Previous experimentation related to:

Keep listening: Grammatical context reduces but does not eliminate activation of unexpected words.

Julia F. Strand, Violet A. Brown, Hunter E. Brown, Jeffey J. Berg

Carleton College

Direct correspondence to jstrand@carleton.edu

Introduction
This document contains information on previous studies related to: Strand, J., Brown, V., Brown, H., & Berg, J. (2017). Keep listening: Grammatical context reduces but does not eliminate activation of unexpected words. *Journal of Experimental Psychology: Learning, Memory, & Cognition.*

The studies described in this document appeared in an earlier version of the manuscript, but were removed due to reviewer concerns about methodology. The are presented here in the interests of transparency and as partial replications of the published experiment. Unless otherwise specified, all materials, methods, and analyses are the same as the published experiment.

Experiment 1
Experiment 1 included only two trial types (NN, NV) and no splicing manipulation.

Methods
- $N = 60$
- 24 Critical trials: 12 NN trials, 12 NV trials
- 44 Filler trials, divided among: N target+3 distractors, V target+3 distractors
- All within subjects (participants heard constrained and unconstrained sentences).
- Consistent sentence context: constrained = "click on the"; unconstrained; "click on"
- Pictures were reused such that a target item on one trial would appear as a distractor on another trial

Results
- First analysis:
  - No significant effect of constraint ($\beta = -.05$, $SE = .05$, $t = -1.02$, $p = .31$)
  - No significant effect of competitor type ($\beta = .10$, $SE = .10$, $t = 1.07$, $p = .30$), indicating no difference in competitor preference (tendency to look at competitors relative to distractors) between unconstrained and constrained contexts and between the noun competitor and verb competitor trials.
  - Significant constraint- by-competitor type, demonstrating that the effect of constraining context differed for NV and NN trials ($\beta = .16$, $SE = .05$, $t = 2.17$, $p = .002$).
- Exploring the interaction
  - NV trials: significantly less competitor preference in the constrained than unconstrained context ($\beta = -.21$, $SE = .09$, $t = -2.51$, $p = .02$),
  - NN trials: no significant effect of context on competitor preference ($\beta = .11$, $SE = .06$, $t = 1.64$, $p = .10$). Although the effect of context on noun competitor trials did not reach significance, it was in the opposite direction of the verb competitor trials—that is, for noun competitor trials, there was numerically more competitor preference in the constrained than unconstrained condition, suggesting that context may have moderately increased activation for candidates that are both grammatically and phonologically appropriate.
- Planned comparisons:
  - NN, constrained condition: significantly more fixations to competitors than distractors ($\beta = .19$, $SE = .04$, $t = 4.18$, $p < .001$).
  - NV, constrained condition: not significantly more likely to fixate on the competitor than distractors ($\beta = -.07$, $SE = .04$, $t = -1.60$, $p = .11$).
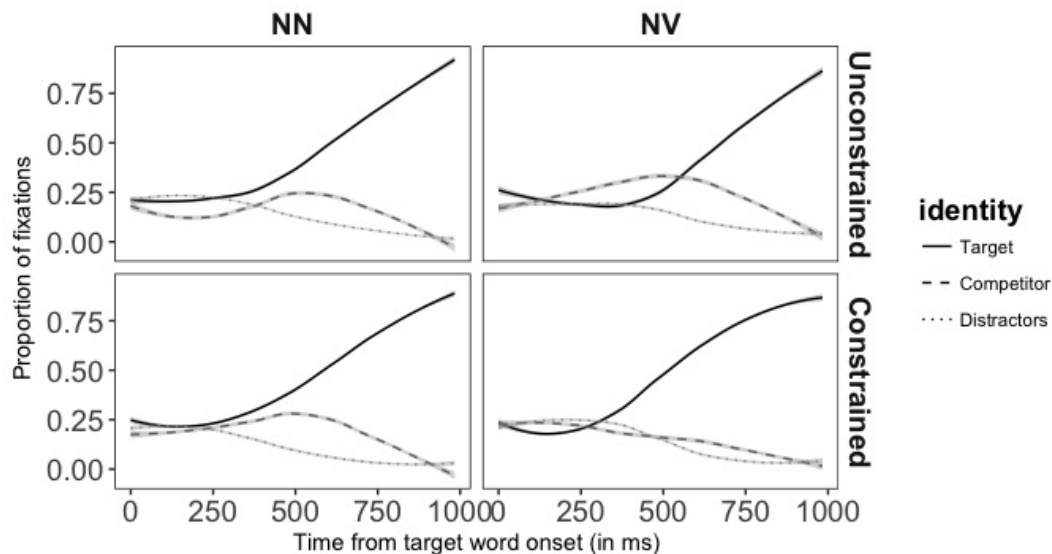
Figure 1. Proportion of fixations to target (solid line), competitor (dashed line), and distractor items (dotted line) in the critical trials in Experiment 1.

