The Role of Memory in a Structural Priming Task

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THE ROLE OF MEMORY IN A STRUCTURAL PRIMING TASK

By

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The Graduate School has verified and approved the above-named committee members, and certifies that the thesis has been approved in accordance with university requirements.
To my family and friends
ACKNOWLEDGEMENTS

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ABSTRACT

Recent research on structural priming has found that cumulative priming effects established in one experimental session can persist for a week and affect a participant’s subsequent linguistic productions (e.g., Kaschak, Kutta, and Schatschneider, 2011). Furthermore, the results of Kaschak, Kutta, and Coyle (under review) indicated that the persistence of the priming effect over the course of a week was dependent upon the participant performing the same language production task that they had a week before. This provided evidence that the long-term cumulative structural priming effect operates in a context-specific manner, however it is unclear exactly what types of memory contribute to these long-term priming effects. The persistence of this long-term cumulative structural priming effect seems to be primarily due to the participant’s implicit learning of the biased syntactic construction and the procedural learning that occurred in the biasing phase. If the priming effect is primarily due to implicit learning, then it should be insensitive to changes in the extrinsic context and follow the pattern of results found in McKone and French (2001). The results of the present study indicate that the long-term persistence of the priming effect was insensitive to any changes in the extrinsic context. This study provides strong evidence that long-term structural priming effects should be attributed to an implicit learning mechanism within the language production system. Implications for the role of memory in a structural priming task and prospective research are discussed.
CHAPTER ONE

INTRODUCTION

Structural priming refers to the tendency for people to subsequently produce the syntactic structures that they have experienced across multiple utterances (e.g., Bock, 1986). For example, an individual who has recently been exposed to a double object construction (DO; Tim handed Karen the book) will be more likely to produce another DO completion when describing the transfer of something to another person (The author gave the editor the manuscript) than to produce a prepositional object construction (PO; The author gave the manuscript to the editor). Over the past few decades researchers have increasingly begun to use structural priming to investigate a wide range of linguistic phenomena. Structural priming has been found using spoken (e.g., Bock, 1986) and written (e.g., Cleland and Pickering, 2006) production, across a wide range of constructions (e.g., Griffin and Weinstein-Tull, 2003; Hartsuiker and Kolk, 1998; Pickering and Branigan, 1998), and across several languages (e.g., Hartsuiker and Kolk, 1998; Hartsuiker et al., 2004). Structural repetition effects are valuable to psycholinguists and cognitive researchers because the tendency to repeat structural features can shed light on the linguistic representations that we use and the nature of the linguistic mechanisms that allow our language system to adapt over time (e.g., Chang, Dell, and Bock, 2006; Bock and Griffin, 2000). If we are to better understand how structural priming affects our linguistic system over time (i.e., language acquisition and language change), then it will be necessary to understand how structural priming effects behave over a broader range of language use and how memory processes contribute to these effects.

Structural priming effects have been attributed to transient spreading activation (e.g., Pickering and Branigan, 1998), implicit learning (e.g., Chang et al., 2006), or as a combination of both (e.g., Hartsuiker et al., 2008; Reitter, Keller, Moore, 2011). There has been empirical support for both mechanisms: the short term increase in priming due to the repetition of lexical items across prime and target trials point towards an activation-type mechanism (e.g., Hartsuiker et al., 2008; Pickering and Branigan, 1998), and evidence for long-term priming effects (e.g., Bock and Griffin, 2000; Kaschak et al., 2011) suggest a role for implicit learning. Although more work needs to be done to understand the learning and memory mechanisms that contribute to structural priming effects, we believe that it is not unreasonable to expect that some combination
of implicit and explicit processes are involved in producing these priming effects (see Hartsuiker et al., 2008 and Chang et al., 2006, for a discussion of the role of explicit and implicit memory in structural priming). Our data also suggests that the nature of these long-term cumulative priming effects varies depending upon the delay between the experimental phases.

