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Competition between orthographically and phonologically similar words during sentence reading: Evidence from eye movements

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ABSTRACT

Two eye movement experiments tested the effect of orthographic and/or phonological overlap between prime and target words embedded in a sentence. In Experiment 1, four types of overlap were tested: phonological and orthographic overlap (O+P+) occurring word initially (*strain–strait*) or word finally (*wings–kings*), orthographic overlap alone (O+P−, *bear–gear*) and phonological overlap alone (O−P+, *smile–aisle*). Only O+P+ overlap resulted in inhibition, with the rhyming condition showing an immediate inhibition effect on the target word and the non-rhyming condition on the spillover region. No priming effects were found on any eye movement measure for the O+P− or the O−P+ conditions. Experiment 2 demonstrated that the size of this inhibition effect is affected by both the distance between the prime and target words and by syntactic structure. Inhibition was again observed when primes and targets appeared close together (approximately 3 words). In contrast, no inhibition was observed when the separation was nine words on average, with the prime and target either appearing in the same sentence or separated by a sentence break. However, when the target was delayed but still in the same sentence, the size of the inhibitory effect was affected by the participants' level of reading comprehension. Skilled comprehenders were more negatively impacted by related primes than less skilled comprehenders. This suggests that good readers keep lexical representations active across larger chunks of text, and that they discard this activation at the end of the sentence. This pattern of results is difficult to accommodate in existing competition or episodic memory models of priming.

Introduction

There is a great deal of evidence from studies of isolated word recognition that reading involves a process of competition between form-related words. Much of this evidence has come from the masked priming paradigm in which a prime word is presented for a very short time (below the threshold of conscious awareness) and a response, often a lexical decision, is made on a following target word (Forster & Davis, 1984; see also Kinoshita & Lupker, 2003). It has been found that when a target word is primed by an orthographic neighbor, i.e. a word that differs from it by only one letter (see Coltheart, Davelaar, Jonasson, & Besner, 1977), the response to the target word can be slowed, especially when the prime is of a higher frequency than the target (e.g. Davis & Lupker, 2006; Grainger, 1990; Grainger & Ferrand, 1994; Nakayama, Sears, & Lupker, 2008; Segui & Grainger, 1990). Our interest was in how these effects

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might influence processing in a more natural reading task, i.e. normal sentence reading. Fluent reading must require the constant activation and suppression of word candidates and success in this task may be related to one's level of reading skill (e.g. Andrews & Hersch, 2010; Andrews & Lo, 2012; Gernsbacher, 1993). However, very little research has investigated the effect of form overlap on lexical access during sentence reading (but see Paterson, Liversedge, & Davis, 2009). The experiments we report were designed to look for evidence of form-based competition between words in sentences. We examined whether different types of overlap, orthographic and/or phonological, resulted in different degrees of competition (Experiment 1), and whether the distance between the overlapping words and the syntactic structure they appear in affected the competition effect (Experiment 2). In addition, we examined whether the size of the competition effect was related to reading comprehension skill (Experiment 2).

A large body of research has now demonstrated that word reading processes are influenced by the availability of form-related words, although the nature of this influence remains an issue for debate (see Andrews, 1997, and Grainger, 2008, for reviews). Words with large orthographic neighborhoods can be processed more quickly than words with small neighborhoods in lexical decision and naming tasks (e.g. Andrews, 1989). However lexical decision can be slowed by the existence of a high-frequency orthographic neighbor (e.g. Grainger, O'Regan, Jacobs, & Segui, 1989) and by the presence of a high-frequency embedded word such as 'car' in 'scar' (Bowers, Davis, & Hanley, 2005, see also Weingartner, Juhasz, & Rayner, 2012, for evidence from eye movements). Indeed, what actually constitutes a neighborhood is also a matter for debate, with evidence of effects of neighborhoods that are defined in a number of different ways, including letter deletion (e.g. *last–blast*; Davis & Taft, 2005) transposed letters (e.g. *clam–calm*, Andrews, 1996), and phonological overlap (e.g. *soup–hoop*, Yates, Locker, & Simpson, 2004). In priming tasks, the shared neighborhoods of primes and targets have also been shown to affect processing speed (e.g. Van Heuven, Dijkstra, Grainger, & Schriefers, 2001).

As mentioned above, research using masked priming has shown that word recognition times are influenced by orthographic neighbor primes. High-frequency prime words (e.g. *wings*) slow responses to lower-frequency target words (e.g. *kings*), whereas orthographic neighboring nonwords (e.g. *fings*), speed up recognition of the same target word (e.g. Davis & Lupker, 2006; Grainger, 1990; Grainger & Ferrand, 1994; Nakayama, Sears, & Lupker, 2008; Segui & Grainger, 1990). These effects of lexicality and relative frequency have been accounted for by the proposal that form priming involves both facilitation from sublexical overlap and competition between lexical items (Davis & Lupker, 2006; Perry, Lupker, & Davis, 2008). Localist models of word recognition, such as McClelland and Rumelhart's (1981) interactive-activation model (IAM) simulate these effects with facilitatory links between letter and word levels and inhibitory links between words. The architecture of this model has formed the basis of other, more performance-based, models of word recognition, all of which propose that lexical retrieval involves a process of form-based lexical competition (e.g. the Multiple Read Out model, Grainger & Jacobs, 1996; the Dual Route Cascaded Model, Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; the Self Organising Lexical Access and Recognition Model, Davis, 1999; and the Bi-modal Interactive Activation model or BIAM, Grainger & Holcomb, 2009).

Masked form priming effects are also influenced by neighborhood size, such that facilitation from nonword primes is observed only for target words with low density neighborhoods (Andrews, 1997; Forster & Taft, 1994). This effect has been taken as evidence that the representations of words in high density neighborhoods are more precisely specified than those in low density neighborhoods, and therefore less likely to be activated by form-related primes (Forster & Taft, 1994; see also Perfetti, 1992). This proposal is supported by studies showing that the neigbourhood density effect is also modulated by individual differences in reading skill levels (Andrews & Hersch, 2010; Andrews & Lo, 2012), and we return to this issue in Experiment 2.

The results reviewed above provide clear evidence that isolated word recognition is affected by the existence and/or priming of formally similar words. Studies of similar effects in sentence reading are much more rare. Fast priming experiments, that have examined orthographic neighbor priming, show facilitation or null effects rather than inhibition (e.g. Nakayama, Sears, & Lupker, 2010). In this methodology, participants read normal text in which one word is initially presented as a random letter string. Once the participant "lands" on this target region, the random letters are replaced by the prime word for a very short period before being replaced again by the target word and eye fixation data are recorded (Sereno & Rayner, 1992). This paradigm is, therefore, very similar to masked priming, but it uses a more natural linguistic environment. Nakayama et al. (2010) tested orthographically overlapping items that had previously shown inhibition in a masked priming paradigm (Nakayama et al., 2008). At a prime duration of 60 ms, they found facilitation when prime and target were presented in lower-case (Experiment 1) and no difference when the prime was presented in capitals. Similarly, Frisson, Bélanger, and Rayner (2014), using prime durations of 32 and 50 ms, found facilitation when prime and target overlapped both at the orthographic and phonological level, slightly less priming when the overlap was only at the orthographic level, and hardly any priming when the overlap was phonological.

In an eye movement study of silent sentence reading, which serves as the inspiration for the current experiments, Paterson et al. (2009; see also Paterson, Alcock, & Liversedge, 2011, for related findings) tested sentences such as *There was a blur as the blue lights of the police car whizzed down the street*, which contains the prime *blur* and the target *blue*. They showed increased gaze durations on *blue* when preceded by an orthographic neighbor prime word (*blur*) compared to a control prime word (*gasp*). In contrast to single-word research which showed inhibition mainly when the *masked* prime was of higher-frequency than the target (Davis, 2003; Davis & Lupker, 2006) and when the *unmasked* prime was of lower-frequency than the target (Colombo, 1986; Lupker & Colombo, 1994; Segui & Grainger, 1990), the inhibition observed by Paterson et al. (2009) did not interact with the relative frequencies of prime and target words. The lack of a frequency interaction in sentence reading might suggest that the task taps into a different processing stage.

One aspect that has been largely ignored in this research is the impact that different types of overlap have on word recognition, in particular the effect of phonological overlap. While orthographic neighbors obviously overlap at the orthographic level, they also very often, though not always, exhibit a high degree of phonological overlap. Phonology and phonological awareness plays a central role in theories of reading acquisition (e.g. Bradley & Bryant, 1983; Harm & Seidenberg, 2004; Perfetti, 2011). Moreover, a large amount of research has shown that during silent reading, phonological codes of the words in a text are accessed quickly and automatically. These data come from studies using a variety of techniques including EEG (e.g. Ashby, 2010; Ashby, Sanders, & Kingston, 2009) and MEG (e.g. Wheat, Cornelissen, Frost, & Hansen, 2010), as well as behavioral studies (for an overview, see Rayner, Pollatsek, Ashby, & Clifton, 2012). For example, masked priming studies have shown facilitatory effects of phonological overlap when orthographic overlap is held constant (e.g. brein–BRAIN compared to broin–BRAIN, e.g. Lukatela & Turvey, 1994; Perfetti & Bell, 1991). Evidence from sentence reading studies shows that when words start with the same sounds, as can be found in tongue twisters such as *The press published the poem and promised to pay for permission* (from McCutchen & Perfetti, 1982), reading is slowed down, both in overt and silent reading (e.g. Corley, Brocklehurst, & Moat, 2011; Hanson, Goodell, & Perfetti, 1991; Zhang & Perfetti, 1993). More recently, Acheson and MacDonald (2011) used a self-paced reading task to show that participants read more slowly, and comprehended less accurately, when they read relative clauses containing phonologically similar words (e.g. *the baker that the banker sought bought the house*). We therefore wanted to determine the extent to which the inhibition effects found in sentence reading (e.g. Paterson et al., 2009) are related to phonological or orthographic factors. In order to examine this, we distinguish between three different types of overlap: prime and targets that overlap both at the orthographic *and* the phonological level, only at the orthographic, or only at the phonological level (see below for examples). If Paterson et al.'s results merely reflect some kind of tongue twister effect, then we would not expect to find an inhibition effect when the overlap is only orthographic (e.g. *bear–gear*).

A second, related aspect that has not received much attention is the type and place of the non-overlapping letter of two neighbors. For example, mismatching letters at word offset (*blue–blur*), word onset (*royal–loyal*), and mid-word (*axle–able*) are all treated the same way; neighbor words can differ in the number of consonants, vowels, and syllables (*unit–knit; tree–trek*), and the sound quality of the vowel does not need to be preserved (*step–stew*) (all examples taken from Paterson et al., 2009). This variation is inconsequential if one assumes that phonology plays no critical part and that all letters contribute equally in the priming effect. However, research using transposed and/or substituted letters has shown that letter identity is more important for exterior letters (at the end and, even more so, at the beginning of the word) than word-internal letters (e.g. Johnson, Perea, & Rayner, 2007; Rayner, White, Johnson, & Liversedge, 2006). In addition, evidence suggests that words with begin overlap are processed differently from words with end overlap. For example, experiments using the phonological priming paradigm tend to show facilitation for end overlap (rhyming) items, while begin overlap items are more likely to show inhibition (for an overview, see Dufour, 2008). In contrast, using the fast priming paradigm during reading, Lee, Binder, Kim, Pollatsek, and Rayner (1999) found stronger facilitatory priming effects the more prime and target overlapped at the beginning.[1] We therefore decided to examine begin and end overlap items separately.

The main aim of Experiment 1 was therefore to examine effects of form-based competition between different words in a sentence during silent reading. In particular, we examined the effects of different types of orthographic and phonological overlap. In Experiment 2, we extended our findings by investigating if the priming we observed in Experiment 1 varied as a function of the delay between prime and target words, the syntactic structure in which they were embedded, and individual differences in reading skill. We postpone our motivation for these manipulations until we have reported the results of Experiment 1.

Experiment 1

Method

Participants

Twenty-six Undergraduate and final year secondary school students participated in the Experiment for course requirement. All participants were native British English speakers.

Materials

A total of 128 item pairs were constructed, 32 per overlap type (see Table 1 for examples and Appendix A for a full list of items; see also Frisson et al., 2014, for a similar manipulation). Four overlap types between prime and target were distinguished: O+P+ (end) prime and targets have the same orthographic and phonological end overlap (i.e. they rhyme; e.g. *wings–kings*) but a different first letter; O+P+ (begin) prime and targets have the orthographic and phonological overlap at the beginning but a different last letter (e.g. *strain–strait*); O+P− primes and targets are orthographic neighbors but have a low phonological overlap (e.g. *bear–gear*); and O−P+ primes and targets rhyme and, thus, have a large phonological overlap, but are spelled differently (e.g. *smile–aisle*). The O+P− prime words are exception words (Glushko, 1979) in that they do not

[1] It's unclear whether rhyming words during normal reading facilitate or inhibit reading. Using rhyming and (modified) non-rhyming fragments from Dr. Seuss books, we observed faster reading times on rhyming words, but only when presentation was blocked (i.e. all rhyming and all non-rhyming fragments presented separately). When presentation was not blocked, no effects emerged (Frisson, Jamali, Pollatsek, & Meyer, in preparation).

