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Processing Contextual and Lexical Cues to Focus: Evidence from Eye Movements in Reading

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Abstract

Three eye movement experiments investigated the interaction between contextual and lexical focus cues during reading. Context was used to focus on either the indirect or direct object of a double object construction, which was followed by a remnant continuation that formed either a congruous or incongruous contrast with the contextually-focused object. Experiment 1 demonstrated that remnants were more difficult to process when incongruous with the contextually-focused constituent, indicating that context was effective in specifying focus. Experiments 2 and 3 investigated the interaction between context and lexical focus arising from the particle *only* which specifies focus on the subsequent adjacent element. When *only* preceded both objects (Experiment 2), the conflict between lexical and contextual focus cues disrupted processing of the remnant element and was resolved in favor of the contextually-focused element. However, when *only* was placed between both objects (Experiment 3), cue-conflict disrupted processing earlier in the sentence, but did not appear to be fully resolved during on-line sentence processing. These findings reveal that the interplay between contextual and lexical cues to focus is important for establishing focus structure during on-line sentence processing.

Key words: Focus particles; discourse processing; sentence processing; eye movements while reading.

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The term *focus* has been used as a general term for the assignment of prominence by prosodic and syntactic means to mark new information or to contrast the focused element(s) with a set of alternatives (Birch & Rayner, 1997, 2010; Breen, Fedorenko, Wagner, & Gibson, 2010; Chomsky, 1971; Halliday, 1967; Ito & Speer, 2008; Jackendoff, 1972; Katz & Selkirk, submitted; Kiss, 1998; Pierrehumbert & Hirschberg, 1990; Rochemont & Culicover, 1990; Rooth, 1992, 1996; Selkirk, 1995;; Ward, Birner, & Huddleston, 2005; Watson, Tannenhaus, & Gunlogson, 2008). Expectations of the focus structure of a sentence can be modified by context (e.g., Beaver & Clark, 2008; Chomsky, 1971; Kadmon, 2001; see also Cowles, Klunder, Kutas, & Polinsky, 2007; Dimitrova, Stowe, Redeker, & de Hoeks, 2010a) and by focus-sensitive particles like *only* (e.g., Dimitrova, Stowe, Redeker, & Hoeks, 2010b; Paterson, Liversedge, Filik, Juhasz, White, & Rayner, 2007). Accordingly, prosodic, syntactic, contextual and lexical factors influence the focus structure of a sentence and may be seen as cues to focus which may interact during sentence processing.

The experiments reported in this paper were conducted to investigate the interaction between contextual and lexical cues to focus during reading comprehension and to provide further insights into (i) the interaction between discourse-level and sentence-level cues to focus, especially if they are in conflict, and (ii) the "resolution" of conflicts between different focus cues. Findings from this research will extend our knowledge of the computation and processing of the focus structure of a sentence during reading, but are also likely to be informative about broader issues concerning the influence of discourse context on sentence processing (e.g., Altmann & Steedman, 1988; Frazier, 1987, 1999; Grodner, Gibson & Watson, 2005).

The use of focus to mark new and contrastive information is illustrated in the question-answer dialogue in (1a-c), where the F-subscript indicates that the expression in brackets is in focus. In (1a), all constituents in the answer are focused, whereas in (1b) and (1c) only the direct object (*the apples*) is in focus.

1a. Q: What happened? A: [Sally gave the children the apples]$_F$.

1b. Q: What did Sally gave the children? A: Sally gave the children [the apples]$_F$.

1c. Q: Sally gave the children the cherries? A: (No), Sally gave the children [the apples]$_F$.

Focus in (1a) is considered to be information focus, as it serves merely to mark new information (e.g., Kiss, 1998; Selkirk, 2008; but see Krifka, 2008). However, (1c) is an instance of contrastive focus, where the new information in the answer provides an alternative to the given information in the question. In this example, the focused element (*the apples*) highlights a set of alternatives (e.g., apples or cherries) that Sally could give the children. Focus in the answer in (1b) is usually taken to be information focus, although it may also be seen as contrastive focus (e.g., Kiss, 1998; Zimmermann, 2008).

Focus that is prosodically and syntactically marked can influence sentence interpretation (Carlson, 2001; Carlson, Dickey, Frazier, & Clifton, 2009a; Schafer, Carlson, Clifton, & Frazier, 2000) and has diverse processing benefits which concern (speech) perception (Birch & Clifton, 1995, 2002; Bock & Mazzella, 1983; Cutler & Fodor, 1979; Hornby, 1974; Noteboom & Kruyt, 1987; Terken & Noteboom, 1987), memory (Birch, Albrecht, & Myers, 2000; Birch & Garnsey, 1995; Malt, 1985; Morris & Folk, 1998; Osaka, Nishizaki, Komori, & Osaka, 2002; Singer, 1976; Ward & Sturt, 2007), and attention (Bredart & Modolo, 1988; Carpenter & Just, 1977; Engelkamp & Zimmer, 1982; Klin, Weingartner, Guzmán, & Levine, 2004; Sturt, Sanford, Stewart & Dawydiak, 2004; Zimmer & Engelkamp, 1981). Indeed, it has been argued that because attention is immediately directed to focused material, focus may have a central and immediate role in organizing the interpretative processes carried out during sentence comprehension (Frazier, 1999).

Focus-sensitive particles like *only* often lexicalize contrastive focus (e.g., Jackendoff, 1972; Kadmon, 2001; König, 1991). These words "associate" with focus, meaning that they usually specify a contrast between a focused element and its alternatives (e.g., Jackendoff, 1972; Krifka, 2008; Rooth, 1992). The examples in (2) and (3) illustrate how focusing different constituents can affect the interpretation of sentences that contain the particle *only*.

2. Mary only introduced [Bill]$_F$ to Sue.

3. Mary only introduced Bill to [Sue]$_F$.

The direct object (*Bill*) is focused in (2) and the indirect object (*Sue*) is focused in (3). If *only* associates with the focused constituent, (2) will mean that Bill alone was introduced to Sue, while (3) will mean that Bill was introduced to no-one other than Sue. It has been argued that syntactic constraints require *only* to associate with a constituent within the particle's syntactic domain (e.g., Jackendoff, 1972; Reinhart, 2006). In (2) and (3) the syntactic domain is the verbal phrase (i.e., *introduced Bill to Sue*) and *only* may associate with the direct object (*Bill*), indirect object (*Sue*), or verb phrase (*introduced Bill to Sue*), but not the subject noun (*Mary*), even if this is focused (but see Brennan, 2008; Ross & Cooper, 1979). As the focused constituent is expected to occur in the syntactic domain of *only*, the particle may be seen to cue focus to its adjacent constituent.

Previous experimental research has investigated the acquisition of the focus particle (e.g. Crain, Ni, & Conway, 1994; Paterson, Liversedge, Rowland, & Filik, 2003; Paterson, Liversedge, White, Filik, & Jaz, 2006; Philip & Lynch, 1999), its influence on sentence processing (e.g., Clifton, Bock, & Rado, 2000; Filik, Paterson, & Liversedge, 2005; Liversedge, Paterson, & Clayes, 2002; Ni, Crain, & Shankweiler, 1996; Paterson, Liversedge, & Underwood, 1999; Sedivy, 2002; for a review, see Filik, Paterson, & Sauermann, 2011), and the factors governing association with focus (Gennari, Meroni, & Crain, 2004; Paterson et al., 2007; see also Filik, Paterson, & Liversedge, 2009).

Of these, Paterson et al.'s (2007) study is particularly relevant for the present research. It used measures of eye movements during reading to investigate the influence of syntactic constraints on the interpretation of the particle *only* during normal reading. Paterson et al. (2007) examined constructions like (4a-c), in which a remnant element in the second conjunct (*her father/the pepper*) of a sentence forms an appropriate contrast with a constituent in the first conjunct. Remnant elements are usually analyzed as contrastively focused remnants of an elliptic construction and, due to parallelism effects, tend to be congruous with a focused constituent in the first conjunct (e.g.,

Drubig, 1994; Konietzko & Winkler, 2010; Winkler, 2005).

4a. At dinner, Jane passed her mother the salt but not (her father/the pepper) as well because she couldn't reach.

4b. At dinner, Jane passed only her mother the salt but not (her father/the pepper) as well because she couldn't reach.

4c. At dinner, Jane passed her mother only the salt but not (her father/the pepper) as well because she couldn't reach.

For constructions without *only* (4a), no reading time differences were observed at the remnant region (*but not her father/the pepper*) or the post-remnant region (*as well because*), indicating that, in the absence of the particle, remnant elements formed an appropriate contrast with both grammatical objects. For constructions with *only*, however, reading times were shorter for remnants that were congruous with the indirect than direct object when *only* preceded the indirect object (4b) and, conversely, shorter for remnants congruous with the direct than indirect object when *only* preceded the direct object (4c), although the congruency effect was stronger for the constructions in (4c) than in (4b). These effects were not observed at the remnants themselves but at the post-remnant region. This delay was attributed to time-consuming inferential processes needed to evaluate the congruency of the supplied contrast and the lexically focused constituent. Nevertheless, it was clear that contrastive focus is computed during comprehension sufficiently rapidly for its referential consequences to affect sentence processing.

Paterson et al. (2007) showed that the focus particle was preferably associated with the adjacent subsequent constituent, and argued that the constructions in (4b) and (4c) are syntactically ambiguous, with preferred parses in which the particle can only associate the adjacent subsequent object and alternative parses in which it may also associate the non-adjacent object or the preceding object. Crucially, the preference of *only* to associate with the adjacent subsequent object indicates that *only* may be seen as cueing focus to this constituent in constructions like (4b) and (4c).

