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Lexical and Syntactic Influences on Structural Selection in Language Production

Alexandra Kate Frazer
Lehigh University

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Alexandra Kate Frazer

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Alexandra Kate Frazer
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Defense Date

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Padraig G. O'Seaghdha, PhD
Dissertation Director

_____

Approved Date

Committee Members:

_____

Barbara Malt, PhD

_____

Almut Hupbach, PhD

_____

Kiri Lee, PhD

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ABSTRACT

We still know surprisingly little about how grammatical structures are selected for use in sentence production. A major debate concerns whether structural selection is competitive or noncompetitive. Competitive accounts propose that alternative structures or structural components actively suppress one another's activation until one option reaches the threshold for selection, whereas noncompetitive accounts propose that grammatical structures emerge as a result of incremental processes that generate an utterance in a piece-by-piece fashion, without direct competition between syntactic components. In this dissertation, I test the hypothesis that a competitive structural selection mechanism may function in tandem with more general incremental processes. Most importantly, I manipulated the structure of prime sentences (active and passive), and also included an unrelated control prime condition (intransitive structure) in order to clearly segregate facilitatory and competitive effects. Syntactic flexibility was manipulated by constraining structural choices or leaving them open. To fully explore syntactic and lexical processes, experiments also manipulated two kinds of verbs (normal agentive verbs and theme-experiencer verbs), verb repetition, and lexical priming of sentence arguments. Dependent measures included structural choices for the unconstrained conditions and initiation latency for all conditions. Across five experiments, results did not consistently show effects of structural priming on syntactic choices for unconstrained targets, or on reaction time. Consequently, there was also no evidence of competition in terms of reversals of choice rates or slower initiation of unprimed structures. Despite this, there was some evidence of increasing passive use within experiments. Given the weak priming effects, the patterns of errors and reaction times were assessed outside of the

priming manipulations. The results of these comparisons generally indicated that production was faster and less error-prone in the unconstrained conditions, consistent with a noncompetitive account, and largely replicating Ferreira (1996). The experiments also demonstrated dramatic differences of flexibility for the two different sub-types of verbs. As a whole, this dissertation provides little evidence for syntactic competition during structural selection in sentence production. However, a definitive test of competition in grammatical formulation must await a more successful manipulation of immediate structural choices.

Lexical and Syntactic Influences on Structural Selection in Language Production

"Very little is currently known about exactly how the activation of syntactic structures is represented" (van Gompel, Arai, & Pearson, 2012, p.385).

The subjective experience of language is simple. Speakers hear sentences and understand them. They open their mouths, and (usually) an understandable and well-formed response tumbles out. However, things are not as simple as they seem. The study of language production unveils the underlying complexities of this process. Here, I attempt to better understand how speakers formulate their utterances, particularly the mechanisms that drive syntactic structure selection in sentence production.

Models of language production differentiate three distinct processes of speaking: conceptualization, formulation, and articulation (Levelt, 1989). Speakers start with a non-linguistic representation or conceptualization of a particular message to be expressed (Bock & Levelt, 1994; Levelt, 1989, Levelt, Roelofs, & Meyer, 1999; see Figure 1). This "message" must minimally include representations of the concepts which will be expressed, and it must contain information about the relationships among those concepts (Bock & Levelt, 1994; Chang, Dell & Bock, 2006; Levelt, 1989). For example, for a simple event with two elements, a message must include an agent or experiencer, another entity, and an action. This message then enters the formulator, where grammatical and phonological encoding processes occur, including lexical retrieval, the construction of syntactic frames, and the retrieval of the sounds of the words. Next, the information proceeds to the articulator and finally results in speech. In this dissertation, I focus on the initial group of the processes in the formulator, those of grammatical encoding. Grammatical encoding involves both the selection of words to be used in an utterance,

and the formulation of the structure of the utterance itself. But models differ in the degree to which they allow syntactic processing to interact with the selection of words, as well as whether syntactic structures are directly linked with one another. The goals of this dissertation are to investigate how lexical and syntactic processes combine to guide the formulation of sentences, and to understand the mechanisms which operate in ultimately determining syntactic structure. More precisely, I wish to illuminate whether syntactic structures are connected through an inhibitory link and can therefore influence one another's availability for selection through competition, or whether structural selection proceeds solely in an incremental non-competitive fashion due to the linear nature of language production, with structures unable to directly influence one another's use and availability.

In order to understand whether syntactic structures are directly linked to one another and if so, whether structural selection is competitive, we must first review some more general accounts and properties of grammatical encoding. First, I review two specific views regarding grammatical encoding, Lexicalist and Abstract structural accounts. Next, I describe the specific lexicalist model I have adopted for the purposes of this dissertation (see Pickering & Branigan, 1998). Then, I will use this model to address the question at hand: the debate between competitive and non-competitive accounts of structural selection in language production. I will review the evidence for and against these two perspectives, and present a series of experiments designed to investigate the potential mechanism of structural selection. Finally, I use evidence from this series of experiments to draw a conclusion about the nature of structural selection in language production.

Grammatical Encoding

Grammatical encoding is the stage of language production where both the lexical content and the structure of an utterance are formulated (see Figure 1).There are differing viewpoints regarding the relationship between words and structures in grammatical encoding (see Wheeldon, Smith, & Apperly, 2011). Some models propose that the formulation of syntax is an abstract structural process whereby speakers possess mechanisms that generate abstract structural frames that are not tied to, or dependent upon lexical retrieval processes (Chang, 2002; Chang, et al., 2006; Konopka & Bock, 2009; Wardlow Lane & Ferreira, 2010). Other models propose that syntactic formulation is a lexically driven process in which lexical selection occurs prior to or is a prerequisite for generation of the structure of the utterance (Bock & Levelt, 1994; Cleland & Pickering, 2003; Pickering & Branigan, 1998; Wheeldon et al., 2011).

Abstract Structure

In abstract structural accounts of production, speakers abstractly represent structural frames. Importantly, these frames are "abstract" in that they are not directly associated with or dependent on specific lexical items (Konopka & Bock, 2009). Support for this idea has come from research showing that as language production proceeds from a non-linguistic to a linguistic representation, syntax is at least partly isolable from both the levels of meaning and sound (Bock, 1986; Bock & Kroch, 1989; Ferreira & Bock, 2006; Ferreira & Clifton, 1986; O'Seaghdha, 1997). In particular, there is an extensive body of research on the phenomenon of structural priming, which has often been interpreted as favoring the idea that abstract structural frames are generated independently of lexical or conceptual content (Pickering & Ferreira, 2008).

Structural priming is simply the tendency for speakers to unknowingly repeat abstract syntactic structures they have recently encountered (also termed syntactic persistence or syntactic priming) (e.g., Bock, 1986, 1987; Bock & Griffin, 2000a, 2000b; Ferreira and Bock, 2006; Melinger & Dobel, 2005; Potter & Lombardi, 1998; Pickering & Branigan, 1999; Smith & Wheeldon, 2001; Wheeldon & Smith, 2003; see Pickering & Ferreira, 2008 for a recent review). For example, in one of the first studies on this topic, Bock (1986) demonstrated that after producing the prepositional object sentence "The rock star sold some cocaine to an undercover agent", participants were more likely to describe a picture of a girl who is handing a brush to a man with another prepositional object sentence, "The girl handed a paintbrush to the man," than as a double object sentence, "The girl handed the man the paintbrush". Thus, speakers were more likely to select the structure that they recently used than they were to select an alternative sentence structure even in the absence of any relation between the two sentences.

Structural priming cannot be explained by repetition of themes, lexical items, or metrical relationships between the prime and target utterances (Bock & Loebell, 1990; Chang, Bock, & Goldberg, 2003), though it is increased with lexical repetition (Hartsuiker, Bernolet, Schoonbaert, Speybroeck, Vanderelst, 2008; Pickering & Branigan, 1999); it has been demonstrated across languages (Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003), in written and spoken production (Branigan, Pickering, & Clelland, 1999 Pickering & Branigan, 1998), between speakers (Bock, Dell, Chang & Onishi, 2007; Branigan, Pickering, & Cleland, 2000), in aphasiac speakers (Ferreira, Bock, Wilson, & Cohen, 2008; Hartsuiker & Kolk, 1998; Saffran & Martin, 1997), in children (Huttenlocher, Vasilyeva, & Shimpi, 2004; Savage, Lieven, Theakston,

& Tomasello, 2006), and can be long-lasting (Bock & Griffin, 2000b), persisting across up to ten intervening sentences, though some studies show a reduction in magnitude over time (Branigan, et al., 1999) (see Pickering & Ferreira, 2008 for a recent review) . Essentially, when other factors are equal in production, syntax shows a tendency to repeat. The key property of structural priming for the current purposes is that structural priming occurs in the absence of any lexical repetition. Thus, structural priming supports the idea that at some early point during sentence formulation, an abstract structural frame is generated before any words are selected.

In one particularly influential model, the dual-path model, these abstract structural representations are linked to the conceptual level (Chang, et al., 2006), but the structures do not interact with words at a lexical level. In this model, structural priming is explained by an implicit learning mechanism that links certain syntactic structures to certain message level representations, and the strength of those links is altered through experience. This learning process results in the persistent effects of structural priming, such that when the same types of message structures are encountered later, the same syntactic structures are likely to be used again (Bernolet & Hartsuiker, 2010; Bock & Griffin, 2000b; Chang, Dell, Bock, & Griffin, 2000; Chang, et al., 2006; Ferreira & Bock, 2006; Kaschak & Borreggine, 2008; Savage et al., 2006). In other words, speakers of a language need to learn about the relationship between structures and meaning in their language. As they learn these mappings, they accumulate information about the frequency with which certain structures are used with certain types of messages. They then use this distributional information when selecting the form of utterances, resulting in structural priming as a natural consequence of implicit learning mechanisms. Whereas

this learning mechanism accounts for the long-lived effects of structural priming, it does not easily account for transient structural priming effects (Smith & Wheeldon, 2001; Wheeldon & Smith, 2003). Significant learning must accumulate over time and therefore should not dissipate rapidly, yet some priming effects are only found between immediately consecutive sentences. This model also does not directly address the fact that structural priming has been shown to be strengthened when lexical repetition is also present (Pickering & Branigan, 1998), though it has been noted that it may be able to account for such effects with additional assumptions (Coyle & Kaschak, 2008), or if considered in conjunction with other production processes (Chang et al., 2006; Ferreira & Bock, 2006; Pickering & Ferreira, 2008). These points will be addressed further shortly.

Lexicalist Accounts

Lexically based accounts of grammatical encoding propose that the retrieval of lemmas, or syntactically specified words, must occur before the generation of sentence structure (see Figure 1 for an illustration of lexically-based sentence formulation; Cleland & Pickering, 2003, 2006; F.Ferreira, 2000; Ferreira, 1996; Hagoort, Brown, & Osterhout, 1999; Kempen & Huijbers, 1980; Levelt, 1989; Levelt, Roelofs & Meyer, 1999; Pickering & Branigan, 1998; Roelofs 1992, 1993; Wheeldon, 2011). The lemma conveys information about the lexical item, such as the syntactic category, and featural information such as whether nouns are count or mass (e.g. *three* chairs - count noun; *less* furniture - mass noun). Lemmas also specify the gender, tense, and number of nouns and the number, person, aspect, and tense of verbs. This information is integral to the formulation of the structure for an utterance. Essentially, lemmas contain syntactic fragments that are necessary building blocks for building larger syntactic structures

(Hagoort, et al., 1999). Thus, in lexicalist accounts, syntactic structures are fully dependent on the lexical items that are selected for production, as structures emerge post-lexically. However, this does not rule out the existence of abstract structural frames, it simply assumes that such frames must be tied to lexical items.

One particular lexicalist model which is quite influential is Bock and Levelt's (1994) model[1] (for a similar "consensus" model, see also Ferreira & Slevc, 2007). Following Garrett (1980), they outline two levels at which grammatical encoding operates to determine the form of a sentence: functional and positional levels of encoding. First, during functional level grammatical encoding, the lemmas that are associated with the preverbal message are accessed from the lexicon of the speaker (lexical selection) and assigned to their respective grammatical roles (i.e. subject, object, verb, complement, or adverbial). Next, during positional level grammatical encoding the utterance is linearized and receives the correct inflections (see Figure 1; Bock & Levelt, 1994; Ferreira & Slevc, 2007; Garrett, 1980; Wheeldon, 2011).

This model was extended by Pickering and Branigan (1998). Pickering and Branigan (1998) proposed that lemmas are not only linked to grammatical category information and syntactic features, but that they are also connected to what they called "combinatorial nodes" (see Figure 1 for an illustration). These combinatorial nodes were proposed to represent various grammatical structures in which a word can successfully occur. In the Pickering & Branigan (1998) model, only the lemmas for verbs were linked with the combinatorial nodes. For example, the lemma for the syntactically flexible verb

[1] Note that Bock is not generally associated with lexicalist accounts of grammatical encoding. Rather, the majority of her work has contributed to the refinement of abstract accounts. Here, I note the Bock and Levelt (1994) model as a way to highlight the separation between functional and positional levels of encoding.

"*give"* would be linked with combinatorial nodes for both Prepositional Object (PO) and Double Object (DO) dative constructions. Conversely, the lemma for the verb "*donate"* would only be linked to the combinatorial node for the DO construction as *"donate"* does not allow the prepositional option. Importantly, because these combinatorial nodes are proposed to be shared between different lemmas, they are abstract. Critically in this model, such combinatorial information must be accessed at the lexical level, from the lemma for each verb. This differs from modern abstract accounts which have strict separation between lexical and syntactic information. Thus, the Pickering & Branigan (1998) model would explain structural priming effects as residual activation of the combinatorial node that was recently selected, making that structure more likely to be subsequently selected. If the same verb was used again, there would also be residual activation in the lemma and the link from the particular lemma to the combinatorial node that was selected.

Pickering and Branigan (1998) provided support for the idea of combinatorial nodes using a written sentence completion task. Because combinatorial nodes are linked directly with lemmas (which are unspecified for, but connected to, the specific features for the utterance), and are shared between lemmas, structural priming should be found in cases where the verb was different in adjacent utterances, as well as when it was repeated. However, Pickering and Branigan predicted stronger structural priming when the verb was repeated because of residual activation in the verb which is linked to the combinatorial node in addition to residual activation in the combinatorial node itself

(which drives priming when the verb differs)[2]. They further predicted that priming should be unaffected by changes in the tense, aspect, or number features of verbs because this information is linked directly to lemmas and is not represented in the shared combinatorial nodes or in the links to them. In a series of 5 experiments, they provided support for all of these predictions.

Cleland and Pickering (2003, 2006) later extended the combinatorial node idea to include nouns as well as verbs. They point out that nouns also have combinatorial properties such as what type of arguments they take and how they combine with adjunct phrases. For example, Cleland and Pickering (2003) describe an item, which could be described by a speaker as either "the sheep that is red" or "the red sheep" (p. 217). The first description of the sheep involves a post-nominal relative clause which would activate combinatorial node "N, RC", whereas the second has pre-nominal adjective modification which would activate the combinatorial node "A, N". They demonstrated that such complex noun phrases showed evidence of structural priming and, similar to the finding that structural priming was increased when verbs were shared, Cleland and Pickering found that when the head noun was repeated, there was increased priming. Thus, combinatorial nodes are not only linked to verbs, but they are also associated with other appropriate lexical items for a sentence, such as noun arguments.

Importantly, the combinatorial node model permits lexical factors to influence structural choices, which allows it to account for enhanced structural priming with lexical

[2] Pickering and Branigan (1998) specifically propose that the links between specific lemmas and combinatorial nodes are themselves activated and "primed". However, it is more difficult to imagine how this could be implemented in terms of a computational model. In terms of their specific idea or more recent computational models of the language system, the essential idea is the same, that residual activation prolongs the communication between specific lemmas and syntactic nodes.

repetition (Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995; Cleland & Pickering, 2003, 2006; Pickering & Branigan, 1998) or what has been termed the "lexical boost" effect (Hartsuiker, Bernolet, Schoonbaert, Spreyboeck, & Vanderelst, 2008). The lexical boost is the short-lived increase in priming when the verb or head noun is repeated from prime to target production, as described above. The fact that lexical repetition can strengthen the effect of structural priming is crucial, because it indicates that lexical processes can affect structural processes in production, which is the hallmark of lexicalist accounts of production.

Interestingly, there are also lexically based structural effects that do not even require prime structures to be produced in order to induce structural priming. Melinger and Dobel (2005) had participants first read ditransitive verb primes that were available in only one syntactic frame (prepositional object or double object datives) and then describe a simple line drawing. For example, *"contributed"* is only available in the prepositional object structure (e.g. "He *contributed* ten dollars to the orphanage" is grammatical but "He *contributed* the orphanage ten dollars" is ungrammatical), whereas *"fined"* is only available in the double object structure (e.g. "He *fined* the orphanage ten dollars" is grammatical but "He *fined* ten dollars to the orphanage" is ungrammatical). Despite the fact that participants did not produce a sentence in the prime, and there was no lexical repetition from prime to target, Melinger and Dobel found evidence of structural priming. Speakers who first read the word "contributed" were more likely to then use a prepositional object structure to describe a picture ("The boy handed the guitar TO the man"), whereas speakers who had read "fined" were more likely to use a double object structure ("The boy handed the man the guitar"). In other words, participants were

more likely to describe the picture with the structure promoted by the prime verb. Lexicalist models can account for such structural priming effects from single words presented in isolation (Melinger & Dobel, 2005). This result is difficult to account for in abstract models, as they do not allow for the interaction of lexical and syntactic information.

On the other hand, a weakness of lexicalist models is that it is unclear how a model based on residual activation in combinatorial nodes and connections between combinatorial nodes and verb nodes, could account for the long-lasting effects of structural priming. If activation in nodes and links decays rapidly, how can they explain long-term structural priming (e.g., Bock & Griffin, 2000b)? Also, recent studies have found that the lexical boost does not increase long-term priming, despite doing so in the short-term (Hartsuiker et al., 2008; Kaschak & Borreggine, 2008). Both of these issues appear to be problematic for the combinatorial node theory. Currently, it remains to be seen whether this class of models can be extended to account for the long-term effects of priming. Ultimately, a model should be able to account for both long-term and short-term effects, but while it is of theoretical interest whether the account can be extended, it is not directly relevant for the empirical work here. This dissertation is focused on the short-term effects of priming between immediately consecutive utterances and how this is modulated by lexical factors, so I will not focus on the explanation of long-term structural priming.

General Theoretical Framework

Based on the previous sections, I conclude that abstract and lexically based accounts of grammatical encoding each have advantages and disadvantages. The lexical

influences and short-term effects of structural priming are more easily addressed by lexicalist accounts, whereas long-term effects are better addressed by abstract accounts. In my view, both abstract structural and lexicalist accounts involve abstract syntax, though it is conceived somewhat differently in those accounts. As one of the purposes of this dissertation is to understand the interaction and integration of lexical and structural factors in language production, I take a lexicalist approach to spelling out my specific predictions, assuming that lexical items are directly related to syntactic structures (as in Pickering & Branigan, 1998). However, I will consider how abstract structural accounts, such as the dual-path model of Chang et al. (2006), would account for the findings of this dissertation when appropriate. I find the evidence in favor of some form of abstract syntax convincing, though based on the current state of the evidence I think that such abstract representations are likely to be linked with lexical items.