Table 1
Sample experimental sentences in the four priming conditions of Experiment 1.

Overlap type	Example
O+P+, end	The birds ruffled their **wings** [**tails**] as the *kings* watched from their palace
O+P+, begin	The captain found it a **strain** [**burden**] to negotiate the *strait* at the end of a long voyage
O+P−	On noticing the giant **bear** [**tree**] John changed *gear* and pedalled away quickly
O−P+	The husband had a big **smile** [**fight**] walking down the *aisle* of the local supermarket

Notes: The prime [control] word is in bold, the target word is in italics. O+P+ stands for orthographic and phonological overlap, O+P− stands for orthographic-only overlap, and O−P+ stands for phonological-only overlap.

adhere to simple spelling-sound rules and do not rhyme with most other words with the same end overlap.

All items were 1 sentence long and contained a target word that was preceded by either a prime word or a control word. Identical sentence frames were used for the prime and control condition. The control word was always of the same length as the prime word and frequency (taken from the CELEX database, Baayen, Piepenbrock, & Van Rijn, 1993, using N-watch, Davis, 2005) was controlled both within ($t(127) = 1.12$, $p > .26$) and between ($F(3,124) < 1$) overlap types. Similarly, the distance between the target/control word and the prime word was controlled between overlap types (number of letters: $F(3,124) < 1$; number of words: $F(3,124) = 1.15$, $p > .33$). The prime word was always of higher-frequency than the target word (average frequency prime/control: 42.6, target: 3.2). Given the restrictions on item selection, it was impossible to control on all neighborhood variables (see Table 2). For example, while there was no difference between the different overlap types in terms of the number of phonological neighbors for the target (all *t*s < 1), the number of all orthographic neighbors varied across overlap type; unsurprisingly, the O−P+ overlap type had significantly fewer orthographic neighbors than the O+P+ (end) and the O+P− overlap types (*p*s < .01). The number of shared overlapping neighbors between the prime and target also differed across overlap type. For example, the O−P+ prime and targets were de-

Table 2
Item characteristics for the experimental words tested in Experiment 1.

Overlap type	Log frequency	Length (letters)	Number of orthographic substitution neighbors	Total number of orthographic neighbors	Number of phonological neighbors	Number of overlapping orthographic substitution neighbors between prime and target	Total number of overlapping orthographic neighbors between prime and target	Number of overlapping phonological neighbors	Distance (letters)	Distance (words)
O+P+, end										
Prime	1.60 (1.82)	5.0 (.5)	5.4 (3.6)	8.2 (4.5)	12.5 (7.9)					
Control	1.55 (1.62)	5.0 (.5)	3.8 (3.2)	5.7 (3.7)	11.6 (6.7)					
Target	.80 (.82)	5.0 (.5)	5.3 (3.1)	7.3 (3.7)	11.5 (6.4)	1.4 (2.0)	2.0 (2.1)	3.6 (3.7)	14.0 (4.7)	3.1 (1.1)
O+P+, begin										
Prime	1.61 (1.63)	5.1 (.5)	4.1 (2.2)	6.3 (2.8)	10.4 (5.0)					
Control	1.62 (1.64)	5.1 (.5)	3.8 (3.5)	5.9 (4.6)	10.0 (5.8)					
Target	.75 (.74)	5.1 (.5)	4.3 (2.7)	6.1 (3.1)	10.1 (4.9)	.8 (1.0)	.9 (1.1)	1.5 (1.9)	13.9 (4.0)	2.9 (.8)
O+P−										
Prime	1.70 (1.85)	5.0 (.8)	6.4 (4.1)	8.9 (5.0)	10.6 (6.7)					
Control	1.65 (1.78)	5.0 (.8)	5.4 (5.2)	7.3 (5.9)	11.4 (8.7)					
Target	.77 (1.03)	5.0 (.8)	6.5 (4.4)	8.7 (5.3)	11.4 (9.0)	2.9 (3.0)	3.2 (3.1)	.25 (.5)	14.0 (4.1)	2.7 (.7)
O−P+										
Prime	1.63 (1.60)	5.1 (.7)	3.6 (4.6)	5.7 (5.1)	11.6 (9.6)					
Control	1.63 (1.54)	5.1 (.7)	3.9 (3.9)	6.1 (4.4)	10.2 (7.2)					
Target	.76 (.82)	5.1 (.7)	2.7 (3.7)	4.3 (4.6)	10.2 (9.2)	0 (0)	0 (0)	2.1 (3.5)	14.2 (3.2)	3.0 (1.0)

Notes. Frequency is the number of occurrences per million words, based on CELEX. Neighborhood estimates are obtained from N-Watch (Davis, 2005). Number of substitution neighbors is also known as Coltheart N. Total number of neighbors is the sum of all substitution, deletion, and addition neighbors. Overlapping neighbors refers to the number of neighbors the prime and target have in common. Distance refers to the distance between the prime/control and the target word. Standard deviations can be found in brackets.

signed not to share any orthographic neighbors; conversely, the O+P− prime and targets hardly shared any phonological neighbors (<1%). We will return to the issue of neighborhoods in the analyses.

Item specifics can be found in Table 2. Yes/no questions appeared after 50% of the trials. Accuracy was 95.1%.

Procedure

The critical sentences, together with 36 filler sentences of comparable length, were divided over two lists, with an equal number of items per condition per list. Presentation was counterbalanced so that each participant only saw one version of an item pair. Control words did not have a high orthographic or phonological overlap with the target words.

An Eyelink 1000 eye-tracker was used for testing, which measured eye position every millisecond. Viewing was binocular, but only data from the right eye was recorded. The distance between the head and the monitor was 70 cm. A chin and forehead rest was used to minimize head movements. Sentences were presented in Courier New non-antialised font, size 14 pt. There were approximately 3 characters per degree of visual angle.

A standard 5-point calibration procedure was performed before the start of the experiment, and repeated whenever the experimenter deemed necessary. Between each trial a drift correction check was performed, and the presentation of the sentence was controlled by a trigger placed just left of the first word. Only when a fixation was detected in this location was the next sentence presented. Participants read each sentence at their own pace, and pressed a button when they had finished reading. The whole experiment lasted about 25 min.

Analyses

An automatic procedure combined short fixations (<80 ms) with another fixation if these were within one character space from each other; fixations <40 ms and not within 3 character spaces from another fixation were deleted. Trials with a blink on the target word and trials that showed tracker loss were deleted from all analyses (3.2%). Fixations <100 ms were removed from the analyses. Outliers over 1400 ms per word were removed from the gaze duration data (<1%).

Three regions of analysis are reported: the prime/control word region (e.g. *wings*), the target region (e.g. *kings*), and a spillover region (e.g. *watched*) defined as the next word if at least four characters long, otherwise the next two words. The same measures as discussed in Paterson et al. (2009) are reported: first fixation duration (the duration of the first fixation on a word or region), gaze duration (the sum of fixation durations on a word or region during first-pass reading), first-pass regressions (the percentage of backward saccades out of a region during first-pass reading), regression-path duration (the sum of all fixation durations on a word/region from first entering the region until going past it, this can include fixations on previously processed text; this measure is also known as the go-past time), and total time (the sum of all fixation durations on a word/region). In addition, we report single fixation duration (the fixation duration on a word/region during first-pass reading if there's only one fixation) and skipping rate (when the target word was not fixated during first-pass reading).

All analyses were carried out using R (R Development Core Team, 2010) and the lme4 package, version 0.999999-0 (Bates, Maechler, & Bolker, 2012). Linear mixed-effect models were constructed for each dependent variable, with participants and items as random effects (Baayen, 2008). Following Barr, Levy, Scheepers, and Tily (2013), we included both random intercepts and random slopes. For the random slopes, we first tried the maximally-appropriate structure. However, since this frequently resulted in non-convergence, we used a reduced model in which we estimated random intercepts and slopes for all relevant terms but assumed a constant covariance rather than estimating covariance (as suggested by Bates, 2009).[2] Model comparisons examining main effects of Priming and Set (the 4 overlap types) and the interaction between Priming and Set were tested. A main effect of Set (the 4 overlap types) is not very informative because prime, control, and target words were controlled between the sets, but other factors (e.g. discourse content) were not. Hence, we will not discuss this effect further. Main effects were tested by comparing the base model (which includes an intercept and the random factors) to the same model but with the factor Prime or Set added. The interaction was tested by comparing the full model to a model containing the two main effects. For the first-pass regression data, which are binomial (either a regression happened or not), we carried out a logistic regression using a generalized linear mixed effect model.

Results and discussion

Average reading times are shown in Table 3. Mixed-effect model analyses for the measures showing significant effects can be found in Appendix B (Table B1). We will discuss each region in turn.

Prime/control word region

No significant effects emerged for any of the reading measures (all $ps > .17$).

Target word region

We first examined whether the number of orthographic substitution neighbors, total number of orthographic neighbors (substitution + deletion + addition neighbors), and number of phonological neighbors of both the prime and the target affected target word reading times (neighborhood values were obtained from N-Watch; Davis, 2005). To this end, we compared two models, one including the neighborhood value in both fixed and random terms and one with no fixed effect term. None of these comparisons showed a significant improvement in model fit (all $ps > .18$, except for total gaze: $ps > .07$). The finding that the number of neighbors mainly affected a late

[2] Concretely, in R, instead of using a model such as: lm1 <-lmer(data = d, RT ~ set * prime + (1 + prime * set|subj) + (1 + prime|item), REML = FALSE) we used the model: lm1 <-lmer(data = d, RT ~ set * prime + (1|subj) + (1|subj:prime:set) + (1|item) + (1|prime:item), REML = FALSE).

Table 3
Eye movement data for Experiment 1.

Region	Overlap type							
	O+P+ end		O+P+ begin		O+P−		O−P+	
	Prime	Control	Prime	Control	Prime	Control	Prime	Control
Prime/control word								
Skip	15.6	13.5	15.9	13.0	14.6	14.2	14.7	17.7
Single fixation	228	229	231	235	237	234	230	224
First fixation	227	227	232	230	236	233	233	225
Gaze duration	263	258	272	270	281	267	264	278
Regressions	11.4	13.8	11.0	11.7	11.1	14.1	11.5	12.8
Regression-path	318	332	337	331	340	347	328	341
Total time	325	335	349	344	364	354	334	354
Target word								
Skip	11.9	11.0	11.7	13.5	11.7	12.7	10.8	14.3
Single fixation	253	246	242	245	249	257	256	249
First fixation	253	242	239	243	247	253	253	248
Gaze duration	308	288	286	300	295	298	315	302
Regressions	15.5	15.3	16.0	15.2	16.2	16.8	15.0	17.0
Regression-path	396	353	370	394	376	398	381	400
Total time	403	374	398	411	393	392	394	397
Spillover								
Skip	18.9	23.0	15.9	15.0	16.6	16.9	19.1	17.9
Single fixation	248	241	248	253	251	244	248	250
First fixation	246	239	246	244	252	238	242	245
Gaze duration	313	327	372	346	339	349	348	355
Regressions	13.7	11.6	20.0	14.4	12.3	12.8	13.8	11.8
Regression-path	405	410	526	457	426	435	461	440
Total time	393	405	506	484	418	434	430	448

Notes. Reading times are in milliseconds, skipping and regressions are in percentages.

Table 4
Sample experimental sentences in the three lag conditions of Experiment 2.

Distance	Example
Short	The students had a late **start [class]** and showed a *stark* contrast in talent. They couldn't wait to finish school for the day
Long-1 sentence	The students had a late **start [class]** at the community school and showed a *stark* contrast in talent. They couldn't wait to finish school for the day
Long-2 sentence	The students had a late **start [class]** at the community school. They showed a *stark* contrast in talent. They couldn't wait to finish school for the day

Notes. The prime [control] word is in bold, the target word is in italics.

measure such as total reading times is somewhat unexpected if one assumes neighborhood size affects early processing stages. However, Pollatsek, Perea, and Binder (1999) also failed to find immediate effects of neighborhood size during reading. We will not discuss this further.

For the main analyses, we examined whether the addition of Set, Prime, or its interaction improved model fit. No significant effects were found for the skipping rate, single fixation, first fixation, and first-pass regression measures (all $ps > .28$). Analyses of the gaze duration measure showed that model fit was significantly improved by including the interaction with prime type ($\chi^2 = 7.87$, $p < .05$). Separate model comparisons conducted for each set showed that this interaction reflected significant inhibition for the O+P+ end set only (Estimate = 23.3, $SE = 10.2$, $t = 2.3$), and no significant effects for the other three sets (all $ps > .16$) (see Appendix B, Table B1, for details). The same pattern was observed for the regression-path reading times: including the interaction with prime type significantly improved model fit ($\chi^2 = 8.34$, $p < .05$), reflecting significant inhibition for the O+P+ end set (Estimate = 49.9, $SE = 16.6$, $t = 3.0$) and no significant effects for the other sets (all $ps > .27$). The total reading time measure did not show significant effects.