Kaschak, Kutta, and Schatschneider (2011) assessed the extent to which cumulative structural priming effects would persist over a long term delay (i.e., one week). The results of that study were straightforward and indicated that the structural priming effect would persist when measured after a week delay when the participants completed the same language production task (i.e., a stem completion task) across both experimental phases. The persistence of this priming effect over such a long term delay was consistent with the idea that structural priming effects are a result of the memory for the implicit/procedural learning that had occurred during the language production task. Kaschak, Kutta, and Coyle (in press) followed up on this finding by testing whether these long-term priming effects would persist when the language production was changed after a week delay. For example, one group of participants completed a stem completion task in the first phase and then completed a picture description task in the second phase. The results of Kaschak et al. (under review) indicated that structural priming effects persisted for at least a week only when the participant performed the same language production task that they had a week before. Presumably, transfer did not occur for those participants that had the language production task changed after a week delay because the syntactic probabilities and procedures that were implicitly learned a week before were not activated and reproduced due to the context-specific mechanism not being activated despite being in the same physical setting. Though it should be noted that there was a weak priming effect observed when the language production task was different after the delay of one week. One possibility is that this weak effect was facilitated by the participant returning to the same physical setting as a week before. In other words, the language production system appears to be sensitive to different syntactic structures through a context-specific mechanism. If the activation of the context-specific mechanism is necessary for priming to persist, then it is important to understand what levels of contextual information are relevant to a participant during a structural priming task. If structural priming follows the pattern of being insensitive to changes on the extrinsic level, then that would provide strong evidence for an implicit learning mechanism.
The transfer of the priming effect across tasks in an immediate condition, but not in the delay condition suggest that the task-specific nature of this mechanism may be driven by more than the adaptations to the abstract syntactic representation. The effects may also be driven partly by the memory for the procedure used while processing the given information in a trial and producing a grammatical sentence (see Kolers and Roediger, 1984, for evidence for the storage of this sort of procedural memory). The evidence from Kaschak et al., (under review) suggest that the abstract syntactic representations may not be as long lasting as memory for the processing of the linguistic input and production of an appropriate response for the stimuli. Therefore, the persistence of long-term priming effects may be driven largely by the procedural aspects of the structural priming task.

Again, it is unclear whether explicit memory processes significantly affect the learning of the syntactic representations and the procedural learning associated with the structural priming task. This study is aimed at providing insight into the task specific nature of these long-term priming effects by manipulating extrinsic processing factors. If the reinstatement of the extrinsic factors (i.e., the physical and virtual settings) facilitates the structural priming effect, then this effect will be attributable to a significant combination of implicit and explicit processes. To clarify, extrinsic sources of contextual information (i.e., the physical setting, time of day, or ambient noise) are those aspects of the experiment that are not directly relevant or necessary for the completion of the task (e.g., Godden and Baddeley, 1980; McKone and French, 2001). Conversely, Godden and Baddeley (1980) defined intrinsic contextual information as that information that was relevant and necessary to complete the experimental task (i.e., the visual processing of the item and the orthographic identification of the letters, the conversion to phonology, the determination of meaning, etc.).

If we find that long-term priming effects are insensitive to changes in the extrinsic context, then this study will provide further evidence that these priming effects are dependent largely upon implicit memory processes. This would also replicate the results found by McKone and French (2001), who found that repetition priming effects were insensitive to changes in the extrinsic context when they asked participants to perform a stem completion task for specific words they had studied previously. Thus, McKone and French found that only intrinsic contextual information was relevant to the participants in their task. These researchers concluded that these results were consistent with Schacter and Tulving’s (1994) assertion that implicit
memory was dependent upon knowledge based memory systems, rather than the episodic memory system necessary for explicit memory. This study will attempt extend these results to a structural priming task.

The task specific nature of long-term priming effects raises the question of whether explicit memory or strategic processes contribute to the persistence of the effect. Much still remains to be understood how different memory mechanisms contribute to structural priming. Using post-task surveys it is apparent that participants can use a number of explicit memory strategies when completing a structural priming task. For example, participants commonly report looking to see if the same sentence stems are being presented in the second phase as the first phase. However, these same participants are rarely, if ever, aware of the structural priming manipulation that they have just experienced. Therefore, it is not entirely clear whether these explicit strategies will contribute to the persistence of the priming effect because the participant lacks any explicit knowledge of the task.

If the context-specific mechanism responsible for the priming effect is sensitive to contextual information on a general level (extrinsic to the task), then the reinstatement of the physical setting would facilitate the priming effect in part presumably through the reinstatement of the explicit strategies. Alternatively, if the context-specific mechanism is insensitive to changes on the extrinsic level, then we can assume that explicit memory strategies do not contribute to the observed priming effect when the extrinsic context is manipulated. The latter case presumes that the context-specific mechanism is only sensitive to the intrinsic contextual information.

In summary, the main goal of the two experiments in this study is to determine whether participants differentiate between long-term episodes of language experience using extrinsic contextual information related to the physical setting of the experiment and/or a virtual setting. A secondary goal was to assess the possible role for explicit memory strategies in a structural priming task when the extrinsic context was manipulated. We manipulated a video being played in the background of the priming task to maximize this extrinsic context manipulation.
1.1 Overview of the Experiments

Both of the experiments in this study utilized a structural priming paradigm comprised of two phases (e.g., Kaschak, 2007; Kaschak et al., 2011). First, participants completed the Bias phase of the experiment. In the Bias phase, participants were either biased 100% towards the double object (DO) construction or 100% to the prepositional object (PO) construction. Thus, the participants were biased to produce one particular syntactic construction over the other. In the second phase, the participants completed the Priming phase of the experiment. During the Priming phase, the participants were able to produce DO or PO constructions at will so we could observe how patterns of experience in the Bias phase affect subsequent language production. This allowed us to measure the cumulative priming effect established in the Bias phase while manipulating the different sources of context.