In sum, I will assume a conceptual message that may involve an entity, an agent/experiencer, and an action (e.g. *NEWS, JOHN, ALARM-Past*) is formulated and this message enters into grammatical encoding. The activated lemmas (e.g. John, alarm, news) are selected for production along with their associated syntactic and other featural information (e.g. *singular noun, past tense verb, singular noun*). These lemmas also spread activation to the combinatorial nodes which are associated with them (e.g. "alarm" activates both passive and active structures). The most highly activated combinatorial nodes are eventually selected (e.g. active structure) and this selection results in the structure of the utterance (e.g., "The news alarmed John"; also see Figure 1).

Lexical and Structural Interaction

The lexicalist model I have outlined is one in which lexical access is a prerequisite for accessing structural nodes. This has specific consequences for structural access when the lexical items related to combinatorial nodes are repeated versus changed. Even when no lexical repetition is present, the previously selected combinatorial nodes should be primed for selection again, and this increased selection likelihood should be even greater when lexical items are repeated. This boost when lexical repetition is present is a result of the combinatorial nodes direct connection to the lemmas (Cleland & Pickering, 2003; 2006; Hartsuiker et al., 2008; Melinger & Dobel, 2005; Pickering & Branigan, 1998). Recently, Wheeldon, Smith, and Apperly (2011) used a moving picture description paradigm to further investigate the consequences of this lexical-structural relationship. In this experiment, participants produced prepositional and coordinate noun phrase sentences, such as "The apple moves towards the dog" or "The apple and the dog move up," respectively. In the first experiment they used only prepositional sentences such that the structure was fixed. One of the objects in the display was repeated in consecutive trials, but that object occurred either in the same or a different sentence position. They found that lexical repetition speeded sentence production when it occurred as the first item in the target (e.g. "the apple" in the previous example), but only when the repeated item was also in the first structural position in the prime. When a repeated item was produced in the prepositional phrase in the prime "The carrot moves above *the watch*", then used as the head of the subject phrase in the target, such as "*The watch* moves towards the clock", no facilitation was observed in comparison to the prime that had no lexical repetition, "The carrot moves above the tree". However, when the prime,

"*The watch* moves above the carrot", and target "*The watch* moves away from the sock", both contained the repeated item in the subject position, facilitation was observed. They also used coordinate noun phrase sentences to further investigate this effect in Experiment 2. The results here demonstrated that whether the repeated item was the first or the second noun in the coordinate phrase (e.g. "the apple and the dog"), when the coordinate phrase was produced first in a target, facilitation was observed. They suggest that this is because both nouns in a coordinate noun phrase share thematic and grammatical roles, which is in contrast to nouns moving from a prepositional phrase to the subject phrase in the first experiment. Finally, in a third experiment, they convincingly demonstrated that the effect in the first study was due to structural assignment. Here, facilitation was obtained for the second noun, which appeared in the prepositional phrase (e.g. "The carrot moves above *the watch*"), when this word was repeated in a simple word production trial following the production of the prime (e.g. "*the watch*"). Thus, the lack of facilitation in the first study must have been caused by the generation of the sentence structure.

Wheeldon et al. (2011) posited that using a specific word in a particular structure interfered with that word's subsequent use in a different structure, and with the reassignment to a different role in the same sentence structure. They point out that the Pickering and Branigan (1998) type of model does not currently have a specific mechanism that is able to account for such an interference effect. Yet, if the Pickering and Branigan account possessed a competitive mechanism for the selection of combinatorial nodes, it could account for these interference effects (Wheeldon et al., 2011).

As the link between a particular lexical item and combinatorial node persists due to residual activation, when that lexical item must subsequently be produced in an alternative structure, competition between two combinatorial nodes would result in slower or more difficult selection (Wheeldon et al., 2011).

What Wheeldon et al. (2011; Wheeldon, 2011) propose is strikingly similar to an earlier description of the possible mechanisms of grammatical encoding by Ferreira (1996). Either grammatical structures actively compete for selection, or they do not. Ferreira's (1996) test of these two accounts supported a non-competitive view of grammatical encoding. However, there are a number of issues with the results of these studies, so they may not be convincing evidence against competition. Competition is a cross-cutting theme in language production research and more broadly in cognitive science. Thus, assessing whether it is involved in selection of structures or structural components is an important question that deserves additional attention and testing. First, I will provide a more detailed overview of the two alternative accounts.

Competitive and Non-competitive Accounts of Production

Some theories of language production predict that grammatical encoding is a competitive process, whereas others posit that it is incremental, or *non-competitive* (Ferreira, 1996). Here, I specifically refer to the latter accounts as *non-competitive* to avoid confusion with the general incremental nature of speech production. Speech is inherently incremental in that it is formulated across a number of levels (e.g. conceptual formulation, functional and positional grammatical encoding, phonological encoding, articulation), and each level must have some processing completed before encoding can begin at the next level, but processing can proceed on all levels in parallel for different

sections of the utterance (Wheeldon, Meyer, & Smith, 2003). Competitive accounts suggest that during grammatical encoding structures actively and directly compete with one another for selection (see Figure 1), whereas non-competitive accounts suggest that encoding proceeds in a piece-by-piece fashion, automatically selecting the most activated structural option. It is also possible that both of these processes are active during grammatical encoding. Specifically, due to the inherently linear nature of language, and the fact that there are well-documented effects of lexical availability on word choice and word order, it seems clear that there are certainly incremental processes at work during the formulation of syntactic structure. However, recent evidence seems to suggest that there is likely to also be a competitive mechanism operating which allows structures to directly affect one another (Wheeldon et al., 2011). Which process, competitive or non-competitive, predominates could be related to the strength of the various grammatical options. For example, if the alternate structures are not closely related, or one is awkward, or strongly dispreferred, then it may be quick and easy to select the dominant structure, consistent with non-competitive accounts. On the other hand, if structures are closely related or equally desirable, then they may have to enter into more direct competition in order for one structure to be selected for use (also see Stallings, MacDonald, & O'Seaghdha, 1998 for discussion). Next, I provide a more detailed overview of the differences between non-competitive and competitive accounts of grammatical encoding. This description is provided within the functional level of encoding, as this is the level at which sentence-level grammatical structure is determined.

The competitive model of grammatical encoding is relatively simple (Ferreira, 1996). Given a lemma that is activated by conceptual input, activation spreads to those

grammatical structures that are compatible with the item (also see Figure 1). For example, the verb "show" is syntactically flexible, and so can be used in both prepositional object (PO) and double-object (DO) dative sentences. However, the verb "display" is only available in PO constructions, and is therefore syntactically inflexible. The lemma for "show" spreads activation to the structural nodes for both PO and DO structures, and an inhibitory link between the PO and DO structural nodes allows the activation of each node to suppress activation in the other. While both nodes are active and competing, they are described as "restricting one another's availability", thus both nodes receive some amount of inhibition prior to the final structural decision (Ferreira, 1996, p. 729). This inhibition is necessary in order for a structure to be selected for production. To contrast with a syntactically inflexible verb, "display" would only activate the PO construction. In this case, there is no need for inhibition and competition, making production more fluent with "display" than with "show". In sum, the competitive model suggests that when a syntactic decision is required, production should be slower and more difficult than if there is only one option, because the alternative structures mutually inhibit one another prior to the final selection of one.

A non-competitive (termed *incremental* in Ferreira, 1996) model of grammatical encoding differs in that there are no inhibitory links between structural components. For example, imagine that a speaker wants to express a message indicating that a student named Bob wants the dean of the school to see a paper that he has written. So, if the speaker has incrementally selected "Bob" and "showed" from the corresponding conceptual input, the sentence can be continued in such a way that it could result in either a PO or a DO construction depending on whether "the dean" or "the paper" is more

activated and so is inserted next in the sentence. If "the paper" is selected, then the resulting construction will be a PO dative, "the paper will be shown TO the dean". Conversely, if "the dean" is selected first, the resulting construction will be a DO. In contrast, if the speaker chose the verb "displayed" there would be only one grammatically appropriate solution, to construct a PO utterance by next inserting "the paper". In this example, a non-competitive account of grammatical encoding essentially proposes that whichever item is "ready-to-go" at the time that the position following the verb is filled will determine the structure of the sentence when there are multiple syntactic options available. Being able to use whichever item is most easily available next in order to determine syntax when multiple structures are available should result in easier and more fluent production (Ferreira, 1996). In sum, a non-competitive account suggests that the incremental nature of language production is exploited to resolve syntactic choices: when a syntactic decision is required, syntactic flexibility should ease production as speakers produce whichever relevant component is most easily accessed next and there are no inhibitory links between structural nodes.

Importantly, the structural representations or nodes described by Ferreira (1996) appear to be analogous to the combinatorial nodes later discussed by Pickering and Branigan (1998) and others (Cleland & Pickering, 2003; 2006). I will use the more general term "structural nodes" for the remainder of this dissertation.

Evaluation of Ferreira's Non-competitive Account

Ferreira (1996) tested the predictions of non-competitive and competitive accounts in a series of 3 experiments. This paper, though not recent, is particularly relevant for the current dissertation because it is one of very few papers that directly

tested these alternative mechanisms. Many other studies have been interpreted in terms of support for a particular account, but most were not directly designed to differentiate between these two mechanisms. According to Ferreira, non-competitive models predict that verbs that are syntactically flexible should result in easier and more fluent production. Thus, if grammatical structure selection is non-competitive, then a relevant structure should be easier to prepare when more options are available, such as with alternating verbs like "show" (Ferreira, 1996; Levelt, 1989). For example, when constructing a ditransitive sentence to express the idea of letting the dean see the paper, with the syntactically flexible "show", speakers can insert either "the dean" or "the paper" in the post-verbal position and still produce a grammatical sentence, whereas with the syntactically inflexible "display", "the paper" must be inserted first in order to create a grammatical utterance, regardless of the ease of selecting either "dean" or "paper". That is, non-competitive accounts assume that the sequential nature of production is exploited to resolve the choices available. Therefore, for syntactically flexible utterances lexical access is a driving factor in determining the grammatical form of an utterance. Conversely, if grammatical structure is selected through a competitive process, the relevant structures must actively compete with one another for selection. The structures in competition mutually inhibit one another, which leads to increased difficulty and increased initiation latency when multiple options are available to the speaker.

In Ferreira's (1996) first experiment, speakers created utterances based on a sentence fragment presented on the screen ("I showed" –flexible alternator verb or "I displayed" –inflexible non-alternator PO verb) followed by two or three words in a random order that were to be used to complete the sentence ("dean/to/paper" –PO only or

“dean//paper” – PO or DO). Thus, some combinations allowed for syntactic flexibility and others did not. When there were syntactic options available, the participants were given alternator verbs and no preposition was presented [e.g. “I showed” and ”dean//paper” – available in both PO and DO constructions]; in contrast, when a choice was not available they were given either non-alternator verbs both with and without order-constraining prepositions and alternator verbs with order-constraining prepositions (e.g. “I displayed” and ”paper/to/dean”; “I displayed” and “paper//dean”; and “I showed” and ”paper/to/dean”: all available in PO constructions only). Both error rates and initiation times were recorded. When a syntactic option existed, speakers constructed utterances significantly more accurately; however initiation times were only marginally faster. Ferreira concluded that syntactic flexibility allows “well-formed grammatical encoding to proceed with a greater accommodation to varying lexical activations, and thus should make grammatical encoding more efficient” (Ferreira, 1996, p. 748-9).

Whereas Ferreira (1996) claimed that these results support a non-competitive account, I find them less convincing for a number of reasons. First, the results of the error analysis in Experiment 1 indicated that sentences produced containing alternator verbs had fewer errors than non-alternator verbs in the unconstrained conditions, as predicted by a non-competitive account. However, this may be explained by the nature of alternator verbs themselves. If there are multiple ways to correctly produce an utterance, then there are fewer overall opportunities to fall victim to an error, regardless of how the final structural decision is resolved. Second, the reaction time results of Experiment 1 are only marginal and could also be due to an inherent property of alternator verbs, their greater frequency in everyday language (see below). Alternatively, these results could be

explained by speakers using an abbreviated planning scope in syntactically flexible utterances. Perhaps when structural decisions are required, people know that there are multiple ways to produce the utterance and start speaking before fully resolving the syntactic structure of the entire utterance, thus devoting less time to planning prior to the onset of speech. Though this is a purely hypothetical criticism, it could be addressed by considering total production times, rather than only production latency. Total production time may more accurately reflect the costs of ongoing planning processes during speech (Meyer, 1994; Frazer, 2009), yet may not be analyzed in many studies because of the extremely time-consuming nature of such analyses, as is the case in this dissertation.

Ferreira's Experiment 2 used a paradigm similar to Experiment 1, but instead of presenting an order-constraining preposition, Ferreira presented an order-constraining pronoun (e.g. "him" instead of "dean") or an unconstraining pronoun (e.g. "it" instead of "paper"). Here, the results indicated that when a syntactic decision was required, responses were initiated more quickly as well as more accurately. However, while the error rate was lower in flexible conditions, it is possible that this is due to a lower overall error rate for alternator verbs (Ferreira, 1996). Ferreira recognized that the difference observed for verb type could be due to the overall higher frequency of verbs in the alternator condition. When he removed the most mismatched items pairs in terms of lexical frequency, both error rate and production latency effects disappeared. This indicates that lexical frequency is the source of the effect of verb type, which makes the evidence for the flexibility effect quite weak.

Ferreira's Experiment 2 is quite problematic for another reason. The results of Experiment 2 indicated that in the flexible conditions, people produced far more DO

utterances (n = 308) than PO utterances (n = 94), and that the DO utterances were produced more quickly (1009ms) than the PO utterances (1177ms). This suggests that the production of the DO structure itself is the source of the production latency effect, as the DO structure is only available in the flexible conditions. Note that PO utterances produced in flexible and inflexible non-alternator and constrained alternator verb conditions (e.g. all functionally inflexible conditions, PO required) all hovered around 1200ms. This was quite similar to the 1177ms latency for POs in the flexible condition, indicating that POs were produced at similar speeds regardless of the condition. These initiation latencies are markedly slower than the unconstraining alternator (flexible) condition. Ferreira notes this issue, but states that because there are so few non-alternating DO specific verbs in English, testing flexible and inflexible production latencies for the DO structure is difficult or impossible. This is not a satisfactory response, as it remains entirely possible that the RT results of Experiment 2 are solely accounted for by the speed with which DO productions are initiated rather than having anything to do with mechanisms underlying syntactic choice. These criticisms imply that the results of Experiment 2 are not particularly informative. However, the issue was addressed by changes to the design of Ferreira's Experiment 3.

The third experiment used active/passive alternations instead of PO/DO alternations. The structure was changed in this experiment because the active-passive alternation is robust in English – almost all transitive verbs can take both active and passive forms. This avoids the problem with the lack of syntactically inflexible DO specific verbs, and makes it possible to use the same verbs in the flexible and inflexible conditions. The transitive verbs used in this experiment were all flexible. They were

classified as normal or theme-experiencer, subtypes that vary in their structural dispositions. Normal verbs, like "devoured," take an animate subject in the active form (e.g. "Pete devoured the cheesecake") and are pre-disposed to be produced in the active structure. Theme-experiencer verbs, like "enticed," instead use the theme as the subject in the active form ("The cheesecake enticed Pete"), which makes them more likely to be produced as passives (e.g. "Pete was enticed by the cheesecake") than normal verbs. To vary syntactic flexibility, participants were presented with an order-constraining or unconstraining pronoun (e.g. subject constraining pronoun "he", or object constraining pronoun "him," versus the unconstraining "you" or "John") (Ferreira, 1996). Participants first saw a past tense verb (e.g. "confused") and then saw two noun arguments (e.g. either "him", "he", "John", or "you" along with "story") and were instructed to use all of the items in their responses. According to Ferreira, the competitive model predicts that the unconstraining pronoun conditions should be more error prone and should be produced more slowly, whereas the non-competitive model predicts faster and easier production for these flexible conditions. The data, consistent with the previous two experiments, supported the noncompetitive view.

Although Experiment 3 is more convincing than the other experiments, there are still some concerns. First, in the error analysis the inflexible conditions were only more error prone when a passive was required. Relatedly, in regard to the initiation latencies, the order-constraining subject (with normal verbs) condition was produced much slower than all other conditions, and importantly this condition required a passive to be produced with verbs for which the passive construction is largely dispreferred. All other initiation times were quite similar to one another (including another cell where passives were

produced, but where the verb type, theme-experiencer, was more amenable to the passive alternation). Previous research has established that English speakers largely prefer to use the active voice (Anisfeld & Klenbort, 1973; Clark, 1965; Frazer & Miller, 2009; Johnson-Laird, 1968; Klenbort & Anisefeld, 1974)[3], and such a strong preference may be enough to explain these effects. In particular, Cook, Jaeger, & Tanenhaus (2009) have demonstrated that when speakers use dispreferred structures they are more disfluent, which could be reflected in both increased error rates and increased initiation latency. Furthermore, their results suggest that this difficulty in producing less preferred structures may actually be consistent with a competitive syntactic process, as the preferred structure may contribute to greater ongoing competition at the time of selection. Thus, the evidence for a strictly non-competitive account of structural selection is not particularly convincing.

Despite these issues with Ferreira's Experiment 3, the active/passive alternation was an improvement over the PO/DO alternation used in his Experiments 1 and 2. If Ferreira had used a more matched comparison of the data, for example comparing

[3] The active and passive structures do not simply differ in the rates of usage in English, though the passive is less commonly used as it is the marked case (Anisfeld & Klenbort, 1973; Hopper & Thompson, 1980). There are also pragmatic differences between the two types of structures. Whereas both structures may express essentially the same semantic or conceptual information, the existence of both of these structures indicates that in reality there is a functional difference between the active and passive (Tannenbaum & Williams, 1968). In this case, the focus is different in the two structures, as in the active structure the emphasis is on the actor or subject, whereas in the passive, the focus is on the acted-upon or the object. Thus, if a speaker wanted to place emphasis on the object, they may be more likely to employ the passive construction than the active, because the passive places the object in the more prominent subject position (Johnson-Laird, 1968; Tannenbaum & Williams, 1968). Furthermore, the fact that the passive construction allows for the deletion of the agent in sentences such as "The proposal was protested (by Mary)", suggests that a related reason for using the passive, other than for placing the focus on the object, is to de-emphasize the importance of the agent (Turner & Rommetveit, 1967; Frazer & Miller, 2009). Lastly, when interpreting the passive voice, there is some indication that readers assume that the passive implies some additional information. Specifically, that there is some reason that the interlocutor has chosen to use the passive rather than the more straightforward and less structurally complex active voice (Klenbort & Anisefeld, 1974).

passives produced in order-constraining situations with passives produced in unconstraining situations, he might have avoided some of the difficulties with this experiment. I will therefore be using the active/passive alternation in the studies in this dissertation as this alternation will allow a balanced design, with the same verbs being used in both constrained and unconstrained conditions.