Spillover region

No significant effects were found for the skipping, single fixation and first fixation duration measures (all $ps > .11$). The gaze duration measure showed no significant interaction, nor an effect of Prime or Set. The 26 ms inhibition found for the O+P+ begin items, while suggestive, failed to reach significance ($p > .20$). The first-pass regression analyses showed no significant interaction, no main effect of Set, but model fit was marginally improved when Prime was added to the model ($\chi^2 = 3.41$, $p < .07$). Separate analyses of each set revealed a near-significant higher percentage of regressions for the primed version of the O+P+ begin items compared to their unprimed counterpart

(Estimate = 0.4, SE = 0.2, t = 1.9). The other sets did not show an inhibitory priming effect (all $ps > .34$). The regression-path analyses mirror this trend: a non-significant interaction or main effect of Prime, though the model was significantly improved with the addition of Set ($\chi^2 = 8.99$, $p < .05$). Separate analyses for each set showed significant inhibition for the O+P+ begin set (Estimate = 64.8, SE = 29.0, t = 2.2), but no effects for the other sets (all $ps > .42$). The total duration analyses showed a main effect of Set ($\chi^2 = 12.65$, $p < .01$) but no other effects.

The pattern of results is clear for three out of the four sets. First, no differences were found for the prime/control word region, indicating that these were well controlled, but also that prime words were not reread more often than control words. Second, a clear and early inhibition effect, with the target word taking longer to process when preceded by an overlapping prime word than when preceded by a non-overlapping control word, was observed for the O+P+ end-overlap target word, which was also noticeable in the later measures. Third, no significant or near-significant effects were observed for any measure at any region for the O+P− and the O−P+ sets, indicating that when the prime and target word overlapped only at the orthographic or at the phonological level, no inhibition ensues. The pattern for the O+P+ begin words is more difficult to interpret. The data indicate longer (but non-significant) gaze durations for the primed condition on the spillover region, but also a nearly significant larger percentage of first-pass regressions. These two tendencies might have influenced each other, making it harder to find a significant effect. The regression-path measure takes both tendencies into account to some degree, and the analyses of this measure indicate that there was indeed significant inhibition for this condition. Why the effect was slightly delayed is puzzling, but could possibly be related to rhyme exerting a stronger phonological cue than begin overlap. We will return to this issue in the discussion of Experiment 2.

We also checked whether the number of orthographically and phonologically shared neighbors between the prime and target influenced target word reading. We contrasted, for each reading measure, a model containing the shared neighborhood size to one without. None of the model comparisons showed a significant difference (all $ps > .30$), indicating that shared neighborhood size did not affected the reading time measures.

Experiment 2

The aim of Experiment 2 was to further investigate the inhibitory priming effect we observed in Experiment 1. First we wanted to test an important prediction of interactive-activation accounts. According to all available models of word recognition, activation levels of lexical candidates decay over time. Although the exact time course is unknown, it is generally assumed to be relatively short. We tested this prediction by comparing the inhibition effect when the distance between the prime and target word in a sentence was varied. We expected to find a reduced inhibition effect when the prime and target were at a greater distance from each other, due to the decay of prime activation over time and, therefore, reduced competition when processing the target word.

We also examined whether syntactic structure plays a role in the degree of activation of the prime word. Evidence from eye movement studies suggests that readers spend more time on a word at the end of a sentence compared to when that word is not sentence-final (sentence "wrap-up" effect; e.g. Just & Carpenter, 1980; Mitchell & Green, 1978; Rayner, Kambe, & Duffy, 2000; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989; see also Hirotani, Frazier, & Rayner, 2006), indicating the operation of integrative processing, e.g. relating sentences of a text to each other. Moreover, Carroll and Slowiaczek (1986) demonstrated priming between semantically associated words in a sentence reading task when the words appeared in the same clause but not when they appeared in different clauses. We hypothesized that at a sentence boundary, low-level information, such as the residual activation of lexical representations, is discarded so that orthographic overlap effects will disappear if the prime and target appear in different sentences. We tested this by inserting a syntactic break in the longer delay sentences.

These manipulations also allowed us to test an alternative explanation for the inhibition effect, suggested by Paterson et al. (2009), which is related to episodic memory effects. According to episodic theories of word identification, which have mainly been proposed to explain (longer term) repetition priming effects, words are stored as episodic memory traces, containing both visual and phonological features. When the same word is presented again, the availability of the memory trace will speed up processing (see Tenpenny, 1995, for an overview, but see Bowers, 2000, for an alternative view). In theory, it's possible to modify this view such that when a neighboring word is presented, this memory trace will interfere with the identification of the target, leading to an inhibition effect (see Paterson et al., 2009). In practice, it can be difficult to distinguish a theory based on episodic memory traces and an account that posits competition between orthographic neighbors. However, one could tentatively suggest that while the inhibition effect should disappear quite quickly in the competition account, the episodic memory account would predict longer-lasting inhibition (repetition priming effects can be seen over several days', or even months', delay, e.g. Jacoby, 1983; Kolers, 1976). In addition, an episodic account, as well as a competition account, would predict that syntactic structure should not affect the degree of priming, as long as the time between prime and target is held roughly equivalent.

Finally, Experiment 2 also tested for a relationship between inhibitory priming and individual differences in reading skill. Masked orthographic neighbor priming has been shown to vary as a function of reading skill, even within groups of highly skilled readers. Andrews and Hersch (2010) found that differences in reading and spelling ability among university students affected neighborhood priming results, such that high-frequency word neighbor primes slowed lexical decision responses for good spellers but speeded responses for poorer spellers. This finding was replicated and extended by Andrews and Lo (2012), who demonstrated that higher spelling ability is also associated with stronger facilitation from nonword neighbor primes. This pattern of results was attributed to differences in the quality of orthographic lexical representations such that more precise lexical representations can more quickly inhibit their lexical competitors.

While we didn't test spelling ability, we were interested in the relationship between reading skill and the persistence of the priming effect. Gernsbacher (1993) suggested that less skilled readers are poorer at suppressing certain types of information than more skilled readers. She demonstrated that while both skilled and less skilled readers show inhibition at a short ISI (100 ms) when they need to reject a word related to the (unintended) meaning of a sentence-final homophone (e.g. rejecting *calm* after *patients* [homophone of *patience*]), only the less skilled readers show an inhibition effect when the ISI was 1 second (Gernsbacher & Faust, 1991). This would suggest that less skilled readers might show a more pronounced inhibition effect than more skilled readers when prime and target are further apart. On the other hand, less skilled readers tend to lose access to more superficial or surface features faster than more skilled readers (e.g. Gernsbacher, Varner, & Faust, 1990). This loss of form information should predict a less pronounced inhibition effect for less skilled readers when the prime and target are further apart.

To summarize, in Experiment 2 we manipulated the delay between prime and target words, testing priming at both a short and a long lag (an average of approximately 3 and 9 intervening words, respectively). We also investigated the effect of syntactic structure by comparing priming within the same sentence to priming across a sentence boundary. Finally we post-tested our participants' level of reading skill to examine whether there was a relationship between reading skill and inhibitory form priming. Only O+P+ items were tested, as the O+P− and O−P+ items did not show any sign of a priming effect in Experiment 1.

Method

Participants

Fifty-four undergraduate, native British English speaking students from the University of Birmingham participated in the Experiment for course credit.

Materials

Sixty items were constructed, all with the prime and target words overlapping in both orthography and phonology and the control and target words not overlapping. Thirty of the primes exhibited begin overlap, 30 exhibited end overlap, and all item pairs were taken from Experiment 1. For each item, six different conditions were constructed (see Tables 4 and 5; all items can be found in Appendix A). The target word was either preceded by a prime word or a control word, which were always of higher frequency than the target word (average frequency prime/control: 40.0, target: 5.2). The prime and control words were of the same length and did not differ in terms of frequency ($t < 1$). For the close (short) conditions, the prime/control and target words were separated by an average of 3.0 words (13.8 characters). For the two long conditions, the distance was 8.8 words (44.0 characters) when prime and target appeared in the same sentence, and 8.8 words (44.3 characters) when they were separated by a full stop ($ts < 1.4$). All items were either 2 (short and long – 1 sentence conditions) or 3 (long – 2 sentence condition) sentences long, and comprehension questions followed 33% of the items. Accuracy was 90.0%.

A fit-in-context test was carried out in order to check whether the target word fitted equally well following the prime or the control word. Forty-eight new participants from the same subject pool, divided over 6 lists, took part for credit. Participants were asked to indicate, using a 7-point scale, how well they thought an underlined word in a sentence fitted in the sentence, with 1 meaning "does not fit at all" and 7 "fits perfectly". In addition to the 60 critical items, 60 filler items were constructed in which the underlined word did not fit the context to different degrees in order to have the participants use the entire scale. After this test, participants completed the Gray Silent Reading Test (GSRT; Wiederholt & Blalock, 2000, 4th Edition). This standardized test, which we also used with the participants in the eye movement experiment, measures reading comprehension; participants read six short passages and answered multiple choice questions, differing in difficulty, related to these passages. Together, the fit-in-context and the GSRT tests took approximately 55 min to complete.

The results of the fit-in-context test revealed no differences between the primed and unprimed conditions: Short: 5.8 (primed) vs. 5.8 (unprimed), $t < 1$; long – 1 sentence: 5.8 vs. 5.9, $t(59) = 1.00$, $p > .30$; long – 2 sentence: 5.8 vs. 5.7, $t < 1$. We also correlated the fit-in-context scores with the participants' GSRT comprehension score (mean = 22.9, range = 11–29). While there were no significant correlations between the two measures ($r = .10$, $p > .50$ for all items tested, and $r = .257$, $p > .07$ for the critical items), there was a trend for good comprehenders to rate the targets as fitting better into the contexts.

Table 5
Item characteristics for the experimental words tested in Experiment 2.

	Log frequency	Length (letters)	Number of orthographic substitution neighbors	Total number of orthographic neighbors	Number of phonological neighbors
Prime	1.39 (.5)	5.1 (.5)	4.8 (3.1)	7.2 (3.9)	11.5 (6.7)
Control	1.39 (.5)	5.1 (.5)	3.8 (3.3)	5.8 (4.2)	10.9 (6.4)
Target	.65 (.3)	5.1 (.5)	4.9 (3.0)	6.8 (3.4)	11.3 (5.5)

Notes. Frequency is the number of occurrences per million words, based on CELEX. Neighborhood estimates are obtained from N-Watch (Davis, 2005). Number of substitution neighbors is also known as Coltheart N. Total number of neighbors is the sum of all substitution, deletion, and addition neighbors.

Table 6
Eye movement data for Experiment 2.

Region	Distance					
	Short		Long – 1 sentence		Long – 2 sentence	
	Prime	Control	Prime	Control	Prime	Control
Prime/control word						
Skip	21.2	16.5	19.8	21.6	19.2	18.9
Single fixation	212	217	215	224	214	215
First fixation	211	218	214	225	215	214
Gaze duration	231	238	234	241	235	233
Regressions	14.1	17.5	15.0	14.6	11.8	15.8
Regression-path	283	306	292	309	280	295
Total time	311	322	291	312	310	308
Target word						
Skip	13.2	12.6	14.6	15.1	13.0	12.5
Single fixation	232	220	228	231	221	230
First fixation	232	220	230	227	222	228
Gaze duration	264	260	262	253	250	261
Regressions	12.8	19.5	19.6	17.7	17.9	18.8
Regression-path	328	351	345	323	319	339
Total time	385	370	343	335	354	341
Spillover						
Skip	12.1	13.6	13.1	15.5	11.2	12.5
Single fixation	244	229	231	234	231	231
First fixation	237	224	230	233	228	226
Gaze duration	312	300	289	296	311	294
Regressions	29.7	23.0	20.0	19.3	22.8	22.2
Regression-path	508	456	399	416	459	437
Total time	431	403	370	370	407	382

Notes. Reading times are in milliseconds, regressions and skips are in percentages.

However, and more importantly, there was no significant correlation with the fit-in-context differences for the primed and unprimed items ($r = .128$, $p > .38$), suggesting that good and poorer comprehenders did not differ in how well they thought primed targets fitted vis-a-vis unprimed targets.

We also tested whether there were any differences in predictability of the target word. Sixty new participants, equally divided over 6 lists, took part in a Cloze test in which the sentences up to but not including the target word were provided and participants had to complete the sentence with the first word or words that came to mind. Predictability was very low for all conditions (short – primed: 2.5%, short – control: 3.5%; long – 1 sentence primed: 3.5%, long – 1 sentence control: 3.0%; long – 2 sentence primed: 3.9%, long – 2 sentence control: 3.0%), and there were no significant differences between the primed and control versions of each condition: short: $t(59) = 1.14$, $p > .25$; long – 1 sentence: $t < 1$; long – 2 sentence: $t(59) = 1.00$, $p > .32$.

Analyses

The same three regions (prime, target, spillover) as for Experiment 1 were analyzed.

Procedure

The critical items were intermixed with 54 filler items of comparable length and divided over six lists. Item presentation was counterbalanced so that each participant saw only one version of an item, and an equal number of items per condition.

