

# Context, Syntactic Priming, and Referential Form in an Interactive Dialogue Task: Implications for Models of Alignment

Kathleen M. Carbary (kcarbary@bcs.rochester.edu)

Ellen E. Frohning (efrohnin@u.rochester.edu)

Michael K. Tanenhaus (mtan@bcs.rochester.edu)

Department of Brain and Cognitive Sciences, University of Rochester  
Rochester, NY 14627 USA

## Abstract

Two experiments examined how context and syntactic priming interact to determine interlocutors' choice of referential form. Pairs of naïve participants took turns producing descriptions of target pictures from a set of alternatives. The first experiment established that a contrast picture in the display (e.g. a striped cat in a display where a spotted cat was the target) primarily determined whether an adjective was used. Priming with an adjective had a only small, secondary effect on adjective use. However, when an adjective was used, it was more likely to occur in the prime-congruent structure than the alternative structure. Experiment 2 compared the effects of a prime produced by the dialogue partner with the effects of a pre-recorded prime played through headphones. Syntactic priming was significant only for the dialogue prime trials, indicating that priming may be stronger in dialogue than outside of dialogue, as previous work has suggested. However, even in dialogue, the primary factor that determined referential form was the set of alternatives. Our results begin to clarify the role of syntactic priming in dialogue, suggesting that it has at most a small effect on message formulation.

**Keywords:** dialogue; language production; referential form; syntactic priming; alignment; message formulation.

## Introduction

How does a speaker choose the content and form of a referring expression? In addition to being a classic question in the philosophy of language, it is an important problem for language generation systems. Such systems aim to approximate the types of utterances that a speaker would produce in a task-oriented dialogue, and thus provide important data for evaluating models of dialogue developed within psycholinguistics.

Work on reference production in the Gricean tradition assumes that a speaker will provide sufficient information for her addressee to identify an intended referent, taking into account the purpose of the conversation (Grice, 1975). Speakers should be specific enough for the addressee to identify the intended referent, without being overly specific by providing unnecessary information. For example, a speaker might say "the cat" when referring to a single cat among several other animals, but refer to the same animal as "the striped cat" when there are multiple cats present.

A more striking observation in language production research is that interlocutors not only converge on the same referring expressions (Clark & Wilkes-Gibbs, 1986), but also begin to use the same syntactic forms. This effect is

often referred to as structural persistence, syntactic persistence, structural priming, or – as we will call it in this paper – syntactic priming (Bock, 1986; Ferreira & Bock, 2006; Pickering & Ferreira, 2008). Some research suggests that syntactic priming might be stronger in dialogue settings than in other types of experimental tasks (Branigan, Pickering, McLean, & Cleland, 2007; Branigan, Pickering, & Cleland, 2000). Pickering & Garrod account for this trend by suggesting that "a major reason why priming effects occur is to facilitate alignment, and therefore they are likely to be particularly strong during natural language interactions" (p. 174, 2004).

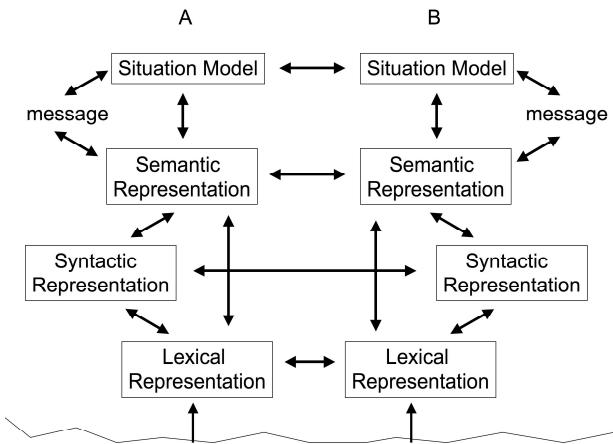


Figure 1: The Interactive Alignment Model (based on Pickering and Garrod, 2004); the mental representations of hypothetical interlocutors, A and B, are shown.

As a first step toward extending this idea and integrating it with a broader model of language production in dialogue, Pickering & Garrod (2004) proposed the Interactive Alignment Model, illustrated in Figure 1. The model assigns a central role to syntactic priming, casting it as a mechanism that aligns interlocutors' representations at multiple levels. Alignment at one level affects alignment at higher and lower levels of representation, making the model interactive.