Both of the experiments utilized a video-context paradigm (e.g., Smith et al., 2010). Using this paradigm, participants were exposed to two sources of extrinsic contextual information. The first source of contextual information was the physical setting of the laboratory. Again, the extrinsic context has been defined as the aspects of the experiment that are not directly associated with the experimental task (e.g., Godden and Baddeley, 1980). In this case, we will only be manipulating the physical setting while controlling for other sources of extrinsic information where possible (i.e., the time of day, temperature, and ambient noise).  

The videos being presented to the participants were the second source of contextual information being manipulated (e.g., Smith et al., 2010). Participants watched the videos on a computer monitor while wearing headphones playing an audio track of nature sounds associated with each video. Using these videos the participants had access to multimodal perceptual information from the virtual environment (i.e., the visual and auditory information). The video context paradigm allowed the virtual context from the video to be nested within the physical setting of the experiment. This allowed us to measure the priming effect while manipulating the two sources of extrinsic context.

There will be two videos used in both Experiment 1 and 2. Both of these videos will be taken from a high definition nature show on the Discovery channel (i.e., Sunrise Earth). The first

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1 The temperature was the same on average for those participants that completed both phases in the lab setting, but for those participants exposed to a different physical setting in the Priming phase the temperature was different relative to the Bias phase. It should also be noted that the ambient noise levels were different at the outdoor location. These differences were considered aspects of the physical setting being different for those participants.
There are two differences between Experiment 1 and 2. The first difference was the delay between Priming and Bias phases. In Experiment 1, the participants completed the experiment in the same day with a ten minute delay between the two phases. Experiment 2 had a week long delay between the Bias and Priming phases. This allowed us to determine if participants were using the contextual information in different ways after the delay of a week relative to the ten minute delay condition. It is known that the match between the retrieval and encoding phases affect the success of retrieval (better match leading to better retrieval; see Crowder, 1993, for a review), it is also known that the importance of the match between the encoding and retrieval phases is affected by the delay between these phases (e.g., Read and Craik, 1995). If the priming effect is sensitive to explicit memory strategies, then the reinstatement of one or both of the extrinsic sources of context should result in a stronger priming effect relative to those participants did not receive this reinstatement.

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2 Unfortunately, we were unable to publish any screen shots of the videos due to copyright laws.
CHAPTER TWO

EXPERIMENT 1

The participants in Experiment 1 completed the video experiment with a ten minute delay between the Bias phase and Priming phase of the experiment. All of the participants began the Bias phase in a standard laboratory setting on a computer display. During the Bias phase, these participants were by themselves in a plain white room with headphones on to further immerse them in the virtual context by listening to sounds that were recorded at the virtual context and to minimize the influence of ambient noise. The participants were instructed to pay attention to the video being played in the background while reading the sentence stems superimposed on the video. Then participants were told to complete the sentence stems with the first thing that came to mind. There was no explicit instruction given to the participants to pay attention to the physical setting.

After the Bias phase, participants were escorted by an experimenter across campus to a specified location. The walk served as the delay between the two phases and on average took ten minutes to complete. This is a similar procedure to the one used by McKone and French (2001). Half of the participants in the experiment were escorted across campus for five minutes until they reached a designated location and then returned to the lab setting to complete the Priming phase. The participants in this condition walked for five minutes to a set location and then walked back to the lab setting by retracing their steps (i.e., reinstating the same physical context).

The other half of the participants in Experiment 1 did not return to the laboratory setting after completing the Bias phase (i.e., not reinstating the same physical context). Instead, these participants were escorted across the campus for the entire ten minutes until they reached the location chosen for the different physical context. The location for the different physical context was the exterior section of the HCB building on campus. The participants were lead to the right side of the building, which is a large open area with a high roof that is exposed to the outdoors on several sides.

The different physical context was distinct from the initial laboratory context in several ways. First, the participants in the lab setting were alone in a plain white room with air conditioning with the door shut. In HCB, the participants were exposed to people walking around them, the elements, and environmental noise. The instructions for the Priming phase were the
same as in the Bias phase. They were instructed to again pay attention to the video in the
background while completing the sentences with the first thing that comes to mind. After
finishing the Priming phase, the participants were escorted back to the lab setting, debriefed, and
awarded credit.

2.1 Method

2.1.1 Participants

Eighty undergraduate students enrolled in introductory psychology at Florida State
University participated for partial course credit. Participants were excluded from the data
analysis if their completions in the Bias phase of the experiment were not skewed at least
80%/20% in favor of the intended construction (i.e., in the DO biased condition, participants had
to produce at least 80% DO). Otherwise, the participant’s experience in the Bias phase would not
reflect the exposure to the intended construction.

2.1.2 Materials

In the Bias phase, there were 12 pairs of prime stems, where one member of each pair
primed the participants to produce a DO construction (i.e., The captain handed the old sailor…) and
the other member primed the participants to produce a PO construction (i.e., The captain
handed the travel log…). In the Priming phase, there were 6 target stems (i.e., The student
handed…) that could have been completed as either a DO or PO construction. There were also
60 fillers stems used in this experiment. Participants are not easily able to complete these filler
stems as a DO or PO construction. Thirty six of the filler stems were assigned to the Bias phase
of the experiment, and the remaining filler stems were assigned to the Priming phase.