While focus is marked at the sentence level by prosodic and syntactic means, context has been used to assess and modify the focus structure of a sentence (e.g., Chomsky, 1971; Jackendoff, 1972; Kadmon, 2001; Rochemont & Culicover 1990; Rooth, 1996). In line with this approach, it has been argued that the semantics of questions is important for a theory of focus: a *wh*-question sets the background for an answer, which, in turn, determines the focus of the answer (see Hamblin, 1973; von Stechow, 1991). The relationship between context and the focus structure of subsequent sentences is illustrated in the examples in (1a-c) above. In a broad question context like (1a) the question *What happens*? places the complete answer to the questions, i.e., *Sally gave the children the apples*, in focus. In the narrow focus context in (1b) the question *What did Sally give the children?* defines the part of the answer that substitutes *what*, i.e., *the apples*, in focus and the remaining parts of the answer (*Sally gave the children x*) as background. The influence of prior interrogative context on focus processing has also been demonstrated empirically by Birch and Rayner (1997; Experiment 2), who conducted an eye movement experiment in which interrogative contexts were used to focus on various constituents within a target sentence. Birch and Rayner found readers spent longer reading focused parts of target sentences than unfocused parts, and took this as evidence that context can modulate focus, and that this, in turn, can influence eye movement behavior.

Other research has shown that sentence processing is disrupted when the focus structure of the target sentence is unexpected or infelicitous in a given context (Cowles et al., 2007; Dimitrova et al., 2010a). This research supports claims that focus is marked on the sentence-level, e.g., in terms of syntax and prosody, while context may modify expectations of the focus structure of an upcoming sentence (e.g., Beaver & Clark, 2008; Cowles et al., 2007). It remains to be determined, however, how expectations of the focus structure triggered by context may interact with the default focus structure (Carlson, Dickey, Frazier, & Clifton, 2009a; Stohlterfoht, Friederici, Alter, & Steube, 2007; see also Selkirk, 1995) or the given-before-new preference (Arnold, Wasow, Losongco, & Ginstrom, 2000; Bresnan, Cueni, Nikitina, & Baayen, 2007; Clifton & Frazier, 2004). Since context modifies

expectations of the focus structure, it may be seen as a cue to focus. Accordingly, sentence-level focus marking and context may be operationalized as different cues to focus which may either agree, i.e. cue focus on the same constituent, or disagree, and therefore specify focus on different constituents.

Previous research has tended to either investigate the resolution of conflicts between focus cues or the detection of cue conflicts. The self-paced reading study by Carlson (2004), investigated sentences like *Apparently, (only) the judge joined (only) the diplomat for coffee, not the senator*, in which the focus particle and interrogative contexts (e.g., *The newspapers were particularly interested in who stayed around for coffee with the diplomat*. vs. *The newspapers were particularly interested in who the judge stayed around to have coffee with afterwards*) each cued focus to either the subject or the direct object. Reading times were higher for the remnant (e.g., *not the senator*) when lexical and contextual cues were in conflict, indicating that cue-conflict can disrupt processing, and sentence-final questions revealed that the cue conflict was not resolved. An ERP study by Cowles et al. (2007), which investigated the interaction between context and syntactic focus in *it*-clefts during reading, showed that the processing of the clefted element was disrupted when a preceding interrogative context did not specify focus on the clefted element. Similarly, Dimitrova et al. (2010b) report an auditory ERP study on Dutch double object constructions (e.g., *They gave only a bonus to the player.*) in which the focus particle cued focus on *a bonus*. Prosodic focus was marked by placing a pitch accent on either the adjacent object (e.g., *a bonus*) or the non-adjacent object (e.g., *to the player*). Violations of expected focus structure (*They gave only a bonus [to the PLAYER]$_F$.*) affected processing at the prosodically focused object (i.e., *to the player*). However, while the studies by Cowles et al. (2007) and Dimitrova et al. (2010b) are informative about the time course of the impact of focus conflict on sentence processing, they do not show whether and how this cue-conflict is resolved. As eye moments have been widely used to investigate the real-time processing of syntactic and focus effects in previous research (e.g., Birch & Rayner, 1997; 2010; Paterson et al., 2007), it

will be of considerable interest to determine how these effects influence eye movements while reading.

The present study investigated the interaction between contextual and lexical cues in double object constructions like those used by Paterson et al. (2007). Interrogative contexts were used to modify expectations about focus structure, i.e., by specifying focus on either the indirect or direct object. At the sentence level, focus structure was modified by the presence of the particle *only*, which preceded either the indirect object (Experiment 2) or the direct object (Experiment 3), or was absent (Experiment 1). In each experiment, the ditransitive sentence was continued by a remnant continuation that supplied a contrast that was congruous with either the direct or indirect object. Example stimuli are shown in Table 1. Reading times for the objects (region 3) were taken to indicate whether different focus cues interact early during the computation of focus structure. Reading times for the remnant and post-remnant region (region 4 and 5) were taken to indicate whether a cue-conflict is resolved with a preference for the upcoming remnant element.

----------Table 1 here----------

In Experiment 1, the focus particle was not present so that the focus structure was not explicitly marked at the sentence-level. Accordingly, remnant elements are expected to be congruous with the contextually-focused object because this is the only focus marked constituent.

In Experiments 2 and 3, contextual and lexical cues may specify focus on two different constituents, leading to a conflict between focus cues. Detection of cue-conflict will be revealed by higher reading times in cue-conflict than cue-match conditions. The findings by Cowles et al. (2007) and Dimitrova et al. (2010b) from ERP studies indicate this may happen quite early in processing, and in the present experiment this may be observed as early as in region 3, the objects region.

Reading times in the remnant and post-remnant region will indicate whether cue-conflict is resolved. That is, a preference for remnants that are congruous with either the contextually or lexically-focused object in the cue-conflict condition will indicate that this conflict was resolved and

readers had clear preferences concerning the contrast at the remnant element. In contrast to Carlson (2004), the present study modifies the remnant element itself to determine remnant preferences during online processing and investigates constructions in which the location of the focus particle may introduce an ambiguity. That is, if the double object constructions are syntactically ambiguous (as argued by Paterson et al., 2007), cue-conflict may lead to a revision of the syntactic structure and cause the focus particle to associate with the dispreferred constituent, in which case reading times will be shorter for the contextually-focused constituent.

Experiment 1

Experiment 1 investigated the influence of interrogative contexts on the processing of elliptical remnant constructions that did not include *only* (see examples in 5).

5a. *Focus on indirect object (IO-context), congruous remnant*

John wondered who Sally would pass the apples. $_1$| Sally passed $_2$| the children the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

5b. *Focus on indirect object (IO-context), incongruous remnant*

John wondered who Sally would pass the apples. $_1$| Sally passed $_2$| the children the apples $_3$| but not the cherries $_4$ |, because $_5$ | they did not want them.

5c. *Focus on direct object (DO-context), congruous remnant*

John wondered what Sally would pass the children. $_1$| Sally passed $_2$| the children the apples $_3$| but not the cherries $_4$|, because $_5$| they did not want them.

5d. *Focus on direct object (DO-context), incongruous remnant*

John wondered what Sally would pass the children. $_1$| Sally passed $_2$| the children the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

Reading times in region 3, the objects region, will give the first indication of processing of focus structure and thus may indicate whether the processing of the focus structure imposed by the interrogative contexts interacts with the "given-before-new" preference (Arnold et al., 2000; Bresnan

et al., 2007; Clifton & Frazier, 2004). If this is the case, longer reading times are expected when the objects follow the "new-before-given" order, than when they follow the "given before new" order. That is, longer reading times would be expected when context specifies focus on the indirect object (IO-context), than when context specifies focus on the direct object (DO-context).

Reading times in regions 4 and 5, the remnant and post-remnant region, will show whether context successfully modified the focus structure of the double object construction. Previous research has shown that sentence processing is disrupted when a remnant element supplies a contrast that is incongruous with the focused constituent (Carlson, 2001; Paterson et al., 2007; but see Carlson et al., 2009a). Therefore, if prior interrogative context influences the focus structure of the double object sentences, processing should be disrupted when the remnant is incongruous with the constituent that is contextually-focused (5b vs. 5a and 5d vs. 5c). Paterson et al. (2007) showed that disruption may be observed one or two words following the remnant element when *only* is used to lexically specify contrastive focus. Disruption to sentence processing in the current experiment may therefore be evident in longer reading times for the remnant region (*but not the grownups/the cherries*) or for a post-remnant region comprising the following word (*because*) in the sentence, with reading times in the remnant region revealing more immediate effects.

Method

Participants. Twenty-four undergraduate Psychology students from the University of Leicester participated for course credit. Participants were native English speakers and had normal or corrected to normal vision.

Materials & Design. Thirty-two experimental items were constructed (see Appendix). Each trial began with an interrogative context sentence followed by a target sentence containing a remnant elliptic double object construction and a subordinate clause introduced by *because* (see 6). Focus was modified by interrogative wh-question contexts, with IO-contexts focusing the indirect object (5a and 5b) and DO-contexts focusing the direct object (5c and 5d). The remnant region supplied a contrast

that was either congruous (5a, 5c) or incongruous (5b, 5d) with the focused element. Thus, two factors were manipulated; Context (IO-context or DO-context), and Remnant Congruency (the remnant was congruous or incongruous with the contextually-focused constituent).