The procedure was identical to Experiment 1, except that after completing the experiment, participants were also administered the Gray Silent Reading Test (GSRT), using the procedure as above. We used individuals' reading comprehension scores to examine whether the size of the inhibition effect was related to reading comprehension level.

Results and discussion

Average reading times are shown in Table 6, linear and generalized linear mixed-effect analyses can be found in Appendix B, Table B2. We will discuss each region in turn.

The data were again analyzed using linear mixed-effect modeling, and generalized linear mixed-effect modeling for the first-pass regression data. Prime (primed vs. control), Distance (short, long – 1 sentence, and long – 2 sentence), and Overlap Type (O+P+ begin vs. O+P+ end) were coded as predictor variables. We first tested whether a model containing overlap type (begin or end overlap) produced a better fit for the target word reading measures than a model without. Since this was not the case (all $ps > .12$), we used the simpler model without overlap type in the remainder of the analyses.

The main effect of Prime was tested as in Experiment 1. The main effect of Distance was not tested as it is not informative with respect to the research question since it can merely indicate that words later in a sentence take longer or shorter to process. The interaction between Prime and Distance is indicative of differential processing for the different distance conditions and was tested by comparing the full model to a model with the two main effects, but without the interaction.

Prime/control word region

No significant effects were observed for the skipping, single fixation, first fixation, gaze duration, first-pass regression, and total reading time measures ($ps > .11$). Model fit for the regression-path duration measures showed a significant improvement when Prime was included ($\chi^2 = 4.01$, $p < .05$), with the control word taking 18 ms longer to process than the prime word.

Target word region

The skipping data did not show any significant effects ($ps > .88$). The single fixation duration measure showed a significant interaction between Prime and Distance ($\chi^2 = 6.04$, $p < .05$; see Appendix B, Table B2, for details). Separate model comparisons for each distance condition revealed that the target word took longer to process in the primed compared to the control condition, but only for the short distance condition (Estimate = 10.2, $SE = 5.1$, $t = 2.0$; all other conditions: $ps > .11$). The same pattern was found for the first fixation duration data: a significant model fit improvement with the inclusion of the interaction ($\chi^2 = 6.37$, $p < .05$), with the inhibitory priming effect restricted to the Short distance condition (Estimate = 11.9, $SE = 4.7$, $t = 2.6$; all other conditions: $ps > .25$). There were no significant effects for the gaze duration data, but the first-pass regression data revealed a significant interaction ($\chi^2 = 6.14$, $p < .05$). While no differences were found for the two Long distance conditions ($ps > .56$), more regressions were found for the control condition in the Short distance condition (Estimate = −0.6, $SE = 0.2$, $t = -2.9$). The finding that more regressions occurred for the control condition is surprising, but the regression data on the spillover region do show a difference in the expected direction.[3] The regression-path and total reading time analyses did not show significant effects.[4]

Spillover region

No significant main effects or interactions were found for the skipping, single fixation and first fixation duration data, though planned comparisons revealed significant inhibition for the Short distance condition in the first fixation data (Estimate = 13.2, $SE = 6.7$, $t = 2.0$), but not for the two Long distance conditions ($ps > .74$). No significant effects were found for the gaze duration measure. The first-pass regression measure showed a marginal effect when Prime was included in the model ($\chi^2 = 3.10$, $p < .08$). While the interaction with Distance was not significant, an inspection of the means indicated that a difference between primed and control condition could only be observed for Short distance condition. This was confirmed in the separate comparisons for each distance condition, with a higher number of regressions for the primed Short condition compared to the unprimed Short condition (Estimate = 0.4, $SE = 0.2$, $t = 2.4$). The difference for both Long conditions was not significant ($ps > .72$). The same pattern was observed for the regression-path data: there was a non-significant model fit improvement when the interaction was added and a marginal improvement when Prime was added ($\chi^2 = 2.98$, $p < .09$), with only a significant inhibition effect for the Short distance condition (Estimate = 53.8, $SE = 23.6$, $t = 2.3$) but not the two Long conditions ($ps > .29$). Finally, the total reading time data showed that the addition of Prime significantly improved model fit ($\chi^2 = 4.25$, $p < .05$), with only the Short distance condition showing significant inhibition, but not the Long – 1 sentence condition ($p > .87$). There was some suggestion that the Long – 2 sentence condition also showed an inhibition effect (Estimate = 25.2, $SE = 13.5$, $t = 1.9$), though it should be noted that this is considered a "late" measure and only approached significance on the region following the target word.

The pattern found for the Short distance condition replicates the findings of the O+P+ conditions of Experiment 1, with early inhibition effects on the target word and the spillover regions. Experiment 1 also showed immediate early effects for the O+P+ end overlap items, and a slight delay for the O+P+ begin overlap items. The items used in Experiment 2 were a mix of both types of O+P+ overlap items, but our analyses did not reveal a clear difference in processing between the two overlap types. The source for this slight discrepancy in the findings is unclear, though one can safely conclude that both end and begin overlap items are capable of generating inhibition during early processing.

We examined whether comprehension skill was related to a number of global processing measures. Reading skill as measured by the GSRT did not affect reading speed (expressed as words per minute), the number of forward fixations, forward fixation duration, forward saccade length, the number of forward saccades, regressive fixation duration, the number of regressive fixations, or the number of regressive saccades (all $ps > .42$). However, it did impact the regressive saccade length ($\chi^2 = 6.15$, $p < .05$) and, as a consequence, the average saccade duration ($\chi^2 = 4.54$, $p < .05$), with better comprehenders tending to make somewhat longer regressive saccades than poorer comprehenders. While there is good evidence that reading skill can have an effect on these global eye movement measures (for example, beginning readers tend to have longer fixation durations and shorter saccades than more skilled readers; see Rayner, 1998, for an overview), it might not be that surprising that for the participants tested here (highly skilled undergraduates) hardly any of these global measures showed a significant effect of comprehension skill.

[3] It is at present unclear whether p-values should be calculated using pMCMC in R. However, Baayen (2008) argues that t-values greater than 2 can be assumed to indicate significance.

[4] We wanted to make sure that the inhibition effect for the Short distance condition found in the single fixation and first fixation data was not caused by this difference in regression probability and carried out an analysis on the data when no first-pass regression was made. While the inhibition effect was comparable in magnitude for the single fixation measure (10 ms vs. 12 ms for the full set), the analysis became non-significant (Estimate = 8.21, $SE = 5.85$, $t = 1.40$), likely due to the limited number of observations with this measure. However, the inhibition effect was nearly significant for the first fixation duration analysis (10 ms; Estimate = 10.13, $SE = 5.25$, $t = 1.93$). Hence, we do not believe that the difference in regression probability had a major impact on the inhibition effect found for the Short distance condition.

In order to test whether reading skill affected the inhibitory priming effect, we constructed a model containing GSRT and priming as fixed effects, and random slopes containing Prime in the subject term and Prime and GSRT in the item term. We will concentrate on the interaction between GSRT and Prime. There were no significant effects for the Long – 2 sentence condition (all $ps > .10$). For the Short condition, the interaction was significant for the first-pass regressions data ($\chi^2 = 7.88$, $p < .05$), due to the tendency for better comprehenders to make fewer regressions when the prime and target overlapped (see Fig. 1). None of the other measures approached significance (all $ps > .16$). More interestingly, the Long – 1 sentence condition showed a trend towards a significant interaction for the gaze duration ($\chi^2 = 4.97$, $p < .09$), and significant interactions for the first-pass regression and the regression-path measures ($\chi^2 = 8.66$, $p < .05$ and $\chi^2 = 13.96$, $p < .001$, respectively). As can be seen from the plots in Fig. 1, these interactions were driven by good comprehenders showing a larger inhibition effect (longer reading times, more regressions) than poorer comprehenders (who were more likely to show facilitation). Inspection of the plots also shows that participants who show an inhibition effect were concentrated towards the higher end of the GSRT scale while participants showing facilitation exhibited a broader range of scores. In order to further examine the interaction between the GSRT scores and the priming/inhibition effect, we divided up the participants into two roughly equal-sized groups: good comprehenders ($N = 25$, average GSRT score of 26, range 24–29) and less good comprehenders ($N = 29$, average GSRT score of 20, range 13–23). For the gaze duration measure, the inhibition effect was 16 ms for the good comprehenders and −2 ms for the less good comprehenders; for the first-pass regressions measure, the good comprehenders showed a 7.1-point increase while the less good comprehenders showed a 2.7-point decrease; and for the regression-path measure, the inhibition effect was 71 ms for the good comprehenders while the less good comprehenders showed a 25 ms facilitation. Hence, the interaction seems to be driven by an increased inhibition effect for the good comprehenders, and a smaller tendency towards facilitation for the less good comprehenders.

There are two main conclusions that can be drawn from the data patterns. First, early inhibitory effects, with longer reading times when the prime overlapped both orthographically and phonologically with the target, were restricted to the Short distance condition. When the prime

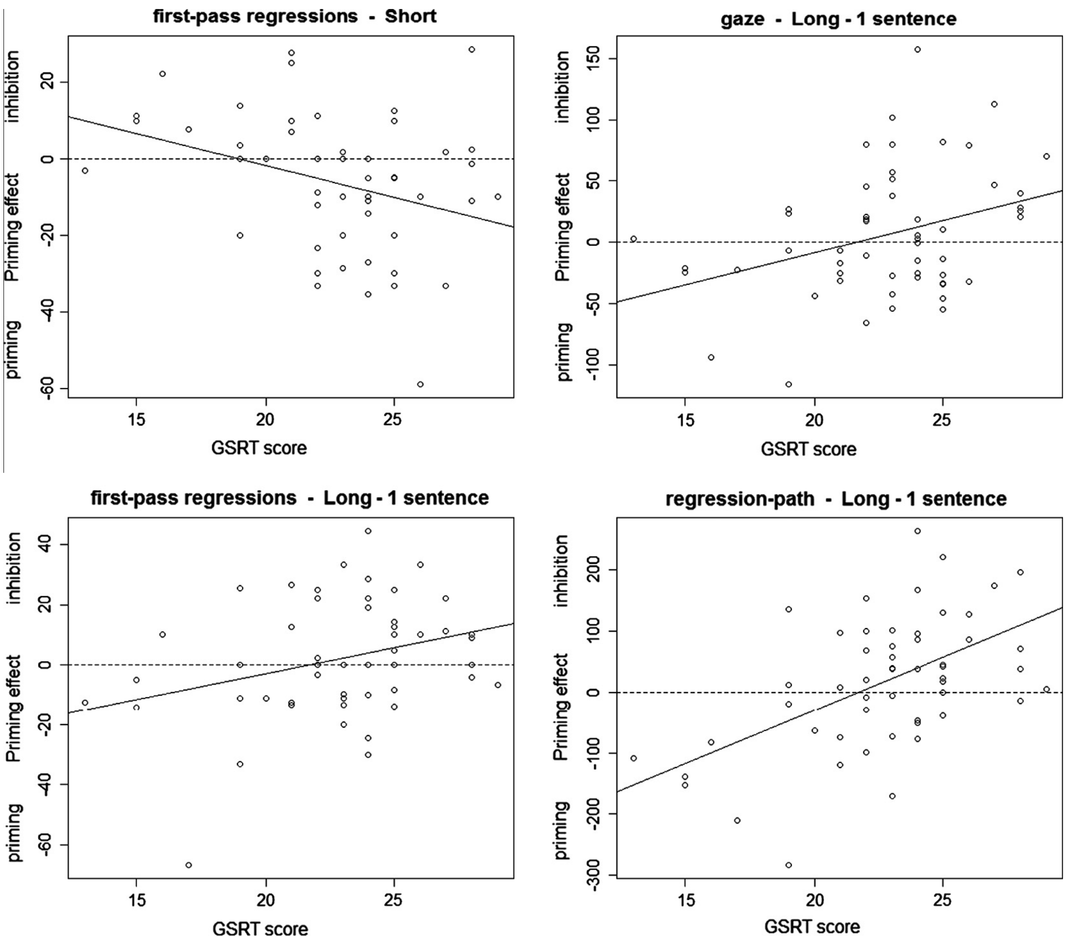

Fig. 1. Interaction plots GSRT and priming effect.

and target appeared in different sentences, but with the same distance as the other long distance condition, no significant inhibition effects were observed. This result can easily be accounted for in an interactive activation account in which an activated representation will rather quickly decay.

Second, analyses including reading measures and individuals' comprehension level indicated that good comprehenders showed a larger inhibition effect than less good comprehenders for the Long – 1 sentence condition. This suggests that good comprehenders were affected by the prime-target overlap for longer than less good comprehenders. Interestingly, when the prime and target were separated by the same distance but appeared in adjacent sentences, no effect of comprehension skill was observed, suggesting that the presence of an overlapping prime word no longer affected processing of the target word for either the good or the less good comprehenders.