2.1.3 Design

This experiment used a 2 X 2 X 2 between-participants design. Bias (DO vs. PO);
Physical Reinstatement (laboratory setting reinstated vs. no reinstatement); and Virtual
Reinstatement (video context reinstated vs. no reinstatement) served as the between-subjects
variables. The presentation order of the videos (i.e., the sea cave and Yosemite) was
counterbalanced. This experiment has sixteen different experimental groups. Participants were
randomly assigned to one of these sixteen groups with five participants in each group. These
sixteen groups were consolidated down to eight groups for the analysis. Thus, there were ten participants in each group for the analysis. For example, the group that watched the sea cave video within the same physical context across both phases of the experiment was combined with the group that watched the Yosemite video across both phases within the same physical context. Therefore, we assumed that the videos themselves will not be significantly different from one other. Subsequent analysis confirmed this assumption. The sentences across both of the phases were in the same presentation order for all of the participants with the only difference being the type of primes (DO vs. PO) in the Bias phase.

A quarter of the participants in this experiment returned to the same physical setting and watched the same video in both of the phases (i.e., Same physical context-Same virtual context). So, these participants returned to the lab setting after a ten minute walk and watched the same video that had previously while completing the Bias phase. Another quarter of participants returned to the same physical setting, but they watched a different video in the Bias phase than they originally watched in the Priming phase (i.e., Same-Different group). The third quarter of participants completed the Bias phase at the different physical setting, but they watched the same video as in the Priming phase (i.e. Different physical context-Same virtual context). The final quarter of participants completed the Bias phase at the different physical setting and watched a different video than in the Priming phase (i.e., Different-Different group). Again, these participants were analyzed as eight experimental groups by looking at the effects as separated by the particular syntactic constructions (i.e., DO or PO) that the participants were biased.

2.1.4 Procedure

All of the participants in Experiment 1 completed the Bias phase of the experiment by themselves in the laboratory setting. The physical context for the Bias phase was always a plain laboratory setting. The participants were instructed to watch and pay attention to the video on the computer screen and focus on the scenery and scene changes in the video (i.e., the camera changed positions periodically to show another view of the virtual context). The participants were also instructed to complete the sentence stems that were superimposed on the same video while watching the video. Each of these sentence stems were presented for nine seconds so the participants were able to comfortably complete the stems without feeling rushed. If the participants were rushed, then they may have only focused on the sentence stems and disregarded the background video. The participant completed the sentence stems aloud while
being recorded by Audacity. The participants in the 100% DO conditions of the Bias phase completed 12 DO-eliciting prime stems. In the 100% PO conditions, the participants completed 12 PO-eliciting prime stems. Throughout both the Bias and Priming phases of the experiment, 3 or 4 filler stems separated each critical prime or target stem. The presentation for each of the videos (i.e., Yosemite and the sea cave) was counterbalanced across both phases of the experiment.

After completing the Bias phase of the experiment, all of the participants had a ten minute delay before beginning the Priming phase. During this ten minute delay, the participants were escorted on a walk around campus along a set path. The participants were told the same cover story used by McKone and French (2001) to explain why the walk was necessary. The participants were told that the goal of the experiment was to investigate the effects of nonstrenuous exercise on the task. After the walk, half of the participants returned to the laboratory setting while the other half were led to HCB to complete the Priming phase. Thus, the physical context of the experiment was reinstated for those participants who returned to the laboratory setting. In the different physical context, the participants completed the Priming phase in the covered exterior area of the HCB building using a laptop and headphones with a microphone attached.

After the ten minute walk, all of the participants completed the Priming phase of the experiment. The participants were exposed to the virtual context manipulation (match vs. mismatch) following the physical context manipulation (match vs. mismatch). Participants either watched the same video as they did in the Bias phase or a different video. Therefore, we were able to detect differences in the priming effect by manipulating the physical and virtual contexts across the eight experimental groups. The instructions given in the Priming phase were the same as in the Bias phase. Participants were instructed to pay attention to the video being played in the background while completing sentence stems aloud. The participants completed 6 target stems that could be completed using either a DO or PO construction. The order of fillers, primes, and target stems throughout the experiment was the same for all of the participants.

2.1.5 Scoring

All the experiments reported in this paper involve the use of written stem completion. The scoring for written stem completions was as follows. For prime stems (e.g., Karen gave Susan…), completions were scored as a DO if the completion was a noun phrase incorporating
the patient of the verb. Completions were scored as a PO if they began with a prepositional phrase using the word “to” that incorporated the beneficiary of the verb. For target stems (e.g., The captain sent…), completions were scored as a DO if they contained two noun phrases, the first denoting the beneficiary of the verb, and the second denoting the patient of the verb. Completions were scored as a PO if they consisted of a noun phrase denoting the patient of the verb and a prepositional phrase using the word “to” that denoted the beneficiary of the verb. All other completions, including completions containing a verb particle (Susan gave the toy back to Karen) and completions that were non-reversible (e.g., a PO completion that would not produce a grammatical DO completion: The girl gave it to her mom), were scored as “other.”