Notably, the model assumes that the process through which interlocutors come to have the same representation of a situation is unconscious and automatic. Alignment at the syntactic level – that is, syntactic priming – is treated as an important factor that allows for communicative success, by increasing alignment at these other levels (Pickering &

Garrod, 2004, 2006). The model treats syntactic priming as a mechanism for alignment at other levels, which in turn explains how interlocutors are able to communicate successfully. In this way, syntactic priming has played a major empirical and theoretical role in the development of alignment models of dialogue. However, few, if any, investigations have attempted to examine how and when syntactic priming might affect representations and processes at various levels of representation in dialogue. We focus on two levels of representation that are typically distinguished in models of language production: message formulation and building the syntactic form of the utterances (see Bock & Levelt, 1994, for a classic language production model that makes this distinction).

According to Bock & Levelt, the message formulation level “captures features of the speaker’s intended meaning and provides the raw material for the processes of grammatical encoding” (p. 946, 1994). In other words, the message formulation stage involves planning the information to be communicated at a pre-grammatical level. Bock & Levelt present this as a stage that occurs before grammatical encoding begins. However, the Interactive Alignment Model is compatible with the possibility that grammatical encoding, such as syntactic category selection, could indirectly affect the message (refer to Figure 1 for a general idea of how this would work in that model). While message selection is most naturally affected by Gricean processes, like including the appropriate amount of information in an utterance, it is possible that the availability of syntactic structures could have some influence on the message that is formed.

Optional adjective use within a noun phrase is ideal for investigating this possibility. Adjectives are often used in referential expressions, even when the context does not require it from a Gricean perspective. Speakers’ are prone to over-informative adjective use when describing objects, including adjectives in their descriptions unnecessarily up to 46% of the time (Belke, 2006; Sedivy, 2003). This makes noun phrases that can optionally contain adjectives (e.g. *the [striped] cat*) ideal for an investigation of how syntactic priming and message formulation interact. Syntactic priming with an adjective-containing structure might increase the likelihood that the subsequent message will include information associated with an adjective, so that the primed syntactic structure can be used again. This structure provides a special opportunity to observe any potential effects of priming on message content, since speakers are free to use adjectives, even when the context does not require it. In addition, previous work has indicated that noun phrase structures containing adjectives are susceptible to syntactic priming effects (Branigan, McLean, & Jones, 2005). This structure should therefore allow us to observe any possible effects of syntactic priming on message formulation.

The hypothesis is that the message selection level of representation could be subtly affected by the increased availability of a primed syntactic representation. We

compare two conditions: one in which syntactic priming could affect message formulation by increasing the likelihood of subsequent adjective use, and another where no increase in adjective use would be expected. For example, will a speaker be more likely to refer to a single cat, among other potential referents, as “the striped cat,” if their interlocutor had used an adjective-containing noun phrase construction on the previous trial?

Our design also allows us to explore the claim that syntactic priming effects are stronger in dialogue than in non-dialogue situations. Although some previous research has suggested that syntactic priming effects are stronger in dialogue, this conclusion has been primarily based on post-hoc comparisons of priming effects between experiments that use different methods (but see Branigan, et. al., 2000, 2007 for exceptions). This creates the potential for confounds which could mimic a difference between dialogue and non-dialogue, and makes it difficult to determine whether differences are significant.

In addition, the few experiments (Branigan, et. al., 2000, 2007) that directly examine syntactic priming effects in dialogue are scripted confederate studies, in which a participant takes part in a highly controlled task with a trained assistant. In this setting, many factors that would normally affect what is said – such as referential context and lexical availability – are highly controlled by the situation, and unlikely to have a strong effect. This is a problem, since syntactic priming effects may appear to be larger when other influences on a referential expression are minimized. It is unclear whether the magnitude of priming effects in such a setting can be considered evidence that priming is a special mechanism that causes language production to occur differently in dialogue than in other experimental settings.

We report two experiments that investigate how syntactic priming affects referential form in an unscripted dialogue task. The first experiment examined the effects of syntactic priming on message formulation during dialogue. The second experiment compared priming effects in dialogue with priming effects outside the dialogue, in an otherwise identical task. Both experiments allowed us to explore how referential constraints interact with syntactic priming to determine referential form, and to address the relationship between syntactic priming and successful communication.

## Experiment 1

Experiment 1 was a first step towards examining how syntactic priming in dialogue affects other levels of representation. Specifically, does priming affect alignment at the level of message formulation, as one interpretation of the Interactive Alignment Model suggests? Or, does syntactic priming exert an effect on language production only after the message to be communicated has been fully planned, as the Bock & Levelt (1994) model predicts?