These results pose challenges to both lexical competition and episodic memory accounts of inhibitory priming. First, a competition account, which generally assumes the decay function to be a constant, would need to explain why decay of lexical representations is slower for better comprehenders. Since the time taken to get from the prime to the target word was not significantly correlated with reading skill ($r = -.23$, $p > .09$), it's unlikely that the good comprehenders showed an inhibition effect in the Long – 1 sentence condition because they just arrived at the target faster than less good comprehenders. A simple competition model would also struggle to explain why the inhibition effect was there for good comprehenders at the Long – 1 sentence condition, but not at the Long – 2 sentence condition. An analysis of the (first-pass) time it took to read the text in-between the prime and target revealed no differences between the Long – 1 sentence and the Long – 2 sentence conditions (1197 vs. 1194 ms, $ts < 1$), indicating that the disappearance of the effect for the good comprehenders was not due to participants taking more time to get to the target word in the Long – 2 sentence condition. While an episodic account could explain why good and less good comprehenders differ at the Long – 1 sentence condition by assuming that the episodic memory trace is stronger for better comprehenders, it cannot provide a straightforward explanation for why this advantage disappears across sentence boundaries. We will return to this in the General Discussion.

General discussion

Both experiments yielded a number of significant effects that help our understanding of inter-word priming effects during reading. Experiment 1 showed that the inhibitory priming effect is restricted to word pairs that overlap both at the orthographic and phonological level, e.g. *wings–kings; strain–strait*. When the pairs overlap only at the orthographic (e.g. *bear–gear*) or only at the phonological (e.g. *smile–aisle*) level, no inhibitory nor facilitatory priming was observed. An account that maintains that the inhibition effect is solely caused by the presence of an orthographic neighbor can explain the lack of an effect for the phonological-only overlap, but cannot explain why there was no inhibition effect for the orthographic-only overlap. Since item pairs in this (O+P−) overlap condition were, by definition, the same kind of orthographic neighbor pairs as the O+P+ conditions, the difference in results indicates that it's the presence of phonological overlap that is necessary for inhibition. However, given that the phonological-only condition did not show a priming effect, it must have been the combination of orthographic and phonological overlap that drove the inhibition and that overlap at only one level was not sufficient.

Hence, at least in a regular reading task, the inhibition effect cannot be explained by a simple account in which the spelling of a previously activated word competes during the recognition of one of its orthographic neighbors. At least, such an account needs to be augmented with a mechanism that restricts inhibitory effects to words that not only look the same, but sound the same as well. It should be noted that this does not necessarily hold for single word tasks. As has been demonstrated by Rastle and Brysbaert (2006), phonological priming effects in lexical decision tasks tend to be very small, leading them to argue for a weak phonological involvement in LDTs. In contrast, numerous reading experiments have shown an influence of phonology during sentence reading (for an overview, see Rayner et al., 2012), which might indicate that readers rely more on phonological information during normal reading. If this is true, then this would make comparisons between LDT and normal reading less straightforward than is sometimes assumed.

Whether the results of Experiment 1 can be explained by an episodic memory model is a matter of debate. While it has been argued that phonological information is part of an episodic memory trace, it's unclear whether this information is so crucial that, without it, orthographic information would be ignored. In any case, this theory will need to spell out the relative contributions of orthographic and phonological features in episodic memory and how these are used during normal reading.

Experiment 2 showed that when the distance (and time) between the prime and target is increased (from about 3 to about 9 intervening words), the inhibition effect disappeared, both when the prime and target appeared in the same sentence and in two consecutive sentences. This finding can easily be accommodated in a competition model as it is generally assumed that the activation levels of words decay quickly (Paterson et al., 2009). Our data provide the first evidence that this also happens during a normal reading task. Whether the same prediction would be made by an episodic memory account is less clear. As discussed above, the main aim of this type of account has been to explain long-term priming effects (Tenpenny, 1995), with effects being found weeks, months, or even more than a year later. It is, therefore, unclear why delaying the target by about six words (equivalent to about 1.2 seconds) would result in the eradication of the inhibition effect.

There are, however, two other aspects of the data that could possibly point to some kind of memory effect. Analyses that included a measure of silent reading skill indicated that good and less good comprehenders differed with respect to how they processed the target when the target word was delayed but still appeared in the same sentence as the prime word. In this case, better comprehenders still showed an inhibition effect while less good comprehenders did not. When the target was delayed for the same distance/time but appeared in separate sentences, no effects of reading skill were observed. This pattern suggests that better comprehenders kept the prime active for longer, or reactivated the prime more readily, than less good comprehenders, as long as both prime and target appeared in the same sentence.

The inhibition effect for better comprehenders at the Long – 1 sentence condition is intriguing as it indicates that the way these readers process information might sometimes lead to a (relative) disadvantage. There are a number of plausible explanations for this inhibition effect for better comprehenders. First, it's possible that these readers hold onto superficial information for longer than less good comprehenders (e.g. Gernsbacher et al., 1990). Second, it might be that better comprehenders keep the prime activated for longer than less good comprehenders. Specifically, some evidence suggests that skilled readers rely more on phonological codes than less skilled readers (Chace, Rayner, & Well, 2005; Unsworth & Pexman, 2003; but see Landi & Perfetti, 2007). If it is, indeed, the case that inhibitory priming depends on the combined activation of orthographic and phonological information (cf. Experiment 1), and if more skilled readers have stronger and/or longer-lasting phonological representations, then it might be that only the more skilled readers still have both sources of information active or available when encountering the target word. Third, better comprehenders might have superior memory compared to less skilled readers, meaning that the episodic memory trace of already processed words will be stronger. Indeed, more skilled comprehension may involve the ability to combine lexical information across larger chunks of text. One aspect of our findings suggests that the increased inhibition shown by better comprehenders is not simply due to a longer lasting memory trace but may indeed reflect different comprehension processes. This is the finding that no inhibition was observed, even for the better comprehenders, when primes and targets were separated by a sentence break. This finding suggests that the presence of a sentence boundary makes readers discard low-level information, such as the spelling of specific words, and/or erase or suppress their memory trace. Given that a sentence boundary is thought to trigger higher-order, more integrative processes (e.g. relating sentences to each other; Rayner et al., 1989), this seems to be the obvious place to dispose of low level information.

These results are difficult to accommodate in existing models. A simple account, whether it is competition or memory based, that explains the size of the effect merely in terms of the time/distance between the prime and the target, can't account for the full set of data. Such an account would predict comparable inhibition effects for both long distance conditions, which was not what was found for the better comprehenders. Hence, a realistic explanation of our data will need to allow for individual differences, the impact of syntactic structure on the activation levels of words in a sentence, and how those two combine.

Clearly, more research is needed to determine exactly what it is that makes more skilled readers continue to show an inhibition effect in the Long – 1 sentence condition. While the Gray Silent Reading Test measures individual's silent reading comprehension, this skill might also be related to memory and/or precision in lexical representations (e.g. Andrews & Hersch, 2010). Indeed, if we assume that good comprehenders are also likely to be better spellers, then the present data fit well with the lexical precision theory, again resulting in the somewhat counterintuitive finding that better comprehension/precision can lead to greater interference effects during reading.

In conclusion, our data show how words within a sentence can influence each other, and how these effects wax and wane during normal reading. We found that words that both looked and sounded alike affect each other the most, and that the size of the effect is changed by both distance and syntactic structure. Finally, significant correlations with a measure of reading skill indicated that good comprehenders were negatively impacted by inter-sentence word overlap for longer than less good comprehenders.

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Appendix A

Stimuli used in Experiment 1 by overlap type.

The words in bold are the prime words with the control word between square brackets. The target words are in italics.

Overlap Type 1: O+P+, end (wings–kings)

The birds ruffled their **wings [tails]** as the *kings* watched from their palace.
Michael watched the **brush [shelf]** fall and *crush* the spider against the wall.
Sarah moved her hand in a circular **motion [manner]** to apply the *lotion* to her skin.
Ben was watching the storm and the **flash [burst]** of light and *clash* of thunder scared him.
The woman was walking down the **trail [aisle]** but she felt *frail* as she was very old.
Playing the lottery John won a **grand [prize]** and bought a top *brand* luxury car.
Jane read the **card [page]** on the back of the *lard* to check the nutritional content.
Steve was extremely **drunk [silly]** and fell over the *trunk* his mother had left in the hall.
The commander of the **fleet [craft]** didn't like the *sleet* that was disrupting communications.
When Graham was running on the **track [roads]** he saw a *crack* that hadn't been there yesterday.
Nobody knew who to **blame [phone]** as the *flame* climbed higher up the wall.

John picked up the small object and **threw [flung]** it at the *shrew* to make it run away.
The boy went feet first down the **slide [shaft]** in order to *glide* down towards the floor.
The wolf continued to **blink [growl]** as it began to *slink* away into the darkness.
The chicken that Jack wanted to **pluck [seize]** started to *cluck* when he advanced on it.
The lady on the bus was very **plump [weary]** and she sat in a *slump* next to John.
The boy gave a **wink [mint]** to the girl on the *rink* because he liked her.
The hunter had set up a **spare [dirty]** trap to *snare* the animal that he had been tracking.
The deck was **large [level]** on the *barge* allowing plenty of room for the crates.
The shortage of **bread [sugar]** caused real *dread* in the village due to the rationing.
As he vacationed by the **shore [ocean]** he remembered the *chore* he still had to complete.
The poor old **whale [goose]** was hit by *shale* that fell off an overhanging cliff.
Paul acted like he was **waking [firing]** up but he was *faking* it because he was still very tired.
Although Lucy felt **sick [wild]** she put a *tick* on her attendance sheet for the day.
It took a certain **breed [grade]** of people to defend their *creed* without hesitation.
Cleaning the ship's **flank [ports]** caused a *clank* as the anchor suddenly came loose.
Laura badly needed a **drink [sleep]** as she was on the *brink* of total exhaustion.
Simon started to **grunt [heave]** when the *brunt* of the weight was placed on him.
Last Saturday Dan had a **dream [laugh]** about a *bream* swimming in the sea.
Jane hoped for a quiet **payday [brunch]** but a *mayday* came over the system.
James had managed to **retain [locate]** the documents to *detain* the criminals in custody.
The pipes began to **swell [shake]** and I started to *dwell* on the impending problem.

Overlap Type 2: O+P+, begin (strain–strait)

The captain found it a **strain [burden]** to negotiate the *strait* at the end of a long voyage.
The mother thought it was very **sweet [crazy]** to see the girl *sweep* the dirty floor.
Because of the **steam [fence]** the thief could *steal* the car without being noticed.
An admission of **guilt [shame]** to the *guild* meant that John would face punishment.
Bob knew the item was **cheap [vital]** and had to *cheat* to make sure he won the bid.
A good supply of **grain [wheat]** was the holy *grail* for the farmer following the poor harvest.
When Lee proposed to Sue he stroked her **cheek [wrist]** and a *cheer* arose from their families.
He had to walk to the **tower [guard]** to get his *towel* as he'd forgotten it.
Malcolm used a **steel [metal]** bar to *steer* the broken bicycle.
The young inexperienced **scout [troop]** helped to *scour* the countryside for the lost dog.
Richard looked in the **chest [rooms]** for a book about *chess* which he needed to study.
The students had a late **start [class]** and showed a *stark* contrast in talent.
Ben bumped his knee on the **stool [ledge]** and then had to *stoop* to stem the pain.
The door of the larder where we keep the **cream [seeds]** opens with a *creak* as it is rarely used.
Tony wrote a catch phrase for the **advert [poster]** using the *adverb* his clients had requested.
Sarah searched through the **market [houses]** for a permanent *marker* to use in her office.
Suddenly everything became **blank [noisy]** after the *bland* meal which had been served for dinner.
Paul was sitting by the **stream [border]** and saw a *streak* of light flash through the sky.
Sarah examined scans of the **brain [teeth]** while twisting the *braid* in her hair.
It's difficult to **train [teach]** any dog with the *trait* of laziness in its breed.
In an argument Jane always **slung [casts]** abuse before she *slunk* off to hide.
The student's eyes started to **gleam [shine]** when he could *glean* the information from the text.
The knight received a **slap [coin]** for his attempt to *slay* the friendly dragon.
The morning's thin **sheet [cover]** of snow left a *sheen* to the pavement that brightened the day.
No one would ever use a **spoon [blade]** instead of a *spool* for winding thread.
Behind the camel he was trying to **mount [climb]** was a *mound* of droppings he needed to avoid.
The film star was able to **swoop [sneak]** in and make her *swoon* with desire as he caught her.
New evidence led to the **repeat [latest]** motion to *repeal* the man's sentence.
The unexpected **storm [turns]** made the *stork* lose touch with its flock.
Attempting to balance the **plant [block]** on the *plank* of wood was not a good idea at all.
The earthquake shook the **roof [bush]** and caused the *rook* to take off into the sky.
Lee tried not to laugh at the **queen [owner]** who was wearing a *queer* hat at the event.

Overlap Type 3: O+P– (bear–gear)

On noticing the giant **bear [tree]** John changed gear and pedalled away quickly.
The supervisor did **allow [agree]** keeping a fire aglow for much longer than we expected.
The reporter thought that a city **awash [laden]** with drugs should abash the police department.
The apprentice started to **cough [relax]** close to the dough which upset the baker.
She had to use **gloves [towels]** whilst picking the cloves in case they ruined her clothes.

