Structural priming from complex sentences

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Abstract: Speakers tend to reuse recently encountered linguistic forms such as alternants of the dative alternation. This study explores whether speakers’ tendency to reuse forms of this alternation is affected by the syntactic context in which the form occurs. Speakers were exposed to forms of the alternation occurring in either matrix position of complex sentences or in an embedded position, i.e., a complement or relative clause. Experiment One found that speakers reused a given form regardless of where it originally occurred. Experiment Two found that the tendency to reuse recently encountered forms persists over long intervals and is independent of the syntactic context of the prime. These findings suggest that structural priming is not influenced by the syntactic complexity of the context of the prime.

1 Introduction

Speakers tend to reuse recently encountered structural forms (Levelt & Kelter 1982). After hearing or producing a particular linguistic form, speakers are more likely to reuse it than if they had encountered or produced an alternate form. For example, the **dative alternation** allows speakers of English to describe the same situation using two different linguistic forms. A speaker can use either the **double object** (DO) form (“Celina gave Mohammad the letter”), where the recipient precedes the object, or the **prepositional dative** (PD) form (“Celina gave the letter to Mohammad”), where the object precedes the recipient. While there are multiple factors that influence a speaker’s choice to use a particular alternant of an alternation, one important factor is recent experience. If a speaker recently heard or produced a DO form, she is more likely to produce another DO than if she had just recently heard or produced a PD (Bock 1986; Pickering & Branigan 1998).

The reuse of recently encountered forms is referred to as **structural priming**. Structural priming has been found for multiple alternations, in various languages, and between languages for bilinguals (for a review see Pickering & Ferreira 2008). Structural priming can also reflect the relative frequency of linguistic forms. For instance, Kaschak (2007) found that exposing speakers to different rates of forms of the dative alternation (e.g. 75% PD and 25% DO) affected the base rate of their productions of these forms, suggesting that speakers were tracking the frequency of each form of the alternation.

Speakers are generally sensitive to both the form and the frequency of alternates. However, there are certain contexts in which speakers fail to replicate the frequency distributions of the different forms they encounter (e.g. Goldrick and Larson 2008; Hudson Kam and Newport 2005). In some cases, speakers
choose one form and use it consistently even when the input had two forms in free variation. There are two classes of explanation for why speakers may fail to replicate the variation they encounter. One reason is that it is due to internal features of the speaker independent of the input (e.g. a speaker’s age or working memory). Another related reason is that it is due to the interaction between the speaker and the properties of the input (e.g. the frequency of the form or its structural complexity). This current study explores the second alternative, namely that syntactic structure influences speakers’ tendency to replicate the linguistic productions they encounter. Specifically, I explore whether the syntactic context in which forms occur affects the likelihood of a speaker reproducing the forms.

2 Effects of structural context on production

To test the effects of syntactic context on structural priming, I place forms of the dative alternation in matrix and embedded positions of complex sentences. This allows me to explore the possibility that forms that occur in embedded positions affect subsequent production differently than those that occur in matrix positions. There are various typological, historical, and theoretical reasons to think that speakers may be affected by whether a form occurs in a matrix or embedded position. Typologically, matrix and embedded contexts can display distinct syntactic behavior. For example, in German matrix clauses, finite verbs must occur in second position, but in embedded clauses, the finite verb can occur in clause final position. Historically, matrix and embedded positions may show different patterns of use for novel forms. Pintzuk (1999) finds that while the overall rate of change may be consistent across contexts, matrix position may show more use of innovating structures. In theoretical work on human language learning, some theorists (e.g. Lightfoot 1991; Pearl & Weinberg 2007) have argued that alternations occurring in embedded positions are not informative to young learners and do not affect their productions. For example, Lightfoot (1991) argues for the Degree Zero Hypothesis, which states that any variation occurring in embedded verb phrases is uninformative to learners. This proposal has been applied to historical changes in English. Pearl and Weinberg (2007) incorporate a Degree-Zero filter into their model of language change. This filter removes forms that occur in non-matrix VPs from the input. By using this filter and another one that restricts the input to only unambiguous forms, the authors account for the shift in Old English from OV to VO ordering. These models of language acquisition suggest that syntactic context may influence linguistic behavior.