## Materials and Methods

**Participants** Fifteen pairs of friends from the University of Rochester were paid to participate. All were native English speakers and naïve to the purpose of the experiment.

**Experimental Setup** Individual participants sat at separate computers on either side of a large cardboard barrier, so that they could not see each other or each other's computer screens. To ensure that they could clearly hear each other, participants wore headphones and spoke into microphones. This setup facilitated audio recording of the entire session. To initiate each trial, one participant clicked a central fixation cross. The same set of four clip-art pictures then appeared on both screens. To discourage participants from using expressions like "the top left picture," picture locations were pseudo-randomized. After a 2-second delay, Participant 1 saw a circle appear around the target picture. Her task was to instruct her partner to click on that picture, using any description she chose. The trial ended when Participant 2 clicked the target picture. The overall error rate was less than 1%, and participants were given no feedback about their performance. Participants alternated between giving and responding to instructions, and found the task very easy and natural (see Figure 2).



Figure 2: The experimental setup.

The order of prime target pairs was pseudo-randomized so that different participant pairs saw the displays in different counter-balanced orders. The experiment was divided into blocks, so that participants had 5 breaks throughout the experiment.

**Experimental Items** There were two types of displays that occurred in pairs: *prime displays* and *response displays*. Half of the prime displays were *adjective primes*, designed to elicit descriptions that included either a pre- or post-nominal adjective; for example, "click the striped cat" or "click the cat with stripes." This was achieved using a contrast set, including the target and a picture that differed from the target in only one adjectival property (e.g. a striped cat vs. a spotted cat). This required participants to use an adjective in their description in order to uniquely identify

the target.<sup>1</sup> The *no adjective prime* displays contained a target picture with no related pictures in the display, allowing participants to successfully describe the target without an adjective.

Each prime display was followed by a response display. The referential context of the response displays was manipulated so that the target was part of a contrast set half the time, and appeared with unrelated pictures only half the time. When there was *contrast* in the display, an adjective was required for a felicitous referential expression, and when there was *no contrast* an adjective was unnecessary. This 3 x 2 design allowed us to test the effects of prime type (no-adjective, prenominal, postnominal) and contrast (present or absent) on the referential expression produced in a response display.

**Coding and Analysis** The entire interaction was digitally recorded. Participants' descriptions of the pictures were later transcribed word-by-word, and coded by the second author according to the syntactic structure had been used (e.g. prenominal, postnominal, noun only, etc.). Task-irrelevant utterances were not included in the analysis. All statistical comparisons were made using mixed-effects regression models,<sup>2</sup> which were computed using the R data analysis software, version 2.6.1 (2007).

## Results and Discussion

We wanted to answer two questions: was there a basic syntactic priming effect, and if so, did priming affect message formulation by increasing adjective use? Looking first at the subset of data where an adjective *was* used in the description of the response display, we asked whether prenominal and postnominal primes types had an impact on the syntactic structure of the description. If syntactic priming effects in dialogue are strong, then we would expect to see a strong syntactic priming effect: participants should produce more prenominal structures following prenominal primes, and more postnominal structures following postnominal primes. When the property associated with an adjective was already included in the message, we expected that the prime type would affect the structure in which the adjective appeared. Two separate mixed-effects regression models, with subject pair and item as random effects, were

<sup>1</sup> Norming data allowed us to classify prime displays as being likely to generate prenominal or postnominal descriptions, and the experiment included half of each display type. This prompted participants to use a prenominal adjective on 47% of prime descriptions, and a postnominal adjective on 43% of prime descriptions, even though no limitations were placed on what participants could say.

<sup>2</sup> Mixed-effects regression models were more appropriate for our dataset than ANOVAs, since the unscripted nature of the task led to unequal numbers and variances in each cell of the design. For a discussion of why this choice was appropriate, see Jaeger (2008).

used to test for significance of prenominal and postnominal priming.<sup>3</sup>

This analysis revealed that the use of a prenominal prime significantly predicted the use of a prenominal adjective in the subsequent response description ( $B = 0.45$ ,  $SE = 0.20$ ,  $p = 0.05$ ). Similarly, the use of a postnominal prime significantly predicted the use of a postnominal response description ( $B = 0.46$ ,  $SE = 0.21$ ,  $p < 0.05$ ). As shown by the coefficients, the magnitude of the effect was approximately equal for pre- and postnominal primes. On average, participants produced a prime-congruent response (i.e. a response that contained the same structure as the prime) 61% of the time, and an incongruent response 39% of the time. This 22% difference is similar to what has been found in classic priming studies not involving dialogue (e.g. the alternating dative priming effect shown by Bock, 1986).