Apparatus & Procedure. A Fourward Technologies Dual Purkinje Image Generation 6 eye-tracker in the University of Leicester eye-tracking laboratory was used to record participants' right eye movements during reading. The eye-tracker has an angular resolution of 10 min of arc and was interfaced with a PC that sampled fixation position every millisecond. Sentences were presented as white text on a black background in Courier font on a 17-inch monitor. At the 80 cm viewing distance used in the experiment, three characters subtended approximately 1 degree of visual angle. Before the start of the experiment, participants received an explanation of the procedure. Participants were then seated at the eye-tracker and a bite-bar was used to minimize head movements. A calibration procedure was then completed. Before the start of each trial, a fixation box the same size as one alphabetic character appeared in the upper left quadrant of the screen. When participants fixated this box, the experimenter initiated the presentation of a sentence, with the first character of the text replacing the fixation box. The eye-tracker was re-calibrated if participants' fixations did not match the fixation box. On each trial, the context and target sentence was displayed on the screen as a short double-spaced passage of text. Each text presentation was followed by a two-alternative forced choice question that tested the participant's comprehension of the text (for example, *Did John pass anything to the children?*). Participants answered the questions by pressing the button corresponding to the correct answer on a button box. Software developed at the University of Massachusetts was used to present stimuli and acquire data and to compute reading time measures.[1] The presentation of experimental items was counterbalanced using a Latin square design so that each participant read only one condition of each item and read an equal number of items in each experimental condition. The experimental items were presented in a pseudo-random order together with 60 fillers, including items from unrelated experiments.

Results

Regions of Analysis. Analyses were performed for three scoring regions (see Table 1): region 3 (the objects region), region 4 (the remnant region), and region 5 (a post-remnant region comprising the word *because*). Prior to the analysis of the eye movement data, an automatic procedure incorporated fixations less than 80 ms into larger fixations within one character and deleted fixations less than 40 ms not within three characters of another fixation. Fixations over 1200 ms were truncated. In addition, trials on which sentences were not read fully or that had tracker loss were eliminated by deleting trials in which no first-pass fixations were made in two adjacent regions. These procedures, which were applied to regions 1-5, accounted for 10% of trials. Accuracy for the comprehension questions was high, above 90%, indicating that participants had read and fully understood the sentences.

A range of standard eye movement measures was then computed for each scoring region (see Rayner, 1998; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989). For each region, we report first-pass reading times (summed duration of all fixations from first fixating within a region before a saccade from it - referred to as gaze duration for regions containing only one word, such as the post-remnant region in the present experiment), total reading times (summed duration of all fixations in a region), and regression-path reading times (summed duration of all fixations from the time a region is first entered from the left until it is first exited to the right). Regression-path reading time (also called go-past reading times; Konieczny, Hemforth, Scheepers, & Strube, 1997; Liversedge, Paterson, & Pickering, 1998; Rayner & Duffy, 1986) includes fixations made to re-inspect earlier portions of text and provides an indication of early processing difficulty along with time spent re-inspecting text to recover from such difficulty (e.g., Liversedge et al., 1998; Rayner & Duffy, 1986). Analyses of reading times for each region excluded trials in which no fixations were made within that region and where reading times were above 5000 ms.

Analysis. Linear mixed-effects models (LME) were used to conduct inferential statistical

analyses, using the lmer function of the lme4 package (Bates, Maechler, & Dai, 2009) provided in the R environment (R Development Core Team, 2009), and were calculated for log-transformed and untransformed data. These analyses correspond to regression models that take into account variations due to participants and experimental items. Although the models for the transformed data fitted the data better, the analyses for the transformed and untransformed data did not differ substantially. For clarity, only results for the untransformed data are reported.[2]

Table 2 reports the mean reading times. LME models were calculated to estimate the fixed effects of Remnant Congruency, Context, and the Remnant-Congruency-Context interaction, and the random effects of Participants and Items for eye movement measures for each region. The contrast coding used for Remnant Congruency (congruous: +0.5, incongruous: -0.5) and Context (IO-context: +0.5, DO-context: -0.5) and the interaction resembled the contrast coding in traditional ANOVA analyses.

Model fitting was performed in a step-wise fashion, starting with the most complex model that included the full factorial set of random effects (random slope-adjustment for Remnant Congruency, Context and the Interaction for both random effects Participant and Item). During model fitting, the complex models were trimmed down in a step-wise fashion using log-likelihood tests for model comparisons (see Baayen, 2008; Baayen, Davidson, & Bates, 2008). Slope-adjustments were kept in the models if the models fitted the data better than the less complex models. Model reduction started with the random effects for Items and excluded first the random slope-adjustment for the interaction and then the adjustment for Context and for Congruency. Model reduction was then applied to the random effects for Participants.

The parameters for the fixed effects, that is, the estimates of the reading time differences (*b*), standard errors (SE), and *t*-values, are given in Table 3. Absolute t-values higher than 2 were taken to be significant at $\alpha = .05$ (Baayen et al. 2008). Figure 1 illustrates first-pass/gaze-durations, regression-path, and total reading times for the objects (region 3), remnant (region 4) and post-

remnant region (region 5).

----------Tables 2 & 3 here----------

----------Figure 1 here----------

Region 3 (objects). The first-pass and the total reading times yielded a significant effect of Context, resulting from longer reading times (63 ms difference in the first-pass and 104 ms difference in the total reading time) when context specified focus on the indirect object (IO-context) rather than on the direct object (DO-context). The regression-path reading times revealed no significant effect of Context on the un-transformed data, but revealed the same Context effect in the log-transformed data (56 ms difference, $b = 0.14$, $SE = 0.04$, $t = 3.18$).

Region 4 (remnant). First-pass and total reading times for the remnant had similar patterns. There was a significant effect of Remnant Congruency in both measures, due to longer reading times for remnants that supplied an incongruous contrast for the focused constituent (89 ms difference in the first-pass reading time; 162 ms difference in the total reading time). The absence of a significant effect of Context or a significant interaction indicated that Congruency effects were similar when context placed either the direct or indirect object in focus. Although a similar pattern was observed in regression-path reading times for this region, the effect of Congruency was only significant in the log-transformed data (108 ms difference, $b = 0.11$, $SE = 0.04$, $t = 2.64$).

Region 5 (post-remnant). There were significant effects of Remnant Congruency in gaze durations, regression-path reading times, and total reading times for the post-remnant region, due to longer reading times when the remnant was incongruous with the focused constituent (26 ms gaze-duration difference, 149 ms regression-path difference, 57 ms total reading time difference). The absence of a significant effect of Context or a significant interaction indicates that congruency effects were similar when context placed either the direct or the indirect object in focus.

Discussion

Experiment 1 revealed processing difficulties in the objects region (region 3) when focus was

specified on the indirect object. This may indicate that the "given-before-new" preference influences the reading times in the objects region and thus that the information structural status of the objects influenced processing early on. However, there was no interaction of Context and Remnant Congruency, and reading times in these regions produced clear congruency effects in both interrogative contexts. These effects indicate that the interrogative context successfully modulated focus, so that remnants had longer reading times, and therefore were more difficult to process, when they mismatched with the contextually-focused object. Moreover, the results showed this had an early influence on the processing of remnant constructions. These findings are consistent with other research that has shown that prior interrogative context can modulate the focus structure of a sentence during reading (Birch & Rayner, 1997).

Experiment 2

Experiment 1 yielded an effect of focus congruity that appeared early in the eye movement record, immediately when the remnant was encountered. In Experiment 2, interrogative contexts were presented together with constructions in which the particle *only* preceded the indirect object (see examples in 6a-d).

6a. *IO-context, congruous remnant (cue-match)*

John wondered who Sally would pass the apples. $_1$| Sally passed $_2$| only the children the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

6b. *IO-context, incongruous remnant (cue-match)*

John wondered who Sally would pass the apples.$_1$| Sally passed $_2$| only the children the apples $_3$| but not the cherries $_4$|, because $_5$| they did not want them.

6c. *DO-context, congruous remnant (cue-conflict)*

John wondered what Sally would pass the children.$_1$| Sally passed $_2$| only the children the apples $_3$| but not the cherries $_4$|, because $_5$| they did not want them.

6d. *DO-context, incongruous remnant (cue-conflict)*

John wondered what Sally would pass the children.$_1$| Sally passed $_2$| only the children the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

The same factors as in Experiment 1 were manipulated: The factor Context distinguishes the conditions in which contextual focus was placed on the indirect or direct object (IO vs. DO-context) and reveals processing difficulties arising from a conflict between contextual and lexical focus cues. In the IO-context contextual and lexical cues match because both specify focus on the indirect object. In the DO-context, however, there is cue-conflict because context specifies focus on the direct object but the particle *only* specifies focus on the indirect object. The second factor, Remnant Congruency, is defined with respect to congruency with the contextually specified focus. In IO-contexts, congruous remnants are congruous with the contextually and lexically-focused constituent while incongruous remnants are incongruous with the lexically and contextually-focused constituent (6a vs. 6b). In the DO-context, however, congruous remnants are congruous with the contextually but not with the lexically-focused constituent (6c vs. 6d).

The reading times in region 3, the objects region, will show when and whether conflict between contextual and lexical focus cues is detected. If conflict between focus cues disrupts early processing, a main effect of context arising from higher reading times in the DO-context (cue-conflict condition) than in the IO-context (cue-match condition) is expected. The reading times in the objects region will therefore be informative about whether conflict between the different focus cues interrupts processing immediately. Reading times in regions 4 and 5, the remnant and post-remnant regions, will indicate whether the cue-conflict is resolved. If contextually-focused constituents are preferred, we expect a main effect of Remnant congruency in these regions but no interaction. However, if the lexically-focused constituent is preferred, or no constituent is preferred, we expect an interaction between Remnant Congruency and Context because the congruency effect should be observed only in the IO-context.

