments, picture fragments, etc.). However, perceptual specificity effects have also occasionally been shown using explicit (or direct) tasks, such as recognition memory tasks (e.g., Rajaram, 1996; Ray & Reingold, 2003; Reingold, 2002). In the rereading literature, perceptual specificity effects were shown with modality manipulations (e.g., Jacoby et al., 1992) but previous findings were less clear with respect to more subtle visual manipulations, such as typography changes. As reviewed by Levy (1993), typography congruency effects have tended to be stronger when more unfamiliar typographies were used instead of normal typographies (Levy, 1993; see also Brown & Carr, 1993; Carr et al., 1989; Graf & Ryan, 1990; Horton & McKenzie, 1995; Jacoby & Hayman, 1987), which is consistent with the present study's approach of using distortions rather than normal typographies.

Although perceptual specificity effects have been shown previously, the present study's findings are unique because eye tracking was used to examine perceptual specificity effects for individual target words that were read twice in two different sentences (for a related application of eye tracking, see Raney, 2003; Raney & Rayner, 1995; Raney et al., 2000). These methodological innovations were designed to address several past criticisms of Kolers' transformed text studies (Craik, 1989; Graf, 1981; Graf & Levy, 1984; Horton, 1985, 1989; Masson, 1984, 1986; Masson & Sala, 1978; Tardif & Craik, 1989; for a review, see Levy, 1993). Specifically, employing a change in context across readings (i.e., instead of Kolers' method of repeating entire passages) served to isolate perceptual processing by ruling out the possibility that participants were using their memory for the meaning of the sentence to help them to decipher the target words. Moreover, the present study manipulated perceptual congruency using pairs of distortions (for a similar design, see Horton, 1985; Tardif & Craik, 1989). This design allowed for the congruent and incongruent conditions to be closely matched because both of these conditions employed distortion typographies at study and at test, and because the same target words served as their own controls across conditions. Due to these methodological advantages, the present study's results constitute strong evidence that typography congruency effects can be (at least partially) driven by perceptual processing, and can be specific to the repetition of individual words. More specifically, the present study's congruent versus incongruent differences

Table 4
First-fixation, single-fixation, gaze duration, total time (ms), and the probability (proportion) of skipping and single fixation for the second reading of the target word in Experiment 2. Standard errors are shown in parentheses.

Variable	Immediate condition			1 week lag condition			Perceptual specificity effect	
	C	I	B	C	I	B	Mean	Significance
Low frequency targets								
First-fixation	262 (11.2)	258 (9.0)	264 (11.2)	253 (7.7)	267 (12.2)	260 (10.3)	5 (6.0)	$F_1 < 1$ $F_2 = 1.49$, $p = .225$
Single-fixation	300 (15.7)	298 (13.1)	316 (18.1)	277 (12.6)	309 (17.2)	302 (15.8)	16 (9.6)	$F_1 = 2.74$, $p = .112$ $F_2 = 1.36$, $p = .248$
Gaze duration	444 (25.8)	451 (24.5)	456 (31.7)	438 (22.8)	487 (31.4)	474 (32.1)	28 (12.7)	$F_1 = 5.04$, $p < .05$ $F_2 = 3.49$, $p = .064$
Total time	554 (33.9)	585 (30.4)	572 (39.4)	580 (38.2)	648 (42.5)	643 (41.8)	50 (18.3)	$F_1 = 7.51$, $p < .05$ $F_2 = 4.50$, $p < .05$
Prob. of skipping	.03 (.01)	.02 (.01)	.05 (.02)	.01 (.01)	.01 (.01)	.01 (.01)	0 (.01)	$F_1 < 1$ $F_2 < 1$
Prob. of single fixation	.39 (.04)	.41 (.03)	.41 (.04)	.42 (.04)	.39 (.04)	.42 (.04)	.01 (.02)	$F_1 < 1$ $F_2 < 1$

Note: For F tests, df for $F_1 = (1,23)$, and df for $F_2 = (1,107)$. C = Congruent, I = Incongruent, B = Baseline. For the fixation time variables, the perceptual specificity effect = I − C. For the probability variables, the perceptual specificity effect = C − I. The means and standard errors shown in the table are based on the by-participant analyses.

constitute evidence that repeating the same word in the same distortion typography produces additional perceptually driven rereading benefits that are over and above rereading benefits that are due to semantic influences and/or a more generalized skill at deciphering distorted text. Such findings are novel within the context of a reading and eye movements paradigm, although similar results have been previously shown in single-word reading studies (see Masson, 1986).