Having established a syntactic priming effect when the message includes an adjective, we evaluated the extent to which priming affected message content. Figure 3 shows the rate of adjective use for response descriptions following each prime type. The pre- and postnominal prime types did not produce different effects, and so they were collapsed into one “adjective prime” type for the purposes of analysis. A mixed-effects regression model with subject pair and item as random effects tested the significance of three predictor variables: Display Type, Trial Order, and Prime Type. The coefficient and significance level for each of these factors is shown in Table 1.

Table 1: The effects of contrast, trial order, and prime type on adjective use.

Predictor	Coefficient (SE)	Significance
Contrast in Display	4.53 (0.43)	$p < 0.001$
No Adjective Prime	0.60 (0.61)	n.s.
Trial Order	-0.0004 (0.002)	n.s.
No Adjective Prime x Contrast in Display	-2.06 (0.88)	$p < 0.05$
No Adjective Prime x Trial Order	-0.0015 (0.005)	n.s.
Contrast in Display x Trial Order	-0.0011 (0.0038)	n.s.
Contrast x Trial Order x No Adjective Prime	-0.0040 (0.0074)	n.s.

There was no effect of trial order, indicating that participants did not prime each other more as the experiment unfolded. Instead, the degree of syntactic priming remained constant over the course of the experiment. This is not what would be expected if syntactic priming was associated with

successful dialogue, as participants became faster and better at this communication task as the experiment unfolded.

As shown in Table 1, adjective use in response display descriptions was predicted only by a main effect of contrast and an interaction between prime type and contrast.

The primary determiner of whether the message included an adjective was the referential context. When a contrast was present in the display, there was a small additional increase in adjective use when the preceding prime had contained an adjective (see Figure 3). However, there was no main effect of adjective prime indicating a complex relationship between priming and adjective use. This was true even though the message could have been modified to include more information based on the presence of an adjective in the preceding prime without any negative consequences for communication.

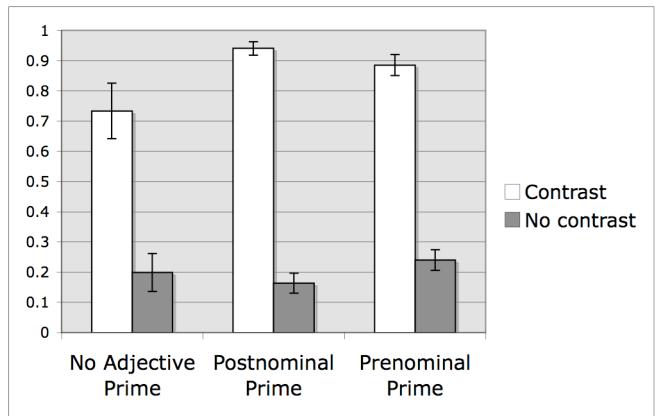


Figure 3: Mean (standard error) adjective inclusion rates in response descriptions following three prime types, for contrast and no-contrast displays.

The only suggestion of an effect of syntactic priming on message content was the slightly higher rate of adjective use following adjective primes. Priming appeared to increase the rate of adjective use only when a contrast was present. An alternative interpretation is that adjective use following no-adjective primes was artificially low. This may have occurred because some of no-adjective primes involved single words that were coded as nouns, but that could also have been considered adjectives (e.g. *wood* for a tree branch or *fluffy* for a Persian cat). This small subset of the data may have increased the likelihood that an alternative adjective-containing structure would be used again, thereby reducing the rate of pre- and postnominal adjective use following no-adjective primes. This is a viable alternative explanation for the lower rate of adjective use following no-adjective primes in this study, which will need to be carefully explored in future work.

## Experiment 2

Experiment 2 was designed to extend the results of Experiment 1, by directly comparing the effects of dialogue and non-dialogue primes using a within-subjects design. If

<sup>3</sup> We tested for prenominal and postnominal priming separately, to determine whether one structure caused stronger priming than the other, and to rule out the possibility that the overall priming effect was driven by only one of these structures. Since priming effects were comparable for both structures, subsequent analyses treat prenominal and postnominal priming together.

syntactic priming is stronger in an unscripted dialogue setting than in a non-dialogue setting, participants should be more likely to reuse a syntactic structure generated by the conversation partner than a description that had been pre-recorded by a speaker not participating in the dialogue.

## Materials and Methods

**Participants** Seventeen pairs of friends from the University of Rochester were paid to participate. All were native English speakers who had not taken part in the first experiment.