2.1.6 Analysis

The responses from the Bias phase were examined to ensure that the participant’s productions reflected the intended construction (as described earlier). The proportion of DO and PO constructions produced by each participant in the Priming phase were calculated by dividing the number of responses for each type by the total number of DO and PO completions produced. This calculation ignored trials where the participants produce an ungrammatical sentence (i.e., an other response). Trials scored as “other” (PO bias=13%; DO bias=15%) were excluded from the analysis, creating a binary dependent variable (DO responses coded “1,” PO responses coded “0”). Mixed logit analysis was conducted to predict the log odds of producing a DO target completion. Analysis was done with the HLM statistical software (Raudenbush, Bryk, Cheong and Congdon, 2004) and the lme4 package (Bates, Maechler, and Bolker, 2011) of R (R development core team, 2011). All predictors in all analyses were centered. For every model reported here, collinearity was assessed using the collin.fnc() procedure in R. All obtained Kappa values were < 2.64. Therefore, collinearity was not a concern.

Models included participants and items as crossed random factors. Intercepts could vary across participants and items. We employed a model comparison approach to determine the best fitting model for our data. The first model we ran was a model including Bias condition (DO bias=1, PO bias=0), Physical condition (Match=1, Mismatch=0), and the Virtual condition (Match=1, Mismatch=0) without random slopes, and the same model with the full complement of random slopes. The model with the random slopes did not significantly improve model fit. We also ran a model with the full complement of interactions. This model also failed to significantly
improve fit. The best fitting model included Bias condition, Physical condition, and Virtual condition without any random slopes or interactions.

2.2 Results and Discussion

The best-fitting mixed logit model predicting the log odds of producing a DO target completion using the HLM software is presented in Table 2.1. The estimated means that were predicted by the HLM software are presented in Table 2.2. The following results are the ones produced by the mixed logit model using the HLM software. It is important to note that the main results from the model using the HLM software were also run and confirmed using R. The main effect of the bias condition was significant (p<.001), but neither the effect of the physical condition (p=.217) or the virtual condition (p=.271) were significant. The results of Experiment 1 indicate that those participants biased towards the PO construction produced more PO completions in the Priming phase relative to the participants biased towards the DO construction regardless of any changes to either source of the extrinsic context changing.

The result of interest indicated that the observed priming effect was insensitive to changes on the level of the extrinsic context (i.e., the physical and virtual settings). The persistence of the priming effect was robust and present across all of the experimental groups regardless of extrinsic contextual manipulation. The overall trend in the data was opposite of what was initially predicted (i.e., the Diff-Diff condition showed a greater priming effect than the Same-Same condition). The reinstatement of the physical or virtual setting after a ten minute delay did not significantly facilitate the priming effect relative to the participants who did not receive this reinstatement. This result provides evidence that long-term structural priming effects are due to implicit memory processes and supports the findings from McKone and French (2001). Therefore, we can assume that the explicit memory strategies, being used by participants, do not significantly contribute to the persistence of long-term priming effects.

One possible reason for this result may be that the ten minute delay is not long enough to observe the contribution of explicit memory to cumulative priming effects. This hypothesis assumes that the extrinsic contextual information will be more relevant or necessary to the

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3 We chose to report the result from the mixed logit model that used the HLM software for both experiments because the estimated means that the model produced were more representative of the raw means from the data set than the ones produced by R.
priming task when there is a week delay between the experimental phases. Again, it is known that the match between the retrieval and encoding phases affect the success of retrieval (better match leading to better retrieval; see Crowder, 1993, for a review), it is also known that the importance of the match between the encoding and retrieval phases is affected by the delay between these phases (e.g., Read and Craik, 1995). Again, Kaschak et al. (under review) demonstrated the dynamic nature of the priming effect due to the decay of the implicitly learned syntactic representations and procedures used by the participants across the short and long-term delays. Thus, the week delay condition may have different results than Experiment 1 because the reinstatement of the extrinsic contextual information after a week may become increasingly important as a memory cue relative to the participants that do not receive this cue. Therefore, Experiment 2 in this study will extend the delay between the Bias and Priming phases to seven days.

Table 2.1: Mixed Models Regression Analysis for Experiment 1.