Building on the present findings, future research could further investigate several methodological differences between the present paradigm and the approach pioneered by Kolers. Specifically, in contrast to Kolers' approach, the present study's typography manipulation was applied to a single target noun instead of the entire sentence. This aspect of our paradigm may be interesting to investigate further in light of findings that typography manipulations produce stronger effects on fixation times when target words are presented in a different typography from the surrounding text (White & Staub, 2012), and in light of findings that rereading benefits may be stronger for content words (such as nouns) than for function words (Raney et al., 2000). Furthermore, although the present study's distortions were more difficult to read than normal text, we did not use Koler's more extreme approach of applying geometrical transformations to the text (Kolers, 1968). Future research could explore the possibility that using transformations instead of the present study's distortions might produce perceptual specificity effects for high frequency (i.e., as opposed to just low frequency) words, and might also produce perceptually non-specific rereading benefits relative to normal text.

In addition to the above methodological contributions, the present paradigm's perceptual specificity effects have theoretical implications for long-standing debates over the nature of the memory representations that underlie text repetition effects (for reviews, see Bowers, 2000; Tenpenny, 1995). To briefly summarize this debate, episodic accounts contend that text repetition effects stem from the reactivation of memories for specific events or information within a text (i.e., episodes), whereas abstractionist accounts argue that text repetition effects stem from the priming of abstract lexical representations. Of particular relevance to the present findings, the episodic perspective predicts that repetition effects will be sensitive to changes in surface variables (such as typography), whereas the abstractionist perspective predicts that repetition effects should be impervious to such changes. Thus, the present study's typography congruency effects are incompatible with an extreme version of the abstractionist perspective, and are instead consistent with both the episodic viewpoint and more recent accounts that have encompassed aspects of both the abstract and episodic perspectives (see e.g., Collins & Levy, 2007; Raney, 2003).

More generally, demonstrations of perceptual specificity effects have shaped a variety of theoretical perspectives in the memory literature (for a review, see Reingold, 2002). To mention a few prominent examples, the transfer appropriate processing approach (for a review, see Roediger et al., 1989) incorporates the idea that memory performance will improve to the extent that there is overlap in the perceptual processing that occurs at study and at test, and several dominant multiple memory systems theories have incorporated a "presemantic, perceptual representation system" that mediates the long-term retention of specific perceptual or surface descriptions of stimuli without representing their meaning (e.g., Moscovitch, 1992; Schacter, 1994; Schacter & Tulving, 1994; Schacter et al., 2000; Squire, 1992; Tulving & Schacter, 1990). In further support of the existence of perceptually specific memory representations, the present study demonstrated that subtle changes in a semantically irrelevant surface variable (i.e., typography) can modulate rereading benefits under tightly controlled conditions. These findings underscore Kolers' original idea that the procedures and perceptual operations that are used to extract semantic content, and not just the semantic content itself, can produce long-lasting memory influences.

Appendix

For each pair of sentences, the two possible target words are shown in italics, separated by a dash (high frequency/low frequency).