Method

Participants. Thirty-two undergraduate Psychology students from the University of Leicester, who had not taken part in Experiment 1, participated for course credit. All participants were native English speakers and had normal or corrected to normal vision.

Materials & Designs. Except for the inclusion of the particle *only* in front of the indirect object, the experimental materials were the same as in Experiment 1, and the same factors of interrogative context and remnant congruency were manipulated. The dependent variables were the reading time measures defined for Experiment 1. The experimental items were presented together with 64 fillers.

Apparatus & Procedure. Experiment 2 used the same eye-tracking apparatus, and the same stimulus presentation and data acquisition procedures as Experiment 1.

Results

Analysis: Experiment 2 used the same data analysis procedures and scoring regions as Experiment 1. Trials without first-pass fixations in two adjacent regions were deleted, accounting for 5% of the trials. Analyses of reading times for each region excluded trials in which no fixations were made within that region and where reading times were above 5000 ms.

Table 4 shows the mean reading times for Experiment 2, and the parameters of the LME models are given in Table 5.[3] Contrast coding for Remnant Congruency was the same as in Experiment 1 (congruous: +0.5, incongruous: -0.5). Contrast coding for Context differed (IO-context: -0.5, DO-context: +0.5) because higher reading times were expected in the DO-context (cue-conflict) conditions. Figure 2 illustrates first-pass/gaze-durations, regression-path, and total reading times for the objects (region 3), remnant (region 4) and post-remnant region (region 5).

----------Tables 4 & 5 here----------

----------Figure 2 here----------

Region 3 (objects). There were no significant main effects in any of the reading time measures, indicating that reading times did not differ when context specified focus on the direct object (DO-

context) rather than the indirect object (IO-context).

Region 4 (remnant). There was a significant effect of Remnant Congruency in first-pass reading times (66 ms effect), regression-path reading times (106 ms effect), and total reading times (94 ms effect), due to longer reading times when the remnant supplied an incongruous contrast for the contextually-focused element. There was also a main effect of Context in total reading times (77 ms effect) and in log-transformed first-pass (36 ms effect, $b = 0.06$, $SE = 0.03$, $t = 2.06$) and regression-path reading times (74 ms effect, $b = 0.09$, $SE = 0.03$, $t = 2.88$), due to overall longer reading times when context focused the direct object (DO-contexts) than the indirect object (IO-contexts). This effect indicated that remnants were more difficult to process in the cue-conflict condition, when context and the focus particle provided conflicting cues to focus.

Region 5 (post-remnant). Gaze durations, regression-path reading times, and total reading times each produced only effects of Remnant Congruency, due to longer reading times for this region when the remnant was incongruous with the contextually-focused element (39 ms gaze duration effect, 122 ms regression-path effect, 44 ms total reading time effect). The absence of a significant effect of Context or a significant interaction in any of the reading time measures suggests that remnant continuations with remnants that were congruous with the contextually-focused constituent were preferred over remnants that were congruous with the lexically-focused constituent.

Discussion

Experiment 2 produced two key findings. First, cue-conflict between lexically- and contextually-specified focus did not cause processing difficulties in the objects region but in the remnant region, as indicated by higher reading times in the cue-conflict condition (DO-context) than cue-match condition (IO-context). Second, reading times for both the remnant and post-remnant regions clearly indicate that remnants that were congruous with the contextually-focused constituent were preferred to ones that were congruous with the lexically focused constituent. Context disrupted processing in the remnant region; however, this may be a late effect given that the clearest Context

effects were found in total reading times and regression-path reading times for this region. In the post-remnant region, the main effect of context no longer influenced reading times, indicating that cue-conflict was resolved in favor of the contextually-focused constituent.

Experiment 3

Experiment 2 showed that when there is conflict between lexical and contextual focus cues (i.e., in the DO-context), this did not immediately cause processing difficulties in the objects region. Effects at the post-remnant region indicate that this conflict was resolved in favor of the contextual focus cue, as reading difficulty was observed when the remnant supplied a contrast that was incongruous with the contextually-focused object.

Experiment 3 investigates the processing of remnant constructions in which the focus particle *only* is placed between both objects and specifies focus on the subsequent direct object. Experiment 3 differs from Experiment 2 in two ways. First, the particle follows the contextually focused constituent, and so cue-conflict occurs when contextual focus is on the constituent to the left of the focus particle. Reading time data from Experiment 2 indicate a preference for processing the remnant as a contrast with the contextually focused constituent. Reading times in the remnant and post-remnant region in Experiment 3 will reveal whether this preference is observed even when the contextually-focused constituent occurs to the left of the particle or whether the strong preference for associating *only* with an adjacent constituent on its right (e.g., Paterson et al., 2007) prevents this analysis. Second, the contextually-focused constituent appears early in the objects region, and therefore effects of cue-conflict may be observed in this region in Experiment 3. Experiment 3 used the same materials as Experiment 2 but in this experiment the focus particle was placed between the indirect and direct object (see examples in 8a-d). The two factors Context and Remnant Congruency were defined as in the previous experiment. However, the contextual and lexical cues are in conflict in IO-contexts (e.g., 7a, 7b), i.e., when contextual cues focus the indirect object but lexical cues focus the direct object, whereas these cues are in agreement in the DO-contexts (e.g., 7c, 7d) where

they both focus the direct object.

7a. *IO-Context, congruous remnant (cue-conflict)*

John wondered who Sally would pass the apples. $_1$| Sally passed $_2$| the children only the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

7b. *IO-Context, congruous remnant (cue-conflict)*

John wondered who Sally would pass the apples. $_1$| Sally passed $_2$| the children only the apples $_3$| but not the cherries $_4$|, because $_5$| they did not want them.

7c. *DO-context, congruous remnant (cue-match)*

John wondered what Sally would pass the children. $_1$| Sally passed $_2$| the children only the apples $_3$| but not the cherries $_4$|, because $_5$| they did not want them.

7d. *DO-context, incongruous remnant (cue-match)*

John wondered what Sally would pass the children. $_1$| Sally passed $_2$| the children only the apples $_3$| but not the grownups $_4$|, because $_5$| they did not want them.

The reading times in region 3 (the objects region) are again informative about whether the conflict between different focus cues is detected early. If this is the case and a cue-conflict disrupts processing, higher reading times are expected in the IO-context (cue-conflict) than DO-context (cue-match) conditions. The reading times in regions 4 and 5 (the remnant and post-remnant region) indicate whether the conflict between the focus cues is resolved. If a contrast with the contextually-focused object is preferred a main effect of Remnant Congruency is expected in both contexts, resulting from higher reading times in the incongruous than congruous conditions. It is also possible that the strong preference to associate the particle with a subsequent element will lead to a preference for remnants that match the lexically-focused constituent, i.e. the direct object. In this case, there may be an interaction between Remnant Congurency and Context, with congruency effects at the remnant being reversed in IO-contexts and reading times being longer when the remnant is congruous with the direct rather than indirect object (8a vs. 8b).

Method

Participants. Thirty-two undergraduate Psychology students from the University of Leicester, who had not taken part in Experiments 1 and 2, participated for course credit. All participants were native English speakers and had normal or corrected to normal vision.

Design & Materials. Experimental materials were the same as in Experiment 2, except that *only* was placed between the indirect and direct object. The same factors of interrogative context and remnant congruency were manipulated. The dependent variables were the reading time measures defined for Experiment 1. The experimental materials were presented together with 82 fillers.

Apparatus & Procedure. Experiment 3 used the same eye-tracking apparatus, and the same stimulus presentation and data acquisition procedures as Experiments 1 and 2.

Results

Analysis. Experiment 3 used the same data analysis procedures and scoring regions as Experiments 1 and 2. Trials in which no first-pass fixations were made in two adjacent regions were deleted, accounting for 2% of trials. Analyses of reading times for each region excluded trials in which no fixations were made within that region and where reading times were above 5000 ms.

Table 6 shows mean reading times for remnant and post-remnant regions. The parameters of the LME models for this experiment are shown in Table 7. Contrast coding was the same as in Experiment 1 because higher reading times were expected in the IO-context (cue-conflict) than DO-context (cue-match) conditions.[4] Figure 3 illustrates first-pass/gaze-durations, regression-path, and total reading times for the objects (region 3), remnant (region 4) and post-remnant region (region 5).

----------Tables 6 & 7 here----------

----------Figure 3 here----------

Region 3 (objects). All three reading time measures produced a main effect of context, resulting from higher reading times in the IO-context (i.e. cue-conflict condition) than in the DO-context (cue-match condition) (first-pass: 71ms difference, regression-path: 104 ms difference, total

reading time: 103 ms difference). This indicates that cue-conflict between lexical focus cues and contextual focus cues caused processing difficulties early on.

Region 4 (remnant). There was a significant effect of Remnant Congruency in first-pass reading times (46 ms difference), regression-path reading times (78 ms difference), and total reading times (73 ms difference) due to longer reading times when the remnant was incongruous with the contextually-focused constituent. There was also an effect of Context in the regression-path (90 ms difference) and total reading times (60 ms difference), that was qualified by a significant interaction. This interaction was due to the presence of a congruency effect in the DO-contexts (regression-path: 145 ms difference, total reading time: 134 ms difference) but no Congruency effect in the IO-contexts (regression-path: 12 ms difference, total reading time: 11 ms difference). Planned comparisons assessed the effect of Congruency in the IO-context and the DO-context respectively. In the DO-context, reading times were significantly higher in the incongruous than congruous condition (regression-path: $b = 139$, $SE = 42$, $t = 3.32$; total reading time: $b = 129$, $SE = 34$, $t = 3.77$). In the IO-context, reading times in the congruous and incongruous condition did not differ (regression-path: $b = 11$, $SE = 42$, $t = 0.26$; total reading time: $b = 17$, $SE = 34$, $t = 0.49$).