Mixed Logit Model

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>t-value</th>
<th>Df</th>
<th>p-value</th>
<th>Odds Ratio</th>
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<td>Intercept</td>
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<td>.399</td>
<td>0.43</td>
<td>346</td>
<td>0.667</td>
<td>1.19</td>
</tr>
<tr>
<td>Bias Condition</td>
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<td>0.46</td>
<td>5.09</td>
<td>346</td>
<td>&lt;.001</td>
<td>10.32</td>
</tr>
<tr>
<td>Physical Condition</td>
<td>-0.564</td>
<td>0.46</td>
<td>-1.24</td>
<td>346</td>
<td>0.217</td>
<td>0.56</td>
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<tr>
<td>Virtual Condition</td>
<td>0.504</td>
<td>0.46</td>
<td>1.10</td>
<td>346</td>
<td>0.271</td>
<td>1.65</td>
</tr>
</tbody>
</table>
Table 2.2: Raw and Estimated Means for Experiment 1.

<table>
<thead>
<tr>
<th>Contextual Environment</th>
<th>Raw Means</th>
<th>Estimated Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DO Bias</td>
<td>PO Bias</td>
</tr>
<tr>
<td>Physical</td>
<td>Virtual</td>
<td></td>
</tr>
<tr>
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<td>.885</td>
</tr>
<tr>
<td>Diff</td>
<td>Same</td>
<td>.808</td>
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<tr>
<td>Same</td>
<td>Diff</td>
<td>.625</td>
</tr>
<tr>
<td>Same</td>
<td>Same</td>
<td>.690</td>
</tr>
</tbody>
</table>
CHAPTER THREE

EXPERIMENT 2

As in Experiment 1, participants in Experiment 2 completed the same structural priming experiment with the same sixteen experimental groups condensed down to eight for analysis. There were two main differences between these two experiments. The first was the delay between the two phases. In Experiment 1, the participants had a ten minute delay between the Bias and Priming phases. In Experiment 2, there was a week long delay between the two phases. The second difference was the physical setting used for the different location in the Priming phase. In the first experiment, the participants were led to HBC to complete the Priming phase. In the second experiment, the participants met the experimenter at Krentzman Lounge in the Union. This change was made to the procedure because Experiment 2 was run during the summer in Florida. If we had kept running the experiment outside at HCB the participants would have been exposed to soaring temperatures and frequent rain storms. Krentzman Lounge was chosen as a replacement to avoid those issues while still exposing the participants to a physical setting that captured all of the contextual differences that HCB did in Experiment 1. The videos for this experiment were the same as in Experiment 1. The materials for both of the phases were the same as in Experiment 1. The goal of this experiment was to determine whether participants would make use of the contextual information in different ways over the week delay relative to the ten minute delay condition.

3.1 Method

3.1.1 Participants

Eighty undergraduate students enrolled in introductory psychology at Florida State University participated for partial course credit. Participants were excluded from the data analysis if their completions in the Bias phase of the experiment were not skewed at least 80%/20% in favor of the intended construction (i.e., in the DO biased condition, participants had to produce at least 80% DO). Otherwise, the participant’s experience in the Bias phase would not reflect the exposure to the intended construction.
3.1.2 Materials

The materials were the same as in Experiment 1.

3.1.3 Design and Procedure

The design and procedure were the same as in Experiment 1, except that there was a week long delay between the two phases and the participants had to meet the experimenter at the Krentzman Lounge to complete the Priming phase.

3.1.4 Scoring

Prime and target stem completions were scored as DO, PO, or “other” using the same procedure as Experiment 1.

3.1.5 Analysis

The responses from the Bias phase were examined to ensure that the participant’s productions reflected the intended construction (as described earlier). The proportion of DO and PO constructions produced by each participant in the Priming phase were calculated by dividing the number of responses for each type by the total number of DO and PO completions produced. This calculation ignored trials where the participants produce an ungrammatical sentence (i.e., an other response). Trials scored as “other” (PO bias=15%; DO bias=13%) were excluded from the analysis, creating a binary dependent variable (DO responses coded “1,” PO responses coded “0”). Mixed logit analysis was conducted to predict the log odds of producing a DO target completion. Analysis was done with the HLM statistical software (Raudenbush, Bryk, Cheong and Congdon, 2004) and the lme4 package (Bates, Maechler, and Bolker, 2011) of R (R development core team, 2011). All predictors in all analyses were centered. For every model reported here, collinearity was assessed using the collin.fnc() procedure in R. All obtained Kappa values were < 2.64. Therefore, collinearity was not a concern.

Models included participants and items as crossed random factors. Intercepts could vary across participants and items. We employed a model comparison approach to determine the best fitting model for our data. The first model we ran was a model including Bias condition (DO bias=1, PO bias=0), Physical condition (Match=1, Mismatch=0), and the Virtual condition (Match=1, Mismatch=0) without random slopes, and the same model with the full complement of random slopes. The model with the random slopes did not significantly improve model fit. We
also ran a model with the full complement of interactions. This model also failed to significantly improve fit. The best fitting model included Bias condition, Physical condition, and Virtual condition without any random slopes or interactions. This is the same model that was used in Experiment 1.