Experiment 2

Methods

- N = 132. The sample size was increased from Experiment 1 because of the addition of two variables (target part of speech and splicing), and because we wanted a sufficiently powered study to detect the potentially subtle effects of competitor activation.
- 64 critical trials (divided among NN, NV, VN, and VV)
- 64 filler trials: 40 included a target (half nouns, half verbs) and three phonologically unrelated distractors, and 24 trials included a target (half nouns, half verbs), a phonologically unrelated distractor, and two distractors that were phonologically unrelated to the target but competitors of one another.
- Splicing was within-subjects, constraint was between subjects
- Included multiple sentence frames Each grammatically constrained sentence started with the word "they" and grammatically (but not semantically) constrained the final word to be either a noun (e.g., "they considered the [target]" or "they discussed the [target]") or a verb (e.g., "they began to [target]" or "they prepared to [target]"). Unconstrained sentences were all "the word is. . .")
- Methodological differences from the published study
  - **Reusing images.** Exp 1 & 2 reused visual items, such that a target on one trial would appear as a distractor on another trial. This may have led participants to try to strategically determine which image was likely to be the target based on which had not yet been referred to. Indeed, for some grids, participants may have been able to guess which image would be the target because it was the only one that had not yet been referred to. To avoid this confound in the published study, we used 512 unique images and trained participants on all of them. This increased the length of the training session but made it impossible for participants to anticipate which image would be the target simply from the visual display.

- **Preview time.** Experiments 1 & 2 had a 2 second preview time (between image onset and sentence onset). A reviewer was concerned that this was unnecessarily long and may allow time for strategic processing. As a result, we shortened the preview time to 500ms in the published study
- **Frequency "manipulation".** In Experiment 2, competitors were, on average, higher frequency than targets. We had chosen to do that to help boost support for competitors. However, due to other stimulus restrictions, many competitors were numerically lower frequency than the targets. Because we were not able to cleanly apply a frequency manipulation like the one used by Weber & Crocker (2012), we opted to match targets, competitors, and distractors on frequency (and other lexical variables) in the published study. We also see this design as a cleaner way of assessing the relative contributions of manipulating top-down support (via grammatically context) and bottom-up support (via cross-splicing) for targets and competitors.
- **Distractor composition**. Trials in Experiment 2 included either two noun distractors, two verb distractors, or one of each. Reviewers suggested that the composition of the distractor items may have influenced recognition, so in the published experiment, we ensured that all grids contained one noun and verb distractor.
- **Onsets.** Some targets and competitors in Experiment 2 begin with /t/, /θ/, or /ð/ may preferentially receive looks given that the carrier phrases contained the words "to" and "the." Thus, we replaced items that started with those sounds in the critical trials in the published study.