**Experimental Setup and Items** The setup was the same as for the first experiment, with a few notable changes. First, primes were now divided into two new categories, depending on dialogue status. Dialogue primes involved one participant describing a prime display to her partner; this was followed by the other participant describing a response display. For one third of trials, non-dialogue primes that had been pre-recorded by a trained female speaker were played through headphones to the participant who was the listener on that trial. The other participant, who would normally be generating the prime description, did not hear the prime, and instead completed an unrelated task (clicking a dot that appeared in an unpredictable location). This prevented the pre-recorded prime from becoming part of the participants' shared knowledge about the situation, or become introduced to the dialogue in any another way. All the response descriptions were participant-generated, regardless of prime status. In order to include enough trials in each condition to support the comparison between dialogue and non-dialogue, the no-adjective primes were eliminated. Thus, we manipulated *prime type* (prenominal or postnominal) and *prime status* (dialogue or non-dialogue) independently.

## Results and Discussion

If syntactic priming in dialogue is truly stronger than outside of dialogue, then participants should be more likely to re-use the syntactic structure just used by an interlocutor than a structure just produced by a prerecorded voice. The results of our second experiment supported this prediction. When all the descriptions that included adjectives were considered together, we saw a small but significant priming effect for both prenominal and postnominal primes ( $p < 0.05$ ), just as in experiment 1. However, when these response descriptions were examined separately by prime status, participant-generated primes had a greater impact on the subsequent descriptions than pre-recorded primes (see Figure 4).

A mixed effects regression model with participant pair and item as random effects was used to test for significance. Whether a response description was syntactically congruent or incongruent with the preceding prime was predicted from the prime status. When only trials containing adjectives were considered, incongruent responses were significantly more likely following pre-recorded primes than following dialogue primes ( $B = 0.58$ ,  $SE = 0.16$ ,  $p < 0.001$ ). The

observation of priming effects in this paradigm depended on dialogue, since syntactic priming was not observed with the pre-recorded primes.

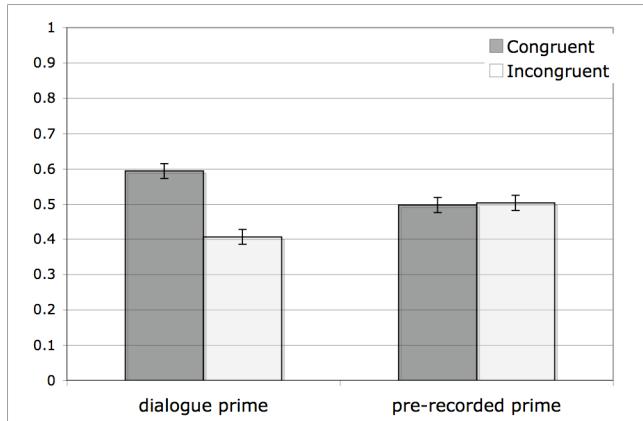


Figure 4: The proportion (standard error) of prime-congruent and prime-incongruent response descriptions following dialogue and non-dialogue primes, when only trials containing an adjective are considered.

Next, we wanted to address the hypothesis that syntactic priming effects in dialogue are instrumental in successful communication, as has been suggested by Pickering and Garrod (2006). One way to test this hypothesis is to examine priming over the course of the experiment. As the experiment unfolded, participants become better at the task, making fewer mistakes, and competing the trials more quickly. If syntactic priming promotes successful communication by increasing alignment at other levels, then we might expect that increased levels of priming should be correlated with this improvement at the task. However, this was not the case: syntactic priming did not significantly increase or decrease over the course of the experiment. Moreover, the degree of syntactic alignment, that is, the proportion of trials where participants re-used the primed structure, was not correlated with a pair completing the task more quickly (Spearman's rho = -0.197, *n.s.*). This was true both for the subset of trials where the response description included an adjective and for all of the trials.

When examined as part of a larger system of language production in dialogue, syntactic priming appeared to play only a small part in determining referential forms. There was no evidence from this experiment to support the idea that syntactic priming contributed to task success. This suggests that syntactic priming and successful communication are not necessarily related.

## General Discussion and Conclusions

In Experiment 1, we examined how referential context and syntactic priming interact to affect referential form. At the level of message formulation, where a speaker makes decisions about what information to include in an utterance, content was determined primarily by referential context.