However, experimental work has not supported the assumption that syntactic context (e.g. presence in an embedded clause) affects structural priming. Some structural priming work (e.g. Scheepers 2003 & Branigan et al. 2006) has found that speakers demonstrate sensitivity to embedding while other work does not find such sensitivity. Scheepers (2003) argues that speakers are sensitive to the ordering and attachment levels of clauses through his work on relative clauses. He
exposed German speakers to high- or low-attaching relative clause primes. He found that speakers tended to reproduce the attachment level of the prime in their subsequent productions, even after accounting for pragmatic and semantic factors. Thus, he argues that speakers attend to attachment level and embedding.

Contra this, Branigan et al. (2006) argue that Scheeper’s results can be accounted for by the semantic differences between high- and low-attaching relative clauses and that embedding doesn’t matter. In a series of studies, they found equal priming from matrix position of single clause sentences (1) below), matrix position of sentences with introductory adverbial phrases and clauses (e.g. (2)), and complement clauses (3).

(1) The racing car driver showed the mechanic . . .
(2) As the Anne claimed, the racing car driver showed the mechanic . . .
(3) The report claimed that the racing car driver showed the mechanic . . .

Because the amount of priming was consistent across syntactic contexts, they conclude that where a primed form occurs does not matter, only that it occurs.

While Scheepers (2003) and Branigan et al. (2006) make conflicting claims about the interaction between syntactic context and structural priming, their results are hard to compare, as they were exploring different hypotheses and using different constructions. The research reported in this paper explores the impact of syntactic context on structural priming by exploring the different possible ways that different contexts may exert an influence on priming, e.g., different forms of embedding may lead to different patterns of priming, or priming may be stronger from some structural positions than others over longer intervals. The results of this research will help to discern whether or to what degree embedding affects priming behavior.

3 Current investigation

In this section, I discuss a series of experiments that test three hypotheses about how syntactic context interacts with structural priming. The first hypothesis builds off of Branigan et al.’s (2006) findings. It argues that priming for particular forms occurs regardless of structural contexts of the prime. This hypothesis, which I will call the CONTEXT DOESN’T MATTER, predicts equal priming for forms that occur in any structural context (e.g. embedded vs. matrix clause). The second hypothesis, which I will call the CONTEXT MATTERS I, argues that primes that occur in embedded positions do not affect subsequent production. This hypothesis builds off of the work of Lightfoot (1991). While Branigan et al. (2006) seems to

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1 Scheepers primed speakers using primes where the relative clause forced a high- or low-attaching completion (e.g. High-Attaching: “The assistant announced the score [mas,sing] of the candidate [fem,sing] that [mas,sing]”; Low-Attaching: “The assistant announced the score [mas,sing] of the candidate [fem,sing] that [fem,sing]”). Participants then completed stems that would allow for either a high- or low-completion.
undermine this possibility, they looked only at complement clauses that immediately followed the prime. It could be that design features (e.g. the effects of lexical priming on immediate testing) confounded their results. Thus, before we completely discount Context Matters I, we should control more for possible lexical priming and explore priming from other embedded positions. The third hypothesis I test is a weakened version of the Context Matters I hypothesis. This hypothesis, which I will call CONTEXT MATTERS II, states that, while priming is possible from all positions, some support priming better than others. One pattern predicted by this theory is that, although we may find priming from embedded domains, embedded primes may not be as strong over time or as flexible in new environments (e.g. it may not generalize to different structural positions as easily).

To test these three theories, I exposed speakers to forms of the dative alternation occurring in complex sentences. By complex sentences, I mean sentences that contain two clauses: one matrix, one embedded. These forms occur in either matrix or embedded positions of two-clause sentences as in (4)-(7) below. The embedded clause is underlined, and the dative alternation is bolded.

(4) As the report disclosed, the mother **promised the child the ring**.
   Matrix position with adverbial clause

(5) The report disclosed that the mother **promised the child the ring**.
   Embedded in complement clause

(6) The mother **who knew the neighbors** promised the child the ring.
   Matrix position with relative clause

(7) The neighbors knew the mother **who promised the child the ring**.
   Embedded in relative clause

Given the aforementioned hypotheses, we can make predictions for the type of effects we would expect to find. These predictions are given in Table (1) below.