When Adam looked at his **pint [fork]** he noticed a tint of green on the side.
Rachel began to **swear [curse]** as the shear cut through her jeans and into her leg.
Lucy wanted to see the **ballet [tennis]** so she got her wallet and checked how much money she had left.
Gregory was wiping his **brow [bike]** when the crow lunged at him without provocation.
The hungry and unpredictable **bull [cats]** stared at the gull which was flying around.
Lynn looks at her **daughter [teachers]** whose joyful laughter fills the whole room.
Greg enjoys **steaks [mutton]** and always sneaks home with the best cuts from the butchers.
Eating outside, Bob yells at the **wasps [teens]** while he rasps the Italian cheese over the pasta.
After Ryan had eaten so many **bowls [packs]** of crisps his jowls started to hurt.
Laura took a **break [glass]** and gazed at the bleak surroundings of her office block.
Dan shouted as he fell into the **bush [lake]** and was told to hush by a passerby.
Wendy and her precious **dolls [cargo]** passed through some tolls on their way to Canada.
The fact that the art was **gross [nasty]** took away the gloss from the opening of the gallery.
The foreigner **heard [wrote]** that his beard had been causing a stir amongst the town folk.
The shark silently **moves [turns]** through the coves whilst searching for its next meal.
Mary needs to pick the **pears [plums]** before the sun sears them and they are ruined.
The careful burglar goes and **pulls [shuts]** the blinds which dulls the light in the room.
The pipe blockage was dislodged with a **push [wire]** causing water to gush out over the floor.
Bill loves watching **doves [hawks]** as he roves aimlessly through the countryside.
The archaeologist is in search of **tombs [vases]** as he combs through the ancient structures.
Sarah loved the soft **touch [lines]** of the pouch that was stitched on her winter jacket.
Because of the **tough [dirty]** terrain, dragging a bough from the oak tree was hard work.
When Fred **wants [takes]** something he rants so everyone knows what it is.
The very expensive **watch [radio]** was in a batch that they delivered yesterday.
On his farm Joe always **wears [picks]** boots as he rears a lot of animals and gets muddy.
Tony will use his **words [hands]** to show how the cords needed to be tied together.
There were a lot of **worms [coats]** in the dorms where the children were sleeping.

Overlap Type 4: O−P+ (smile–aisle)

The husband had a big **smile [fight]** walking down the aisle of the local supermarket.
Out to sea just off the **remote [desert]** island I stay afloat by blowing air in the lifejacket.
Believe it or not but the **truth [issue]** is that the booth was removed by Health and Safety.
The soldiers did some **indoor [tiring]** training for the prewar simulation that had been planned.
Mary had to wipe the **grease [stains]** off the fleece she was wearing.
Sarah claimed her pies were **divine [stolen]** and gave a benign kind of smile.
The police started to **shoot [panic]** after the brute was hit by several bullets.
Leo gave me his **design [advice]** for fake canine teeth that he wanted to bring on the market.
There was a nice **suit [ring]** in the burglary loot that the men brought back.
I heard that the foreign **male [king]** needed to pay bail so he could be released.
I told Carl that I would **salute [summon]** him if he could uproot the sturdy tree on his own.
Ben threw the **fruit [waste]** down the chute because it was rotting and smelly.
Because Brad Pitt funds this **cause [hotel]** it naturally draws a lot of attention.
After he went inside to **greet [scorn]** Sue I heard a bleat from an animal just behind me.
The builder accidently hit the **drain [ridge]** with the crane and broke it.
The sculptures were not the right **scale [style]** causing Ed to flail his arms in anger.
Accusations of cheating in the game in the **saloon [lounge]** served to impugn the player's honesty.
It was clear that the bull was not **tame [numb]** as it tried to maim the inexperienced matador.
The King walked into the hallway and **spoke [shook]** as he hung his cloak on the hook.
James must feel **insane [shaken]** if he does not attain a higher grade in the exam.
I'm afraid he will **screw [tense]** up and break the taboo of crying in public.
Kate folded the **sheet [cloth]** to give it the pleat that she wanted.
The sentimental woman **cried [waves]** after the bride threw her bouquet in the air.
The tourists listened as the **guide [agent]** began to chide the driver for taking a wrong turn.
It was Ben's **fate [luck]** that caused his gait to increase as he had a surge of happiness.
I heard about the ridiculous **claim [rules]** which brought shame on his family for many years.
The parrot flew up from his **perch [slump**] as the cat made a lurch towards him.
Before they can **equip [shred]** the car we need to unzip the covers from the new loudspeakers.
The security men tried to **ignore [defeat]** the sudden uproar amongst the inmates.
Jenny loved the cake's **taste [shape]** but her waist was a concern to her.
Jeff had a dish of **soup [rice]** and then shot a hoop or two with his friends.
Because of Jennifer's sore **elbow [wrist]** lugging her cello to practice was a real ordeal.

Stimuli used in Experiment 2

The words in bold are the prime words with the control word between square brackets, the target words are in italics.

Version a = Short condition.
Version b = Long, 1-sentence condition.
Version c = Long, 2-sentence condition.

1
a The woman was walking down the **trail [aisle]** but she felt *frail* as she was very old. She turned eighty last week.
b The woman was walking down the **trail [aisle]** holding a red umbrella but she felt *frail* as she was very old. She turned eighty last week.
c The woman was walking down the **trail [aisle]** holding a red umbrella. But she felt *frail* as she was very old. She turned eighty last week.

2
a Playing poker Al won a **grand [prize]** and got a top *brand* car for himself. He then went to show his girlfriend.
b Playing poker Al won a **grand [prize]** so he went to the city and got a top *brand* car for himself. He then went to show his girlfriend.
c Playing poker Al won a **grand [prize]** so he went to the city. He got a top *brand* car for himself. He then went to show his girlfriend.

3
a The chicken that Jack wanted to **pluck [seize]** started to *cluck* when he advanced on it. He managed to grab it by the feet.
b The chicken that Jack wanted to **pluck [seize]** was in a bad mood and started to *cluck* when he advanced on it. He managed to grab it by the feet.
c The chicken that Jack wanted to **pluck [seize]** was in a bad mood. It started to *cluck* when he advanced on it. He managed to grab it by the feet.

4
a The lady on the bus was very **plump [weary]** and she sat in a *slump* next to John. John decided to move away a bit.
b The lady on the bus was very **plump [weary]** and seemed really tired as she sat in a *slump* next to John. John decided to move away a bit.
c The lady on the bus was very **plump [weary]** and seemed really tired. She sat in a *slump* next to John. John decided to move away a bit.

5
a Cleaning the ship's **flank [ports]** caused a *clank* as the anchor suddenly came loose. All of the sailors looked up in shock.
b Cleaning the ship's **flank [ports]** for the ship to set sail tomorrow caused a *clank* as the anchor suddenly came loose. All of the sailors looked up in shock.
c Cleaning the ship's **flank [ports]** the sailors suddenly stopped. They heard a *clank* as the anchor suddenly came loose. All of the sailors looked up in shock.

6
a Laura needed a **drink [sleep]** as she was on the *brink* of near total exhaustion. She poured herself a large glass of water.
b Laura needed a **drink [sleep]** after her big sponsored run as she was on the *brink* of near total exhaustion. She poured herself a large glass of water.
c Laura needed a **drink [sleep]** after her big sponsored run. She was on the *brink* of near total exhaustion. She poured herself a large glass of water.

7
a When Lee proposed, he stroked Sue's **cheek [wrist]** and a *cheer* arose from their families. Sue then showed off her engagement ring.
b When Lee proposed, he stroked Sue's **cheek [wrist]** as he slid the ring on and a *cheer* arose from their families. Sue then showed off her engagement ring.
c When Lee proposed, he stroked Sue's **cheek [wrist]** as he slid the ring on. And a *cheer* arose from their families. Sue then showed off her engagement ring.

8
a Ben bumped his knee on the **stool [ledge]** and then had to *stoop* to stem the pain. His mother had to phone the doctor.
b Ben bumped his knee on the **stool [ledge]** which was beside of him and then had to *stoop* to stem the pain. His mother had to phone the doctor.
c Ben bumped his knee on the **stool [ledge]** which was beside of him. He then had to *stoop* to stem the pain. His mother had to phone the doctor.

9
a Sarah searched the **market [houses]** for a permanent *marker* to use in her office. It took her a long time to get to work.
b Sarah searched the **market [houses]** just up the street from me for a permanent *marker* to use in her office. It took her a long time to get to work.
c Sarah searched the **market [houses]** just up the street. She wanted a permanent *marker* to use in her office. It took her a long time to get to work.

10
a The knight received a **slap [coin]** for his attempt to *slay* those two friendly dragons. The queen told him to leave the city.
b The knight received a **slap [coin]** from the rest of his friends for his attempt to *slay* those two

(*continued on next page*)

friendly dragons. The queen told him to leave the city.

c The knight received a **slap [coin]** from his friends. This was due to his attempt to *slay* those two friendly dragons. The queen told him to leave the city.

11

a The birds ruffled their **wings [tails]** as the *kings* and the queens watched from their palace. The fair-haired princes strolled past.

b The birds ruffled their **wings [tails]** elegantly while sitting on the balcony as the *kings* and the queens watched from their palace. The fair-haired princes strolled past.

c The birds ruffled their **wings [tails]** elegantly. They sat on the balcony as the *kings* and the queens watched from their palace. The fair-haired princes strolled past.

12

a Rob watched the **brush [shelf]** fall and *crush* the spider against the wall. It left a dirty mark.

b Rob watched the **brush [shelf]** fall at a rapid speed onto the floor and *crush* the spider against the wall. It left a dirty mark.

c Rob watched the **brush [shelf]** fall at a rapid speed onto the floor. Then *crush* the spider against the wall. It left a dirty mark.

13

a Lyn's hand moved in a circular **motion [manner]** to apply some *lotion* onto her skin. She then went off to her lecture.

b Lyn's hand moved in a circular **motion [manner]** while lying on her bed to apply some *lotion* onto her skin. She then went off to her lecture.

c Lyn's hand moved in a circular **motion [manner]** while lying down. She applied some *lotion* onto her skin. She then went off to her lecture.

14

a Graham was running on the **track [roads]** and saw a *crack* that hadn't been there yesterday. He decided to tell the council.

b Graham was running on the **track [roads]** next to his old high school and saw a *crack* that hadn't been there yesterday. He decided to tell the council.

c Graham was running on the **track [roads]** next to his old high school. He saw a *crack* that hadn't been there yesterday. He decided to tell the council.

15

a The boy went down the **slide [shaft]** in order to *glide* down towards the floor. He hit the floor and ran to the swings.

b The boy went down the **slide [shaft]** in the local playground as he wanted to *glide* down towards the floor. He hit the floor and ran to the swings.

c The boy went down the **slide [shaft]** in the local playground. He wanted to *glide* down towards the floor. He hit the floor and ran to the swings.

16

The wolf continued to **blink [growl]** as it began to *slink* away into the darkness. All that you could see were its glowing eyes.

The wolf continued to **blink [growl]** when he smelled the rabbits and it began to *slink* away into the darkness. All that you could see were its glowing eyes.

The wolf continued to **blink [growl]** when he smelled the rabbits. It then began to *slink* away into the darkness. All that you could see were its glowing eyes.

17

a Elsa said it was **sweet [crazy]** to see the girl *sweep* the floor on weekends. She decided to give the girl a chocolate for doing it.

b Elsa said it was **sweet [crazy]** to see the girl who works in the clothes shop *sweep* the floor on weekends. She decided to give the girl a chocolate for doing it.

c Elsa said it was **sweet [crazy]** to see the girl. They both work in the shop and *sweep* the floor on weekends. She decided to give the girl a chocolate for doing it.

18

a Rick looked in the **chest [rooms]** for a book about *chess* which he needed to study. He had an important tournament coming up.

b Rick looked in the **chest [rooms]** in his old countryside manor for a book about *chess* which he needed to study. He had an important tournament coming up.

c Rick looked in the **chest [rooms]** in his manor. He was looking for a book about *chess* which he needed to study. He had an important tournament coming up.

19

a Kate tried to use the **spoon [blade]** instead of a *spool* in order to wind thread. She wanted to make her mother a present.

b Kate tried to use the **spoon [blade]** that she took from the counter instead of a *spool* in order to wind thread. She wanted to make her mother a present.

c Kate tried to use the **spoon [blade]** that she found. She used that instead of a *spool* in order to wind thread. She wanted to make her mother a present.

20

a The terrible **storm [turns]** made the *stork* lose touch with its flock. It flew on its own for many miles.

b The terrible **storm [turns]** and heavy rain caused

utter confusion which made the *stork* lose touch with its flock. It flew on its own for many miles.
c The terrible **storm [turns]** and heavy rain caused utter confusion. This made the *stork* lose touch with its flock. It flew on its own for many miles.