### 3.2 Results and Discussion

The best-fitting mixed logit model predicting the log odds of producing a DO target completion is presented in Table 3.1. The estimated means that were predicted by the HLM software are presented in Table 3.2. The following results are the ones produced by the mixed logit model using the HLM software. Again, these same results were compared and replicated when the model was run using R. The effect of the bias condition was significant (p<.001), but neither the effect of the physical condition (p=.998) or the virtual condition (p=.974) were significant. The results of Experiment 2 indicate that on average those participants biased towards the PO construction produced more PO completions in the Priming phase relative to the participants biased towards the DO construction.

The result of interest indicated that the observed priming effect was still insensitive to changes on the level of the extrinsic context (i.e., the physical and virtual settings) despite the delay being extended to a week. This experiment replicated the null finding from Experiment 1 (i.e., the Diff-Diff condition again demonstrated a greater structural priming effect relative to the Same-Same condition). Thus, the long-term cumulative priming effect did not become increasingly dependent upon explicit memory processes as the delay between the phases increased because the reinstatement of the extrinsic context did not significantly facilitate the priming effect relative to the participants who did not receive this reinstatement. In fact, there was almost no variability between the groups within the specific grammatical bias. The raw and estimated means for the DO and PO biased participants are much more uniform relative to Experiment 1 (Table 3.2).

This normalization of the priming effect was attributed to the language exposure that the participants experienced during the week delay. During the delay, the participants were exposed to normal the normal base rates of DO and PO production by conversing with their friends and peers. When the participants returned to the experiment and performed the same language production task from a week before we see that a uniform priming effect across both syntactic
constructions. This leads us to believe that the reinstatement of the extrinsic context and explicit strategies do not significantly facilitate the persistence of the priming effect regardless of the delay length (i.e., ten minutes vs. a week). This result supports the findings from McKone and French (2001) and provides further evidence that the persistence of the priming effect is largely dependent upon the participants’ implicit memory processes.
Table 3.1: Mixed Models Regression Analysis for Experiment 2

Mixed Logit Model

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>t-value</th>
<th>Df</th>
<th>p-value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.377</td>
<td>0.50</td>
<td>0.76</td>
<td>346</td>
<td>0.450</td>
<td>1.46</td>
</tr>
<tr>
<td>Bias Condition</td>
<td>1.48</td>
<td>0.36</td>
<td>4.06</td>
<td>346</td>
<td>&lt;.001</td>
<td>4.38</td>
</tr>
<tr>
<td>Physical Condition</td>
<td>-0.0089</td>
<td>0.36</td>
<td>-0.025</td>
<td>346</td>
<td>0.980</td>
<td>.991</td>
</tr>
<tr>
<td>Virtual Condition</td>
<td>0.029</td>
<td>0.36</td>
<td>0.083</td>
<td>346</td>
<td>0.934</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Table 3.2: Raw and Estimated means for Experiment 2

<table>
<thead>
<tr>
<th>Contextual Environment</th>
<th>Raw Means</th>
<th>Estimated Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DO Bias</td>
<td>PO Bias</td>
</tr>
<tr>
<td></td>
<td>DO Bias</td>
<td>PO Bias</td>
</tr>
<tr>
<td>Physical Diff</td>
<td>.745</td>
<td>.453</td>
</tr>
<tr>
<td>Physical Same</td>
<td>.757</td>
<td>.427</td>
</tr>
<tr>
<td>Virtual Diff</td>
<td>.760</td>
<td>.400</td>
</tr>
<tr>
<td>Virtual Same</td>
<td>.663</td>
<td>.583</td>
</tr>
<tr>
<td>Same Diff</td>
<td>.751</td>
<td>.408</td>
</tr>
<tr>
<td>Same Same</td>
<td>.755</td>
<td>.413</td>
</tr>
</tbody>
</table>
CHAPTER FOUR
GENERAL DISCUSSION

The results of this study are consistent with the idea that the language production system tracks the probabilities of use for particular syntactic constructions in a task specific manner. Furthermore, the results indicate that long-term priming effects are insensitive to the reinstatement of processing factors that are extrinsic to the processing of the language production task. Experiment 1 in this study demonstrated that the reinstatement of extrinsic contextual information does not contribute to the persistence of the structural priming effect following a ten minute delay. Experiment 2 in this study replicated this result across the delay of a week. Simply reinstating the general context of the experiment (in terms of the physical and virtual settings) does not appear to be enough to reinstate the effects of the Bias phase across a long-term delay. This evidence indicates that the persistence of these long-term priming effects follows the pattern that would be expected from an implicit or procedural learning mechanism within the language production system (e.g., Ferreira et al., 2008; Chang et al., 2006). This insensitivity to changes to the extrinsic context in a priming task replicates the results found by McKone and French (2001).