<table>
<thead>
<tr>
<th>Tested hypotheses</th>
<th>Predictions</th>
</tr>
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<tbody>
<tr>
<td>Context Doesn’t Matter:</td>
<td>Main effect of prime, no effect of position. All priming is equal.</td>
</tr>
<tr>
<td>Context Matters I:</td>
<td>Main effect of prime, main effect of position. Priming only from matrix position.</td>
</tr>
<tr>
<td>Context Matters II:</td>
<td>Main effect of prime, main effect of position. Priming from both positions but at different magnitudes.</td>
</tr>
</tbody>
</table>

Table 1: Predictions of the tested hypotheses.

4 Experiment One

2 Some of the prime sentences were adapted from previous studies such as Bock & Griffin 2000, Pickering & Branigan 1998, and Branigan et al. 2006.
Experiment One had two primary goals: (i) to replicate Branigan et al.’s (2006) findings using a different methodology and (ii) to extend their research to different forms of embedding (i.e. relative clauses). First, one filler item was placed between the prime and target to minimize any possible contribution of purely lexical priming (Hartsuiker et al. 2008). Second, all test items and some of the fillers contained embedded clauses to mask the complexity of the embedded primes. Third, Experiment One compared different forms of embedding, i.e. relative and complement clauses.

4.1 Design and materials

In Experiment One, participants read aloud whole sentences, which were either primes or fillers. They also completed experimental and filler sentence fragments aloud using a set of given words. An example of a prime-filler-target sequence is given in Figure (1).

<table>
<thead>
<tr>
<th>Prime</th>
<th>Filler</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>READ</td>
<td>READ</td>
<td>COMPLETE</td>
</tr>
<tr>
<td>As the report disclosed, the mother promised the child the ring.</td>
<td>The librarian somehow convinced the researcher to be quiet.</td>
<td>As the paper declared, the lord . . . rubies duchess PROMISE</td>
</tr>
</tbody>
</table>

Figure 1: Example of prime-filler-target sequence.

For the Complete slides (e.g., the rightmost slide marked “Target” in the above Figure (2)), the verbs always occurred at the bottom of the list under a noun-adjective pair or a noun-noun pair. For the experimental complete slides, the ordering of the noun pairs was counterbalanced between and within subjects. For the filler complete slides, the nouns pairs or noun-adjective pairs were counterbalanced within subjects.

Previous research has found that the choice between dative object (DO) and prepositional dative (PD) completions may be sensitive to factors including semantics, discourse features (e.g. information status), and morphological and phonetic characteristics (Green 1974; Oehrle 1976; Bresnan & Nikitina 2007). To help control for the effects of discourse status, all primes used definite NPs. Also, by giving the participants noun-noun pairs for the experimental target items, I was able to more fully control for relevant factors. In particular, the noun pairs were matched for four features: morphological complexity, segmental length, number of syllables, and frequency.3

3 Ratings for these factors were obtained from CELEX. While there were differences between the frequencies of the nouns, the overall frequency of direct objects and indirect objects was not significantly different. Likewise, neither the direct nor the indirect objects tended to be more morphologically complex or have more segments. All of the nouns were equally matched for number of syllables, ranging from one to three syllables.
I chose eighteen dative verbs based on their collocations with DO and PD structures as discussed in Gries 2005. The primary goal in choosing the set of verbs was to make sure that there was a wide array of verbs with different biases. Of these verbs, three tend to co-occur with the PD construction (i.e. sell, take, and make) and the rest tend to co-occur with the DO form. Of those that tend to attract the DO form, all collocate with DO constructions at or below average (collocational strength 8.27, stdev 20.7), save three that occurred less than over two standard deviations from the means. I assigned eight of the verbs to matrix position and eight to embedded positions as shown in (8) and (9) below.

(8) Matrix verbs: award, buy, feed, issue, lend, make, pass, teach, throw
(9) Embedded verbs: bake, hand, offer, owe, promise, sell, serve, show, take

There were two major conditions that refer to the position of the embedded primes: Complement Clauses and Relative Clauses. Both conditions used the same verbs and noun pairs. In the Complement Clause condition, the verbs for non-prime clause (e.g. the introductory adverbial clause or the embedding matrix clause) were taken from Branigan et al. (2006) and included verbs such as declare, reveal, and report. For the Relative Clause condition, the verbs used in the non-prime clause included verbs such as know, see, and marry.

For both the Complement Clause and Relative Clause conditions, there were two conditions: DO-matrix/PD-embedded and PD-matrix/DO-embedded. Thus, there were a total of four conditions. Each participant took part in only one. Depending on the condition, a participant would encounter stimuli corresponding to either the Complement Clause or Relative Clause conditions as in Table (2).