Results

- First analysis:
  - Significant effect of constraint condition (β = .49, SE = .12, t = 3.92, p <.001), with participants showing greater competitor preference in unconstrained trials.
  - No significant effect of trial type (β = .12, SE = .11, t = 1.12, p = .25),
  - Significant effect of splicing (β = -.34, SE = .16, t = -2.15, p < .001), indicating greater competitor preference in cross-spliced conditions.
  - Significant congruence-by-constraint interaction, (β = -.27, SE = .07, t = -3.69, p < .001), suggesting that the effect of constraint differed by type.
- Exploring the constraint by trial type interaction
  - In congruent trials (NN & VV), competitor preference did not differ between the unconstrained and constrained conditions (β = .10, SE = .08, t =1.30, p = .19)
  - In incongruent trials (NV & VN), competitor preference did differ between the unconstrained and constrained conditions (β = .02, SE = .07, t =2.10, p = .002)
- Planned comparisons of incongruent (NV & VN) constrained trials
  - Identity-spliced trials: competitors were not fixated on more than distractors (β = .01, SE = .05, t = 0.14, p = .89)
  - Cross-spliced trials: competitors were fixated on more than distractors (β = .11, SE = .05, t = 2.20, p = .03)
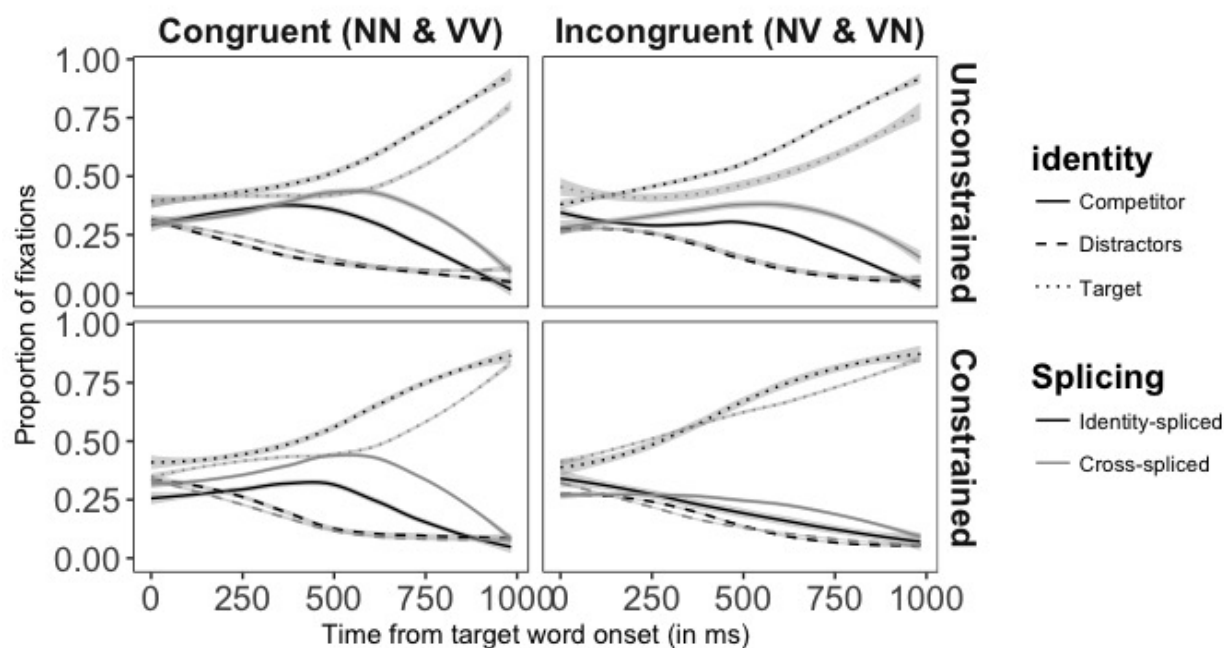
Figure 2. Proportion of fixations in trials with a target and competitor of the same grammatical class. Black lines show cross-spliced (CS) stimuli; grey lines show identity-spliced (IS) stimuli in Experiment 2

* Note that fixation rates at time 0 are not equivalent - indeed, listeners seemed able to anticipate which item was likely to be the target prior to target word onset. We speculate that this may be a function of reusing images over the course of the study, such that listeners may have been able to strategically eliminate items from consideration because they had previously served as targets. This was the primary motivation for using 512 unique images in the published study.

General Discussion
The results of these studies support the same conclusion as the published report. Listeners appear to be using grammatical context to flexibly guide expectations while remaining sensitive to bottom-up input.