The data reported here have implications for our understanding of structural priming. Dual representation accounts, like this one, attribute the persistence of structural priming effects to a combination of the implicit learning of the syntactic representations and the memory for the procedural learning. Again, our data suggest that adaptations to abstract syntactic representations may not be as long lasting as memory for the processing work (e.g., Kaschak et al., under review). Kaschak and Glenberg (2004) proposed a single representation account of structural priming and asserted that the syntactic representations learned may contain not only elements of linguistically-relevant information, but also elements of the processing work (such as the processing required to read a sentence stem superimposed on a nature video to generating a completion for the stem) that goes into handling that linguistic information. A proceduralist approach to syntactic representation (or, as Kaschak and Glenberg, 2004, called it, an episodic-processing approach) is consistent with functional linguistics approaches (such as Construction Grammar; Goldberg, 1995; Kay and Fillmore, 1999; Kaschak and Glenberg, 2000) which hold that representations of syntactic constructions contain information about the structure, function,
and pragmatics of particular sentence types (i.e., not only abstract syntactic information, but also information about conventional uses and interpretations for a given construction). This study does not allow us to draw conclusions between the dual-representation and single-representation approaches to integrating syntactic knowledge with other sorts of procedural knowledge, but both approaches rely upon the memory for the procedural aspects of a structural priming task to account for long-term priming effects. This study provided insight into the task specific nature of these long-term priming effects and demonstrated that the procedural knowledge related to the extrinsic context does not significantly contribute to the persistence of these effects. These results provide further evidence that long-term priming effects are largely dependent upon implicit memory processes. This result leads us to believe that explicit memory strategies do not significantly contribute to the priming effect, else we would have observed a facilitation of the priming effect when the extrinsic context was reinstated. Instead, across both experiments we found no effect of the context being reinstated and the trend between the experimental groups followed the opposite pattern than was predicted (i.e., the Diff-Diff group performing better than the Same-Same group).

An avenue for future research is to further investigate the temporal dynamics of the interaction between the persistence of the implicitly learned syntactic representations and the procedural learning. One possibility is to present the same kind of language production task (i.e., sentence stems) between both phases over a week delay and manipulate the instructions for the task to change the way the sentence stems are processed between the phases (i.e., only giving them the standard instructions to use the first thing that comes to mind vs. instructions to complete the stem, but also focus on an aspect of the sentence stems for a forced choice recognition task later). If we manipulate the qualitative type of processing used in a structural priming task and find that the priming effect will diminish over the delay of a week, then that would provide evidence that the context-specific mechanism’s level of sensitivity to the intrinsic context is fine grained vs. coarse.
APPENDIX A

IRB APPROVAL LETTER

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

RE-APPROVAL MEMORANDUM

Date: 3/22/2011

To: Michael Kaschak

Address: Department of Psychology, FSU
Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research
The role of memory for specific experiences in language comprehension

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 3/20/2012, you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.
You are invited to be in a research study which requires you to sample products and make judgments. You were selected as a possible participant because you are enrolled in general psychology or another undergraduate course at Florida State University requiring you to complete research credits. We ask that you read this form and ask any questions you may have before agreeing to participate in this study.

This study is being conducted by Timothy J. Kutta, a graduate student at Florida State University, and Michael P. Kaschak, a professor at Florida State University.

**Background Information:**
The purpose of this study is 1) to determine the nature of language use and change over time.

**Procedures:**
If you agree to be in this study, we would ask you to do the following things: Complete sentence stems across two experimental phases.

**Risks and benefits of being in the Study:**
The study has minor risks because the participants will be completing part of the experiment outside of the laboratory setting at a location on campus. The chosen campus locations were a classroom building and a lounge in the student union.

The benefit to participation is becoming familiarized with psychology research and the research process through hands-on participation in this study. You will learn more about how scientific knowledge is acquired in the field of psychology.
**Compensation:**
The amount of credit you receive will depend on the length of the experiment. You will receive 1 credit for 60 minutes of participation or 2 credits for 120 minutes of participation. (The duration and compensation amount was indicated to you when you signed up for this experiment online.) Your credit will be posted online immediately after your participation, and you will be given a credit slip as proof of your credit before you leave the laboratory.

**Confidentiality:**
The records of this study will be kept private and confidential to the extent permitted by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records.

**Voluntary Nature of the Study:**
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

**Contacts and Questions:**
You may ask any questions you have now. If you have a question later, you are encouraged to contact the researchers conducting this study, Michael P. Kaschak by email (kaschak@psy.fsu.edu), by phone (850-644-9363), or in person (at A407 PDB).

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at jjcooper@fsu.edu.

You will be given a copy of this information to keep for your records.

**Statement of Consent:**
I have read the above information. I have asked questions and received answers. I consent to participate in the study.

________________  _________________
Signature                                          Date

________________  _________________
Signature of Investigator                    Date
REFERENCES


BIOGRAPHICAL SKETCH

Timothy J. Kutta

Tim grew up in Jacksonville, Florida and attended college at Florida State University. In the summer of 2009, Tim graduated from Florida State University with a Bachelor’s degree in Psychology. Tim enrolled in the Doctoral program in Cognitive Psychology at Florida State University in the fall of 2009.

Tim’s research interests include language production, comprehension, and the use of eyetracking. Tim is also interested in the contribution of memory and the structural nature of language to language acquisition and change across generations.