<table>
<thead>
<tr>
<th>Complement Clauses</th>
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<tbody>
<tr>
<td><strong>Primes</strong></td>
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<tr>
<td>Matrix</td>
</tr>
<tr>
<td>Embedded</td>
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<tr>
<td><strong>Targets</strong></td>
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<tr>
<td>Matrix</td>
</tr>
<tr>
<td>Embedded</td>
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<table>
<thead>
<tr>
<th>Relative Clauses</th>
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<tbody>
<tr>
<td><strong>Primes</strong></td>
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<tr>
<td>Matrix</td>
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<tr>
<td>Embedded</td>
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<tr>
<td><strong>Targets</strong></td>
</tr>
<tr>
<td>Matrix</td>
</tr>
<tr>
<td>Embedded</td>
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</tbody>
</table>

Table 2: Example of experimental materials.
Primes and targets were matched such that the prime and target verbs and structural contexts were the same (e.g., if a participant read *promise* in embedded position, she completed a target that had *promise* in embedded position).

The fillers consisted of four sentence types with equal numbers of full sentences and sentence fragments. The four sentence types were two-place predicates (e.g., “The couple put the gifts in the closet”), object-control (e.g., “The father persuaded the girl to be patient”), object-raising (e.g., “The clique believed that the substitute was cool”), and *where*-clause sentences (e.g., “The lawyer knew where the documents were”). Verbs occurring in the filler sentences also occurred in a subset of the filler fragments. The fillers were randomized and grouped into eighteen blocks of four items (either full sentences or sentence fragments). Each block also contained one prime-target pair, and the prime was randomly assigned to first, second, third, or fourth position so that one filler item could be assigned to occur between it and the target.

4.2 Instructions

Participants were told that they would perform 3 tasks: reading sentences, completing partial sentences, and taking a memory test at the end of the experiment; however, there was no memory test. This test was mentioned to distract participants from the real manipulation and to encourage them to attend to the sentences they were reading and completing. Participants were instructed to read the *READ* slides aloud as accurately as possible. For the *COMPLETE* slides, they were told they would first see a partial sentence, and then after hitting the space bar, they would see a list of three words. They had to use all three of these words in their completion, but they could change the tense of the verb or ordering of the words and could add articles or prepositions as necessary. However, they were told that they should not do more than what was necessary.

The participants used a set of training materials to familiarize themselves with the reading and completing tasks. During the practice set, if the participants had questions or failed to use all the words correctly, they were reminded of the instructions. After the training, they began the testing phase, which was recorded for subsequent analysis. Participants were recorded individually in a sound-attenuated booth.

4.3 Participants

A total of 123 native speakers of North American English from the Northwestern community were run for pay or for partial fulfillment of course credit. Participants were randomly assigned to one of the conditions (i.e. DO-matrix/PD-embedded Complements and DO-matrix/PD-embedded Relatives) of either the Complement Clause or Relative Clause conditions. There were 30 participants in each condition. Data from three participants were excluded, as will be discussed below. Participants proceeded at their own pace, and the entire experiment took under 30 minutes on average.
4.4 Scoring Conventions

There were three possible scores for a response: DO, PD, or OTHER. For a target production to be scored, participants had to read the prime sentence correctly, save minor disfluencies for all words but the dative verb. For example, if a speaker misread owed as owned, the subsequent target response was marked as OTHER. Likewise, in reading the prime, if a participant used the wrong preposition (e.g. with instead of to/for) or omitted one of the arguments, the subsequent target production was scored as OTHER. If a participant accidentally skipped a prime, the associated target was scored as OTHER.

If the prime was read correctly, the response was scored as either OTHER, DO, or PD based on the actual target completion. Given the oral nature of the task, subjects would at times correct themselves, either for pronunciation or syntax. Only the final responses were scored. For a completion to count as either a PD or DO, the target verb had to be the main verb of the embedded or matrix completion and, if it was a relative clause completion, it had to be a subject-relative clause. Non-subject relative clauses were excluded to maintain consistency and because it was not always clear whether subjects were producing PD or DO completions in object-relative clauses. For a token to count as a DO, the target dative verb had to be followed by two NPs, the first of which could be the recipient or beneficiary of the verb, the second being the patient of the verb. For a completion to count as a PD, the target dative verb had to be followed by an NP that could be the patient of the verb followed by prepositional phrase headed by either to or for, depending on the verb, that contained an NP that could be the recipient or beneficiary of the verb. Using these criteria, the following responses would have been scored as an OTHER, DO and PD respectively.