Region 5 (post-remnant). All three reading time measures (gaze duration, regression-path and total reading times) produced significant interactions. In addition, the effect of Remnant Congruency was significant in gaze durations (24 ms difference) and total reading times (26 ms difference) and arose from higher reading times for incongruous than congruous remnants. In order to investigate the interactions between Remnant Congruency and Context, planned comparisons assessed the effect of remnant congruency in IO-contexts and DO-contexts.

Reading times were longer for remnants that were incongruous with the contextually-focused constituent in DO-context conditions. This effect was significant in the untransformed gaze-durations (47 ms difference, $b = 49$, $SE = 17$, $t = 2.81$, id slope-adjustment) and total reading times (58 ms difference, $b = 62$, $SE = 22$, $t = 2.80$, id slope-adjustment), but only in the log-transformed

regression-path reading times (62 ms difference, $b = 0.13$, $SE = 0.05$, $t = 2.46$). In IO-contexts, however, the effect of congruency was absent in the gaze durations (0 ms difference, $b = -0.50$, $SE = 16$, $t = -0.03$) and total reading time (7 ms difference, $b = -7$, $SE = 20$, $t = -0.37$). The absence of a congruency effect in the IO-contexts indicates that when contextual and lexical cues were in conflict there was no preference for remnants that are congruous with the contextually-focused constituent. In the regression-path reading times there were higher reading times for congruous than incongruous remnants (72 ms difference, b = -80, SE = 39, t = -2.06; id slope-adjustment) that suggested readers had difficulty in the cue-conflict condition. Planned comparisons revealed longer reading times for congruous remnants in IO-contexts than DO-contexts (90 ms difference, $b = 100$, $SE = 44$, $t = 2.26$, id slope-adjustment). The effect was primarily due to readers making a regressive saccade to re-inspect earlier text when the remnant is congruous with a contextually-focused constituent that is to the left of the focus particle in the sentence.

Discussion

The reading times in the objects region showed that a conflict between focus cues caused processing difficulties early on, indicating that contextual cues to focus have an early influence on sentence processing. Reading times in the remnant and post-remnant regions revealed an interaction between Context and Remnant Congruency indicating that the effect of Congruency was modulated by context. Congruency effects occurred in the DO-context, i.e., when both contextual and lexical cues focused the direct object, but not in the IO-context, i.e., when contextual cues focused the indirect object but lexical cues the direct object. Accordingly, when the focus cues specify focus on different constituents, there was no preference for remnants to be congruous to with either the contextually- or lexically-focused constituent. This suggests that cue-conflict was not resolved, although there is also some indication from the regression-path reading times of difficulty when remnants were congruous with the contextually-focused constituent, suggesting that readers had difficulty when contextual cues focused on a constituent to the left of the focus particle.

General Discussion

We have reported three eye movement experiments that investigate the interaction of contextual and lexical cues to focus during sentence processing. Experiment 1 showed that focus processing in the objects region was disrupted when context specified focus on the indirect object (*Mary gave [the children]$_F$ the apples.*); that is, when the focus structure triggered by a preceding context "violated" the preferred given-before-new order (Arnold et al., 2006; Bresnan et al., 2007; Clifton & Frazier, 2004). This indicates that context initially did not completely override the default given-before-new preference and its corresponding focus structure. This disruption, however, was relatively short-lived and no corresponding effects were observed at the remnant or post-remnant regions. Instead, clear congruency effects were observed at this region. These showed that remnants were more difficult to process (and therefore had longer reading times) when they mismatched with the object that the interrogative context placed in focus. The results therefore showed very clearly that prior interrogative context can specify focus in a subsequent target sentence and thereby influence the processing of an elliptical remnant construction that provides an overt contrast for the focused constituent. This effect of contextually-specified focus was observed early in the eye movement record, during first-pass processing of the remnant, indicating that focus is computed on-line during reading and that context has a rapid influence on the processing of a sentence's focus structure (see also Birch & Rayner, 1997).

Experiments 2 and 3 investigated the interaction between contextual and lexical cues to focus. In Experiment 2, the focus particle *only* preceded both objects and was taken to specify focus on the indirect object, while in Experiment 3 this particle was placed between both objects and specified focus on the direct object. The results revealed two main findings. First, cue-conflict between contextual and lexical cues disrupted processing in both experiments although disruption occurred earlier in Experiment 3 than in Experiment 2. Second, reading times for the remnant elliptic clause suggests that cue-conflict was resolved in Experiment 2 but not in Experiment 3. That is, Experiment

2 revealed a preference for the contextually-focused constituent irrespective of the preceding context, while Experiment 3 revealed clear congruency effects only in the cue-match condition but no preference for either the contextually- or lexically-focused constituent in the cue-conflict condition in first-pass and total reading times, but some indication of greater difficulty in regression-path reading times when the remnant was congruous with the contextually-focused constituent.

Reading times in the objects region of the target sentence were taken to be informative about the early processing of the sentence's focus structure. The results of Experiments 1 and 3 indicated that contextual focus cues have an early influence on processing, i.e., in the objects region, while the results of Experiment 2 revealed a later impact of contextual focus cues, i.e., in the remnant region. These differences, in particular the differences between Experiments 2 and 3, may result from the location of the focus particle and/or the different contexts in which cue-conflict occurs. That is, in Experiment 3 the cue-conflict was predicted to occur in the IO-context, while in Experiment 2, cue-conflict was predicted to occur in the DO-context. Given that in both Experiment 3 and Experiment 1, the effect of Context resulted from longer reading times in the IO-context than DO-context, it was possible that processing difficulties in these experiments did not arise from violations of the expected focus structure or a conflict between different focus cues but from difficulties in processing the interrogative context sentence itself.

To investigate this possibility, we examined first-pass reading times for regions preceding the objects region, i.e., the context sentence (region 1) and the subject and verb in the first conjunct of the remnant elliptic target sentence (region 2), to determine if there were processing differences for the interrogative sentences, and if effects spilled over to influence processing in the following regions (e.g., Rayner & Duffy, 1986). Reading times for interrogative sentences in Experiment 1 were longer in the IO-context than DO-context (3257 ms vs. 3099 ms), but this effect did not spill-over to influence reading times in the following region.[5] In Experiments 2 and 3, no effects of context were observed for the interrogative sentence or the spillover region. [6] Even though

differences in the processing of interrogatives were found in Experiment 1, no spill-over effects were observed, and so this difference would not be expected to affect processing of objects, remnant, or post-remnant regions. There were no differences in the processing of context sentences in Experiment 2 and 3, indicating that the interrogatives were equally easy to process in these experiments. It therefore seems that context effects at the objects region in Experiments 1 and 3 did not arise from difficulties in processing the interrogatives, and must instead have been due to processing of the double object region itself. The context effect in Experiment 2 occurred even later in the sentence (at the remnant region) and so could not be attributable to differences in the processing of the interrogative either.

The apparent difference in the timing of cue-conflict effects in Experiments 2 and 3 may simply be due to the location of the focus particle *only* in the sentences. In Experiment 2, the particle was placed before both objects in the double object construction (e.g., *Sally gave only the children the apples…*) and in-between these objects in Experiment 3 (e.g., *Sally gave the children only the apples…*). Accordingly, the earliest that cue-conflict could be detected in Experiment 3 was during the processing of the particle itself, whereas the earliest that cue-conflict could be detected in Experiment 2 was during the processing of the contextually-focused direct object (e.g., *the apples*). Alternatively, the differences between Experiment 2 and 3 may have resulted from an interaction with the given-before-new preference. The given-before-new preference was violated in the IO-context in both experiments. In Experiment 2, the DO-context condition was also the cue match condition where both focus cues agreed, so that processing difficulties due to a violation of the given-new preference (IO-context) may have eliminated any processing difficulties due to a cue conflict (DO-context). In Experiment 3, however, the cue conflict condition also violated the given-before-new preference so that both effects may have been additive.

A second key finding from the present studies was that differences in the pattern of reading times in remnant and post-remnant regions suggested that cue-conflict was resolved in Experiment 2

but not Experiment 3. This contrast between the experiments can be accounted for in several ways. On the one hand, the results may be explained in terms of association with focus and the syntactic ambiguities introduced by the location of the focus particle. Experiment 2 revealed a clear processing benefit for remnants that were congruous with the contextually-focused constituent. In this case, it is possible that the focus particle associates with the contextually-focused constituent, even though this constituent is not adjacent to the particle. This possibility was considered by Paterson et al. (2007), who argued that although there is a strong preference for associating *only* with an adjacent constituent, the particle can nevertheless associate with a non-adjacent constituent to its right in the sentence. Thus, following this account, focus cue-conflict is resolved by associating *only* with *the apples* in a construction like *Sally gave only the children the apples.*

In Experiment 3, there was a clear congruency effect in the cue-match condition (DO-context) that emerged relatively early in processing and was first observed in first-pass reading times for the remnant element itself. By comparison, congruency effects were weak in the cue-conflict condition, and were entirely absent in reading times for the remnant, appearing only in regression-path reading times for the post-remnant region. This effect, however, was reversed and showed that readers had difficulty when the remnant was congruous with the contextually-focused constituent, suggesting that this contrast was dispreferred.