Lastly, a final issue with Ferreira (1996) is that he only briefly addressed structural priming in a paragraph regarding rates of selection of PO and DO structures for Experiment 1. Ferreira (1996) considered syntactic choice and initiation time for individual sentences produced in these experiments, but he did not consider the sequence of structures that was produced. As addressed previously, research has shown robust effects of structural priming on the choice of structures as well as on initiation times (see recent review by Pickering & Ferreira, 2008), yet these influences were not considered or analyzed in Ferreira's study. In this dissertation, the focus is precisely on the interplay between lexical and structural processes during grammatical formulation, so both structural and lexical repetition will be manipulated. Thus, I will be able to disentangle the effects of structural priming from the effects of syntactic flexibility, which Ferreira (1996) did not.

Despite the issues with Ferreira (1996), these studies still make an important theoretical and empirical contribution to understanding the mechanisms underlying grammatical encoding. Few studies have directly followed up on this topic, but in those that have the interpretation has been somewhat controversial (see Cook et al., 2009). In perhaps the most direct follow up study to date, Hwang and Kaiser (2013) used a very similar method to Ferreira (1996) in a Korean language study. The results of their studies

supported a competitive account of grammatical encoding for Korean speakers, but the authors did not dispute the evidence for a non-competitive mechanism in English. However the authors state that their findings suggest that a competitive mechanism may function alongside of noncompetitive incremental processes in production, but their relative influences may vary across languages. Their argument for why there might be different results in Korean and English was based on differences in the freedom of word ordering in the two languages; however, this then gives us little insight into how grammatical encoding works in English.

Evidence for Competition

In contrast to the results of Ferreira (1996) and others, previous research from our own lab (Frazer & O'Seaghdha, 2011) and by Wheeldon and colleagues as more consistent with Wheeldon's (2011) proposal that a competitive mechanism is employed to decide between alternative structures. However, it is important to recognize that these groups of studies are actually looking at grammatical encoding at two distinct levels. The Ferreira (1996) studies consider functional level grammatical encoding, where the studies to be discussed below assess positional level encoding. There are reasons to believe that the processes governing these stages may differ. The first stage is focused on assigning grammatical roles and the second is focused on linearization of the items in the sentence. It is entirely possible that syntactic competition could 1) be realized differently at the different levels of grammatical encoding, or 2) that it is only present at one level of grammatical encoding. I would expect that if competition were restricted to a single level, it would be the functional level, as this is where syntactic roles are assigned to lexical items in conjunction with structural selection.

Smith and Wheeldon (2001) employed a picture description task in which participants produced coordinate noun phrases prescribed by the movements of pictures on a screen (e.g. “The eye and the fish move apart” or “The eye moves up and the fish moves down”). They discovered a small, but robust initiation time benefit of approximately 50ms across 6 experiments for structurally primed productions. Like the lexical boost of Hartsuiker et al. (2008), phrase structure priming was short-lived, occurring only between consecutive sentences (Wheeldon & Smith, 2003). This is in marked contrast to the long-lived effects of structural priming found by Bock and others at the functional level (Bock & Griffin, 2000b).

Related to the Smith and Wheeldon work, in Frazer and O’Seaghdha (2011), we used a spatial description task that directed participants to describe the location and spatial relationships of words presented on the screen. We varied the structures of the utterances (Compound NP1 - VP - Short NP2 or Short NP1 - VP - Compound NP2) and also manipulated the spatial relationship described by the verb phrase from the prime to target (…“is/are left of/right of/above/below”…), such that the spatial relationship was either repeated (e.g. “above” to “above”), flipped across the spatial dimension (e.g. “above” to “below”), or in a different spatial dimension (e.g. “above” or “”below” to “left” or “right”). We found a noun phrase structure repetition benefit only when the entire verb phrase was also repeated, which originally appeared to be a lexically boosted structural priming effect. Most importantly, when the structure of the sentence was different but the verb phrase was repeated from prime to target, we saw increased reaction times relative to all other conditions. Frazer & O’Seaghdha (2011) concluded that the increase in reaction times when the verb repeated but the structure differed was

better accounted for as a plan reconfiguration cost in those conditions, than a structural priming benefit in the conditions where the verb and the structure also repeated. Remapping the same verb phrase to a different structure was costly, slowing down the speaker's initiation of the utterance, which we termed a "remapping cost". This result could be explained by the structural node (e.g. "Compound NP1"), the link from the lemma level to the structural node, and the most relevant lemma (e.g. "above") being primed from the first production, making it more difficult to select the alternative structural node in the second utterance (e.g. "Simple NP1"), especially when using the same verb phrase. This situation is consistent with the competitive mechanism that Wheeldon proposed was needed to explain their results (Wheeldon, 2011; Wheeldon et al., 2011). Specifically, as the sentence structure is primed (e.g. "Compound NP-VP-Simple NP") and the link between that structure and the verb phrase is primed (e.g. "are above"), this would make it more difficult to subsequently use that same verb phrase (e.g. "is above") in the alternate structure (e.g. Simple NP-VP-Compound NP), especially if competition had rendered the alternate structure less available through inhibition on the previous trial. However, it is entirely possible that Frazer & O'Seaghdha (2011) observed a mix of costs and benefits, that structural priming was present when both the structure and the verb were repeated, and a cost was present when the structure was changed but the verb was repeated. This could account for the much larger effect in our study than seen in those by Smith and Wheeldon (2001). In addition, prior to Frazer and O'Seaghdha (2011), I conducted a study using the same paradigm (Frazer, 2009), but the verb phrase was never repeated from the prime to target production. The results of this study showed no significant evidence of structural priming in initiation times, thus

lending credence to the idea that some lexical repetition may be required in order for structural priming effects to emerge at the positional level.

Although my results are largely consistent with Wheeldon's (2011) remapping proposal, I am not fully convinced by Wheeldon's own data. The main reason is that Wheeldon fails to address the lexical repetition that is inherent in the procedure. In these experiments, though the specific movement of the pictures always varied between productions, the main verb always repeated from prime to target (e.g., MOVE/S up, down, together, apart). This issue is present in *ALL* productions in the moving picture description paradigm used in the Wheeldon (2001, 2003, 2011) studies. Based on my research regarding lexical repetition and structural priming (Frazer, 2009; Frazer & O'Seaghdha, 2011) and on other lexical repetition findings (e.g. Arai, van Gompel & Scheepers, 2007; Corley & Scheepers, 2002; Hartsuiker et al., 2008 Pickering & Branigan, 1998), the repetition of the main verb may be crucial to the findings of the Wheeldon studies. This is particularly important for the 2011 results, where lexical repetition of the nouns was directly manipulated, but verb repetition (even in their unrelated conditions) was always present. If remapping the same verbs to different structures has a cost, even if using the same verb in the same structure has a benefit, they cannot distinguish to what extent the net effects in these studies actually reflect facilitation benefits or reconfiguration costs.

Interim Summary

Whereas the question of whether or not grammatical encoding contains a competitive process to select between structural alternatives has not often been directly addressed in the literature, there are a number of studies whose results speak to this issue.

Clearly, evidence exists to suggest that lexical items are directly linked to their grammatical options, and such options can be affected by the accessibility of lexical components in sentence production. Furthermore, some studies have uncovered structural effects that would be easily explained by a competitive mechanism in production (Wheeldon et al., 2011; Wheeldon, 2011; Frazer & O'Seaghdha, 2011), but are not easily explained by noncompetitive models. Whereas effects of these studies were strongly influenced by lexical repetition, studies that have not found support for competition in grammatical encoding (Ferreira, 1996), have also not considered lexical (or structural) repetition as a factor. Ultimately, if competition plays a significant role in grammatical encoding, its presence should be found in cases with and without lexical repetition. This has not been thoroughly investigated, and doing so is one purpose of the current studies.

Current Studies

Based on the conclusions from the preceding analysis of the literature, I posit that neither a competitive nor a noncompetitive mechanism alone can provide a complete account of structural formulation. Rather, both competitive and non-competitive processes operate during structural formulation. The purpose of the current studies is to reconcile these two accounts. As reviewed above, both competitive and non-competitive accounts have data to support them, and in some cases empirical results can be explained by both competitive and non-competitive accounts. Yet, studies supporting each position have considered the influence of somewhat different factors, including lexical and structural availability, both of which may be crucial to understanding grammatical encoding. Structural priming may provide a window into understanding the mechanisms of grammatical encoding. Structural priming has established that repetition of structures

facilitates production of those same structures. Competition would posit the reverse: alternation of structures would impede the formulation of a structure, because the previously used structure should interfere with formulation of the current structure. Exploiting the structural priming effect is a way to determine if grammatical encoding possesses a competitive mechanism alongside the known incremental processes.

My goal is to investigate to what extent grammatical formulation is competitive at the functional level of encoding, rather than simply attempting to determine if structural selection is competitive OR non-competitive. Because all theories agree that general incremental processes are at work during the formulation of syntactic structure, an important first step will be to provide an effective test of a competitive process. If evidence of competition is established, then it will be possible to integrate such a competitive process with more general incremental (noncompetitive) production processes during grammatical formulation.

In order to best accomplish the goal of providing an effective test for the presence of competition, it is necessary to clearly distinguish between and separate the effects of lexical and syntactic processes. Previous research has not fully assessed the role of syntactic processes in isolation or the influence of lexical items on grammatical formulation. It is important to consider how grammatical formulation operates both with and without lexical repetition or other lexical manipulations in order to understand the priorities in grammatical formulation: Is it words, abstract structural nodes, or a combination of the two that provide the driving force in production? Clearly, the separation of lexical and syntactic factors is essential to the understanding of the underlying processes in grammatical encoding. Therefore, the overall ambition of these

studies will be to understand how a competitive structural selection mechanism may function along with more general incremental processes in production, both in isolation and in conjunction with lexical influences.

The goal of Experiments 1a and 1b was to provide a rigorous test of the alternative mechanisms of grammatical encoding, specifically to test for the presence of syntactic competition. In these experiments, participants produce a series of target sentences (e.g. active and passive structure) which either requires a syntactic decision to be made (Experiment 1a) or not (Experiment 1b) (similar to Experiment 3, Ferreira, 1996). These utterances were produced as a series with target utterances embedded in the series but not distinguishable from non-target primes. Prime sentences were always syntactically constrained (e.g. intransitive [control], active, or passive structure) and prime and target sentences vary in whether or not the verb repeats between them. The dependent measures are structural selection (Experiment 1a) and initiation latency (Experiment 1a and Experiment 1b) based on the structure of the immediately preceding utterance and the presence or absence of verb repetition. According to the Pickering and Branigan (1998) model, structural priming should result between utterances even in the absence of lexical repetition, because activation persists in the relevant structural node (e.g. active or passive) for the initial utterance. Regardless of whether grammatical encoding is competitive, when speakers are able to choose the structure of the utterance, they should be more likely to repeat structures and these repeated structures, whether selected (Experiment 1a) or forced (Experiment 1b), should be initiated more quickly. Crucially, under a competitive account, when speakers switch structures (e.g. active to passive), they should initiate speech more slowly than when the first utterance structure is

unrelated to the target structure (e.g. intransitive to passive). But, under a non-competitive account, when structures differ from prime to target there should be no cost to producing a syntactic alternative relative to an unrelated structure.

I also tested the role of lexical repetition in boosting structural priming and syntactic competition in Experiments 1a and 1b. According to the Pickering and Branigan model, residual activation of the structural node will be present, but because of the repetition of the verb, the link between the specific lemma for the verb and the structural node is also reactivated (Hartsuiker et al., 2008; Pickering & Branigan, 1998). Under a competitive account, this increased structural priming should lead to increased competition, resulting in more pronounced differences in rates of selection for the alternative structure and in slower initiation latency. In contrast, non-competitive accounts do not predict increased competition, as none is present to begin with. However, they do still predict increased structural priming effects when the verb is repeated in comparison to when it is not.

Experiment 2 was designed to further clarify the results of Experiment 1a & 1b by including both syntactically flexible and syntactically inflexible target conditions within-subjects. The verb repetition factor from the previous experiments was removed. This within subjects design allows a more precise analysis of the effects of flexibility. Experiment 3 was a replication of Experiment 2, but with a revised procedure designed to simplify the presentation of the primes and reduce the error rate. Primes were distinguishable from targets, as participants were now asked to read, and then repeat a prime sentence aloud. Targets were produced in the same way as in the previous studies.

Experiment 4 was designed to provide insight into how the more general incremental processes of production interact with grammatical formulation. This should be especially revealing if there is a competitive process between the alternative structures. Participants experienced the updated procedures from Experiment 3, but here all targets were syntactically flexible (as in Experiment 1a). In addition to the structural manipulations of the previous experiments, in Experiment 4, prior to the presentation of the information needed to construct the target utterance, one of the noun or pronoun ingredients of the target sentence was presented using a masked priming technique. This presentation should affect lexical availability through priming one of the noun arguments which should therefore be more likely to be placed earlier in the sentence. The key point is that the lexical priming may be congruent or incongruent with the structural priming. In some conditions, the primed ingredient was the subject of the primed structure and the object of the alternative structure. In other conditions, the primed ingredient was the object of the primed structure and the subject in the alternative structure. Regardless of a competitive or noncompetitive account, increased rates of selection of the primed structure should occur when the priming conditions are congruent, and increased facilitation in producing that structure should occur as measured by reduced initiation latencies (compared to when incongruent). However, a competitive account predicts increased competitive effects when the priming conditions are incongruent because the structures activated by the lexical versus structural priming manipulations are at odds with one another. For example, if speakers have most recently produced an active sentence (e.g. “Pete devoured the cheesecake”), that structure is more likely to be used as the structure of a target (e.g. “Barbara protested the conflict”). But, if the theme is made

more available for that sentence (e.g. primed “conflict”), that should promote the passive structure (e.g. “The conflict was protested by Barbara”). This should result in increased competition between the active and passive structures – slowing initiation time and increasing error rates. Conversely, if the agent is made more available (e.g. “Barbara”) that promotes the active structure, just as the structure of the previous sentence did, which would be a congruent trial. This should result in very little or no competition between structures and faster and less error-prone production of the active structure, even under the competitive account.

To summarize, the major goal of the current studies was to determine whether there is direct evidence of syntactic competition, and whether this competition exists independently of lexical repetition or is simply magnified by repetition (Experiments 1a & 1b, 2, and 3). If there is evidence of competition, then I will assess how such a competitive process may work with more general incremental processes in production. In addition, I consider how structural choice may interact with non-competitive, or incremental, processes of lexical availability (Experiment 4) which also influences the production of sentences.

Experiments 1a & 1b:

How does using a syntactic structure affect the later accessibility of alternative structures?

The purpose of Experiments 1a and 1b was three-fold. First, I aimed to test whether the use of a syntactic structure reduces the later availability of alternative structures as described in the competitive model. To my knowledge, this has yet to be examined in the structural priming literature. If previously produced structures negatively affect the production of syntactic alternatives, that outcome would be incompatible with strictly noncompetitive accounts of syntactic formulation and would provide the first evidence of direct syntactic competition. Conversely, if prior use does not affect the availability of alternatives, this is more consistent with noncompetitive accounts of production (see Figure 2 for an illustration of how activation levels may be affected under both accounts for grammatical alternatives). In addition to my main interest in priming effects and their relation to competition, the experiments also provide an opportunity to reexamine the evidence for and against competition without regard to priming as in Ferreira (1996).

The other two goals were more exploratory in nature than the first one. The second goal was to gain evidence regarding the effects of structural and lexical priming on initiation time. This is a measure that has rarely been used in the research on structural priming (Hartsuiker et al., 2007; Smith & Wheeldon, 2001; Wheeldon & Smith, 2003) and when it has been used it has rarely been assessed alongside syntactic choice data (Corley & Scheepers, 2002). Initiation time was a dependent variable of interest in the

study by Ferreira (1996), but this was not in conjunction with a structural priming manipulation.

The third goal was to assess long-term changes in structural preference over the course of the experiment. Implicit learning accounts predict that the cumulative effects of structural priming may increase the rate of passive voice selection over the course of the experiment, and that this increase may be accompanied by corresponding gains in accuracy and speed (Bock, et al., 2006; Bock & Griffin, 2000; Chang, et al., 2000; Ferreira & Bock, 2006; Kaschak, Kutta, & Jones, 2011). The rate of use of the passive structure would increase, rather than the active, as this is the less preferred structure. An increase in recent experience in using the passive, as in the constrained primes, should lead the passive to be more associated with the type of message used in the experiment.

As mentioned, Experiments 1a and 1b are similar in procedure to those conducted by Ferreira (1996), but without the problematic factors previously noted with those experiments. Recall that in competitive encoding, when multiple syntactic options are available, the various structural nodes mutually inhibit one another. This results in lower overall activation levels for each node and therefore there is more difficulty in reaching the activation threshold and ultimately selecting a structure (Ferreira, 1996). On the other hand, in the noncompetitive account, there is no direct inhibition between structural nodes – whatever structural node is the first to reach the activation threshold is selected and determines the structure of the utterance. Furthermore, the model of grammatical encoding previously described assumes that structural persistence is a form of priming of such structural nodes. If structural priming persists, at least between immediately consecutive utterances, inhibition then should also persist according to a competitive

account of structural selection. Therefore, when speakers produce utterances that alternate in structure, the relative difficulty of producing these alternatives should provide insight regarding the availability of these alternatives, and into the mechanisms underlying structural selection. Here, I manipulated the relationship between immediately consecutive utterances, in order to understand how using one structure affected the use of the same structure, a syntactic alternative, or an unrelated structure. I will now spell out the predictions of the two classes of accounts for the paradigm.

Previously, Ferreira (1996, Experiment 3) measured the syntactic choice (active or passive) and initiation time for conditions where a structural choice was necessary (unconstrained) or not (constrained), but did not consider the influence of the structure of the previous production. In that experiment, all items were critical, in that every production was available in either the active and/or the passive construction (depending on whether it was a constrained or unconstrained trial). There were no filler items unlike in many structural priming studies. Thus, producing the first trial in the active voice should prime that structure for selection in the second trial. Yet, the active structure may not have been available for production if that trial was constrained by the noun arguments. This indicates that there were factors at work in that experiment that influenced both 1) what was selected and 2) how easy it may have been to access each structure. The current experiments exploit such priming effects in order to more accurately assess how speakers select the structures of utterances.

Specifically, under a competitive account, after producing one structure (an active or a passive), the alternative structure is inhibited and therefore more difficult to activate than following an unrelated structure. Thus the alternative structure is less available for

the succeeding production whether or not that production is syntactically constrained. Therefore, if the alternative structure is produced more slowly, this will be strong evidence in support of a competitive mechanism operating during structural formulation. Furthermore, the effects of competition may be more pronounced in syntactically unconstrained productions, because here the choice is not determined by the constraining arguments, meaning there is no predetermined resolution to the competitive process. This results in the active and the passive structure continuing to compete for selection after the arguments are provided. In contrast, a strictly noncompetitive account does not predict any costs to initiation time when a syntactic choice is necessary as there is no inhibitory link present between alternative structures (see Figure 1). Thus, a syntactic alternative should be no more difficult to access than any other structure. Note that the predictions under a competitive account are specifically for production latency. With regards to syntactic choice, both accounts predict the same outcome, increased disposition towards the recently used structure.