(10) The fans all loved the pitcher who threw the ball at the coach. OTHER
(11) The fans all loved the pitcher who threw the coach the ball. DO
(12) The fans all loved the pitcher who threw the ball to the coach. PD

The total number of useable responses was 92% of the completions, with OTHER responses constituting 8% of the data (stdev = 0.07). This rate of useable responses is slightly higher than other rates reported in the literature, e.g. Branigan et al. (2006) used about 90% of their responses, and Bock and Griffin (2000) used about 80%. Three speakers had significantly higher rates of OTHER responses due to skipping slides or generating non-standard responses, suggesting that they were having difficulty with the task. Their data were excluded.

4.5 Analysis

Two items were removed from the analysis, leading to a total of sixteen items, eight matrix and eight embedded. Using the remaining pairs, the rau transformed (Studebaker 1985) proportions for PD completions were calculated for each participant against the total number of PD and DO (i.e. PD/(PD+DO)). Each participant had two scores, one for the number of PD completions following matrix primes, one for the number of those following embedded primes.
4.6 Results and discussion

The data for each of the conditions (Complement Clauses and Relative Clauses) were analyzed separately by using two repeated measures ANOVA with a 2*2 design: prime (DO or PD) and position (matrix or embedded). A second 2*2*2 ANOVA comparing data from the Complement Clause and the Relative Clause conditions was also run. The results of the Complement Clause condition and the Relative Clause condition will be presented separately and then compared.

For the Complement Clause condition, there was a main effect of prime for both participants ($F_1(1,58) = 22.45, p < .00$) and items ($F_2(1,14) = 19.52, p < .00$). Participants were more likely to produce a PD following a PD prime (54%) than following a DO prime (39%). There was no main effect of position for either participants or items ($F_1(1,58) = .32, p = .57$; $F_2(1,14) = .32, p = .58$) nor was there a significant interaction ($F_1(1,58) = 2.77, p = .10$; $F_2(1,14) = .74, p = .40$). Figure (2) below shows the distribution of PD completions following PD and DO primes for each position. Overall, the data suggest a preference for DO completions, but participants were still more likely to produce a PD completion following a PD prime than a DO prime. This trend was true regardless of whether the prime occurred in matrix or in embedded position.

![Figure 2: The percent of PD completions in the Complement Clause condition.](image)

For the Relative Clause condition, there was also a main effect of prime for participants ($F_1(1,58) = 5.06, p < .03$) but not for items ($F_2(1,14) = 2.41, p > .14$). Participants were more likely to produce a PD following a PD prime (55%) than following a DO prime (49%). Consistent with the Complement Clause condition, there was no main effect of position ($F_1(1,58) = .11, p = .75$; $F_2(1,14) = .00, p = .98$) nor was there a significant interaction ($F_1(1,58) = .00, p = .94$; $F_2(1,14) = .16, p = .70$). Speakers were more likely to produce a PD completion following a PD prime than following a DO prime regardless of the structural context in which the prime occurred, and the DO bias that seemed to arise in the Complement Clause condition did not arise in the Relative Clause condition.
Figure 3: The percent of PD completions in the Relative Clause condition.

An additional 2*2*2 ANOVA (condition*prime*position) was run to compare the Complement Clause and Relative Clause conditions. The only significant finding was a main effect of prime for both participants and items ($F_1(1,116) = 24.09, p < .00; F_2(1,28) = 15.09, p < .00$). Nothing else reached significance. The apparent DO bias in the Complement Clause condition wasn’t significantly different from the use of DO completions in the Relative Clause condition as demonstrated by the lack of a prime and condition interaction ($F_1(1,116) = 2.79, p = .10; F_2(1,28) = 1.04, p = .17$). Furthermore, the different types of embedding and the different sentence structures did not seem to affect the overall priming patterns as demonstrated by the lack of a condition effect ($F_1(1,116) = 2.30, p = .13; F_2(1,28) = .98, p = .33$). PD completions were more likely following a PD prime regardless of other structural features in the sentence.