(1A) Jim wanted to buy the *chair*/*cloak* that was on display in the window.
(1B) Rose found a new *chair*/*cloak* at the bazaar.
(2A) To make his mom happy, Tim took another *piece*/*patty* and ate it.
(2B) He dropped a *piece*/*patty* while carrying the tray across the room.
(3A) John decided to sell the *table*/*banjo* in the garage sale.
(3B) I was told that the *table*/*banjo* was made out of expensive wood.
(4A) He ran away from the *crowd*/*troll* and hid behind a wall.
(4B) To escape from the pouring rain, the *crowd*/*troll* hid under a large tree.
(5A) I felt the wind on my face when the *train*/*racer* flew by me.
(5B) Jeanette was amazed that the *train*/*racer* was so fast.
(6A) Amy sat down on the *stage*/*quilt* and crossed her legs.
(6B) Alice began to decorate the *stage*/*quilt* in preparation for the fair.
(7A) The noise coming from the *motor*/*flute* was too loud for their ears.
(7B) Carmen looked at the shiny *motor*/*flute* with admiration.
(8A) I found the *story*/*icing* to be kind of bland.
(8B) Nora enjoyed the *story*/*icing* even though no one else did.
(9A) Mary removed the *cover*/*gauze* using her thumb and index finger.
(9B) The laser burned through the *cover*/*gauze* and left it in shreds.
(10A) Everyone stayed away from the *block*/*plaza* where the fight had happened.
(10B) Vendors took over the *block*/*plaza* without any permission from the city.
(11A) We stepped into the small *space*/*hovel* and looked around cautiously.
(11B) I saw that the *space*/*hovel* was full of dirt and grime.
(12A) In the darkened room, the *voice*/*audio* seemed to come out of nowhere.
(12B) I complained because the *voice*/*audio* was too difficult to hear.
(13A) I heard that the *judge*/*valet* was very well paid.
(13B) It was necessary for the *judge*/*valet* to give them some instructions.
(14A) The curious little boy saw the *horse*/*roach* and ran towards it.
(14B) There was a large *horse*/*roach* inside the shed.
(15A) It was an unfortunate *issue*/*fluke* that I would like to forget.
(15B) Jennifer admitted that the *issue*/*fluke* had caught her by surprise.
(16A) The farmer picked up the *plant*/*melon* and carried it to the truck.
(16B) Sally bought a *plant*/*melon* from the stall at the side of the road.
(17A) It was upsetting to hear about *death*/*polio* on the evening news.
(17B) The class discussion about *death*/*polio* caused a great deal of fear.
(18A) Yesterday, I found a *woman*/*medic* standing near the store front.
(18B) The tourists were mesmerized by the *woman*/*medic* with the flashy uniform.
(19A) We were concerned that her *heart*/*colon* would not recover from the surgery.
(19B) Clair was studying the *heart*/*colon* in preparation for the anatomy exam.
(20A) Ben and John had been planning the *party*/*heist* for months.
(20B) We were relieved that the *party*/*heist* went smoothly.
(21A) We tricked the kids into cleaning the *water*/*slime* out of the old barrel.
(21B) Samantha had to remove the *water*/*slime* from the basement.
(22A) He examined the *radio*/*rhino* with interest.
(22B) The boy admired the *radio*/*rhino* even though it bored his little sister.
(23A) The mayor went to the *event*/*vigil* even though his schedule was busy.
(23B) The road was closed because of the *event*/*vigil* that was happening later that evening.
(24A) Beth ran her fingers along the *board*/*tunic* and was shocked at its roughness.
(24B) I picked up the *board*/*tunic* that had been left haphazardly on the ground.
(25A) She found a *dress*/*skunk* inside the box in the garage.
(25B) Jessica told us about the *dress*/*skunk* that she had seen.
(26A) She was very proud of her *smile*/*girth* and her sense of fashion.
(26B) The man was distinctive because of his *smile*/*girth* and his loud laugh.
(27A) Jenn swallowed in fear when a *light*/*robin* came out of the cave.
(27B) Henry noticed a *light*/*robin* near the top of the roof.
(28A) In my dream, the *scene*/*oasis* was filled with lush greenery.
(28B) She stared at the *scene*/*oasis* on the other side of the river.
(29A) Tom first heard about the *trial*/*toxin* from his tutor.
(29B) She decided to ask about the *trial*/*toxin* to learn more about it.
(30A) Everyone agreed that the *night*/*broth* had been better than usual.