A syntactic explanation suggests that in Experiment 3 readers strongly dispreferred an analysis in which *only* is associated with a constituent to its left in the sentence, and this provided an advantage for lexical over contextual cues to focus when these were in conflict. It has been argued in the theoretical literature (e.g., Brennan, 2008; König, 1991; Ross & Cooper, 1979) that *only* usually associates with a following element, but under restricted circumstances it can associate with a preceding element. In particular, it is argued that when *only* associates with a preceding element, both *only* and the preceding element must be accented (König, 1991) and thus may require special emphasis. It is also likely that processing principles influence the likelihood of adopting such an

analysis. When *only* appears sentence-finally, the parser has no option but to associate *only* with a preceding element. However, in Experiment 3 there was no obligation to associate the particle with the preceding constituent, and the parser may simply defer assigning an interpretation until subsequent constituents are processed. It may be that a prosodic boundary is required to prevent the focus particle from being associated with a subsequent element (as indicated by Schafer, 1997; see also Carlson, Frazier & Clifton, 2009b), although further research is needed to investigate the influence of clause and prosodic boundaries on processing of association with focus and the possible locations of prosodic boundaries within a clause.

On the other hand, it is possible that *only* was not associated with the contextually-focused element in either experiment so that there were two foci in the sentence, one contextual and one lexical focus (e.g., Carlson, 2004; Grell, 2008; Sauermann, 2009). A preference for the contextually-focused element in Experiment 2 may result from contextual factors or parallelism effects. The interrogative context may have introduced a set of alternatives, that could substitute for the interrogative *wh*-phrase (e.g., Hamblin, 1973), and the availability of this set may provide a natural contrast for the remnant. The preference may also result from prosodic parallelism between the contextually-focused constituent and the remnant element (e.g., Carlson, 2001; Carlson et al., 2009a on auditory processing). If readers computed an implicit prosodic focus structure during reading (Bader, 1998; Fodor, 1998, 2002; Stolterfoht et al. 2007), the remnant and the focused constituent were both discourse-new (and thus accented) while the lexically-focused element was discourse-given (and possibly deaccented).

Alternatively, as suggested to us by an anonymous reviewer, alignment with the given-before-new preference may facilitate the computation of the focus structure. In Experiment 2, the cue-conflict condition follows the given-before-new ordering because context focused the direct object. In the Experiment 3, the cue-conflict condition follows the new-before-given ordering, with context focusing the indirect object. In this case, the given-before-new preference may not facilitate

focus assignment because it wasn't aligned with the contextual focus cues. Note that this explanation implies that the given-before-new preference not only influenced the processing of the arguments in the double object region, but also directly affected the outcome of the cue-conflict.

The results of the present experiments provide insights into the interplay between contextual and lexical-syntactic cues to focus during sentence processing. In these experiments the remnant phrase provided a diagnostic of the outcome of focus processing and reading times were informative about the timing of factors influencing the processing of this phrase. The findings show that lexical-syntactic and contextual factors had a rapid influence on remnant processing, especially when not in conflict. However, when focus cues were in conflict, the position of the focus particle influenced the resolution of cue-conflict. While in both Experiments 2 and 3, remnants may be congruous with the contextually-focused constituent, context could not always override the preference for remnants to match the lexically-focused element. Thus, although cue-conflict was resolved in favour of the contextually-focused element in Experiment 2, this was not the case in Experiment 3. However, further aspects of focus processing remain to be determined.

In particular, the effects observed in the objects region revealed differences in the time course of effects of cue-conflict on focus processing, and although these differences may result from the location of the focus particle and the given-before-new preference, our results do not provide unambiguous insight into the influence of contextual focus on sentence processing as contextual focus was naturally confounded with givenness (as the focused element, but not the unfocused element, was mentioned explicitly in the context). Moreover, the present research relied on expectations of the upcoming remnant element to investigate the focus structure of the target sentence. However, remnant elements do not distinguish between contrastive and information focus and therefore cannot reveal whether *only* was associated with the non-adjacent element in constructions tested in Experiment 2. Thus, it is far from clear what kind of (prosodic) focus structure is computed on the basis of conflicting lexical and contextual focus cues. Accordingly,

further research is required to disentangle the effects of focus from givenness and to investigate the (prosodic) focus structure that is computed in sentences with different focus cues.

It is noteworthy that the experiments reported here produced earlier congruency effects than reported by Paterson et al. (2007), who observed effects only in eye movements at a post-remnant region and attributed the relative delay in these effects to time-consuming inferences needed to evaluate the congruency of the remnant and focused constituent. Congruency effects in the present experiments generally emerged earlier in the eye movement record, in first-pass reading times for the remnant phrase itself when there was no conflict between contextual and syntactic focus cues. The difference in the relative timing of effects in the two studies may result from parallelism effects between the remnant and the contextually-focused constituent facilitated processing, or the presence of the alternative set facilitated processing. In the absence of context, as in Paterson et al. (2007), the set of alternatives is introduced by the focused element itself. In this way, the earlier established presence of the alternative set may have facilitated the processing of focus in the present experiments and so led to earlier congruency effects. Indeed, it has been shown in syntactic processing studies that using interrogative context to evoke overt contrast sets for a target sentence that contains a focus particle can help to resolve syntactic ambiguities (Filik et al., 2005; Sedivy, 2002), and context may have had a similar facilitatory influence in the present experiments.

The experiments reported here are some of the first to examine the computation of focus on eye movements while reading, in particular the interaction between contextual and lexical cues to focus during online sentence processing. Our findings reveal that the interplay between context and lexical cues has an important influence on processing of focus structure and its effects are sufficiently rapid to influence on-line sentence comprehension. Clearly more work is needed to more fully reveal the underlying processing mechanisms. However, the current research provides important groundwork for future research by revealing the nature and limits of contextual influences on the processing of focus.

Footnotes

1. Available from (April 2010): http://www.psych.umass.edu/eyelab/software/

2. Additional ANOVA analyses conducted for the log-transformed data did not lead to results that differed from the results of the LME models.

3. ANOVA-analyses on the log-transformed reading times revealed a similar pattern of results as LME models.

4. Traditional ANOVA analyses produced similar results as the LME models although the ANOVAs did not show all effects of the LME models in the post-remnant region.

5. Statistics for Experiment 1: Interrogative sentences (IO-context vs. DO-context, 3257 ms vs. 3099 ms; $b = 170$, $SE = 76$, $t = 2.24$); Subject+Verb region (IO-context vs. DO-context: 560 msec vs. 547 msec; $b = 11$, $SE = 20$, $t = 0.55$)

6. Interrogative sentences (IO-context vs. DO-context, Experiment 2: 2856 ms vs. 2773 ms, $b = 70$, $SE = 58$, $t = -1.21$; Experiment 3: 2845 vs. 2840 ms, $b = 17$, $SE = 54$, $t = 0.32$, id slope adjustment for Remnant Congruency and Context); Subject+Verb region (IO-context vs. DO-context, Experiment 2: 589 vs. 607 ms; $b = 16$, $SE = 17$, $t = 0.95$; Experiment 3: 572 vs. 580 ms, $b = -8$, $SE = 15$, $t = -0.58$)

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Appendix

1. John wondered who/what Sally would pass the apples/children. Sally passed (only) the children (only) the apples but not the grownups/cherries, because they did not want them.
2. The referee wondered who/what Robert would give the towel/champion. Robert gave (only) the champion (only) the towel but not the trainer/water, because he did not want it.
3. Lucy wondered who/what the judge would forgive the error/witness. The judge forgave (only) the witness (only) the error but not the expert/slander, because that was the law.
4. The neighbour wondered who/what Peter would show the bathroom/plumber. Peter showed (only) the plumber (only) the bathroom but not the landlord/kitchen, because it was not tidy.
5. The pastor wondered who/what Lord Smith would leave the Bentley/driver. Lord Smith left (only) the driver (only) the Bentley but not the butler/Harley, because he could not drive it.
6. Laura wondered who/what Harriet would feed the berries/ hedgehogs. Harriet fed (only) the hedgehogs (only) the berries but not the badgers/mushrooms, because they did not like them.
7. The reporter wondered who/what the state would provide the clothing/victims. The state provided (only) the victims (only) the clothing but not the soldiers/blankets, because the second convoy had not arrived.
8. The housekeeper wondered who/what the butler would bring the breakfast/baron. The butler brought (only) the baron (only) the breakfast but not the duchess/tabloid, because he forgot to do so.
9. The headmaster wondered who/what the musician would teach the verses/pupils. The musician taught (only) the pupils (only) the verses but not the teachers/chorus, because he did not have so much time.
10. The watchman wondered who/what the electrician would send the invoice/landlord. The electrician sent (only) the landlord (only) the invoice but not the tenant/passkey, because he forgot to do so.

11. The walker wondered who/what Tim would throw the Frisbee/terrier. Tim threw (only) the terrier (only) the Frisbee but not the collie/football, because it was getting late.
12. The scouts wondered who/what the official would award the trophies/winners. The official awarded (only) the winners (only) the trophies but not the losers/badges, because this was what the rules said.
13. The audience wondered who/what Susan would present the flowers/singers. Susan presented (only) the singers (only) the flowers but not the dancers/chocolates, because she was asked to do so.
14. The spa manager wondered who/what the patient would give the mussels/nurses. The patient gave (only) the nurses (only) the mussels but not the doctors/pebbles, because she had not found enough.
15. Marissa wondered who/what Jim would lend the paint-brush/cleaner. Jim lent (only) the cleaner (only) the paint-brush but not the porter/toolbox, because he did not ask for it.
16. The passer-by wondered who/what the smoker would pass the lighter/woman. The smoker passed (only) the woman (only) the lighter but not the stranger/ashtray, because she did not ask for it.
17. The lawyer wondered who/what the debtor would pay the mortgage/banker. The debtor paid (only) the banker (only) the mortgage but not the broker/interest, because he had not earned that much.
18. The trainee wondered who/what the director would hand the make-up/actress. The director handed (only) the actress (only) the make-up but not the actor/lipstick, because it was not necessary.
19. The construction workers wondered who/what the site manager would show the altar/bishop. The site manager showed (only) the bishop (only) the altar but not the chaplain/organ, because he was in a hurry.