The above results are consistent with those reported in Branigan et al. (2006) while extending their findings to new embedded positions and demonstrating that the priming effects can be found after an intervening item. There was only a main effect of prime and no effect of position nor any interaction between prime and position. Thus, we seem to have support for the Context Doesn’t Matter hypothesis. The strong Context Matters I hypothesis, i.e. that priming is not possible from embedded positions, is not supported. Priming is possible from both of the tested embedded clause types. However, we cannot fully discount the possibility that there may be some forms of embedding or some level of embedding that would negate priming effects, but for the time being, it is safe to say that speakers replicate variation that occurs in some embedded domains.

The third possibility, Context Matters II, which states that both positions can prime but that one might support priming better, also does not appear to be supported by the current data. However, it is possible that there are subtle differences between the priming from the two positions that Experiment One’s design masked. For example, the design of Experiment One may have created an environment artificially favorable to priming. The differences between the positions may be detectable only when the task is more natural or demanding. In Experiment One, both the verbs and the contexts were repeated, and the number of items between the prime and target was low (i.e. one item). If we remove one of these supports and find a difference in priming patterns from embedded and matrix positions, we have evidence that position affects priming.
5 Experiment Two

Experiment Two aimed to further test the possibility that embedding may affect speakers’ ability to reuse forms. This experiment explores the possibility that differences between priming from matrix and embedded positions may arise after longer intervals (or lags) between the prime and the target. It could be that when the target immediately follows the prime, as in Branigan et al. (2006) or after one intervening item, as in Experiment One, both positions prime equally as well. But as the lag between the prime and the target increases, priming from matrix positions may be stronger than that from embedded ones or vice versa.

Previous studies that have explored the effects of lag have found an immediate drop off in priming if there is one intervening item. This drop is probably due to a decline in lexical priming (Hartsuiker et al. 2008). After the initial drop, priming tends to remain fairly steady over subsequent lags up to ten intervening items (Bock & Griffin 2000) with some studies finding occasional increases (Ferreira et al. in press). However, all of these studies have used single clause primes. Thus, the effect of priming from embedded positions over different lags is not known. It could be that primes in embedded positions may not affect priming as strongly as those in matrix positions.

If, as the Context Doesn’t Matter hypothesis predicts, embedding does not influence the strength of priming, we should see the same pattern of priming from both positions over time, leading to a main effect of prime with a possible main effect of lag (e.g. both matrix and embedded primes are weaker or stronger at longer lags), but we would not expect an interaction. On the other hand, if, as the Context Matters II hypothesis predicts, embedding exerts some effect on priming behavior, we would expect a main effect of prime and possibly a main effect of lag, but more importantly we would expect an interaction between position and lag such that primes from matrix positions differ from those in embedded ones at longer lags but not at shorter ones. Experiment Two tests these two hypotheses by increasing the number of items between the prime and target from one to three.

5.1 Materials and Methods

For Experiment Two, I increased the number of filler items between the prime and target in the Relative Clause condition of Experiment One. In Experiment One, there was one filler item between the prime-target pair and three other filler items in a given block. For Experiment Two, I kept the same prime-filler-target triad and moved two of the fillers into this group making sure that the filler-target pair from Experiment One remained together, as in Table (3).

<table>
<thead>
<tr>
<th>Experiment One</th>
<th>Experiment Two</th>
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<tbody>
<tr>
<td>Filler 1</td>
<td>Prime</td>
</tr>
<tr>
<td>Filler 2</td>
<td>Filler 1</td>
</tr>
<tr>
<td><strong>Prime</strong></td>
<td>Filler 2</td>
</tr>
<tr>
<td>Filler 3</td>
<td>Filler 3</td>
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</tbody>
</table>
5.2 Participants
Sixty-two native speakers of North American English participated for pay or partial course credit. Two participants exhibited difficulty with the task and were excluded from the final analysis.

5.3 Results and discussion
The scoring conventions were the same as in Experiment One. Similar to Experiment One, other responses accounted for 8% of responses (stdev = .08). Data from the remaining responses in Experiment Two were run through a 2*2 ANOVA (prime*position) and then were compared to the data from the Relative condition of Experiment One in a 2*2*2 ANOVA (lag*prime*position). The results of Experiment Two are presented in this order.