Ferreira (1996) looked at syntactic choice for both constrained and unconstrained productions along with initiation latency. In the constrained conditions, there was only one acceptable response, so the data for this condition are effectively a manipulation check – did they choose the only grammatical option available, or was there an error? In my study, the unconstrained (1a) and constrained (1b) conditions were split across two experiments and syntactic choice was only considered a dependent variable in the unconstrained Experiment 1a. However, the initiation times for target sentences produced under similar conditions (i.e. whether self-selected or pre-determined) can also be compared across experiments in order to assess the influence of syntactic constraint (also

see Experiments 2 & 3 for direct tests of syntactic constraint). According to Ferreira (1996), overall slower production latencies for unconstrained conditions would indicate the presence of competition, as competition results in greater difficulty formulating an utterance. Thus, if initiation is slower overall in Experiment 1a than 1b that would suggest that competition is present. However, I cannot exclude the possibility that increased initiation latency could also be a result of an additional task being completed, that of the structural selection. If a difference in the initiation time between the constrained and unconstrained versions exists, it should be interpreted with caution, but if other data also supports the competitive account, then this may be interpreted more strongly.

To concretely illustrate these predictions, consider a few examples. Under a competitive account, if a syntactically flexible verb is selected for production, both of the available constructions would be activated. Thus, if the lemma for "alarmed" is selected, it spreads activation to the structures for both active and passive constructions. If there is an inhibitory link between the two structures, the two nodes mutually suppress one another, resulting in a longer latency to choose a winning structure than if there is no inhibitory link (Ferreira, 1996). On the next trial, if the losing structure, the one that was not selected for production, is now selected for production with another verb lemma, the time to select it should be longer as the inhibition needs to be overcome (Wheeldon, 2011). For example, if a speaker has recently produced the passive sentence "Mary was angered by the conflict", it should be subsequently more difficult to produce the active sentence "The news alarmed John" than it would be following a structurally unrelated sentence (e.g. an intransitive or ditransitive). Previous research has not addressed this

factor adequately because using a structural alternative is often considered a control condition, which a competitive account suggests is inappropriate. It is more appropriate to consider the alternative as a potentially competing structure, and to use unrelated prime structures as controls.

Previous research has indicated that in some cases structural priming could be strengthened with lexical repetition occurring in the same grammatical role (Pickering & Branigan, 1998; Wheeldon, 2011). Repetition of the verb from prime to target productions is also varied in the current studies, in order to understand how lexical repetition interacts with structure selection and sentence initiation. Based on the model of grammatical encoding previously outlined, verb repetition should result in both increased structural priming as shown in choice, and in reduced initiation latency for sentences with repeated structures and repeated verbs (Hartsuiker et al., 2008). Conversely, verb repetition should also result in more difficulty when switching to an alternative structure, as the links from the specific verb to the competing structural node should still be engaged, in addition to the activation persisting in the structural node itself. For example, if a speaker has recently produced the passive sentence "Mary was *angered* by the conflict", it should be subsequently more difficult to produce the active sentence "The news *angered* John" than it would be following either an unrelated sentence, "Peter was intrigued", or an active sentence, "The conflict *alarmed* Mary", which does not share the verb. But it is important to think of these proposed intensified effects as having two contributing sources – lexical and structural. Therefore, priming both structures and words should augment structural priming effects. Conversely, repeating only the verb and using a different structure should increase difficulty in the production of that alternative

structure because of either increased competition (described above), or due to potential remapping costs (Frazer & O'Seaghdha, 2011), which could be considered another form of competition. Remapping costs would manifest as more difficulty reusing the same word in an alternate structure than a different word in that structure. If repetition of the verb only improves production, as a noncompetitive account suggests, lexical repetition should hasten initiation latency whenever the verb was repeated regardless of the structure.

The above predictions assume that syntactic competition in production is present both when verbs are repeated and when they are not. However, syntactic competition may be evident only in cases where the verb is repeated. The addition of verb repetition should result in increased priming benefits regardless of whether grammatical encoding is noncompetitive or competitive, but only the competitive account predicts increased structural switching costs. It is possible that lexical repetition may be required for the evidence of competition to emerge, as competition without a lexical boost may be small, short-lived, or fragile. In sum, the key prediction discriminating between competitive and noncompetitive accounts in the first two experiments is whether following the prime sentence, the alternative grammatical construction is less available (produced less often, or more slowly) than following an unrelated prime.

Experiment 1a: Unconstrained Active and Passive Productions with Manipulation of Lexical Repetition

In this experiment, participants were first required to produce an active, passive, or intransitive sentence for each prime production. Next, participants produced active and passive target sentences in conditions where both structural options were available. For

example, participants were able to choose to produce either "Jon was enticed by the cheesecake" or "The cheesecake enticed John." I examined both the choice of structure and how quickly participants were able to initiate speech for the target productions.

The central goal of Experiments 1a & 1b was to test for direct syntactic competition between alternative structures as posited by a competitive model of grammatical encoding. These experiments varied the structure of consecutive utterances so that it was the same (active – active, passive - passive), different (passive - active, active - passive), or unrelated (intransitive – active, intransitive - passive) while also either repeating (same) or changing (different) the verb. In Experiment 1a (unconstrained) participants chose the structure of their utterances. In Experiment 1b (constrained), all productions were limited to a specific structure by including an order-constraining pronoun (he, him).

In the unconstrained Experiment 1a, I expected that speakers would tend to choose to repeat structures, especially when the verb was repeated. However, I predict that regardless of whether a competitive mechanism is present or not, the responses in both experiments should be fastest in the repeated structure conditions because of structural priming (Pickering & Ferreira, 2008), and this should be particularly true when the verb also repeated because of the lexical boost (Hartsuiker et al., 2008). More importantly however, my main prediction suggests that if a competitive mechanism is present in the form of an inhibitory link between alternative structures, then, assuming that the inhibitory effect persists at least to the next production, participants should produce the alternative structure targets more slowly than the unrelated targets. In contrast, a noncompetitive account of structural selection predicts that the alternative and

unrelated targets should be produced at the same speed, as no inhibition would be present from the production of the prime. Finally, when the verb repeats but the structure differs, a competitive mechanism predicts increased difficulty in switching to an alternate construction. However, there may be a separate remapping process outside of direct syntactic competition that also incurs costs when remapping a recently used verb to a new structure, in contrast to when no lexical repetition is present. A noncompetitive account predicts no cost to using an alternative structure.

Method

Design. The experiment used a 3 prime structure (active, intransitive, passive) X 2 verb repetition (same, different) X 2 target verb type (normal, theme-experiencer) X 2 block design for the choice data. In addition, target structure selected (active, passive) was a factor in the analysis of initiation time. In Experiment 1a, the target utterances were syntactically flexible or unconstrained, as the noun arguments were not syntactically constraining (e.g. "you", "John"). The prime productions were always constrained and were evenly distributed between all conditions.

Materials. Sentence prompts consisted of the 40 verb pairs and arguments used in the third experiment of Ferreira (1996) with minor modifications (see Table 1). Various common male and female proper names were used in addition to "you" as the agents in the target sentences. In the prime trials, either "he" or "him" accompanied the noun argument in order to constrain syntactic choice. In order to set the unprimed control condition, one-third of the primes were produced as intransitives (see Bock & Griffin, 2000). On these trials, there was only one noun argument accompanying the verb, and a

string of five asterisks was presented in place of the second noun to maintain visual consistency.

The verbs used belong to two classes, normal and theme-experiencer (F. Ferreira, 1994). In normal verbs, the experiencer is the subject and the theme is the object in an active sentence. When a normal verb, such as "disliked," is used in the active voice it results in: "*John* disliked the proposal," and "John" is both the subject of the sentence, and the experiencer. In contrast, in theme-experiencer verbs, the theme is the subject and the experiencer is the object. For example, "angered" is a theme experiencer verb. When it is used in the active voice it results in: "The proposal angered *John*", where "John", who *experiences* the anger, is the object of the sentence. Therefore, sentences with theme-experiencer verbs are more likely to be uttered as passives (e.g. John was angered by the proposal) than are sentences with normal verbs because of the general preference to assign agents and experiencers as the subject of a sentence (F. Ferreira, 1994).

Thirty-six of the verb pairs were used in the main experiment and four pairs were practice items. Each participant completed a total of 288 experimental trials divided between two blocks (144 primes, 144 targets total). Each verb was used twice in each block, once as a prime and once as a target and each verb was paired with both of its associated arguments in each block (see Table 1). Between blocks, the verbs were used in different conditions. Thus, in a version where the verb "angered" appeared in the first half of the experiment in a repeated verb production, it was then produced in a different verb production in the second half (once as a prime with a different verb used in the target, and once as a target with a different verb used in the prime). Each item was rotated through all conditions, and these specifications resulted in 6 between-subjects

counterbalanced versions of Experiment 1a. The order in which the arguments appeared on the screen was also balanced. Half of the verbs had the animate argument presented on top, and half had the inanimate argument presented on top.

Each verb was presented with the arguments in the same locations in both blocks. Although the name and pronoun changed according to the condition, the same inanimate argument was used with each verb when it was used as a target in both the first and second blocks of the experiment and was presented in the same location (i.e. above or below the center of the screen). It is doubtful that this consistency affected the results, because the nouns used in the sentence were somewhat immaterial to the process in this experiment. Nonetheless, the position of arguments was counterbalanced in subsequent experiments.

Apparatus. The experiment was controlled by a Dell Optiplex GX745 computer with a flat panel monitor using E-Prime 2.0 software. Production latency times were recorded with a microphone connected to the computer through a Serial Response (SR) Box. Sessions were audio-recorded using a Creative Technology NOMAD Jukebox recorder for later coding.

Procedure. Participants were told that during the experiment they would be producing sentences aloud and that the information they needed to produce the sentences would be presented in pieces. Participants were instructed to create sentences that included all of the words they had seen in that trial (e.g. "*John* was *angered* by the *news*" or "The *news angered John*"), to add relevant function words as necessary, (e.g. "the" "a" "was" "of", etc.) but not to add additional arguments or nouns, and that their sentences should make sense semantically (e.g. not to say things like "The news was angered by

John"). They were directed to produce these sentences fluently, but also told that they should begin speaking as quickly as possible.

Participants first completed 16 practice trials before proceeding to the 288 experimental trials. During the practice trials, participants were provided with specific feedback about their responses. If a response was correct they were told "Correct", but if they responded incorrectly or not quickly enough, the experimenter provided the correct answer to them orally along with an explanation, or encouraged them to begin speaking more quickly on future trials if necessary.

The participant began each trial by pressing a button labeled START on the SR Box as directed by the on-screen prompt (see Figures 2 & 3). For each trial, first a fixation cross appeared in the center of the screen for 500ms, followed by a blank screen for 500ms. Then, a past-tense transitive verb (e.g. "alarmed") was presented in the center of the screen for 1500ms, again followed by a blank screen for 500ms. A 250ms beep then alerted the participants to upcoming arguments. Two arguments were displayed in a systematically varied vertical order (e.g. either "he" or "him" (constrained prime trials), "you" or "John" (unconstrained target trials), and "news" (both prime and target trials)) with one appearing just above the center of the screen and the other just below with one skipped line in the center. For those trials that required an intransitive production, only one noun or pronoun was presented and a string of five asterisks appeared ("*****") in the second position to maintain visual consistency. These words persisted for 2000ms while the microphone was open to detect a spoken response which triggered the voice key and recorded the production latency in milliseconds. The latency was measured from the onset of the presentation of the nouns to the initiation of sentence production. If a

response was detected within the 2000ms window, the words disappeared and the screen was blank for 1500ms. If no response was detected, a feedback screen appeared for 1500ms that stated "No response detected." in red letters to indicate to the participants that they did not respond in the allotted time. Following this feedback or blank interval, the prompt that read "START" appeared on screen again until the participant pressed the button on the SR Box to continue. The cycle then started again. Words were presented in 18 point boldface Calibri font. Except for proper nouns where the first letter was capitalized, all words were in lower case. Prime (see Figure 3) and target trials (Figure 4) were essentially indistinguishable, but participants could have noticed that intransitives never occurred in two trials in a row (prime trials only) nor did pronouns (target trials only).

Participants. Fifty-three Lehigh University undergraduates enrolled in introductory psychology participated for a research experience credit. All were native English speakers. The experiment took approximately 60 minutes to complete. Eight participants were excluded from analysis: two participants were not attending to the task throughout the experiment (not coded), one file contained no audio record due to a recorder malfunction (not coded), two participants exceeded an error rate criterion (see below), and three participants did not meet the criterion for passive use (see below). The data of the remaining 45 participants were analyzed.

Results

Scoring and Exclusions. Responses from 50 subjects were coded for accuracy. Incomplete productions, target responses beginning after 2000ms or with reaction times shorter than 200ms, responses lacking required items, responses that contained

substantial additions, non-responses, responses that were semantically (e.g. “He enticed the cheesecake”) or grammatically incorrect (e.g. “The cheesecake enticed he”), false starts, alternative grammatical constructions (e.g. not active or passive), and trials that were disrupted by noises, were categorized as errors and excluded from analysis. When a prime was eliminated due to error, the following target was also eliminated from analysis. Utterances were categorized as acceptable and coded if participants sometimes chose to use “is” instead of “was” in constructing passives, or if they produced prime trials correctly but after the 2000ms deadline. Of the 50 participants whose data was coded, the overall error rate was 24.38% (*SD* = 12.59%). Participants whose error rate exceeded two standard deviations above the mean error rate, 49.56%, were excluded, resulting in two participants being eliminated.

The overall rate of passive selection for the 50 participants whose data was coded was 31.46% (*SD* = 13.37%). Participants whose rate of passive selection was not within two standard deviations above or below the mean, 4.72% - 58.21%, were also excluded, resulting in two participants with extremely low rates of passive usage being excluded. Finally, the rate of passive selection for the theme verbs was considered separately, as the overall rates of passive selection for normal verbs was very low. Of the 50 participants coded, the average rate of passive selection for theme verbs was 59.18% (*SD* = 25.12%). Similarly, participants whose passive usage for theme verbs was not within two standard deviations of the mean, 8.94% - 100%, were excluded. Three participants were identified based on these criteria – the same two who were identified for low overall rates of passive production, and a third participant who was additionally removed from subsequent analyses. These three participants were excluded because 1) the choice data

was uninformative for these subjects, 2) the resulting RT data from these participants had many empty and unbalanced cells that complicated analyses and 3) these participants may have employed some response formula that resulted in non-natural selections or second-guessing of structural selection.

For the remaining 45 participants, the overall error rate for the target sentences was 23.16% (*SD* = 11.35%). The overall rate of passive selection for normal verbs was 4.58% (*SD* = 5.72%), for theme verbs 63.66% (*SD* = 21.23%), and for both verb types combined 33.97% (*SD* = 11.24%).

Syntactic Choice. The dependent measure for this analysis was the number of target sentences that were produced as passives as a proportion of all valid target sentences produced by the participant in that condition (see Bock & Griffin, 2000). Thus, if a participant produced one passive sentence and three active sentences in one condition, their score for the condition would be .25 (or 25%)[4]. In the items analysis, verb type (normal or theme-experiencer), was a between-items variable

The mean proportion of passive sentences produced as a function of target verb type, verb repetition, and target structure by both subjects and items was calculated (see Figure 7). The most obvious effect was a large difference in the rates of passive usage for the normal and theme-experiencer verbs, which was not unexpected. Ferreira (1996) similarly saw that participants were unlikely to construct passive sentences with the normal verbs under any circumstances; specifically, his participants produced passives only 2.6% of the time in the unconstrained conditions in his Experiment 3, which is consistent with the data reported here using the same items.

[4] Any empty cells (only relevant for the analysis by Block) were also given a score of 0. So, if participants produced no correct targets in a condition, they produced 0% passive sentences.

The syntactic choice for each target verb for the items analysis was also calculated (see Tables 2 and 3). Here, each verb was similarly given a value based on the number of times it was produced as a passive in any of the conditions across all participants in order to gain a sense of the degree of flexibility of each verb. In the current study, as well as across all relevant experiments in this dissertation, the theme-experiencer verbs showed much greater flexibility, being used in the passive structure on 92%-17% of trials, while normal verbs were produced in the passive on only 25%-0% of the time.

Because of the added structural manipulations in the current experiment, I expected the rates of passive usage, especially for normal verbs, to be higher than in Ferreira (1996). I did see an increased rate of passive use over the course of the experiment. Figure 8 displays the percentage of correct targets which were produced in the passive voice for each verb type for each quarter of the experiment. There was an overall increase in the use of the passive over the course of the experiment for both verb types, though it appears to be stronger for the theme-experiencer verbs. This may be indicative of cumulative priming effects altering the overall availability of the passive. Participants were required to use the passive to complete the task correctly in a subset of the constrained prime sentences, and as the overall dispreferred structure, it would be the structure expected to show such cumulative effects of recent experience. I will return to this point in the Discussion.

To test whether the manipulations in this experiment affected patterns of syntactic choice, a 2 (block) X 3 (prime structure: active, intransitive, passive) X 2 (verb repetition: repeated, not repeated) X 2 (target verb type: normal, theme-experiencer) Repeated

Measures ANOVA was conducted in SPSS 20 on the percent passives produced in each condition, by both subjects and by items (the specific verbs). An analysis including version (a counterbalancing control) as a between-subjects factor did not differ from the primary analysis and so will not be reported. The analyses revealed a main effect of block, *F1* (1, 44) = 9.53, *p* = .003, *F2* (1, 70) = 8.89, *p* = .004 (see Figure 9)[5]. Participants were significantly more likely to produce passives in the second half of the experiment (*M* = 35.13% passive, *SE* = 1.74%)[6], then in the first (*M* = 32.08% passive, *SE* = 1.71%) which is reflected in the graph of passive use over quartiles (Figure 8).

For the variables of theoretical interest, first I examined whether the structural priming manipulations were effective in biasing syntactic choice. The effect of prime structure was not significant by subjects, *F1* (2, 88) = .37, *p* = .694. It was marginally significant by items, *F2* (2, 140) = 2.58, *p* = .079. Specifically, in the items analysis, there was an increase in the rate of passive production after a passive prime (36.6%), relative to the control, intransitive prime (33.6%; simple main effect: *F* (2, 69) = 3.34, *p*= .086).

More importantly, I was interested in whether verb repetition interacted with the structural priming manipulations. Verb repetition did modulate the effect of prime structure in the subjects analysis, *F1* (2, 88) = 3.51, *p* = .034, though not by-items, *F2* (2, 140) = 1.39, *p* = .253. This was further modulated by block, *F1* (2, 88) = 4.25, *p* = .017, *F2* (2, 140) = 5.04, *p* = .008, significant both by subjects and by items. More specifically, verb repetition did significantly modulate the effect of prime structure, in the first block, *F1* (2, 88) = 6.33, *p*= .003, *F2* (2, 140) = 3.95, *p* = .021. As displayed in Figure 9, the pattern of results for the repeated verb conditions was exactly as predicted by a

[5] F1 analyses refer to effects assessed by-subjects and F2 analyses refer to effects assessed by-items.
[6] Means and standard errors are reported from the F1 analyses.

competitive account of grammatical encoding for both normal and theme-experiencer verbs. Yet, for the different verb conditions, the exact reverse pattern is present for both verb types, which was not predicted by any of the accounts I outlined in the introduction. A sufficient explanation for such variations in the patterns remains to be found. No other effects were significant.