One hypothesis was that syntactic priming would increase the likelihood that a speaker would include an adjectival property in the message, in order to re-use the structure that had just been primed. When the context strongly supported including an adjective in the message, priming with structures containing an adjective had a small additional effect on adjective use. However, when the context did not support adjective inclusion, priming had no effect on message content. This rules out the possibility that syntactic priming has a strong effect on message formulation independent of other factors. Our results are compatible with a model in which context constrains message content, and syntactic priming exerts a small additional effect. However, it is also possible that syntactic priming affected the message structure, but not the content; the rate of adjective use following no-adjective primes might have been lower due to adjective-like content being incorporated into the message in other ways.

In Experiment 2, we compared syntactic priming in dialogue and non-dialogue trials during an unscripted interaction between two naive participants. We found that syntactic priming depended on a prime that was generated by the conversation partner, as the Interactive Alignment Model suggests. This is in line with the trends that have been observed in previous experiments: syntactic priming effects are greater in dialogue than in response to a non-dialogue prime. We did not, however, find a relationship between syntactic alignment and task success. These results, taken together with the findings of previous work, raise questions about whether priming facilitates communication by aligning interlocutors' mental representations. In future research it will be important to address the relationship between priming and task success more directly. This could involve using more complex tasks, where there is a greater likelihood of differences in how well participants perform in a task-oriented dialogue.

These experiments shed light on how syntactic priming affects the selection of referential forms in dialogue, suggesting that while priming occurs, it is secondary to contextual factors that more strongly constrain what is said. This represents an initial step toward more carefully evaluating if and how syntactic priming impacts other levels of representation in dialogue. It also highlights the importance of using experimental designs where potential priming can be observed in interaction with other variables affecting message formulation. Experimental situations in which speakers have a larger range of options, (e.g. Gómez Gallo, Jaeger & Smyth, 2008), will allow priming to be examined in conjunction with such variables in single utterances and pairs of utterances. Situations like these are also ideal for future investigations because they closely approximate natural dialogue settings.

### Acknowledgments

We thank Dana Subik for years of assistance with data collection, and current and former members of the Tanenhaus lab for helpful comments on this project. These

experiments were supported by the NIH grant HD-27026 to Michael Tanenhaus.

### References

Belke, E. (2006). Visual determinants of preferred adjective order. *Visual Cognition*, 14(3), 261-294.

Bock, J.K., & Levelt, W.J.M. (1994). Language production: grammatical encoding. In M. Gernsbacher (Ed.), *Handbook of Psycholinguistics* (pp. 945-984). Orlando: Academic Press.

Bock, J.K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, 18, 355-387.

Branigan, H., Pickering, M., McLean, J., & Cleland, A. (2007). Syntactic alignment and participant role in dialogue. *Cognition*, 104, 163-197.

Branigan, H., McLean, J., & Jones, M.W. (2005). A blue cat or a cat that is blue? Evidence for abstract syntax in young children's noun phrases. In *Proceedings of the 29th Annual Boston University Conference on Language Development*, (p. 109-121). Somerville, MA: Cascadilla Press.

Branigan, H., Pickering, M., & Cleland, A. (2000). Syntactic co-ordination in dialogue. *Cognition*, 75, B13-B25.

Clark, H.H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition*, 22, 1-30.

Gómez Gallo, C., Jaeger, T.F., & Smyth, R. Incremental syntactic planning across clauses. In *Proceedings of the 30th Annual Meeting of the Cognitive Science Society* (pp. 845-850). Austin, TX: Cognitive Science Society.

Ferreira, V. & Bock, K. (2006). The functions of structural priming. *Language and Cognitive Processes*, 21(7-8), 1011-1029.

Grice, H.P. (1975). Logic and conversation. In P. Cole & J. Morgan (Eds.), *Syntax and Semantics. Volume 3: Speech Acts* (pp. 41-58). Academic Press.

Jaeger, T.F. (2008). Categorical data analysis: away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language (Special Issue on Emerging Data Analysis)*, 59, 434-446.

Pickering, M., & Ferreira, V. (2008). Structural priming: a critical review. *Psychological Bulletin*, 134(3), 427-459.

Pickering, M. & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences*, 27, 169-226.

Pickering, M. & Garrod, S. (2006). Alignment as the basis for successful communication. *Research on Language and Computation*, 4, 203-228.

R, version 2.6.1, The R Foundation for Statistical Computing, 2007.

Sedivy, J. C. (2003). Pragmatic versus form-based accounts of referential contrast: evidence for effects of informativity expectations. *Journal of Psycholinguistic Research*, 32(1), 3-23.