Firstly, just as in Experiment One, there was a main effect of prime for participants and items in Experiment Two ($F_1(1,58) = 33.11, p < .00; F_2(1,14) = 10.78, p < .00$). Speakers were more likely to produce a PD completion following a PD prime (51%) than a DO prime (36%). As in the Complement Clause condition of Experiment One, there seems to be a slight overall DO bias. Also as in Experiment One, there was no main effect of position ($F_1(1,58) = .00, p < .98; F_2(1,14) = .69, p = .69$) nor an interaction between prime and position ($F_1(1,58) = 2.99, p = .09; F_2(1,14) = .00, p = .98$) in Experiment Two for either participants or items. Figure (4) shows that speakers are more likely to produce a PD following a PD prime regardless of where in the larger syntax the prime occurred.

The comparison of Experiment One and Two found a significant main effect of prime for both participants and items, again suggesting that if speakers encounter a PD prime, they are more likely to produce a PD completion than if they had encountered a DO prime. Figure (5) shows the percent of PD completions following PD and DO primes, separated by their position (matrix or embedded).

<table>
<thead>
<tr>
<th>Target</th>
<th>Filler 4</th>
<th>Target</th>
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Table 3: Block design for Experiments One and Two.
The difference between the PD and DO primes is significant at both lags (a difference of 6% at lag one and 15% at lag three), but the difference between embedded and matrix primes is never significant. However, there were other significant effects. There was a significant main effect of lag but only for participants not for items (F₁(1,116) = 4.10, p = .05, F₂(1,28) = 2.35, p = .12) and a significant interaction between lag and prime but again only for participants (F(1,116) = 3.99, p = .05; F₂(1,28) = 1.72, p = .20). The main effect of lag suggests that priming was stronger at the longer lag, but this appears to be driven by the DO primes, which led to more DO completions at lag three than lag one. Note that the priming from PD primes at both lags is relatively consistent, as demonstrated by the flat slope for PD-matrix. The differences between PD primes at the two lags were not statistically significant (t(59) = 1.17, p > 0.20). However, the percent of PD completions following DO primes drops significantly (t(59)= 2.92, p < 0.00) after a lag of three, as demonstrated by the sharply decreasing slope from lag one to lag three. An increase in priming over longer lags has been found in other studies (Ferreira et al. in press); however, the interaction between DO primes and lag is curious. Determining whether this DO and lag interaction is stable or if it is an effect of experimental noise will require further exploration and is beyond the scope of the current work.

6 Conclusion
The current study explored the possible effects of two forms of embedding on speakers’ tendency to reuse recently encountered forms of the dative alternation. In keeping with the results reported in Branigan et al. 2006, I found that speakers were just as likely to be primed by forms in embedded positions as they were to be primed by forms in matrix positions. In addition, I found that this tendency was unaffected by the form of embedding (complement clauses vs. relative clauses) and was unaffected by the number of intervening items between the prime and the target. There was never an effect of position. Furthermore, there was never any interaction between position and prime or lag.

This pattern of results supports the Context Doesn’t Matter hypothesis, which states that priming from embedded and matrix positions is the same. The Context Matters I theory, which states that priming is not possible from embedded
positions, fails to account for the results. While the data also do not support the Context Matters II theory, which states that priming is possible from both positions but that one position may support priming better, this hypothesis may still be viable. As mentioned above, the design of Experiments One and Two may mask subtle effects of embedding. For example, in both experiments, the verbs were the same in the prime and target. This repetition may have supported priming more so than a more naturalistic task. Future work should explore the possibility that, as task demands become more similar to conversation, differences in priming from matrix and embedded positions will arise.

Knowing how priming interacts with embedding can inform our models of language learning and change. Some have argued that priming is a form of implicit learning, so knowing the features of the input that may affect priming behavior is relevant (Chang et al. 2000, Ferreira & Bock 2006). It may be that the form of the linguistic input affects how speakers process it and that these differences in processing may lead to differences in production. Likewise, there is evidence that speakers may track probabilistic distributions of some linguistic forms differently depending on where they occur, e.g. the distribution of phonotactic constraints within syllable structure (Goldrick & Larson, 2008). However, this may not be true for syntactic structure. It may be that structural priming is not sensitive to such factors. On the other hand, it may be that such factors do matter but only in certain situations. Perhaps priming is possible from both embedded and matrix positions, but speakers are not able to track fine-tuned probabilistic distributions of forms that occur in some structural contexts as well as others. Either way, knowing the environments from which priming is possible helps focus our attention on the environments that are relevant for language learners. When we know what environments are and are not accessible to learners, we will be able to develop better models of language learning and change.

References

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