Overall, this pattern of results suggests that the structural priming manipulation was only weakly effective in promoting the selection of the passive structure. This was modulated by the repetition of the verbs themselves, but only for the first block of the experiment. The results of the second block were much less consistent across conditions, and inconsistent with the results of the first block. Yet, there was an overall increase in the rate of passive selection in the second block. One potential explanation could be that the priming of the passive structure bled across conditions through weight changes to the structural options via an incremental learning mechanism, obscuring trial-to-trial manipulations in the second block.

Considering the influence of verb type on structural choice, there was a large main effect of verb type, $F1$ (1, 44) = 284.35, $p < .001$, $F2$ (1, 70) = 387.39, $p < .001$, with passives selected for production far more often with the theme-experiencer target verbs than normal verbs (see Figures 7 & 9, Table 4). There was also a significant effect of verb repetition by subjects, $F1$ (1, 44) = 10.94, $p = .002$, but marginal by items $F2$ (1, 70) = 3.30, $p = .073$. Qualifying the main effect of verb type, there was an interaction of verb type and verb repetition for the rate of passive usage, $F1$ (1, 44) = 7.97, $p = .007$, though it was not significant by items, $F2$ (1, 70) = 1.90, $p = .172$. Specifically, verb repetition appeared to have no effect on the rate of passive selection for the normal verbs

(different M = 4.31%, SE = .92%; same M = 4.78%, SE = .92%), but it increased the chances of passives being produced for the theme-experiencer verbs (different M = 60.25%, SE = 3.49%, same M = 65.07%, SE = 3.19%). This was not explicitly predicted. However, given that the theme-experiencer verbs were more likely to be produced as passives overall, this seems like a possible consequence of that preference. Even if the theme verb was not produced as a passive in the prime, the slight preference for the passive may have been present, making the reappearance of the verb in the target more likely to result in the production of a passive.

Syntactic choice for theme-experiencer verbs only. Because of the large difference in the percentage of passives produced in the normal verbs and the theme-experiencer verbs, a secondary analysis on only the more flexible theme-experiencer Verbs was warranted. This analysis again showed an overall effect of block, *F1* (1, 44) = 6.45, $p = .015$, *F2* (1, 35) = 6.75, $p = .014$, where significantly more passives were produced in the second block of the experiment ($M = .65$, $SE = .03$), than in the first ($M = .60$, $SE = .03$). This suggests that there may have been a cumulative priming effect of the passive structure as the experiment progressed. This was also seen in the descriptive analysis of the use of the passive by quartile (See Figure 8). This effect was independent of the trial-by-trial priming manipulations. There was no effect of prime structure by subjects, *F1* (2, 88) = 0.37, $p = .690$, or by items, *F2* (2, 70) = 1.98, $p = .146$. Again, in this analysis, there was a main effect of verb repetition, significant by subjects, *F1* (1, 44) = 11.32, $p = .002$, but marginal by items, *F2* (1, 35) = 3.36, $p = .075$. When the verbs were repeated from the prime to the target, there was an overall increase in the number of

passive targets produced (*M* = .65, *SE* = .03) compared to when the verb differed (*M* = .60, *SE* = .04).

Importantly, I again examined the interaction of structural priming and verb repetition, as I had predicted that competition should be most evident when the structures change but the verb repeats. The interaction of prime structure and verb repetition was not significant in this analysis, *F1* (2, 88) = 1.87, *p* = 0.160, *F2* (2, 70) = .59, *p* = .558, but the three-way interaction with block was again significant by items, *F2* (2, 70) = 3.68, *p* =.030, though only marginal by subjects, *F1* (2, 88) = 2.41, *p* = .096. In the first block, there was a clear pattern in the repeated verb conditions, as predicted by the competitive account. The highest rate of passive selection was in the condition where the same verb had just been used in the prime sentence in the passive construction (*M* = .68, *SE* = .04). The rate of passive selection for a target where the verb had just been used in an active prime was the lowest (*M* = .60, *SE* = .04). Also consistent with a competitive account, the rate of passive selection following an active was lower than in the intransitive control condition (*M* = .63, *SE* = .04). No other effects were significant, all F's < 1.

Despite the absence of consistent support for a competitive mechanism, or for robust structural priming effects in the overall structural choice analysis, I further explored the effects of prime structure and verb repetition in order to clarify the pattern of results. Paired comparisons t-tests were conducted for the contrasts for which an increase in the percentage of passive production was most strongly predicted. The different verb, unprimed condition (after an intransitive prime) most accurately represents the baseline rate of passive usage as there is no lexical or structural relation to the prime sentence. Conversely, the same verb, passive prime condition could result in increased passive

production from both lexical and structural influences, so is most likely to show a high rate of passive selection. This comparison was significant by subjects across both blocks, t (44) = -2.69, p = .01, as well as by items, t (35) = -2.83, p = .008. The same verb, primed condition was not significantly different than the planned structural comparison (same verb, unprimed) by subjects, t (44) = -1.16, p = .253, or by items, t (35) = -1.45, p = .157, suggesting that the structural influences alone were not enough to bias syntactic choice. The same verb, primed condition was, however, different than the planned lexical comparison (different verb, primed) by subjects, t (44) = -2.86, p = .007, marginal by items, t (35) = -1.97, p = .056, indicating that lexical repetition was an important factor in determining structural choice. Thus, structural priming was only reliably found under the most optimal conditions in the syntactic choice data, and it was significantly impacted by the presence or absence of lexical repetition.

I next considered the initiation latencies of the target sentences. Reaction time data may give further guidance to the interpretation of the syntactic choice data.

Initiation time. I used Linear Mixed-Effects Models (LMM) for the initiation time analysis rather than Repeated Measures ANOVA (as in the choice data) for three main reasons: 1) LMMs are the analysis of choice for continuous data such as reaction times, 2) LMMs capture both participant and item variance, and 3) LMMs allow for unbalanced data sets (Baayen, Davidson, & Bates, 2008; Barr, Levy, Scheepers, & Tily, 2013; West, Welch, & Galecki, 2014). Because this was a free choice experiment, participants were able to choose the structure of the target sentences and the resulting data were unbalanced. The free choice nature of the experiment also makes the results of this analysis more difficult to interpret, as the reasons why participants make a given

selection is tied into factors affecting the speed with which they do so. Nonetheless, such an analysis is potentially informative about such processes, and will provide useful comparisons to the constrained choice data of Experiment 1b.

The initiation time data was analyzed using a Linear Mixed-Effects Model (LMM) with REML estimation in IBM SPSS 20. The model included fixed and random effects of prime structure, target verb type, verb repetition, target structure selected, and trial order[7]. The fixed effects included all possible interactions of the first four variables, but only the main effect of trial order because it was entered as a continuous predictor variable. Participants and items were included as random effects to account for subject and item level differences and each included a random intercept, allowing both subjects and items to vary in overall speed. By-subject random slopes were also included for each fixed effect, which allowed subjects to vary with respect to each main effect of treatment. By-items random slopes were not entered because that would unnecessarily increase the complexity of the model. Repeated effects of trial order were entered and assessed using the Compound Symmetry (CS) covariance structure[8], which assumes that the correlation between participant responses is constant over trials, that is, regardless of how far apart the trials are from one another. The initial model demonstrated that both prime structure (Wald $Z = .42$, $p = .674$) and verb repetition (Wald $Z = 1.03$, $p = .305$) were not significant random factors in the estimates of covariance parameters, so those factors

[7] Trial order refers to the sequence of the target trials in the experiment. This was used in place of block as it is a more fine-grained variable allowing for a more complete understanding of changes over the course of the experiment.

[8] Repeated Effects of trial order were also assessed using the First-Order Autoregressive (AR1) covariance structure, which allows participant's data for trials that occur closer together in time to be more correlated with each other than those that occur further apart. This seemed likely given the experimental design. However, the model fit with the AR1 covariance structure was slightly less strong (original AIC = 68396.28, updated AIC = 68393.40) than with the CS covariance structure, so the CS was used in the final analysis.

were removed from the model to improve the fit[9]. The Akaike's Information Criterion (AIC) was used to evaluate the fit of the model, where smaller AIC values represent a better fit. The AIC was selected because the model was fairly complex and it encourages a parsimonious model without oversimplifying, thus decreasing the chances of a Type I error[10]. The original model fit (AIC = 68389.89) was improved by the removal of the non-significant random factors (final model AIC = 68387.54).

The analysis showed a significant main effect of trial order, b = -1.07, t (46) = -6.13, p = <.001[11], which indicates that each trial was on average 1ms faster than the one preceding it, showing an overall decrease of 154ms in initiation time over the course of the experiment.

I first considered whether there was evidence of structural priming and structural competition in the latency data, and whether it was affected by repetition of the verb. There were no significant main effects of prime structure, F (2, 4669) = .15, p = .858, or of verb repetition, F (1, 4330) = .31, p = .578, on reaction time. Crucially, there was no interaction of prime structure and target structure selected, F (2, 4760) < 1, and no interaction with verb repetition, F (2, 4793) < 1. This suggests that structural priming, if present, did not result in facilitation for repeating structures, even when the verb was

[9] The effect of target structure selected was only marginal (Wald Z = 1.89, p = .058), but was retained in the final model. Removal of this parameter did not improve the model fit. In all future models, marginal effects (p < .10) were always retained.

[10] In addition, because I used data-driven backwards model selection it was particularly desirable to decrease the chances of a Type 1 error. Data-driven model selection has been shown to potentially increase the chances of making a Type-1 error (Barr, et al., 2013), but may be necessary for complex experimental designs and when it is difficult to achieve model convergence, as in the current studies.

[11] The corresponding tests of fixed effects also indicated a significant effect of trial order, F (1, 46) = 37.57, p < .001, but because this does not contain an estimate of the effect, the result from the estimates of fixed effects was reported. This will apply for all future descriptions of fixed effects of trial order.

repeated. And, relatedly, there was no evidence of competition when participants switched structures.

However, there were still some interesting results, especially relevant to the two classes of verbs assessed, and how quickly they were produced as actives and passives. First, there was a significant fixed main effect of target verb type on initiation time, F (1, 141) = 16.75, $p < .001$, however the by-subjects random slope was also significant, indicating that people varied in their sensitivity to this effect, Wald $Z = 2.84$, $p = .005$. Target sentences that contained a normal verb were produced overall more quickly (M = 1038ms, SE = 28.27ms), than those that contained a theme verb (M = 1121ms, SE = 26.23ms). This difference may be a consequence of the structural preferences of the two types of verbs. As seen in the syntactic choice data, the normal verbs showed a strong structural preference and were almost always produced in the active structure. Yet, there was no significant fixed main effect of target structure selected (active M = 1072ms, SE = 25.26ms; passive M = 1087ms, SE = 27.51ms), F (1, 106) = 1.03, p =.313. This may seem counter-intuitive from a visual examination of the data (see Figure 10, Table 4), but recall that the items are more likely to be produced in active versus passive structures based on their verb type (normal, theme-experiencer), so the latencies of actives and passives are accounted for by the effect of verb type and the verb type by target structure selected interaction described below. This issue relates to the problem noted at the start of the analysis – that interpreting latency data for a free-choice experiment can be problematic, because the participants are selecting which type of target structure to produce, rather than that variable being directly manipulated. In other words, because participants are selecting which structure they use, and they are more likely to choose a

certain structure based on the verb type of the item, there is no simple main effect of target structure selected.

The relative speeds of active and passive productions varied significantly with verb type, F (1, 3889) = 52.22, $p < .001$. As can be clearly observed from the active and passive means displayed for each verb type in Table 4, the speed of active and passive productions varied with the verb type used in the target sentence. Sentences containing normal verbs were produced more quickly when produced as actives, while sentences containing theme verbs were produced more quickly as passives. This is congruent with the preferences for each verb type that were seen in the syntactic choice analysis and consistent with the idea that speakers prefer the structures that are easier to produce. There was also a marginally significant interaction of verb repetition and target structure selected, F (1, 4713) = 3.17, $p = .075$. When the verb differed from prime to target, there was a clear benefit for the active structure relative to the passive. When the verb repeated from the prime to the target, active and passive sentences were produced at similar speeds (see Figure 10, Table 4), suggesting that lexical repetition eased production for the generally slower passive structure. No other interactions were significant (all F's < 2, *ns*).

Overall, the effects that I predicted based on the presence of a competitive mechanism for initiation latency were not present. However, the data are also largely inconsistent with a noncompetitive account in that lexical repetition did not uniformly speed production, producing the same structure twice in a row did not uniformly speed production for either structure (e.g. actives or passives), and the combination of the structural priming manipulations and verb repetition didn't consistently facilitate production as a noncompetitive account would predict.

Initiation time for theme verbs only. Similar to the analysis of the syntactic choice data, a separate analysis of the theme verbs was conducted because of the lack of passives produced with normal verbs. Another LMM was run with the original specifications, but with only the data for the theme verbs (and thus discarding the target verb type factor). In this analysis (original model AIC = 34212.32), prime structure and verb repetition were again non-significant or redundant random factors and were removed to improve the final model fit (final model AIC = 34208.32).

As before, the analysis showed a significant main effect of trial order, b = -1.11, t (48) = -5.35, p <. 001, which indicates that each trial was initiated just over a 1 ms faster than the target trial prior, showing an overall decrease of 160ms in initiation time for theme verbs across the experiment.

I again first examined whether the structural priming manipulations and verb repetition lead to changes in the initiation latency of the targets. The main effects of prime structure, F (2, 2219) = .68, p = .507, and verb repetition, F (1, 1366) = 2.62, p = .106, were again not significant. As in the complete analysis, neither the interaction of prime structure and target structure selected, F (2, 2327) = 1.21, p = .30, nor the three-way interaction of prime structure, target structure selected, and verb repetition, F (2, 2347) = .99, p = .37, was significant. This result suggests that even for the more flexible theme verbs, structural priming did not result in facilitation for repeating structures from prime to target, even when the verb was repeated. Again, there was also no evidence of syntactic competition when participants switched structures, even when the verb repeated. I predicted that scenario as the most likely place to find evidence of competition.

Again with the theme verbs, there were some interesting variations in initiation latency for verb type, verb repetition, and target structure selected. There was a significant main effect of target structure selected, F (1, 40) = 19.67, $p < .001$. Here, passive target sentences were produced more quickly (M = 1085ms, SE = 28.89ms) than were active target sentences (M = 1170ms, SE = 28.89 ms). This is consistent with a decomposition of the significant interaction of target verb type and target structure selected in the overall analysis, where passives were produced faster with theme verbs and the active was produced faster with normal verbs.

There was a significant interaction of verb repetition and target structure selected, F (1, 2029) = 4.43, p = .036. The pattern of the interaction was similar to that in the overall analysis: active sentences were produced faster when the verb differed and active and passives were produced at similar speeds when the verb repeated. This suggests that even for the theme verbs, the active structure was the default structure, even though it was produced less often than the passive in the context of the experiment, because in the absence of lexical repetition, the active structure was produced the fastest. Finally, in this analysis verb repetition modulated the effects of prime structure on initiation latency, F (2, 2240) = 4.95, p = .007. Here, there was little difference in initiation latency in the target sentences between the same verb and different verb conditions with passives and intransitive primes (see Table 4). However, for targets following an active prime, when the verb repeated in the target, production was notably slower than when the verb differed between prime and target production. Currently, there is no theoretically motivated explanation for such differences.

Thus, even for the syntactically flexible theme verbs, the effect of structural priming on reaction time was not robust, even when lexical repetition was present. This finding is in contrast with some previous results in the main analysis, which suggested that speakers may, in fact, produce more easily accessible structures faster. If structural priming makes such structures more likely to be repeated, then I should have seen a consistent effect on the initiation latency of primed productions even with only weak influences on syntactic choice. The lack of these interactions suggests that, even if syntactic competition is present in the grammatical encoding process, initiation times may not reflect it.

Discussion

This experiment produced sparse evidence for structural priming in the syntactic choice data. The positive evidence of priming (namely, the difference between the control and the conditions that were both lexically and structurally primed), was rather weak and somewhat inconsistent between the subjects and items analyses, in some cases because of item variability. Despite the weak evidence of structural priming across conditions, I can still draw some conclusions. I did find that passive use increased relative to the baseline following a passive prime when the verb repeated from prime to target, at least in the first block. The magnitude of this priming effect was congruent with previous structural priming studies which used the active/passive alternation (Bock & Griffin, 2000). And more importantly, I saw that in the repeated verb condition, passive use decreased relative to the baseline following an active prime sentence. This was precisely what a competitive account would predict under such conditions. But there are a few issues with interpreting this finding in the context of the data from the rest of the experiment.

First, this pattern was found in the first block of the experiment only. By the second block of the experiment, the overall use of the passive structure increased (see Figure 9), which may have overwhelmed these small effects. In other words, in the second block, the passive may have been more likely to be selected in all cases, not only in those where the verb repeated or following a passive prime. Explanations of the long-term effects of priming have described the source of this increase in terms of a learning mechanism, where participants start to associate certain types of messages with the use of a particular structure (Bock & Griffin, 2000b; Chang et al., 2000; Chang et al., 2006). All of the messages in this experiment were quite similar as they could be described using a monotransitive construction (i.e. either active or passive), with a subject and a single direct object. As the dispreferred option, the passive structure is more "prime-able" than the active, which could have resulted in the passive voice becoming associated with the characteristics of the messages used in all the trials.

Second, the lack of structural priming effects across the experiment is inconsistent with previous accounts of the omnipresent nature of structural priming, even in the absence of lexical repetition (Tooley & Bock, 2014). The magnitude of priming has been small but reliable in previous research using the active and passive transitive alternation, and has been found in numerous experiments (Bock, 1986; Bock & Griffin, 2000; Bock & Loebell, 1990; Bock, Loebell, Morey, 1992; Potter & Lombardi, 1998; Saffran & Martin, 1997; Weiner & Labov, 1983). There was no a priori reason to assume that this paradigm or these particular items should fail to produce a similar priming effect, but perhaps the procedure was not particularly sensitive to the effects of priming manipulations. The fact that active and passive alternation may have low "flippability"

(i.e. speakers are unlikely to use the two alternative structures interchangeably; Chang, et al., 2006), that picture description tasks tend to produce greater priming than do word-based tasks (Pickering & Ferreira, 2008), and that actives are much more common than passives in spoken English (estimated 7:1; Bock & Griffin, 2000) are all issues that may have contributed to the lack of consistent structural priming effects in this study. However, despite the weak effects of structural priming, there are still a number of interesting findings that warrant discussion.