20. The employee wondered who/what the brewery would supply the vodka/nightclub. The brewery supplied (only) the nightclub (only) the vodka but not the hostel/whiskey, because the temporary worker had lost the orders.
21. The blackmailer wondered who/what the bank robber would tell the rumours/jailbird. The bank robber told (only) the jailbird (only) the rumours but not the warden/secrets, because he did not trust him.
22. The reporters wondered who/what the airline would grant the bonus/pilots. The airline granted (only) the pilots (only) the bonus but not the stewards/discounts, because it would be too expensive.
23. Steve wondered who/what Mary would buy the tickets/nanny. Mary bought (only) the nanny (only) the tickets but not the neighbour/programme, because she had not enough money.
24. The chairperson wondered who/what the chef would bring the oysters/dentists. The chef brought (only) the dentists (only) the oysters but not the surgeons/lobsters, because he had to prepare the desserts.
25. The critic wondered who/what the artist would show the painting/patron. The artist showed (only) the patron (only) the painting but not the agent/sculpture, because they had a quarrel before.
26. The clerk wondered who/what the company would sell the lorry/farmer. The company sold (only) the farmer (only) the lorry but not the miller/tractor, because he could not afford it.
27. The assistant wondered who/what the secretary would read the headlines/lawyer. The secretary read (only) the lawyer (only) the headlines but not the client/gossip, because he was in a hurry.
28. The mayor wondered who/what the guide would show the city/tourists. The guide showed (only) the tourists (only) the city but not the locals/harbour, because they already knew it.
29. The media team wondered who/what the detective would hand the ransom/gangsters. The detective handed (only) the gangsters (only) the ransom but not the hostage/weapons, because

that was the order.

30. The walker wondered who/what Tim would offer the donuts/angler. Tim offered (only) the angler (only) the donuts but not the swimmer/biscuits, because he did not have enough.
31. The receptionist wondered who/what the porter would bring the suitcase/woman. The porter brought (only) the woman (only) the suitcase but not the driver/hand-bag, because he could not carry that much.
32. The hotel manger wondered who/what the cook would carve the turkey/waitress. The cook carved (only) the waitress (only) the turkey but not the waiter/chicken, because he had so much to do.

Table 1: Example of stimuli in Experiments 1-3. Vertical lines delimit regions of analysis, slashes denote alternatives, and parentheses indicate the alternative positions of the focus particle. Note that the focus particle was absent in Experiment 1.

IO-context (focus on the indirect object, e.g., *the children*)

John wondered who Sally would pass the apples. region 1 | Sally passed region 2 | [only] the children [only] the apples region 3 | but not [the grownups / the cherries] region 4 | , because region 5 | they did not want them. region6 |

DO-context (focus on the direct object, e.g., *the apples*)

John wondered what Sally would pass the children. region1 | Sally passed region 2 | [only] the children [only] the apples region 3 | but not [the cherries / the grownups] region 4 |, because region 5 | they did not want them. region6 |

Table 2: Mean reading times in ms (SE) in the remnant and post-remnant region, depending context and remnant in Experiment 1

	IO-context ([the children]$_F$ the apples)		**DO-context** (the children [the apples]$_F$)	
	Congruous (the adults)	*Incongruous* (the cherries)	*Congruous* (the cherries)	*Incongruous* (the adults)
Region 3 (objects)				
First-pass	645 (24)	679 (25)	611 (22)	586 (19)
Regression-path	975 (55)	948 (57)	956 (70)	860 (61)
Total reading time	1114 (45)	1148 (53)	1005 (39)	1049 (44)
Region 4 (remnant)				
First-pass	631 (21)	708 (23)	658 (22)	759 (27)
Regression-path	916 (60)	1005 (58)	959 (55)	1085 (59)
Total reading time	852 (31)	981 (37)	888 (33)	1078 (43)
Region 5 (post-remnant)				
Gaze-duration	228 (9)	257 (14)	242 (12)	263 (11)
Regression-path	271 (20)	416 (45)	264 (17)	417 (43)
Total reading time	247 (10)	308 (17)	263 (15)	316 (16)

Table 3: Fixed effects for the linear mixed model predicting the reading times for each reading time measure in the critical regions in Experiment 1 (* | t | > 2), m: slope-adjustments (id: participants, it: item)

	First-pass / Gaze duration				***Regression-path***				***Total reading time***			
	b	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**
Region 3 (objects)												
Intercept	627	28	22.51*		955	68	13.96*		1084	62	17.54*	
Context	67	21	3.23*		64	57	1.14		109	40	2.74*	
Remnant	0.1	21	0.00		-60	57	-1.06		40	40	1.01	
Context x Remnant	31	21	1.48		32	57	0.57		-11	40	-0.28	
Region 4 (remnant)												
Intercept	688	34	20.18*		1000	59	17.08*		949	55	17.22*	
Context	-31	20	-1.52		-52	55	-0.96		-66	39	-1.69	id
Remnant	84	20	4.14*		105	55	1.91		156	40	3.91*	id, it
Context x Remnant	-9	20	-0.45		-30	55	-0.54		-36	30	-1.23	
Region 5 (post-remnant)												
Intercept	246	18	13.85*		350	35	10.03*		277	19	14.92*	
Context	1	13	0.11	id	-0.1	30	-0.00		-2	13	-0.19	
Remnant	33	12	2.83*	id	162	61	2.68*	id	60	13	4.69*	
Context x Remnant	7	14	0.49	id	-7	30	-0.24		7	13	0.57	

Table 4: Mean reading times in ms (SE) in the object, remnant and post-remnant region, depending context and remnant in Experiment 2

	IO-context (cue-match) (only [the children]$_F$ the apples)		**DO-context (cue-conflict)** (only the children [the apples]$_F$)	
	Congruous (the adults)	*Incongruous* (the cherries)	*Congruous* (the adults)	*Incongruous* (the cherries)
Region 3 (objects)				
First-pass	926 (32)	911 (26)	876 (32)	918 (33)
Regression-path	1184 (47)	1122 (38)	1145 (45)	1241 (52)
Total reading time	1398 (54)	1396 (52)	1368 (53)	1438 (54)
Region 4 (remnant)				
First-pass	681 (19)	783 (26)	755 (23)	785 (24)
Regression-path	873 (40)	1013 (51)	981 (46)	1055 (49)
Total reading time	865 (31)	1022 (40)	1007 (39)	1038 (42)
Region 5 (post-remnant)				
Gaze-duration	258 (11)	289 (12)	258 (11)	305 (13)
Regression-path	321 (20)	480 (41)	355 (27)	439 (42)
Total reading time	299 (16)	333 (16)	285 (14)	340 (15)

Table 5: Fixed effects for the linear mixed model predicting the reading times for each reading time measure in the critical regions in Experiment 2 (* | t | > 2), m: slope-adjustments (id: participants, it: item)

	First-pass / Gaze-duration				***Regression-path***				***Total reading time***			
	b	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**
Region 3 (objects)												
Intercept	905	40	22.82		1175	59	19.85		1407	95	14.88	
Context	-22	28	-0.77		35	41	0.87		19	42	0.45	
Remnant	7	28	0.25		5	41	0.13		35	42	0.83	
Context x Remnant	27	28	0.96		76	40	1.86		49	42	1.16	
Region 4 (remnant)												
Intercept	750	31	24.25*		987	65	15.16*		980	64	15.41*	
Context	38	21	1.83		76	41	1.83		79	31	2.60*	
Remnant	65	23	2.82*	id	112	42	2.69*		100	31	3.26*	
Context x Remnant	-33	21	-1.63		-32	41	-0.77		-54	31	-1.76	
Region 5 (post-remnant)												
Intercept	276	12	23.72*		405	31	12.97*		312	15	20.90*	
Context	9	11	0.82		4	32	0.14		-2	14	-0.11	
Remnant	38	11	3.42*		132	32	4.08*		43	14	2.98*	
Context x Remnant	7	11	0.63		-41	32	-1.27		11	14	0.74	

Table 6: Mean reading times in ms (SE) in the object, remnant and post-remnant region, depending context and remnant in Experiment 3

	IO-context (cue-conflict) ([the children]$_F$ only the apples)		**DO-context (cue-match)** (the children only [the apples]$_F$)	
	Congruous (the adults)	*Incongruous* (the cherries)	*Congruous* (the cherries)	*Incongruous* (the adults)
Region 3 (objects)				
First-pass	905 (26)	913 (25)	840 (26)	837 (22)
Regression-path	1108 (32)	1078 (30)	1028 (36)	950 (30)
Total reading time	1353 (42)	1301 (38)	1198 (41)	1256 (43)
Region 4 (remnant)				
First-pass	700 (18)	732 (19)	708 (19)	768 (23)
Regression-path	840 (30)	852 (30)	863 (30)	1008 (39)
Total reading time	885 (26)	896 (27)	884 (28)	1018 (31)
Region 5 (post-remnant)				
Gaze-duration	295 (13)	295 (13)	262 (9)	309 (14)
Regression-path	405 (33)	333 (19)	315 (15)	377 (25)
Total reading time	323 (17)	316 (14)	289 (11)	347 (18)