(30B) Samuel was surprised that the *night*/*broth* was still so blistering hot.
(31A) None of the kids wanted to play the part of the *enemy*/*gnome* in the play.
(31B) He saw the *enemy*/*gnome* on the other side of the trees.
(32A) I pointed at the *hotel*/*pooch* on the other side of the road.
(32B) Angela loved to talk about the *hotel*/*pooch* that her uncle owned.
(33A) It was difficult to make the *drink*/*curry* because of all the ingredients.
(33B) She decided to try the *drink*/*curry* because her buddy had recommended it.
(34A) Janice picked up the *tooth*/*acorn* and put it in her pocket.
(34B) Timmy found the *tooth*/*acorn* on a bench in the park.
(35A) The young girls laughed at the silly *dance*/*spoof* the jester was performing.
(35B) Mike told us about the *dance*/*spoof* from the day before.
(36A) She began to mold the *earth*/*crust* with her fingers.
(36B) It appeared that the *earth*/*crust* had dried out and hardened.
(37A) Aisha complimented her cousin's *garden*/*bonnet* even though she was secretly jealous.
(37B) I was distracted by the *garden*/*bonnet* because of its bright colours.
(38A) She was annoyed because the *system*/*zipper* could not be replaced.
(38B) Lena told me that the *system*/*zipper* was broken again.
(39A) Kelly and George were looking forward to their *dinner*/*brunch* at the new restaurant.
(39B) Tony was nervous about the *dinner*/*brunch* because his boss was going to be there.
(40A) They were proud of the *church*/*cohort* for raising so much money for charity.
(40B) Most members of the *church*/*cohort* were in favour of the new policies.
(41A) The messenger told Olivia to hide the *weapon*/*amulet* from the sorcerer.
(41B) The museum contained an old *weapon*/*amulet* that had once belonged to royalty.
(42A) After the little cabin burned down, the *family*/*damsel* had nowhere left to go.
(42B) As soon as the war erupted, the *family*/*damsel* fled from the kingdom.
(43A) Almost nobody knew about the *bridge*/*ravine* on the east side of town.
(43B) Be careful near the *bridge*/*ravine* because the ground is slippery.
(44A) Karen went to the *doctor*/*matron* and asked for advice.
(44B) In the small town, the *doctor*/*matron* was very well-respected.
(45A) Anne told them to avoid the *forest*/*cavern* because many dangers lurked there.
(45B) There was a large *forest*/*cavern* near my grandfather's home.
(46A) It was obvious that the rundown *street*/*duplex* would need major repairs.
(46B) The elderly lady was surprised that the old *street*/*duplex* had not changed at all.
(47A) The city had been home to the *artist*/*beggar* for most of his life.
(47B) The kids stared at the *artist*/*beggar* with the green hat.
(48A) Joan went to her *friend*/*mentor* for advice about her finances.
(48B) The young executive felt certain that his new *friend*/*mentor* was trustworthy.
(49A) Everyone knew that the *animal*/*badger* was dangerous.
(49B) The little girl wanted to touch the *animal*/*badger* but she ran away when it snarled.
(50A) The girl hoped that her *mother*/*healer* would be able to help her.
(50B) Larry stayed home because his *mother*/*healer* had told him to rest.
(51A) Rachel noticed the *object*/*spider* just before she stepped on it.
(51B) She knew that the *object*/*spider* was probably harmless.
(52A) Allen was confused by the *answer*/*module* in the textbook.
(52B) He was relieved that the *answer*/*module* had been finalized before the deadline.
(53A) When his truck broke down, Toby asked the *police*/*ranger* for help.
(53B) When the little girl went missing, the *police*/*ranger* searched everywhere.
(54A) It was important to find the *letter*/*carton* before anyone noticed it was missing.
(54B) Suzie carried the *letter*/*carton* into her room.
(55A) The pirate king needed to discuss the *attack*/*bounty* with his crew.
(55B) Larry was convinced that the *attack*/*bounty* was not worth the effort.
(56A) The confusing and complicated *design*/*rubric* was going to be very unpopular.
(56B) Boris could not understand the *design*/*rubric* that Mike had given him.
(57A) It was time for the *leader*/*sniper* to make a decision.
(57B) It was difficult for the *leader*/*sniper* to predict what was about to happen.
(58A) She went to the *market*/*pantry* to get some vegetables for the stew.
(58B) Billy was sent to the *market*/*pantry* to find some spices.
(59A) The shop owner waited impatiently for the *supply*/*toffee* to be delivered.