With regard to syntactic choice, the most interesting result was the finding in the repeated verb conditions in the first block that supports the presence of a competitive mechanism. But two other findings are also of particular interest: the overall rate of use of the passive voice over the course of the experiment, and that the normal verbs were very rarely produced as passives. I have already addressed the first point when discussing why the results of the prime structure and verb repetition interaction were limited to the first block. Whereas this finding is interesting in terms of the mechanisms that underlie long-term structural persistence, it does not directly speak to the more short-term or immediate effects of structural selection, which was the goal of the current manipulations.

The second finding about the rate of passive use for normal and theme-experiencer verbs was also interesting from a broader perspective. Whereas I expected that rates of passive usage for normal verbs would be low, I did not expect passives to be almost absent or that the rates were largely unaffected by lexical repetition, structural priming manipulations (though neither verb type was strongly affected), or over the course of the experiment. This suggests that these "normal" verbs may be immune to

syntactic flexibility. These verbs may be so predisposed to the active structure that the passive structure is not considered as an option during structural formulation. If the passive structure is not considered an option, then there would be no basis for syntactic competition to occur, even if a mechanism for such competition was in place. This is an important finding and will be discussed further at several later points.

In regards to the syntactic choice data, there was some support for syntactic competition, though it was limited to a subset of conditions, but on the whole the choice data were not affected by the manipulations as strongly as I expected. Despite this, I can still interpret the initiation latency results, albeit with some caution.

First, note that interpreting latency in a free choice experiment is inherently difficult. Speakers may select an option for a variety of reasons, not all of which can be known or controlled for, so we cannot assume that the only source of differences in latency are due to factors manipulated in the experiment.

One finding that is quite clear is the effect of verb type. Target sentences that contained normal verbs were initiated more quickly overall than theme verbs. But this was qualified by target structure. Passive sentences were initiated more slowly than active sentences when they contained normal verbs. Although caution is warranted because there were so few instances of passive target sentences being produced with normal verbs, the effect is plausible. These findings further show that the normal verbs are inflexible. Whereas it is impossible to know exactly what motivated the choice of the passive in these cases, it is clear that it was much more difficult for speakers to initiate those sentences, perhaps because the passive is so rarely considered an option. Similarly, production of active target sentences with normal verbs was initiated very quickly – more

quickly than with the obviously flexible theme experiencer verbs. If it is in fact the case, that the normal verbs are behaving inflexibly, then they are not really appropriate for use in drawing conclusions about grammatical encoding processes under syntactically flexible conditions.

For theme verb targets, passives were actually produced more quickly than their active counterparts. This result is consistent with the syntactic choice data. If speakers show a preference for choosing the passive structure with theme verbs, it follows that they would initiate passive sentences more quickly. This observation is congruent with the noncompetitive account of grammatical encoding: speakers choose whichever structure is easier to encode, resulting in faster speech initiation. However, this observation is not incompatible with a competitive account. Because speakers showed a slight preference for the passive construction with theme verbs, it could be argued that this structure is more easily activated than the active (and vice-versa with the normal verbs and the active structure). There is no evidence of structural inhibition in the reaction time data, which was not surprising because there was little evidence of priming, and inhibition is simply the flip side of the same coin.

Next, regarding the separate analysis of the target sentences that contained theme-experiencer verbs, a few particular points are worth addressing in detail. First, the fact that the repetition of the verb modulated the effects of the prime structure for initiation latency was interesting as I predicted that the interaction of structural and lexical factors would result in the clearest differences between structurally primed and unprimed conditions. Although the three-way interaction of verb repetition and prime structure with target structure was not significant, the pattern in each target structure warrants a separate

examination (see Table 4), since the patterns differ. When the verb differed, the pattern of results in the active target sentences reflects the overall pattern suggested by the competitive account of grammatical encoding – slower initiation time for targets that follow an alternative structure, faster initiation time for those that repeat the prime structure. In contrast, for the matching conditions with passive targets, the targets produced in the control condition or after a passive prime were both produced more slowly than those produced after an active prime. This is inconsistent with a competitive mechanism. Thus, the pattern in the passives overall was *not* suggestive of a competitive mechanism. Yet, it seems unlikely that competition would only exist for one outcome of a structural alternation.

When the verb was the same in the prime and target, there were somewhat similar findings. Here, the mean initiation latency for active target sentences was very similar to that in the different verb conditions, except for the active targets following active prime – these were strangely slow to produce. Again, the pattern of the passive targets in the same verb conditions was different. Here, the passive targets following a passive or intransitive prime were produced at similar speeds, but in this case they were both produced slightly more quickly than passive produced after an active (see Table 4). Though not strong support, this would be largely consistent with a competitive account because it was more difficult for participants to switch structures (though there was no priming benefit from repeating structures in this case). However, these findings suggest that a competitive mechanism would be affected by lexical factors as there was competition evident for the active structure only when the verb differed and competition

for the passive structure only when the verb repeated. Again, it is unclear why this would be the case.

One possible explanation for the latency of the passives produced following passive and intransitive primes being so similar throughout this experiment could be because of the items used. The intransitive sentences in this experiment were sentences such as “The cheesecake was devoured” and “He was scared” which may have been processed as partial or truncated passive sentences. And perhaps rightly so, as they were shortened versions of the sentences that were used as passives such as “The cheesecake was devoured [BY HIM]” and “He was scared [BY THE BOMBS].” If this interpretation is correct, it is possible that there was some facilitation of passive targets following intransitive as well as passive productions. This indicates that the intransitives may not be an optimal control condition for comparison. This point will also be addressed in the discussion of Experiment 2b.

In light of these potential issues regarding the data, it is difficult to draw any strong conclusions about the nature of grammatical encoding from the results of this experiment alone. The syntactic choice data provided some evidence that was consistent with syntactic competition, but only under certain conditions. Similarly, the analysis of the initiation latencies uncovered some results that are consistent with what I predicted under a competitive account of grammatical encoding, but there was also evidence inconsistent with such an account. Overall, I must conclude that the results of this experiment do not provide convincing support for a competitive account. However, the evidence from this experiment does not rule out the possibility of a competitive mechanism, thus not providing clear support for strictly noncompetitive processes either.

Experiment 1b: Constrained Active and Passive Productions with Lexical Repetition

The primary goal of Experiments 1a & 1b was to test for direct syntactic competition between alternative structural options. In Experiment 1a (unconstrained), participants chose the structure of their utterances, and I found little clear evidence to support syntactic competition. Yet, there was also no clear evidence in favor of noncompetitive processing. The results of that experiment may have been limited because participants chose the structures of their utterances – resulting in low rates of passive use with normal verbs and complicating the interpretation of the initiation latency data. In Experiment 1b (Constrained), all target sentences were constrained to a single structural option by including an order-constraining pronoun.

By removing syntactic choice and requiring participants to produce equal numbers of actives and passives, my main prediction should be more effectively addressed. I previously hypothesized that if a competitive mechanism operates between syntactic alternatives, participants should produce the alternative structure targets more slowly than the unrelated targets. In contrast, if structural selection is strictly a noncompetitive process, the alternative and unrelated targets should be similar in initiation latency, as there would be no role for inhibition. Finally, when verb repetition is present but structures differ between prime and target, a competitive mechanism predicts that switching to the syntactic alternative will be more costly. A noncompetitive account predicts relatively smaller switching costs, though it still predicts increased difficulty when producing an alternative structure with a recently used verb.

Method

Design. The general design was the same as Experiment 1a: 3 prime structure (active, intransitive, passive) X 2 verb repetition (same, different) X 2 target verb type (normal, theme-experiencer) X 2 target structure (active, passive) X 2 block. In Experiment 1b, the target utterances were all syntactically inflexible or constrained, as the arguments presented (e.g. "he", "him") limited productions to one possible structure, so target structure was a manipulated variable in this experiment.

Materials. Materials were the same as in Experiment 1a (see Table 1). In Experiment 1a, I was unable to balance the use of verbs for each prime structure by target structure combination, because the participants selected the target structure. However, this was fully balanced in Experiment 1b because the target structures were all constrained. These specifications resulted in 12 between-subjects counterbalanced versions of Experiment 1b, rather than the 6 versions in Experiment 1a.

Apparatus & Procedure. Same as Experiment 1a.

Participants. Fifty-one Lehigh University undergraduates enrolled in introductory psychology participated for a research experience credit. All were native English speakers. The experiment took approximately 60 minutes to complete. Nine participants were excluded from analysis: five participants were not attending to the task throughout the experiment or did not follow directions (not coded), one participant was excluded because the experimental program crashed resulting in data loss (not coded), and three participants had an error rate that exceeded the criterion (see below). The data of the remaining 42 participants were analyzed.

Results

Scoring and Exclusions. Responses were first coded for accuracy as in Experiment 1a. Of the 45 participants whose data was coded, the overall error rate was 33.55% (*SD* = 12.84%). Participants who exceeded two standard deviations above the mean error rate, 59.24%, were excluded, resulting in three participants being eliminated from further analysis. The overall rate of passive selection was not assessed in this experiment as targets were all syntactically constrained. For the remaining 42 participants the overall error rate for the target sentences was 31.40% (*SD* = 10.49%).

Initiation Time. Similar to the analysis of Experiment 1a[12], the initiation time data was analyzed using a Linear Mixed-Effects Model (LMM) with REML in IBM SPSS 20. The model again included fixed and random effects of prime structure, target verb type, verb repetition, target structure, and trial order. Fixed effects included all possible interactions of the variables of conceptual interest, but again only the main effect of trial order. Participants and items were included as separate random effects and each included a random intercept. By-subject random slopes were again included for each main fixed effect, but no by-item random slopes were included. Repeated effects of trial order were assessed as in Experiment 1a, using the Compound Symmetry covariance structure[13]. The initial model demonstrated that prime structure, target verb type, and verb repetition were each either non-significant or redundant parameters for the random

[12] Also see model description for Experiment 1a for details and additional elaboration on model specifications.

[13] Original model fit with AR1 Covariance structure = 59856.15, updated AIC = 59850.97.

effects structure, so those factors were removed from the model (original model fit AIC = 59854.52) to improve the fit (final model AIC = 59849.43)[14].

In this analysis, the fixed effect of trial order was only marginally significant, b = -.41, t (38) = -1.70, p = .098, indicating each trial was only one half of a millisecond faster than the previous trial, 59ms overall.

Of the variables of theoretical interest, I first considered whether there was evidence of structural priming and competition in the latency data, and how verb repetition affected these patterns. There was no main effect of prime structure, F (2, 3658) = 2.11, p = .121, or verb repetition, F (1, 2216) < 1, for the latency data in this experiment (see Figure 11 and Table 5). However, there was a significant interaction of prime structure and target structure, F (2, 3837) = 3.77, p = .023, which did not vary based on verb repetition, F (2, 3748) = 1.73, p = .178. Active target sentences were produced faster than passives in all three prime structure conditions, but the pattern of influence of prime structure varied for passive targets (see Figure 12). In particular, Passive target sentences produced in the control condition, directly following an intransitive prime, were slow relative to the other passive targets. Simple effects tests showed that passives produced after passive primes were significantly faster than those following intransitive primes (p = .006), but those following active primes were not produced more slowly than in the control (p = .135). This is support for the presence of structural priming in reaction time. However, the actives also appeared to be facilitated

[14] The random intercept for Items was not significant in this analysis, (Wald Z = .54, p = .587), however this parameter was retained. When this parameter was removed, it only slightly improved the model fit (AIC = 59847.76), but retention of this variable was conceptually desirable and maintains consistency with the previous analyses (also see Barr et al., 2013). The pattern of overall results was consistent across the two possible analyses. The fact that the Items did not significantly vary in initiation time when syntactic choice was removed is an interesting finding and will be addressed in the discussion.

relative to the control condition, which is not consistent with a competitive account. The pattern of results for the active target sentences was consistent with a competitive account, with active targets produced fastest following an active prime and slowest after a passive prime. But simple effects tests indicated that the comparisons of interest were not significant. This result will be addressed further in the discussion.

Results of other manipulations were also interesting, especially in regard to the two classes of verbs assessed, and how quickly they were produced as actives and passives. First, while the main effect of target verb type on initiation time was not significant, F (1, 69) = 1.74, p = .191, the main effect of target structure was significant, F (1, 37) = 49.60, p < .001. Active sentences were initiated significantly more quickly (M = 1029, SE = 32.01) than passive sentences (M = 1123, SE = 32.17). More interestingly, there was a significant interaction of target verb type and target structure, F (1, 2228) = 72.46, p < .001. However, this interaction was qualified by the influence of verb repetition, F (1, 2297) = 3.97, p = .046, (see Table 5). Production was facilitated when normal verbs were produced as passives and the verb repeated (M = 1138, SE = 34.73), in contrast to when the verb was not repeated (M = 1180, SE = 35), whereas for theme verbs, there was little to no influence of verb repetition on the speed of production for either active or passive sentences. In Experiment 1a, speakers were more likely to select the passive structure when verbs were repeated from prime to target. This result may have been a consequence of reduced cognitive load when the verb was repeated, and the same explanation fits with these data. Production of the passive structure is more difficult with normal verbs, so if that verb is re-used, it may free up resources making it easier to use the dispreferred structure with that verb. This is not the case with the theme verbs for

which the production of active and passive structures appears to be, on average, equivalent in difficulty. No other interactions were significant.

Initiation time for theme verbs only. A secondary analysis for only the theme-experiencer verbs was conducted for comparison to the matching analysis of Experiment 1a. The original model specifications were the same, but with the target verb type factor eliminated. After running the initial model (AIC = 30030.14), non-significant and redundant covariance parameters were removed to improve the model fit. The final model did not include random slopes for prime structure, target structure, or verb repetition as random effects[15], which improved the fit (AIC = 30025.43)[16].

In this analysis, trial order was significant, b = -.63, t (73) = -2.80, p = .006. This indicates that, in contrast to the overall analysis participants showed a significant decrease in initiation latency during the course of the experiment – speeding up approximately .63 milliseconds from trial to trial. However, none of the main effects of the manipulated variables were significant, all F's < 1.5, *ns*. There was a marginally significant interaction between prime structure and target structure, F (2, 1901) = 2.78, p = .062[17], similar to the overall analysis. Here, the active target sentences were produced more slowly than passives after an active prime and after a passive prime, but were produced more quickly than passives following an intransitive prime. And, consistent with the overall analysis, passive target sentences produced in the control condition, after

[15] The random intercept of Items was again not significant, (Wald Z = 0.16, p = .876), but was retained as in the previous analysis.
[16] Original model fit with AR1 Covariance structure AIC = 30031.20, updated AIC = 30025.96.
[17] Note that this interaction was significant in the AR1 comparison model of the same structure, F (2, 1951) = 3.01, p = .049, which has a very similar AIC value. The CS model was reported for consistency with the main analysis and with Experiment 1a. No other significance levels differed significantly between model types.

an intransitive prime, were surprisingly slow relative to the other passive targets even among only the theme verbs. Here and in the overall analysis, for the passive targets, it appears that both active and passive structures were facilitated relative to the control condition. Simple effects tests showed that passive targets following an intransitive prime were marginally slower than the primed passives (p = .051), and not significantly different than the passive targets following an active prime (p = .513). This finding further suggests (as in Experiment 1a) that the conditions used for the control may not have been the most appropriate baseline, making it difficult to draw conclusions about the roles of facilitation and inhibition in grammatical encoding. This will be addressed further in the discussion. No other interactions were significant, all F's < 1.5, *ns*.

Discussion

The overall interpretation of the results of Experiment 1b was much more straightforward than the results of Experiment 1a. This experiment provided a fully-crossed test of outcomes for initiation latency. The key finding of the current experiment was the structural priming effects highlighted by the interaction of prime structure and target structure. The pattern was not entirely consistent with what I predicted based on the competitive account. For normal verbs, actives that were primed were facilitated regardless of verb repetition; the pattern for passive targets was consistent with this, but the patterns were less robust. For the theme-experiencer verbs, the results were more variable. Thus, the complete pattern of results was less reliable across conditions (see Figure 11) than the data collapsed across verb type and repetition suggested (see Figure 12). In both figures, there is one condition that sticks out – passive sentences produced when verbs were repeated were very slow when they followed an intransitive prime for

both verb types. One possible explanation for this finding was suggested by the results of Experiment 1a. The intransitive sentences that were used as the control sentences were in reality truncated versions of the passive targets. There may have been a rebound effect from the production of these partial passives to the complete passive. Essentially, in this condition, the verbs had to be remapped to what could be interpreted as a related structure (at least in a linearization sense, if not conceptually). If this is the case, this slowed initiation time would in fact be evidence of syntactic competition. The data from Experiment 1a showed a similar pattern but only in the normal verbs, were the data was limited due to there being so few passives produced in those conditions. Whatever the reason for it, the elongated initiation time in the control is driving the interaction with prime type in the current data, as the primed passive targets are significantly faster than the control. If the slower response times in this control condition are actually a demonstration of syntactic competition at work, then it is not really an appropriate comparison to assess competition between alternative forms of the transitive structure. Comparing the initiation latency of primed passives to that of passives preceded by active primes (regardless of verb repetition), there is clearly no difference.

Regardless of the interpretation of the unexpectedly slow outcomes for passives primed by intransitives, finding evidence of syntactic priming in the reaction time was not the main goal of the experiment. Rather, the goal was to assess whether the manipulations in the experiment were working. Essentially, this was a litmus test for whether I could expect to find any evidence of competition. As I noted in Experiment 1a, there would be no reason to expect to find competition if there are no structural effects on choices. *Remapping* the same verb from an intransitive construction in the prime to a full

passive in the target may be evidence of a form of syntactic competition, albeit in an unexpected way. The fact that the alternative structural condition was not significantly different than the structurally primed condition for either active or passive sentences does not diminish this finding.

Another way to look at this finding is to consider the role of "forced" remapping costs when verbs are syntactically inflexible. As I saw in Experiment 1a, the normal verbs resisted being produced in the passive structure in every condition throughout the experiment. Thus, I suggested that they may be immune to priming and not syntactically flexible in practice, though they may be theoretically flexible as they can be used correctly in both active and passive structures. In other words, the same verb, same structure conditions appear to show some facilitation, especially relative to the same verbs different structure conditions. But this is a false comparison because really the facilitation observed when verbs and structures repeat is relative to a condition where there are costs associated with the manipulations, that is, when the same verb is "remapped" to a different structure. This finding is consistent with what Frazer & O'Seaghdha (2011) called "remapping costs." We suggested that some previous structural priming results (also using RT as the dependent measure), should be reassessed because they were confusing costs and benefits, as could happen here – what appears to be a priming benefit in the current experiment is more likely a cost to the control condition, rather than facilitation in the primed condition. However, in this case, that costs may reflect evidence of competition between structural alternatives. But it is difficult to exclude other possibilities for such costs.

Additional Comparisons

Comparison between Experiments 1a and 1b.The overall error rates were higher in Experiment 1b (*M* = 31.40%, *SD* = 10.49%) than in Experiment 1a (*M* = 23.16%, *SD* = 11.35%; see also Tables 4 & 5). This finding is consistent with a noncompetitive account of production. When speakers have more structural options available, this should result in faster and more fluent (less error-prone) sentence production. This is also consistent with the results of Experiment 3 in Ferreira (1996), and the percentages in his paper for both constrained (*M* = 34.06%) and unconstrained (*M* = 23.28%) were strikingly similar to those reported here using the same items despite the differences in experimental design.