21
a Ian admitted that the **flash [burst]** of light and *clash* of the thunder scared him. The dogs all started to howl in fear.
b Ian admitted that the **flash [burst]** of light that suddenly appeared and the *clash* of the thunder scared him. The dogs all started to howl in fear.
c Ian admitted that the **flash [burst]** of light suddenly appeared. As always the *clash* of the thunder scared him. The dogs all started to howl in fear.

22
a Tina read the **card [page]** on the back of the *lard* to check the nutritional content. She found out that it was very high in fat.
b Tina read the **card [page]** that she had found stuck on the back of the *lard* to check the nutritional content. She found out that it was very high in fat.
c Tina read the **card [page]** that she found. It was stuck on the back of the *lard* to check the nutritional content. She found out that it was very high in fat.

23
a Joe was extremely **drunk [silly]** and fell over the *trunk* his mother had left in the hall. She was very angry the next day.
b Joe was extremely **drunk [silly]** after a night out and fell straight over the *trunk* his mother had left in the hall. She was very angry the next day.
c Joe was extremely **drunk [silly]** after a night out. Once home he fell over the *trunk* his mother had left in the hall. She was very angry the next day.

24
a The commander of the **fleet [craft]** didn't like the *sleet* that was now disrupting communications. He couldn't hear what the captain was saying.
b The commander of the **fleet [craft]** didn't like the heavy snow and the dreadful *sleet* that was now disrupting communications. He couldn't hear what the captain was saying.
c The commander of the **fleet [craft]** didn't like the heavy snow. And the dreadful *sleet* was now disrupting communications. He couldn't hear what the captain was saying.

25
a Nobody knew who to **blame [phone]** as the *flame* climbed higher up the wall. They all looked on in fear.
b Nobody knew who to **blame [phone]** for the fire at the town hall as the huge *flame* climbed higher up the wall. They all looked on in fear.
c Nobody knew who to **blame [phone]** for the fire. Everyone watched as the huge *flame* climbed higher up the wall. They all looked on in fear.

26
a John picked up the object and **threw [flung]** it at the *shrew* to make it run away. He missed by a few inches.
b John picked up the object and **threw [flung]** it across the large garden at the *shrew* to make it run away. He missed by a few inches.
c John picked up the object and **threw [flung]** it across the large garden. The *shrew* got scared and ran away. He missed by a few inches.

27
a The boy gave a **wink [mint]** to the girl on the *rink* because he liked her. She turned and skated over his toes.
b The boy gave a **wink [mint]** to the very tall and slim blonde girl on the ice *rink* because he liked her. She turned and skated over his toes.
c The boy gave a **wink [mint]** to the very tall blonde girl. She was at the ice *rink* because she liked skating. She turned and skated over his toes.

28
a The hunter had set up a **spare [dirty]** trap to *snare* the animal that he had been tracking. The animal was too clever and outwitted him.
b The hunter had set up a **spare [dirty]** trap in the dense woods in order to *snare* the animal that he had been tracking. The animal was too clever and outwitted him.
c The hunter had set up a **spare [dirty]** trap in the dense woods. He wanted to *snare* the animal that he had been tracking. The animal was too clever and outwitted him.

29
a The deck was **large [level]** on the *barge* allowing extra of room for the crates. They made the boat wobble to and fro.
b The deck was **large [level]** and spacious and only recently fitted on the *barge* allowing extra of room for the crates. They made the boat wobble to and fro.
c The deck was **large [level]** and spacious. It had recently been fitted on the *barge* allowing extra of room for the crates. They made the boat wobble to and fro.

30
a The shortage of **bread [sugar]** caused real *dread* in the village due to the rationing. Everyone had to cut down a bit.
b The shortage of **bread [sugar]** in the country during the crisis caused real *dread* in the village due to rationing. Everyone had to cut down a bit.
c The shortage of **bread [sugar]** in the country was

(*continued on next page*)

awful. It caused real *dread* in the village due to rationing. Everyone had to cut down a bit.

31

a He vacationed by the **shore [ocean]** but remembered the *chore* he still had to complete. However he decided to leave it until tomorrow.

b He vacationed by the **shore [ocean]** close to the tiny island but remembered the *chore* he still had to complete. However he decided to leave it until tomorrow.

c He vacationed by the **shore [ocean]** close to the tiny island. He remembered the *chore* he still had to complete. However he decided to leave it until tomorrow.

32

a The poor old **whale [goose]** was hit by *shale* that fell off an overhanging cliff. Somebody saw and decided to call a vet.

b The poor old **whale [goose]** which liked to swim in the water was hit by *shale* that fell off an overhanging cliff. Somebody saw and decided to call a vet.

c The poor old **whale [goose]** liked to swim in the water. Sadly it was hit by *shale* that fell off an overhanging cliff. Somebody saw and decided to call a vet.

33

a Leo acted like he was **waking [firing]** up but he was *faking* it since he was still very tired. He'd had a very late night.

b Leo acted like he was **waking [firing]** up and getting ready for work but he was *faking* it since he was still very tired. He'd had a very late night.

c Leo acted like he was **waking [firing]** up and getting ready for work. But he was *faking* it since he was still very tired. He'd had a very late night.

34

a Lucy felt **sick [wild]** but still put a *tick* on her blue attendance sheet for the day. She wanted to try and impress her boss.

b Lucy felt **sick [wild]** from all the white chocolate she ate but she still put a *tick* on her blue attendance sheet for the day. She wanted to try and impress her boss.

c Lucy felt **sick [wild]** from all the white chocolate she ate. But she still put a *tick* on her blue attendance sheet for the day. She wanted to try and impress her boss.

35

a Last Saturday Dan had a **dream [laugh]** about a *bream* swimming in the sea. He'd been fishing the day before.

b Last Saturday Dan had a **dream [laugh]** when he was lying on his sofa about a *bream* swimming in the sea. He'd been fishing the day before.

c Last Saturday Dan had a **dream [laugh]** when he was lying down. It was about a *bream* swimming in the sea. He'd been fishing the day before.

36

a Lily hoped for a quiet **payday [brunch]** but a *mayday* came over the system. She was a bit annoyed but tried to stay calm.

b Lily hoped for a quiet **payday [brunch]** so she could go and relax a bit but a *mayday* came over the system. She was a bit annoyed but tried to stay calm.

c Lily hoped for a quiet **payday [brunch]** so she could relax a bit. However a *mayday* came over the system. She was a bit annoyed but tried to stay calm.

37

a Ed had managed to **retain [locate]** the documents to *detain* these two criminals in custody. He was very proud of himself.

b Ed had managed to **retain [locate]** the important signed documents in order to *detain* these two criminals in custody. He was very proud of himself.

c Ed had managed to **retain [locate]** the important signed documents. He was to *detain* these two criminals in custody. He was very proud of himself.

38

a The pipes began to **swell [shake]** and I started to *dwell* on the big impending problem. I wrote a list of all the things that were wrong.

b The pipes began to **swell [shake]** due to the amount of water and we started to *dwell* on the big impending problem. I wrote a list of all the things that were wrong.

c The pipes began to **swell [shake]** due to the amount of water in them. I began to *dwell* on the big impending problem. I wrote a list of all the things that were wrong.

39

a Andrew found it a **strain [burden]** to negotiate the *strait* at the end of a long voyage. He felt like he just wanted to sleep.

b Andrew found it a **strain [burden]** to negotiate the very challenging and winding *strait* at the end of a long voyage. He felt like he just wanted to sleep.

c Andrew found it a **strain [burden]** to negotiate the boat. He came to the winding *strait* at the end of a long voyage. He felt like he just wanted to sleep.

40

a An admission of **guilt [shame]** to the *guild* meant that he would face punishment. He soon regretted his bad behavior.

b An admission of **guilt [shame]** about the crime that was committed today at the *guild* meant he would face punishment. He soon regretted his bad behavior.

c An admission of **guilt [shame]** was felt by John. The crime he committed at the *guild* meant he would face punishment. He soon regretted his bad behavior.

41

a Ed knew the item was **cheap [vital]** and had to *cheat* to make sure he won the bid. He had wanted the item for a long time.

b Ed knew the item was **cheap [vital]** yet he still could not afford it and had to *cheat* to make sure he won the bid. He had wanted the item for a long time.

c Ed knew the item was **cheap [vital]** yet he still couldn't afford it. He had to *cheat* to make sure he won the bid. He had wanted the item for a long time.

42

a A good supply of **grain [wheat]** was the holy *grail* for the farmer following the poor harvest. The rest of the village were also thankful.

b A good supply of **grain [wheat]** for the harsh winter season was the holy *grail* for the farmer following the poor harvest. The rest of the village were also thankful.

c A good supply of **grain [wheat]** for the winter was vital. It was the holy *grail* for the farmer following the poor harvest. The rest of the village were also thankful.

43

a He walked back to the **tower [guard]** to get his *towel* as he had forgotten it again. On the way back a fox ran past him.

b He walked back to the **tower [guard]** of the castle during his day out to get his *towel* as he had forgotten it again. On the way back a fox ran past him.

c He walked back to the **tower [guard]** of the imposing castle. He wanted to get his *towel* as he had forgotten it again. On the way back a fox ran past him.

44

a Malcolm used a **steel [metal]** bar to *steer* the broken bicycle. He had to get back to his friend's house.

b Malcolm used a **steel [metal]** bar which he had found in a dirty skip to *steer* the broken bicycle. He had to get back to his friend's house.

c Malcolm used a **steel [metal]** bar which he had found. He used it to *steer* the broken bicycle. He had to get back to his friend's house.

45

a The inexperienced **scout [troop]** helped to *scour* the very wet countryside for the lost dog. After a while there was a heavy downpour.

b The inexperienced **scout [troop]** who had just finished a nice lunch helped to *scour* the very wet countryside for the lost dog. After a while there was a heavy downpour.

c The inexperienced **scout [troop]** had just finished a nice lunch. He helped to *scour* the very wet countryside for his lost dog. After a while there was a heavy downpour.

46

a The students had a late **start [class]** and showed a *stark* contrast in talent. They couldn't wait to finish school for the day.

b The students had a late **start [class]** at the community school and showed a *stark* contrast in talent. They couldn't wait to finish school for the day.

c The students had a late **start [class]** at the community school. They showed a *stark* contrast in talent. They couldn't wait to finish school for the day.

47

a The larder where I keep the **cream [seeds]** opens with a *creak* as it is rarely used. I needed the ingredients to make a dessert.

b The larder where I keep the **cream [seeds]** contains a lot of foods and opens with a *creak* as it is rarely used. I needed the ingredients to make a dessert.

c The larder where I keep the **cream [seeds]** contains a lot of foods. It opens with a *creak* as it is rarely used. I needed the ingredients to make a dessert.

48

a Tom designed the **advert [poster]** using the *adverb* his clients had requested. The owner of the company really liked the design.

b Tom designed the **advert [poster]** for a new Ferrari and made sure to use the *adverb* his clients had requested. The owner of the company really liked the design.

c Tom designed the **advert [poster]** for a new Ferrari. He made sure to use the *adverb* that his clients had requested. The owner of the company really liked the design.

49

a Everything became **blank [noisy]** after the *bland* meal which had been served for dinner. Despite that everyone had a nice evening.

b Everything became **blank [noisy]** and we all started to complain after the *bland* meal which had been served for dinner. Despite that everyone had a nice evening.

c Everything became **blank [noisy]** and we started to complain. We hated the *bland* meal which had been served for dinner. Despite that everyone had a nice evening.

(*continued on next page*)

50

a Paul rested by the **stream [border]** and saw a *streak* of light flash through the sky. This was followed by a clap of thunder.

b Paul rested by the **stream [border]** during a day out in the village and saw a *streak* of light flash through the sky. This was followed by a clap of thunder.

c Paul rested by the **stream [border]** during a day out in the village. He saw a *streak* of light flash through the sky. This was followed by a clap of thunder.

51

Sue made scans of the **brain [teeth]** while twisting the *braid* in her hair. She wanted to become a surgeon.

Sue made scans of the **brain [teeth]** in her fancy laboratory while twisting the *braid* in her hair. She wanted to become a surgeon.

Sue made scans of the **brain [teeth]** in her laboratory. She began twisting the *braid* in her hair. She wanted to become a surgeon.

52

a It's difficult to **train [teach]** any dog with the *trait* of laziness in its breed. The dog received a bone after learning a trick.

b It's difficult to **train [teach]** any type of dog which was born with the *trait* of laziness in its breed. The dog received a bone after learning a trick.

c It's difficult to **train [teach]** any type of dog. Certainly those with the *trait* of laziness in its breed. The dog received a bone after learning a trick.

53

a Due to the **steam [fence]** the thief could *steal* the car even without being noticed. The neighbors then phoned the police.

b Due to the **steam [fence]** the thief and his good-for-nothing accomplice could *steal* the car even without being noticed. The neighbors then phoned the police.

c Due to the **steam [fence]** the thief and his mate could easily hide. They could *steal* the car even without being noticed. The neighbors then phoned the police.