(*continued on next page*)

(59B) Rodney was excited about the *supply*/*toffee* that his cousin gave him.
(60A) Alex was upset when the *demand*/*felony* was made public.
(60B) According to the reporter, the *demand*/*felony* was very unusual.
(61A) William majored in *science*/*algebra* because he loved the subject.
(61B) Clive hates studying *science*/*algebra* because he finds it very hard to understand.
(62A) Christine put the remaining money into her *account*/*satchel* for safekeeping.
(62B) Please take sixty dollars out of the *account*/*satchel* and use it to pay the plumber.
(63A) Liz showed us a photo of her *husband*/*toddler* during lunch the other day.
(63B) Diana rushed her *husband*/*toddler* to the hospital after he fell and hurt himself.
(64A) The nurse said that Dad's *trouble*/*amnesia* was only temporary.
(64B) Unfortunately, my neighbour's *trouble*/*amnesia* started when she turned seventy.
(65A) We could tell from the *quality*/*emerald* that the necklace was very expensive.
(65B) Ruth admired the ring's *quality*/*emerald* and asked Becky where it was purchased.
(66A) At the meeting, the *officer*/*admiral* gave a short presentation.
(66B) They asked the *officer*/*admiral* at the embassy for help.
(67A) I was amazed that Sean was able to repair the broken *machine*/*trellis* so quickly.
(67B) Peter climbed to the top of the large *machine*/*trellis* in order to clean it thoroughly.
(68A) Please clean the dirty *surface*/*platter* before you put any food on it.
(68B) Rebecca had to soak the *surface*/*platter* with soap to get the grease off of it.
(69A) We saw the *teacher*/*rooster* from across the yard.
(69B) She could hear the *teacher*/*rooster* on the other side of the wall.
(70A) Brenda realized she had left the *picture*/*mascara* in her other handbag.
(70B) Ken picked up the dropped *picture*/*mascara* off the ground and handed it to Pam.
(71A) Mary loved her little *brother*/*terrier* and was often accused of spoiling him.
(71B) Janet took care of Bob's *brother*/*terrier* when he went away for the weekend.
(72A) All I need is some *support*/*aspirin* and then I will be able to finish the project.
(72B) Nick asked his roommate for some *support*/*aspirin* when he was not feeling well.
(73A) Dennis had too much *success*/*tequila* very quickly and was not able to handle it.
(73B) It was nice of Robert to share his *success*/*tequila* with his colleague.
(74A) Paul wanted to know how long the *process*/*autopsy* would take.
(74B) We witnessed the entire *process*/*autopsy* being performed by the surgeon.
(75A) The boy was brought to the *council*/*dungeon* after he had committed his awful crime.
(75B) Logan went to see the *council*/*dungeon* as soon as he arrived.
(76A) Beth wanted to study *history*/*zoology* next year at a college in England.
(76B) My aunt thought that a degree in *history*/*zoology* would be very helpful.
(77A) The lady in the red blouse asked the *manager*/*caterer* for his number.
(77B) Ben wasn't sure if the *manager*/*caterer* was prepared for so many people.
(78A) Duncan thought that the young *student*/*sparrow* was small for his age.
(78B) Jane yelled as the *student*/*sparrow* fell out of a tree on the playground.
(79A) Emma refused to read the *chapter*/*tabloid* when I told her what was in it.
(79B) Patrick opened up the *chapter*/*tabloid* and read it out loud to his wife.
(80A) We toured a local *company*/*brewery* and wrote a report about it.
(80B) I heard that the *company*/*brewery* made a large profit this past year.
(81A) Before the guests arrived, the *kitchen*/*armoire* needed to be cleaned.
(81B) The girl searched the *kitchen*/*armoire* for the missing candle holder.
(82A) For such an expensive restaurant, the *service*/*cuisine* is surprisingly bad.
(82B) I enjoyed the great *service*/*cuisine* at the Indian restaurant.
(83A) Sam decided that the *village*/*hammock* was his favourite part of the trip.
(83B) Ralph decided to rest in the *village*/*hammock* before he started on his journey.
(84A) The boy was confused by the *problem*/*anagram* and had to ask for help.
(84B) There was a challenging *problem*/*anagram* on the test.
(85A) We were unable to repair the damaged *marriage*/*ligament* even though we tried.
(85B) I was sad to hear that my aunt's *marriage*/*ligament* could not possibly be fixed.
(86A) Valerie needed to get some *material*/*scissors* before she could start the project.
(86B) Please bring me the *material*/*scissors* and a thread and needle right away.
(87A) My father loved his *business*/*vocation* and always looked forward to going to work.
(87B) After college, Lynn did well with her new *business*/*vocation* and made a good salary.
(88A) Betty says that she hates *children*/*broccoli* but I am not sure if I believe her.
(88B) Fiona stopped to pick up the *children*/*broccoli* after she got out of work.