The overall initiation time was only slightly faster in Experiment 1b (M = 1076ms, SE = 31.38ms) than in Experiment 1a (M = 1082ms, SE = 25.30). This is inconsistent with a noncompetitive account of production, as having more structural options available (Experiment 1a) should decrease initiation latency compared to when there is only a single structural option (Experiment 1b) according to the noncompetitive account. It can be argued that a competitive mechanism slows down production when multiple structural options are available even though the error rates indicate it is easier to produce the sentences. But, this suggestion should be interpreted with caution, as the difference in latency between the two studies was extremely small (6 ms).

However, if I only compare the data for the theme-experiencer verbs across Experiments 1a and 1b, there is a 36ms difference between the two studies, where the sentences containing theme-experiencer verbs were produced quite a bit more slowly under syntactically flexible conditions. This is more consistent with the prediction of a

competitive than a noncompetitive account because syntactic flexibility slows rather than expedites production. Interestingly, the effect is the opposite (though smaller) for normal verbs, with sentences containing normal verbs being produced faster (24ms) in syntactically flexible conditions. But if normal verbs aren't behaving flexibly, as suggested previously, then this difference may only reflect differences across groups of participants in each experiment or the fact that speakers were slow in conditions when they were forced to produce passives. Using a within-subjects manipulation of syntactic flexibility would give us a better estimation of these differences, which I do in Experiment 2.

Comparison to Ferreira (1996). I also compared the more general patterns in my data with those of Ferreira's (1996) Experiment 3, dropping the verb repetition and structural priming manipulations from consideration in my data. The main graph from Ferreira's (1996) Experiment 3 displayed mean production latency by verb type for constrained (using subject constraining and object constraining pronouns) and unconstrained (using proper names or an unconstraining pronoun; here collapsed) productions. My data from Experiment 1a is relevant to the categories for the constrained data, and Experiment 1b for the unconstrained data, though I did not segregate the data by name or pronoun, as this comparison was not of interest.

My data are largely consistent with his findings, although the pattern from the current studies was somewhat less dramatic (see Figure 13). But one limitation of Ferreira's presentation is that he did not separate the unconstrained initiation times based on the structure selected by participants. In his study, whether or not people used a constraining name or pronoun made little difference to speech onset time. I suggest,

based on the data from the current experiments, that whether they selected an active or a passive (and for which verb type) may have had a significant impact. This point cannot be assessed based on the data provided in his paper.

Luckily, Ferreira was kind enough to send me his twenty year old data set. I have re-segregated his data from the unconstrained conditions based on the syntactic structure that participants selected (see Figure 14)[18]. This reanalysis shows that speakers were not only slow when they were required to produce passives with normal verbs, as suggested in Ferreira (1996). Speakers were also slow when they chose to produce a passive sentence. Why would they choose to produce these sentences that took longer to initiate? Of course there are a number of possible explanations, but none of them fit well with a completely noncompetitive process because such an account of grammatical encoding suggests that speakers select whatever structure is most easily available, or is a result of which words in the sentence are more easily available. Speakers selected the passive in only a small number of productions with normal verbs, and they initiated these sentences almost as slowly as when there was no syntactic choice available to them. This supports the idea that speakers may not always be selecting the structure that they can initiate most easily, even when they have multiple options available to them, which is more in line with a competitive process operating in grammatical encoding.

[18] While I was able to obtain this data set from Dr. Ferreira, I was not able to replicate the precise data cleaning procedures used in the original paper. Therefore, the data as I present it is an approximation of the original results as it was not possible to know exactly what criteria had been used for inclusion/exclusion previously. While this means that the current estimates do not exactly match the original values, the overall patterns are the same and the exact values appear to be close. In any case, it is the general patterns of data that are of interest.

Combined Discussion

There were a few significant findings within each of Experiments 1a and 1b and across them that require further discussion. First, normal verbs may not be very flexible in practice, though they can be used grammatically in both active and passive structures. At least for the population I used, normal verbs were very rarely produced as passives voluntarily (see syntactic choice graphs for Experiment 1a, Figures 7 & 9). Even when normal verbs were forced to be produced as passives (see RT for Experiment 1b), these sentences took substantially longer to initiate. If normal verbs are not flexible, then the outcomes of these items will not show any effects of syntactic flexibility. In fact, comparing the patterns of initiation latency for the normal verbs between Experiments 1a and 1b, there were many similarities. The main difference was that the latencies in Experiment 1b were all longer than in 1a for the same conditions, especially for conditions that resulted in passive target sentences. This was not the case with theme experiencer verbs. They were not produced consistently more slowly in Experiment 1b, and differences in latency were not concentrated in the passive target conditions.

Relatedly, note that the random intercept for items was highly significant in Experiment 1a, but was not in 1b. When the intercept is significant, it shows that properties of individual items contributed to the overall speed with which sentences were initiated. Essentially, the items contributed little to no unexplained variance in Experiment 1b, but they did contribute variance that is not explained by other variables in Experiment 1a. Thus, this speaks to the influence of syntactic flexibility with verb use. In the constrained conditions, speakers were forced to use each verb type in both constructions with the result that the direct influence of specific items was reduced. For

example, if constraint required the speaker to overcome the preferred structure in order to produce a syntactically viable sentence, this would obscure the preference of that verb. Thus, in Experiment 1b, the items themselves contributed little variance because variance was accounted for by the target structure and other manipulated effects. If this interpretation is correct, there may still be syntactic competition happening at the level of individual items, influenced by the structural preferences of particular verbs, but it will not necessarily appear as such in the LMM model when choices are constrained. For example, if a particular verb (normal) is only rarely produced in the passive, syntactic competition between the active and passive alternatives is predicted to be weak and has little effect on initiation time and syntactic choice. In contrast, if a speaker must produce that verb in the passive (i.e. force the dispreferred option), competition may be much stronger, resulting in much slower initiation time when it must be produced as a passive. When a verb has a weaker predisposition to a particular structure (theme-experiencer), competition might affect syntactic choice and latency in both flexible and inflexible conditions. This process could be further impacted by lexical availability and structural priming manipulations. However, the current experiments were not designed to test this idea and so cannot fully address it.

Yet there is some evidence consistent with a competitive account. I suggested that syntactic competition might only happen for some verbs and may depend on the structural preferences of those verbs, so would affect various items differently. The pattern of increased initiation latency for normal verbs in Experiment 1b (compared to 1a) would largely support that claim. First, recall that participants rarely selected the passive for use with normal verbs, confirming that this is not the preferred structure for

normal verbs (also see Table 2 and Figure 7). When there was no syntactic flexibility, and participants were forced to produce passives with these verbs, there was a cost in terms of slower initiation latency. This was not seen in the preferred structure, the active, for normal verbs. Nor was this consistently seen for the theme verbs in either the active or passive targets. Theme-experiencer verbs have less preference for the active or passive, so we would expect smaller differences based on whether or not they were produced in flexible or inflexible contexts.

However, the more specific patterns in the latency data considering the effects of the priming manipulation and verb repetition were not consistently in-line with how a more general competitive mechanism was proposed to affect grammatical encoding. Similarly, the rates of passive selection in various conditions in Experiment 1a were not consistently affected by structural priming or verb repetition across the experiment, though the patterns in the first block were precisely as predicted by a competitive mechanism for both verb types. At this point, while there is some suggestion of competition acting on the grammatical encoding process, it remains unclear exactly how, when, and to what extent such competition affects production.

Potential Limitations. In both experiments, the intransitive that I used as a control condition may not have been the optimal control for the passive targets because it may be a partial passive or a truncated passive. However, this same structure was used again in the next experiment (Experiment 2). Note however that the problematic issues with this structure were concentrated in the conditions where the verb repeated from the prime to the target sentence. The verb repetition factor was dropped in Experiment 2 to more thoroughly assess the structural component in isolation, so this issue should be less

problematic, or irrelevant, in the next study. The intransitive controls were eventually changed in Experiment 3.

Conclusion. The main question of these studies was whether there is evidence of a competitive mechanism *operating in tandem* with an incremental mechanism. There was some evidence for this, especially from the syntactic choice data in the first block of Experiment 1a, potentially from the within-verbs structural competition mechanism that I outlined above, and from the cross-experimental assessment of initiation latency. To consider the potential interpretation of the cross-experimental analysis and the constraint factor in greater depth, the next experiment will consider the influence of syntactic flexibility using a within-participants design.

Experiment 2: How does syntactic flexibility contribute to structural formulation?

Experiment 2 was designed to directly assess the effects of syntactic flexibility in sentence formulation. Participants were required to produce an active, passive, or intransitive sentence for each prime production, as in Experiments 1a & 1b. In half of the target trials, participants were given a syntactic choice between active and passive, and in half of the trials they were limited to a single structural option. I examined the choice of structure in those trials where a choice was available, and I examined how quickly participants initiated speech for the target productions on all trials.

As discussed previously, Experiments 1a & 1b were analyzed separately, but were also compared descriptively in order to consider the effects that syntactic flexibility had on utterance formulation through error rates and initiation latency. However, between-experiments assessments of effects can either over- or underestimate effects due to group differences or other situational factors. A within subjects manipulation of syntactic constraint is necessary in order to more thoroughly understand how syntactic constraint affects structural formulation. Furthermore, given that the structural priming effects in Experiment 1a were weak, fully understanding the effect of constraint is important for clarifying the preliminary interpretations offered for Experiments 1. Therefore, in order to gain a clearer picture of the effects of syntactic flexibility on production, and to understand how a competitive process may affect both structural choice and the difficulty of producing an utterance, the effect of constraint was considered with a within-subjects design.

Accordingly, the goal of Experiment 2 was to apply a more powerful, better matched, within-subjects design to the consideration of syntactic flexibility in conjunction with other key variables. To retain sufficient power, it was necessary to drop one factor while adding constraint. I decided to retain the structural priming manipulations and to drop the verb repetition factor for the following reasons. First, because the structural priming manipulations allow for an clear way to consider the influence of grammatical availability on syntactic choice, and second, because I am interested in understanding grammatical encoding, it seemed most appropriate to consider strictly grammatical influences on structural selection. Despite the fact that structural priming was demonstrated only weakly and in the repeated verb conditions in Experiments 1a & 1b, structural priming according to previous research is not dependent on lexical repetition in order to be expressed, though it may be strengthened or boosted by lexical repetition (Hartsuiker et al., 2008). Thus, using a method with purely structural and no lexical manipulations is appropriate for the investigation of the influence of syntactic flexibility on structural formulation.

For Experiments 1a & 1b I predicted that, regardless of whether a competitive mechanism was present, responses would be faster in the repeated structure conditions in both syntactically flexible and syntactically inflexible productions because of the facilitation of structural priming. However, if a competitive mechanism was present, participants should produce alternative structures more slowly (for both flexible and inflexible productions) than the unrelated structures because of the recent inhibition of the alternative. Conversely, strictly noncompetitive accounts of structural selection suggest that the alternative and unrelated targets should be produced at the same speed, as

no inhibition is present from the production of the prime. Despite the weak support for my predictions based on the competitive account in Experiments 1a & 1b, in the current experiment, I again predicted this overall pattern of effects based on the findings of previous literature. If I fail to find such effects, I will still be able to assess the effects of flexibility on sentence production, which will provide some insight into the mechanisms of grammatical encoding.

Therefore, the design of the current experiment allowed within-subjects assessment of the effects of syntactic flexibility on initiation latency. The competitive account predicts slower initiation latencies for syntactically flexible productions. This was assessed by comparing equivalent productions when they are produced under syntactically flexible conditions and when speakers were constrained to a particular structure. These matched comparisons allow a direct measure of whether syntactic competition generally slows production through inhibition. A noncompetitive account predicts the opposite, that having multiple syntactic options available should speed and ease production by reducing the number of errors made and allowing speakers to begin their sentences more quickly. Thus, if the initiation latency for the same utterances is faster in the constrained conditions that would suggest a competitive mechanism is operating, but if initiation is faster in the unconstrained conditions that would instead suggest a stronger influence of incremental, noncompetitive processing on structural selection.

Method

Design. The design was the same as Experiments 1a & 1b, except that the manipulation of verb repetition was removed and syntactic flexibility was manipulated

within subjects: participants received both constrained and unconstrained target productions. The overall design was a 2 constraint (constrained, unconstrained) X 3 prime structure (active, intransitive, passive) X 2 target verb type (normal, theme-experiencer) X 2 target structure selected (active, passive) X 2 block design. As in Experiment 1a, for the unconstrained productions, target structure selected was a measured variable in regard to syntactic choice, but was used as a predictor variable for latency. And as in Experiment 1b, for the constrained productions, target structure was a manipulated variable only.

Materials, Apparatus, & Procedure. The same 40 verb pairs used in Experiment 1a & 1b were used here (see Table 1), except in the current study the verbs never repeated from prime to target. Each verb was again produced 4 times, twice in the prime condition and twice in the target condition, once as prime and once as target in each block of the experiment. The counterbalancing was updated from the previous experiments, as it was found that specific noun arguments were accidently consistently paired with the same verbs throughout Experiments 1a and 1b. Here, the inanimate arguments (e.g. "delay" or "roadwork") were varied in their pairings with the verb between (and within) blocks. Each verb was presented once with each noun in each block, but the pairings were reversed between the prime and target (e.g. in Block 1, "annoyed" was presented with "delay" when it was used as a prime and "roadwork" when used as a target and vice-versa in Block 2). In addition, because constraint was manipulated within-subjects, half of the productions contained an unconstraining pronoun or proper noun (e.g. "you" or "John"), and half contained a constraining pronoun (e.g. "he" or "him"). Thus, the assignment of items to conditions was fully counterbalanced

across six between-subjects versions of the experiment. In the current experiment, target verb type was blocked within the constraint variable: all unconstrained targets in one block contained normal verbs and all theme verbs were unconstrained in the other block. Thus, for half of the participants, all of the unconstrained target trials in the first block would contain theme verbs, and all the constrained trials would contain normal verbs, and vice-versa in the second block. For the other half, it was reversed. Accordingly, the choice data was not analyzed by block. The apparatus and procedure were the same as the previous studies.

Participants. Forty-two Lehigh University undergraduate students enrolled in introductory psychology participated for a research experience credit for class. All were native English speakers. The experiment took approximately 60 minutes to complete. Five participants were excluded from analysis: three participants exceeded the error rate threshold, and two participants did not satisfy the criteria for rate of passive selection in the unconstrained condition. The data from the other 37 participants were analyzed.

Results

Scoring and Exclusions. Responses from all 42 participants were coded for accuracy in the same way as in Experiment 1a. For the 42 participants, the overall error rate was 21.25% (*SD* = 10.57%). Three participants whose error rate exceeded two standard deviations above the mean error rate, 42.38%, were excluded from further analysis (error rates for those participants were 51.38%, 46.53%, and 45.83%). The overall rate of passive selection in the syntactically flexible conditions for the 42 participants was 37.39% (*SD* = 10.73%). Participants whose rate of passive selection in the unconstrained conditions exceeded two standard deviations above or below the mean,

15.93% - 58.84%, were also excluded from analysis, resulting in two additional participants being removed (passive rates were 12.07% and 7.27%)[19]. For the remaining 37 participants, the overall error rate for the target sentences was 18.84% (*SD* = 7.94%), and the overall rate of passive selection for the syntactically flexible conditions was 38.85% (*SD* = 9.03%).

Error Rates as a Function of Constraint. The error rate was higher in the constrained conditions (*M* = 21.88%, *SD* = 9.15%) than the unconstrained conditions (*M* = 15.80% *SD* = 8.07%), t (36) = 5.50, $p < .001$. This is consistent with the results of Experiments 1a and 1b and with the results from Ferreira (1996, Experiment 3). This is consistent with a noncompetitive account of syntactic encoding.

Syntactic Choice. The unconstrained, syntactically flexible, data were first analyzed for syntactic choice in the same manner as for Experiment 1a. Figure 15 shows the overall rate of selection for the passive structure for each verb type and prime structure (also see Table 6). Similar to the results of Experiments 1a, the most dramatic result was that speakers were extremely unlikely to choose the passive under any conditions for the normal verbs. Syntactic choice was also calculated for each verb as a part of the items analysis (see Tables 2 and 3), and again, the rate of passive use was very low for all of the normal verbs. This again suggests that these verbs are not flexible and that they are rarely used in the dispreferred passive structure by choice. Unfortunately, because the unconstrained items were blocked by verb type it was not possible to effectively assess rates of passive use over the course of the experiment.

[19] The rates of passive usage in the theme-experiencer target conditions was examined separately as in Experiment 1a, but identified no additional participants for exclusion.

A 3 (prime structure: active, passive, intransitive) X 2 (target verb type[20]: normal, theme-experiencer) RM ANOVA was calculated in SPSS 20 for the percent passives produced in each condition. As in Experiment 1a, this analysis demonstrated a significant influence of verb type, $F1$ (1, 36) = 577.68, $p < .001$, $F2$ (1, 70) = 428.03, $p < .001$. Participants constructed passives more often when they used theme-experiencer verbs (M = .73, SE = .028) than when they used normal verbs (M = .03, SE = .007). There was no significant effect of prime structure by subjects, $F1$ (2, 72) < 1, or by items, $F2$ (2, 140) = 1.33, p = .267, and the effect of prime structure did not vary by verb type, $F1$ (2, 72) < 1, $F2$ (2, 140) = 1.04, p = .355. Thus, there was no evidence of structural priming or competition in the syntactic choice data for the syntactically flexible conditions in this experiment.

Because of the large difference in the rates of passive use in the normal and theme-experiencer verbs, a separate analysis of the theme-experiencer verbs was conducted. However, the effect of prime structure was again not significant by subjects, $F1$ (2, 72) = .67, p = .516, or by items, $F2$ (2, 70) = 1.37, p = .262, indicating that there was still no evidence of structural priming influences, even among the more syntactically flexible theme-experiencer items.

Finally, a paired-samples t-test was conducted for the theme-experiencer targets between the active and passive prime sentences conditions, as this was predicted to be the largest difference in rates of passive use: passive primes should increase the rate of passive use in targets, active primes should not affect passive use in targets according to a noncompetitive account, or should reduce the rate of passive selection in targets,

[20] Entered as a between-items factor in the F2 analysis.

according to a competitive account. But even in this best case scenario, there was still no statistical evidence for structural priming in the rate of passive production by subjects, t (36) = 1.03, p = .310, or by items, t (71) = 1.46, p = .148, and as such, no evidence of competition.

Initiation Time. The initiation time data were analyzed as in Experiments 1a and 1b using LMM with REML estimation. Refer to Experiment 1a for a detailed explanation of the parameters used. In the current study, there was no verb repetition, but constraint was manipulated within subjects. Thus the verb repetition factor was removed and replaced by the constraint variable. The by-subject random slope of prime structure (Wald Z = .04, p = .968) was not a significant random factor in the initial analysis (AIC = 59413.54) and was removed to improve the model fit[21] (AIC = 59411.54).

The analysis showed a marginally significant effect of trial order, b = -.386, t (212) = -1.70, p = .091, which indicated that each target trial was approximately .4 ms faster than the one preceding it, showing an overall decrease of 56ms over the course of the experiment.