54

a Matt's eyes started to **gleam [shine]** when he could *glean* all the key information from the text. He wanted to work hard to pass his exam.

b Matt's eyes started to **gleam [shine]** when he was reading this book as he could *glean* all the key information from the text. He wanted to work hard to pass his exam.

c Matt's eyes started to **gleam [shine]** when he was reading this book. He could *glean* all the key information from the text. He wanted to work hard to pass his exam.

55

a The morning's thin **sheet [cover]** of snow left a *sheen* to the new pavement that brightened the day. It then began to feel like Christmas.

b The morning's thin **sheet [cover]** of snow which was not predicted to fall left a *sheen* to the new pavement that brightened the day. It then began to feel like Christmas.

c The morning's thin **sheet [cover]** of snow was not predicted to fall. It left a *sheen* to the new pavement that brightened the day. It then began to feel like Christmas.

56

a Behind the camel he was about to **mount [climb]** was a *mound* of big and smelly droppings he needed to avoid. The sun was burning strongly.

b Behind the camel he was about to **mount [climb]** in order to cross the desert was a *mound* of big and smelly droppings he needed to avoid. The sun was burning strongly.

c Behind the camel he was about to **mount [climb]** was a rather large pile. It was a *mound* of big and smelly droppings he needed to avoid. The sun was burning strongly.

57

a The actor was able to **swoop [sneak]** in and make her *swoon* with desire as he caught her. He had the reputation of being a ladies' man.

b The actor was able to **swoop [sneak]** in behind the make-up girl and make her *swoon* with desire as he caught her. He had the reputation of being a ladies' man.

c The actor was able to **swoop [sneak]** in behind the make-up girl. It made her *swoon* with desire as he caught her. He had the reputation of being a ladies' man.

58

a Ella attempted to balance the **plant [block]** on a *plank* of wood but this was not a good idea at all. The wood turned out to be rotten.

b Ella attempted to balance the **plant [block]** that was a deep green and red on a *plank* of wood but this was not a good idea at all. The wood turned out to be rotten.

c Ella attempted to balance the **plant [block]** that was orange. She placed it on a *plank* of wood but this was not a good idea at all. The wood turned out to be rotten.

59

a The earthquake shook the **roof [bush]** and caused the *rook* to take off into the sky. The ground then shook vigorously.

b The earthquake shook the **roof [bush]** because it was so forceful and caused the *rook* to take off

into the sky. The ground then shook vigorously.
c The earthquake shook the **roof [bush]** because it was so forceful. It caused the *rook* to take off into the sky. The ground then shook vigorously.

60
a Lee didn't laugh at the **queen [owner]** who was wearing a *queer* hat for the event. The event was to raise money for a good cause.
b Lee didn't laugh at the **queen [owner]** who had just arrived by car wearing a *queer* hat for the event. The event was to raise money for a good cause.
c Lee didn't laugh at the **queen [owner]** who had just arrived. She was wearing a *queer* hat for the event. The event was to raise money for a good cause.

Appendix B

See Tables B1 and B2.

Table B1
Linear and generalized linear mixed-effects analyses of Experiment 1.

	Target			Spill		
	Estimate	*SE*	*t/z*	Estimate	*SE*	*t/z*
Gaze duration						
Prime	No significant improvement ($p > .29$)			No significant improvement ($p > .91$)		
Set	No significant improvement ($p > .57$)			No significant improvement ($p > .11$)		
Interaction	$\chi^2(3) = 7.87, p < .05$			No significant improvement ($p > .15$)		
(intercept)	284.6	15.6	18.3			
Set2	13.5	14.2	0.9			
Set3	9.7	14.2	0.7			
Set4	13.3	14.2	0.9			
Prime	22.5	10.5	2.1			
Prime:Set2	−36.5	14.9	−2.5			
Prime:Set3	−25.5	14.8	−1.7			
Prime:Set4	−5.7	14.9	−0.4			
Priming effect in individual sets						
O+P+(end)	$\chi^2(1) = 5.17, p < .05$			No significant improvement ($p > .31$)		
(intercept)	283.5	16.4	17.3			
Prime	23.3	10.2	2.3			
O+P+(begin)	No significant improvement ($p > .16$)			No significant improvement ($p > .20$)		
O+P−	No significant improvement ($p > .74$)			No significant improvement ($p > .58$)		
O−P+	No significant improvement ($p > .17$)			No significant improvement ($p > .69$)		
Regressions						
Prime	No significant improvement ($p > .79$)			$\chi^2(1) = 3.41, p < .07$		
(intercept)				−2.1	0.1	−17.4
Prime				0.2	0.1	1.9
Set	No significant improvement ($p > .96$)			No significant improvement ($p > .17$)		
Interaction	No significant improvement ($p > .91$)			No significant improvement ($p > .51$)		
Priming effect in individual sets						
O+P+(end)	No significant improvement ($p > .90$)			No significant improvement ($p > .34$)		
O+P+(begin)	No significant improvement ($p > .84$)			$\chi^2(1) = 3.40, p < .07$		
(intercept)				−2.0	0.2	−9.8
Prime				0.4	0.2	1.9
O+P−	No significant improvement ($p > .78$)			No significant improvement ($p > .82$)		
O−P+	No significant improvement ($p > .49$)			No significant improvement ($p > .36$)		
Regression-path duration						
Prime	No significant improvement ($p > .84$)			No significant improvement ($p > .10$)		
Set	No significant improvement ($p > .86$)			$\chi^2(3) = 8.99, p < .05$		
(intercept)				393.2	28.0	14.0
Set2				86.8	29.6	2.9
Set3				22.5	29.6	0.8
Set4				40.6	29.7	1.4
Interaction	$\chi^2(3) = 8.34, p < .05$			No significant improvement ($p > .11$)		
(intercept)	345.4	28.1	12.3			
Set2	46.7	25.9	1.8			
Set3	47.9	25.8	1.9			
Set4	47.9	25.9	1.9			
Prime	49.3	20.9	2.4			
Prime:Set2	−73.5	29.6	−2.5			
Prime:Set3	−70.9	29.5	−2.4			
Prime:Set4	−61.8	29.6	−2.1			

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Table B1 (*continued*)

	Target			Spill		
	Estimate	*SE*	*t/z*	Estimate	*SE*	*t/z*
Priming effect in individual sets						
O+P+(end)	$\chi^2(1) = 8.17$, $p < .01$			No significant improvement ($p > .78$)		
(intercept)	343.8	28.4	12.1			
Prime	49.9	16.6	3.0			
O+P+(begin)	No significant improvement ($p > .38$)			$\chi^2(1) = 4.62$, $p < .05$		
(intercept)				450.1	34.3	13.1
Prime				64.8	29.0	2.2
O+P−	No significant improvement ($p > .27$)			No significant improvement ($p > .82$)		
O−P+	No significant improvement ($p > .60$)			No significant improvement ($p > .42$)		
Total time						
Prime	No significant improvement ($p > .43$)			No significant improvement ($p > .71$)		
Set	No significant improvement ($p > .83$)			$\chi^2(3) = 12.65$, $p < .01$		
(intercept)				385.7	27.9	13.8
Set2				100.4	28.5	3.5
Set3				27.2	28.6	0.9
Set4				39.7	28.6	1.4
Interaction	No significant improvement ($p > .35$)			No significant improvement ($p > .50$)		
Priming effect in individual sets						
O+P+(end)	No significant improvement ($p > .07$)			No significant improvement ($p > .42$)		
O+P+(begin)	No significant improvement ($p > .56$)			No significant improvement ($p > .44$)		
O+P−	No significant improvement ($p > .95$)			No significant improvement ($p > .52$)		
O−P+	No significant improvement ($p > .79$)			No significant improvement ($p > .50$)		

Notes. Set refers to the different overlap sets: Set 1 = O+P+(*end*), Set 2 = O+P+(*begin*), Set 3 = O+P−, Set 4 = O−P−. The values from the linear mixed-effect comparisons are *t*-values, those from the generalized mixed-effect comparisons (for the regression data) are Wald *z*-values. A *t*/*z* value > 2.0 is considered significant.

Table B2
Linear and generalized linear mixed-effects analyses of Experiment 2.

	Target			Spill		
	Estimate	*SE*	*t/z*	Estimate	*SE*	*t/z*
Single fixation duration						
Prime	No significant improvement ($p > .84$)			No significant improvement ($p > .34$)		
Interaction	$\chi^2(2) = 6.04$, $p < .05$			No significant improvement ($p > .33$)		
(intercept)	221.9	5.6	39.6			
Prime	10.0	5.5	1.8			
Long-1	8.8	5.5	1.6			
Long-2	7.6	5.5	1.4			
Prime:Long-1	−13.0	7.8	−1.7			
Prime:Long-2	−18.5	7.7	−2.4			
Priming effect in individual conditions						
Short	$\chi^2(1) = 3.76$, p = .053			$\chi^2(1) = 2.70$, p = .10		
(intercept)	222.3	5.9	37.9	229.7	7.5	30.8
Prime	10.2	5.1	2.0	14.0	8.4	1.7
Long-1	No significant improvement ($p > .60$)			No significant improvement ($p > .71$)		
Long-2	No significant improvement ($p > .11$)			No significant improvement ($p > .86$)		
First fixation duration						
Prime	No significant improvement ($p > .27$)			No significant improvement ($p > .23$)		
Interaction	$\chi^2(2) = 6.37$, $p < .05$			No significant improvement ($p > .16$)		
(intercept)	219.8	5.2	41.9			
Prime	11.8	5.0	2.4			
Long-1	6.8	5.0	1.4			
Long-2	7.3	5.0	1.5			
Prime:Long-1	−9.0	7.1	−1.3			
Prime:Long-2	−17.7	7.0	−2.5			
Priming effect in individual conditions						
Short	$\chi^2(1) = 6.40$, $p < .05$			$\chi^2(1) = 3.85$, $p < .05$		
(intercept)	219.8	5.4	40.4	222.9	6.1	36.6
Prime	11.9	4.7	2.6	13.2	6.7	2.0
Long-1	No significant improvement ($p > .60$)			No significant improvement ($p > .80$)		
Long-2	No significant improvement ($p > .25$)			No significant improvement ($p > .74$)		

Table B2 (*continued*)

	Target			Spill		
	Estimate	*SE*	*t/z*	Estimate	*SE*	*t/z*
Regressions						
Prime	No significant improvement ($p > .15$)			$\chi^2(1) = 3.10$, $p < .08$		
(intercept)				−1.5	0.1	−11.3
Prime				0.2	0.1	1.8
Interaction	$\chi^2(2) = 6.14$, $p < .05$			No significant improvement ($p > .25$)		
(intercept)	−1.6	0.2	−9.7			
Prime	−0.5	0.2	−2.8			
Long-1	−0.1	0.2	−0.7			
Long-2	0.1	0.2	−0.3			
Prime:Long-1	0.6	0.3	2.4			
Prime:Long-2	0.5	0.3	1.8			
Priming effect in individual conditions						
Short	$\chi^2(1) = 7.66$, $p < .01$			$\chi^2(1) = 5.26$, $p < .05$		
(intercept)	−1.7	0.2	−9.2	−1.4	0.2	−8.4
Prime	−0.6	0.2	−2.9	0.4	0.2	2.4
Long-1	No significant improvement ($p > .56$)			No significant improvement ($p > .76$)		
Long-2	No significant improvement ($p > .68$)			No significant improvement ($p > .72$)		
Regression-path duration						
Prime	No significant improvement ($p > .42$)			$\chi^2(1) = 2.98$, $p < .09$		
Interaction	No significant improvement ($p > .11$)			No significant improvement ($p > .11$)		
Priming effect in individual conditions						
Short	No significant improvement ($p > .22$)			$\chi^2(1) = 5.04$, $p < .05$		
(intercept)				449.6	25.9	17.3
Prime				53.8	23.6	2.3
Long-1	No significant improvement ($p > .17$)			No significant improvement ($p > .55$)		
Long-2	No significant improvement ($p > .11$)			No significant improvement ($p > .29$)		
Total time						
Prime	No significant improvement ($p > .09$)			$\chi^2(1) = 4.25$, $p < .05$		
(intercept)	345.8	15.3	22.7	376.4	18.0	20.9
Prime	12.7	7.4	1.7	18.8	8.9	2.1
Interaction	No significant improvement ($p > .96$)			No significant improvement ($p > .39$)		
Priming effect in individual conditions						
Short	No significant improvement ($p > .23$)			$\chi^2(1) = 4.10$, $p < .05$		
(intercept)				394.9	21.2	18.7
Prime				28.2	13.9	2.0
Long-1	No significant improvement ($p > .40$)			No significant improvement ($p > .87$)		
Long-2	No significant improvement ($p > .40$)			$\chi^2(1) = 3.37$, $p < .07$		
(intercept)				375.7	18.8	20.0
Prime				25.2	13.5	1.9

Notes. Short, Long-1, and Long-2 refers to the distance between the prime and the target word: Short distance (in the same sentence), Long-1: longer distance with the prime and target in the same sentence, Long-2: longer distance with the prime and target in separate sentences. The values from the linear mixed-effect comparisons are *t*-values, those from the generalized mixed-effect comparisons (for the regression data) are Wald *z*-values. A *t/z* value > 2.0 is considered significant.

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