Table 7: Fixed effects for the linear mixed model predicting the reading times for each reading time measure in the critical regions in Experiment 3 (* | t | > 2), m: slope-adjustments (id: participants, it: item)

	First-pass / Gaze-duration				***Regression-path***				***Total reading time***			
	b	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**	**b**	**SE**	**t**	**m**
Region 3 (objects)												
Intercept	869	32	27.27*		1037	43	23.88*		1272	70	18.37*	
Context	74	22	3.32*		109	36	3.04*	id	98	33	2.93*	
Remnant	7	22	0.29		-48	30	-1.60	id	0.4	33	0.01	
Context x Remnant	9	22	0.42		29	33	0.88	id	-40	33	-1.20	
Region 4 (remnant)												
Intercept	726	28	26.18		893	42	21.38*		918	41	22.43*	
Context	-15	27	-0.56	id	-88	30	-2.98*		-59	24	-2.44*	
Remnant	47	17	2.72*		75	30	2.53*		73	24	3.01*	
Context x Remnant	-12	17	-0.69		-64	30	-2.16*		-56	24	-2.32*	
Region 5 (post-remnant)												
Intercept	289	16	18.57*		361	25	14.39*		318	20	15.72*	
Context	8	13	0.58	id	28	31	0.90	id	1	14	0.06	
Remnant	24	11	2.14*		-6	26	-0.24	id	28	14	2.03*	
Context x Remnant	-25	11	-2.29*		-71	22	-3.26*		-35	14	-2.55*	

Figure 1: First-pass reading times / gaze-durations and regression-path reading times (with ± 95%-CI) in the objects, remnant and post-remnant regions in Experiment 1

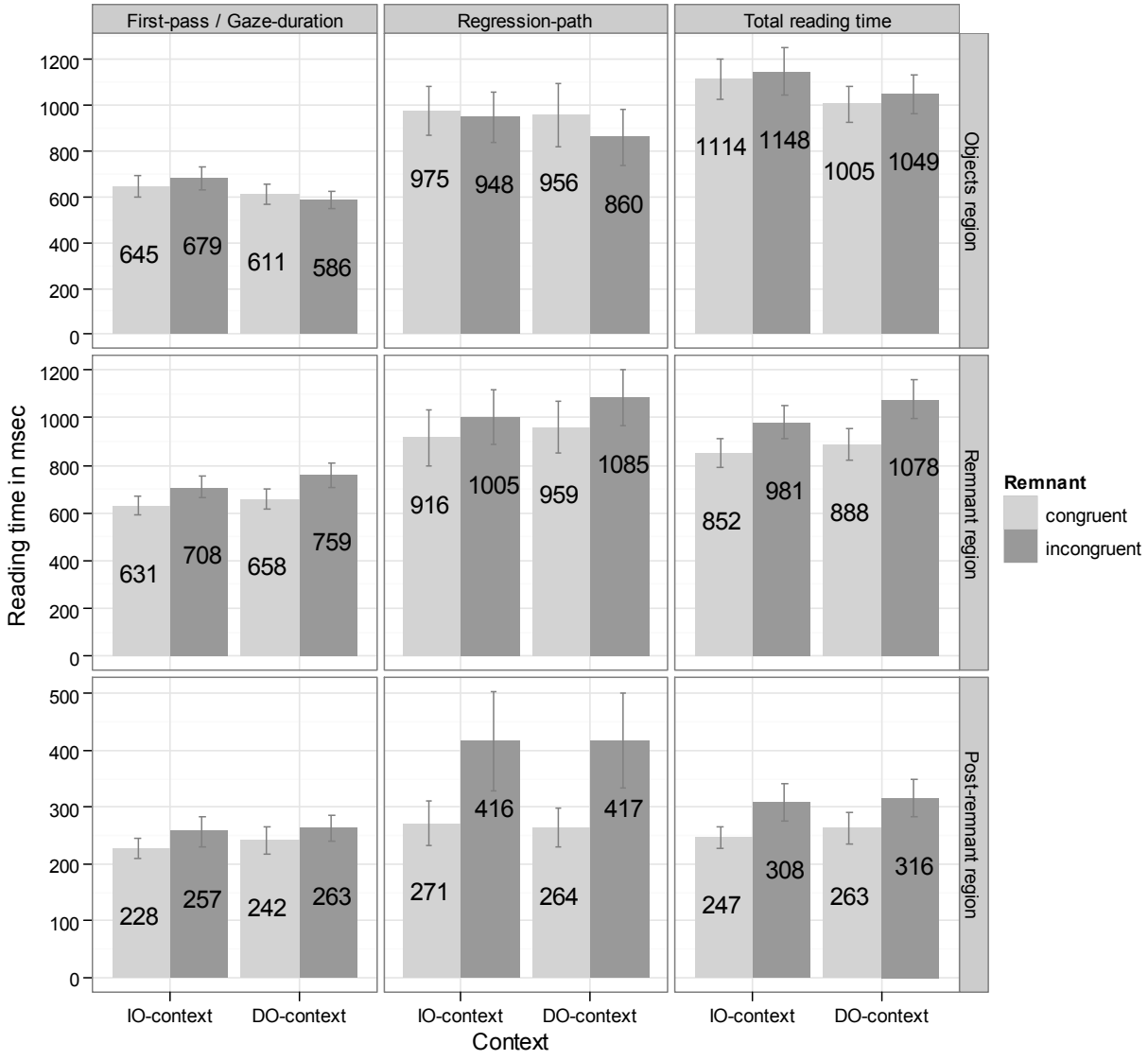

Figure 2: First-pass reading times / gaze-durations and regression-path reading times (with ± 95%-CI) in the objects, remnant and post-remnant region in Experiment 2

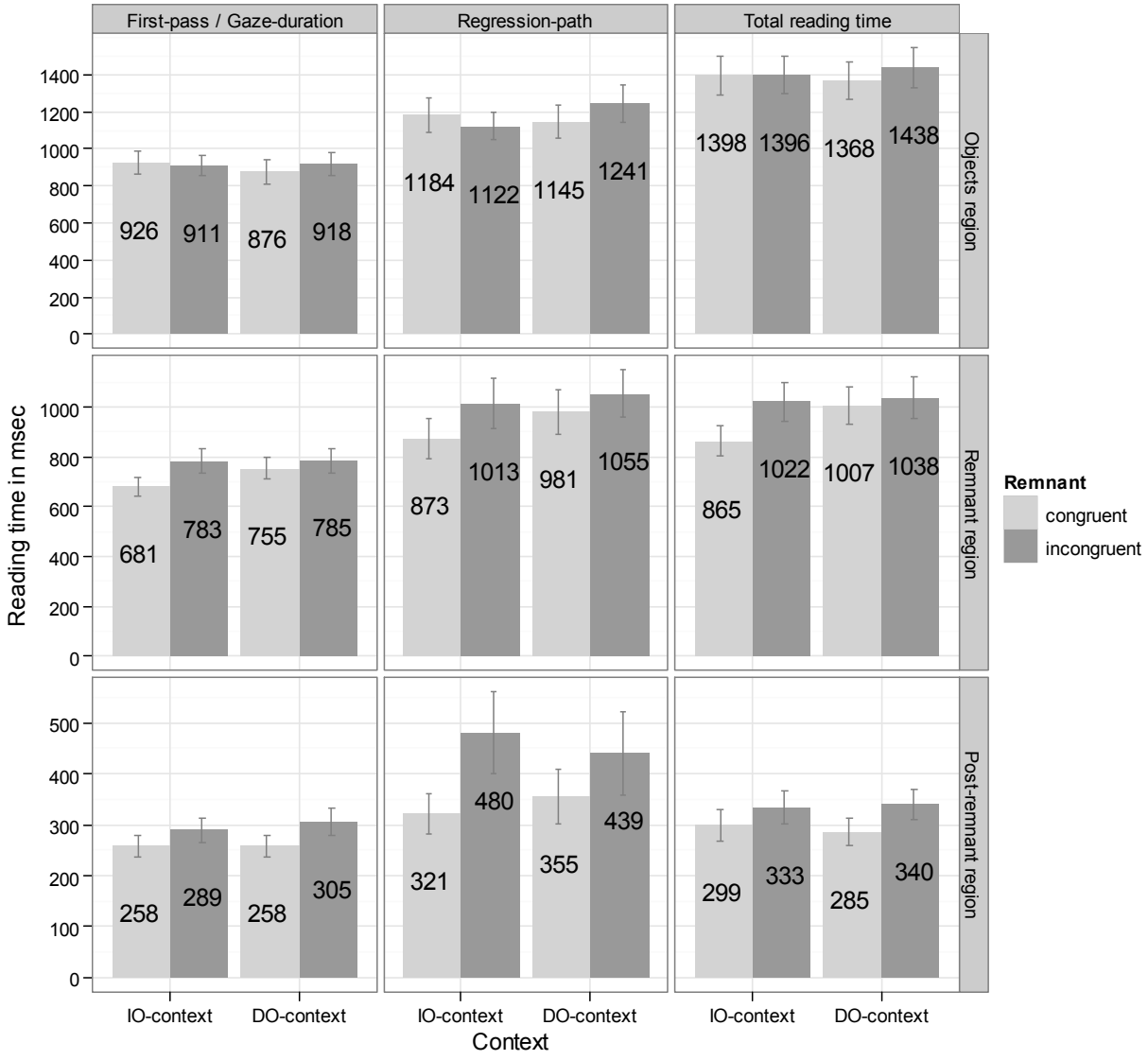

Figure 3: First-pass reading times / gaze-durations and regression-path reading times (with ± 95%-CI) in the objects, remnant and post-remnant regions in Experiment 3