(89A) The actor ended his monologue with an unexpected *question*/*flourish* that made us laugh.
(89B) The boy's bizarre *question*/*flourish* took everyone in the audience by surprise.
(90A) They closed off the dangerous *building*/*catacomb* and refused to let anyone enter.
(90B) We took a tour of a famous *building*/*catacomb* while we were on holiday in Paris.
(91A) He admired his father's *religion*/*humility* very much.
(91B) At a young age, I learned that *religion*/*humility* was very important.
(92A) I found the *research*/*abstract* interesting and wanted to read more about the experiments.
(92B) The young man's *research*/*abstract* was submitted to an important journal.
(93A) Peter said that the painful *argument*/*splinter* caused him much distress.
(93B) I told Beatrice about the *argument*/*splinter* to see if she could help.
(94A) Billy said that the extensive *practice*/*tutorial* helped him get a good grade on the test.
(94B) Melanie attended the lengthy *practice*/*tutorial* in the afternoon.
(95A) Sue discovered an unknown *language*/*dinosaur* while she was in Africa.
(95B) My uncle studies a particular ancient *language*/*dinosaur* that was common in Asia.
(96A) We followed the specific *approach*/*protocol* preferred by our boss.
(96B) I was taught the preferred *approach*/*protocol* for dealing with customers.
(97A) When I first arrived in the city, the *community*/*publicist* was very helpful.
(97B) When the announcement was made, the *community*/*publicist* was shocked.
(98A) After the boy was caught stealing erasers, the *principal*/*caretaker* yelled at him.
(98B) He was hired to be the *principal*/*caretaker* at the new academy.
(99A) I read a book about a useless *character*/*scoundrel* who no one liked.
(99B) My uncle is a strange *character*/*scoundrel* with lots of unusual habits.
(100A) It was difficult for the *secretary*/*mercenary* to find work.
(100B) He needed to find a *secretary*/*mercenary* to help with the assignment.
(101A) Jeremy received his *education*/*doctorate* from a very prestigious university.
(101B) Chris finished his *education*/*doctorate* and then found a good job.
(102A) The man looked up from the *newspaper*/*parchment* when his son came into the room.
(102B) Because it was so old, the *newspaper*/*parchment* had to be handled very carefully.
(103A) The man shared his *knowledge*/*portfolio* with the other employees.
(103B) Margaret was certain that her *knowledge*/*portfolio* was a source of envy.
(104A) Michael's strange *situation*/*moustache* was the topic of many conversations.
(104B) Ken was so embarrassed by his *situation*/*moustache* that he refused to see guests.
(105A) We wanted to get his *attention*/*autograph* but he did not see us waiting.
(105B) I was glad to get her *attention*/*autograph* after the show ended.
(106A) The sudden sound of her roommate's *telephone*/*accordion* woke Valerie up from her nap.
(106B) Barbara hated her neighbor's loud *telephone*/*accordion* and bought some earplugs.
(107A) Tina witnessed the clumsy *president*/*ballerina* tripping on the stairs.
(107B) Kathy did not like the snobby *president*/*ballerina* and told everyone how she felt.
(108A) My aunt told me that I could be a famous *professor*/*astronaut* when I get older.
(108B) I had a great deal of respect for the *professor*/*astronaut* who spoke in my class.

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