There was a significant main effect of constraint, F (1, 181) = 4.83, p = .029. Sentences produced in the constrained conditions (M = 1129, SE = 23.46) were produced significantly more quickly than those produced in the unconstrained conditions (M = 1163, SD = 26.03) (see Figure 16). This is consistent with a competitive account of structural formulation, in which syntactic flexibility slows production.

I also tested whether the effects of structural priming significantly influenced initiation latency, with repeated structures predicted to decrease latency for both

[21] Initial model fit with AR1 covariance structure (AIC = 59414.23).

competitive and noncompetitive accounts, but alternating structures expected to slow initiation for the competitive account only. The effect of prime structure was not significant, F (2, 3946) = .90, p = .41, nor did it vary with the structure of the target sentence, F (2, 4196) = 2.07, p = .127, as I would have expected. This suggests that there was no reliable evidence of structural priming in the initiation latency data for either passive or active targets – repeating structure did not reliably facilitate the speed with which participants produced the target sentences. Similarly, we did not see evidence of competition in the form of slower production for conditions in which participants switched structures.

Again, I also examined the effects of the different verb types and the target structures produced on initiation latency. There was a main effect of target structure/selected, F (1, 125) = 76.84, p < .001. Passive sentences were initiated more slowly overall (M = 1216, SE = 26.11) than active sentences (M = 1076, SE = 23.57). Though the effect of verb type on initiation latency was not significant alone, F = (1, 168.230) = 1.73, p = .191, but, as expected, it varied strongly with whether the target structure produced was active or passive, F (1, 4224) = 98.26, p < .001. Normal verbs were initiated more quickly when produced in actives (M = 1021, SE = 24.51) than in passives (M = 1295, SE = 33.67), while theme-experiencer verbs were initiated at the same speed whether they were active (M = 1131, SE = 25.35) or passive (M = 1137, SE = 24.82) (see Figure 16 and Table 6). This difference corresponds to the structural choice preferences of the two verb types as previously discussed. No other interactions were significant.

Initiation time of theme verbs only. A separate analysis of the theme verbs was conducted as in the previous experiments with target verb type removed from the model (original AIC = 28759.94). The by-subject random slopes of prime structure (Wald Z = .77, p = .441) and constraint (Wald Z = 1.43, p = .152) were not significant in the estimates of covariance parameters, and were removed to improve the fit of the model (AIC = 28759.93), though the improvement was extremely small.

In this analysis, the main effect of trial order was significant, b = -1.02, t (213) = -3.13, p = .002, thus target sentences containing theme verbs only were initiated about 1 ms faster each time they were produced, an overall increase of 150ms in speed over the course of the experiment.

Again, there was a significant main effect of constraint, F (1, 832) = 7.20, p = .007. As in the main analysis, overall the constrained productions were produced more quickly (M = 1100, SE = 28.33) than were the unconstrained productions (M = 1161, SE = 27.77), which is consistent with a competitive account of structural selection. However, the interaction of constraint and target structure/selected was also significant, F (1, 1995) = 4.89, p = .027. The interaction indicated that the effect of constraint was modulated by the structure produced in the target sentence, such that the effect of constraint was greater for actives. Active sentences were produced significantly more quickly in the constrained conditions (M = 1085, SE = 30.04) than in the unconstrained conditions (M = 1171, SE = 31.09), F (1, 1119) = 10.06, p = .002. Passive sentences were also produced more quickly in the constrained conditions (M = 1116, SE = 30.13) than in the unconstrained conditions (M = 1151, SE = 28.46), but this difference was not significant, F (1, 930) = 2.30, p = .130. This may suggest that the active structure is still the "default" structure for

the theme verbs, despite the fact that they are much more flexible than the normal verbs – the active structure was still produced more quickly when it was required than when it was selected. No other interactions approached significance.

Comparison to Ferreira (1996). As in the first two experiments, I also considered the results of this study in relation to the patterns from Ferreira's (1996) original study (see Figure 17). In the current study, when participants were required to produce passive targets with normal verbs, they were quite slow in initiating speech. This was not surprising as I saw similar effects in Experiment 1b and in Ferreira's original study; clearly, participants have strong preference for the active structure with normal verbs (also see Figure 15). However, when participants occasionally chose to produce passive sentences with normal verbs, these productions were also quite slow. This was somewhat surprising because it suggests that participants may not be selecting the easiest to produce option. That raises the question, what is driving their selection? This same pattern was found in Experiments 1a and 1b (see Figure 14), and in my reanalysis of the original Ferreira data, so the pattern appears to be robust.

Discussion

The most interesting result from Experiment 2 replicated the patterns in the previous experiments and the new analysis of Ferreira's (1996) Experiment 3, and indicated that passives were produced more slowly in both constrained and unconstrained conditions. This suggests that passives are just more difficult to produce in general, not simply that constrained sentences are more difficult to produce. The priming data from the current study showed no reliable effects of structural priming, so it does not appear that speakers are selecting passives in the unconstrained conditions because that structure

is more easily activated. Why exactly participants choose to produce passives if starting them is difficult is unclear. It is possible that the long initiation latency and large degree of variability for unconstrained passives, especially for those containing normal verbs, are simply consequences of 1) few observations present in these cells, and 2) the overall difficulty of producing passive sentences with normal verbs. Yet, these explanations are profoundly unsatisfying. It seems rather to suggest a disconnection between speed and ease in sentence production. The easiest thing to produce may not be the fastest and vice-versa, though why this would be the case is unclear. But, this idea was also supported by the discrepancy between the findings for the error rates and the latency data in the constrained and unconstrained conditions.

The overall pattern of errors was suggestive of a noncompetitive mechanism, as participants were more likely to commit an error in the constrained conditions relative to the unconstrained conditions. This supports the pattern observed in Experiments 1a and 1b, and is similar to the pattern of errors in the original research by Ferreira (1996). In other words, despite the difference in the magnitude of the error rates in this and the previous experiments, they both seem to lead to the same conclusion. The relative error rates for constrained and unconstrained production through the first 3 experiments are consistent with a noncompetitive mechanism.

However, the results of the overall analysis indicated that there was a significant influence of syntactic flexibility on initiation time. The mean reaction time in the constrained conditions was faster than in the unconstrained conditions (see Table 6), which was consistent with the pattern between Experiments 1a and 1b, though here the

pattern was much more robust. This is consistent with a competitive account of structural selection and inconsistent with the findings of Ferreira (1996).

Recall that noncompetitive accounts claim that having more structural options available should both speed and ease production, resulting in faster and less error prone sentence production. While the pattern of errors was consistent with this proposal, the overall pattern of initiation latency was not. It is difficult to reconcile the patterns of errors with the latency findings – either competition is present and it speeds production but results in increased errors, or syntactic encoding is strictly noncompetitive which results in greater accuracy in production but does not speed initiation. Both of these options are possible, but we cannot conclude which is the case based on the design of the current studies.

Also, I noted earlier that the overall error rate was substantially lower in the current experiment than in Experiments 1a and 1b. This may be due to the mix of flexible and inflexible productions in the current experiment, or to the absence of verb repetition in this experiment. With regard to the latter, the results of Experiment 1a and 1b suggested that there may have been either "remapping costs" or lexically based syntactic competition happening in the previous experiments in the conditions where the verb repeated. Eliminating those conditions may have made the current experiment easier than the first two, lowering the error rate.

Limitations. In Experiment 1a and 1b, I highlighted that the content of the intransitive productions may be problematic in that they could be considered partial passive sentences. In the current study, this issue did not seem to be present, likely because there was no verb repetition in the current study. However, regardless of

whether it affected the current study in the same way as Experiments 1a and 1b, the intransitive controls that were used here may not have been the most appropriate control condition. To better meet the goals of this project, these items needed to be altered. In the final two studies, I selected new intransitive prime items for the control conditions that were not used elsewhere in the experiment, making it less likely that those items would be processed as truncated versions of passives.

Conclusions. In sum, the results of this experiment are difficult to reconcile as effects of syntactic flexibility on latencies supported a competitive account, whereas error data supported a noncompetitive account. Similarly, the error rates in Experiments 1a compared to 1b were consistent with a noncompetitive account, and differences in overall latency were consistent with a competitive account, though I was unable to test that statistically in the first set of studies. Furthermore, structural priming, which was only weakly present in Experiments 1a and 1b and mainly in conditions with verb repetition from prime to target, was largely absent in the current experiment. This is likely a consequence of the removal of the verb repetition factor in this design. However, I again noted problems with the control condition that may be interfering with the detection of structural priming effects from the structural manipulations between prime and target. In an effort to increase the sensitivity of the design to structural priming, Experiment 3 used a simplified procedure more similar to standard structural priming paradigms, and had an improved control condition. This was designed to allow for a more complete understanding of the influence of syntactic flexibility and structural availability on sentence production.

Experiment 3: How does syntactic flexibility contribute to structural formulation in a simplified task?

Experiments 1a, 1b, and 2 have produced some interesting results regarding the target productions for normal versus theme verbs and in regards to initiation latency. However, they have produced little evidence of structural priming, which was a key manipulation in this dissertation. There may have been a number of reasons why structural priming has been largely absent in the current studies, including the difficulty of the task and the nature of the control condition.

The procedure used in the previous experiments could bear some responsibility for the lack of priming effects, as it may be more difficult that other procedures used to investigate structural priming. The error rates in the previous studies are indicative of the task difficulty. The error rates in the previous experiments in this dissertation (Experiments 1a, 1b, 2) were not alarmingly high, but they were high enough to suggest that the task I used was difficult for many participants, perhaps more so than in previous structural priming studies. One reason the error rate was so high is because all target productions, even when produced accurately, were required to be preceded by a correctly produced prime utterance created using the same procedure as the target production. Originally, I thought that this task would engage the production system fully, and it would be simpler than using multiple tasks. In the 3 studies so far, participants used the same sentence construction task for the primes and the targets, whereas in many previous studies (e.g., Pickering & Branigan, 1998; Bock & Griffin, 2000b, who also used active/passive and intransitives as filler items), participants completed two distinct tasks.

In these studies, the participants were presented with prime sentence fragments visually which they read and completed in writing (e.g. Pickering & Branigan, 1998), or heard an audio recording of a prime sentence and they repeated it aloud (e.g. Bock & Griffin, 2000b). These methods are both in contrast to the sentence generation task used in the first three studies in this dissertation. Because the characteristics of the prime productions are not of interest in this study, and all prime sentences are syntactically constrained, altering the experimental procedure to require that participants read the prime sentences directly on the screen, and then repeat them in response to a cue, is a simple and effective way to potentially reduce the error rate and data loss in this and the following final study. I also added additional instructions which provided definitions and pronunciation information for a number of items that participants previously struggled with in order to reduce errors.

The second major change in Experiment 3 was to change the intransitive prime sentences in the control condition. In the discussion of the previous experiments, a potential issue with the intransitive prime sentences was noted. In this procedure, the intransitive primes could be seen as partial passives as they were the same as the first section (e.g. "*He was alarmed*") of passive sentences (e.g. "*He was alarmed* by the news") that would be produced with these same items. This may have had unintentional consequences for the production of the target sentences. Therefore, in the current study we replaced the items used in the intransitive prime sentences, so the primes did not use items used elsewhere in the experiment (e.g. "The flying saucer landed", see Table 9). By using items not used elsewhere in the experiment, I reduced the possibility that

participants would interpret the intransitives as truncated passives, because they were not used as passives in other sentences in the experiment.

The overall design of this experiment was the same as Experiment 2, making it possible to assess any benefits of the updated procedure and changes in the control condition. The overall goal was still the direct assessment of the effects of syntactic flexibility on initiation latency to understand whether a competitive process operates during structural selection. However, here I used a streamlined procedure. To reiterate, the competitive account predicts that initiation latency should be greater for productions containing syntactically flexible components than for inflexible components. In contrast, the noncompetitive account predicts that production should be facilitated when multiple syntactic options are available for a sentence compared to when multiple options are not available. Both competitive and noncompetitive accounts predict facilitation when structures repeat from prime to target – both for syntactic choice and for initiation latency. A competitive account also predicts that using a structural alternative will be costly, both in terms of a reduction of switching in the syntactic choice data, and when a structural alternative is used there should be an increase in initiation latency in the reaction time data. These competitive effects should be more robust in unconstrained than constrained conditions, as there will be increased competition when a choice needs to be made. The noncompetitive account predicts no cost to using a structural alternative relative to an unrelated structure.

Method

Design. The design was the same as Experiment 2, a 2 constraint (constrained, unconstrained) X 3 prime structure (active, intransitive, passive) X 2 target verb type

(normal, theme-experiencer) X 2 target structure selected (active, passive) X 2 block design. Again, in the unconstrained productions, target structure selected was a dependent variable for syntactic choice, but a manipulated variable in terms of initiation latency. For the constrained productions, target structure/selected was only a manipulated variable.

Materials & Apparatus. The apparatus was the same as for previous experiments. The materials were largely the same as Experiment 2, but with changes to the prime items. Intransitive prime sentences no longer consisted of the verb and argument pairs used elsewhere in the experiment. Twenty-eight of the new items were taken from the intransitive primes used in Bock & Griffin (2000), and the remaining 20 were constructed from common intransitive verbs to be as similar as possible to the other items (see Tables 7, 8 & 9 for all prime items). These new intransitive prime sentences contained an adjective which was in contrast to the previous experiments, but this addition made the length of the sentences more consistent with the other prime sentences (Table 9). The active and passive prime sentences were composed of the same items as in the previous studies. However, they were modified to no longer include only pronouns as a way to constrain productions to the active or passive construction. Rather than always using "he" or "him" in order to constrain the syntactic flexibility of the prime sentences, sentences were given to participants directly. Therefore, to increase variability in the content of the primes, I used a variety of proper names, relevant nouns, and pronouns (e.g. "Gordon", "the boy", "she"; see Tables 7 & 8). However, the verbs and noun arguments were the same as in the previous studies. For example, in Experiment 2 an active prime would have provided the items "scared," "him" and "cave", resulting in the

construction “The cave scared him.” Here, participants were given an exact sentence such as “The cave scared the pirate,” to learn and repeat.

As in Experiment 2, the constrained and unconstrained targets for each verb type were blocked. For half of the participants, in the first block all the unconstrained targets were normal verbs and all the constrained targets were theme verbs, with the opposite in the second block. For the other half of participants the groupings were reversed. The prime sentences did vary by verb type throughout the experiment, and the target sentences were mixed by whether or not they were syntactically flexible.

Procedure. The procedure was similar to that of Experiments 1a, 1b, & 2, with some minor changes. First, a screen listing some of the more uncommon words that would be encountered was added during the instructions. This provided the definition of the word, an example sentence, and allowed the experimenter to demonstrate the correct pronunciation of those words as a means to familiarize participants with the meaning and use intended in the experiment. The items provided in this section were: loathed, demoralized, ensured, appalled, blunder, & carnage. Experimenters in the previous 3 experiments noted a significant portion of participants who struggled with some facet of these items.

Second, during the production of the prime sentences, participants no longer needed to formulate the sentence based on the required sentence components provided. Instead, upon initiation of each prime trial, the prime sentence was displayed in the center of the screen for 2500ms. Participants were asked to read the sentence silently and to remember it. The sentence then disappeared and a brief countdown appeared on the screen where the numbers “3”, “2”, and “1” were each displayed for 750ms in the center

of the screen. After the countdown, a 250ms "beep" preceded the appearance of a color photograph of an old-fashioned microphone in the center of the screen for 2000ms. Participants were to repeat the prime sentence aloud when the microphone appeared on the screen (see Figure 5). Participants then moved on to each target trial in the same way as in the previous experiments, by pressing the "Start" button. The target trials were the same as before except that, for consistency with the prime trials, the picture of the microphone appeared for 1500ms where there had been a blank screen in the previous experiments, beginning when the voice key detected the onset of speech (see Figure 6). When no response was detected, the procedure was the same as in previous experiments. An error message reading "No response detected" in red font was displayed on the top third of the screen.

Participants. Forty-two Lehigh University undergraduate students were recruited and received research experience credit in an introductory psychology class for their participation. All were native speakers of English. The experiment took approximately 60 minutes to complete. Three participants were eventually excluded from analysis: one exceeded the error threshold and two did not reach the threshold for passive use in the unconstrained trials. The data from the other 39 participants was analyzed.

Results

Scoring and Exclusions. Responses were first coded for accuracy, as in the previous experiments. Of the 42 participants whose data was coded, the overall error rate was 20.12% (*SD* = 8.12%). Again, participants whose error rate exceeded two standard deviations above the mean error rate, 36.36%, were excluded, resulting in one participant being eliminated from further analysis (error rate = 38.19%). The overall rate of passive

selection in the syntactically flexible conditions for all 42 participants was 31.95% (*SD* = 11.53%). Participants whose rate of passive selection was not within two standard deviations above or below the mean, 55.01% - 8.88%, were also excluded, resulting in two participants being excluded, both for low rates of passive use (passive rates in unconstrained were 8.06% and 4.76%). A separate analysis of passive selection rate was done for theme verbs only, but did not identify any additional participants for removal. For the remaining 39 participants the overall error rate for the target sentences was 19.77% (*SD* = 7.84%) which was similar to the previous experiment though there was less variability, particularly in the initial assessment. The overall rate of passive selection in syntactically flexible conditions was 33.78% (*SD* = 9.73%), which was overall lower than in the previous experiment. The fact that the overall error rate was not lower in the current study does not necessarily mean that the task was not easier. Instead, this indicates that the overall rate of error for target sentences was actually higher in this experiment than with the previous procedure, as errors occurred on only 1.3% of prime trials in the current study.

Error Rates as a Function of Constraint. The error rates in the constrained and unconstrained conditions were also evaluated. The overall error rate in the constrained conditions (*M* = 26.71%, *SD* = 10.32%) was higher than in the unconstrained conditions (*M* = 12.82%, *SD* = 7.25%). This is consistent with the results of the first three studies presented in this dissertation and with previous research (Ferreira, 1996). A paired sample t-test showed that the difference was significant, $t(38) = 10.21$, $p < .001$. As in the previous studies, this finding is consistent with a noncompetitive view of syntactic encoding.

Syntactic Choice. Data were analyzed for syntactic choice in the same manner as Experiment 2. Figure 18 shows the overall rate of selection for the passive structure for each target verb type and prime structure by subjects. As in the previous experiments, speakers were very unlikely to choose to produce passives with normal verbs (see also Tables 2 & 3), again suggesting normal verbs may not be flexible in the same way that the theme verbs are. Due to the blocking of the verb types by constraint discussed in the Materials section, it was not possible to examine the patterns of passive use over quartiles.

A 3 (prime structure: active, passive, intransitive) X 2 (target verb type[22]: normal, theme-experiencer) RM ANOVA was conducted in SPSS 20 for the percent passives produced in each condition. There was a significant effect of verb type, $F1$ (1, 38) = 496.77, $p < .001$, $F2$ (1, 70) = 317.69, $p < .001$. As in the previous experiments, the passive structure was used significantly more frequently with theme-experiencer verbs ($M = .66$, $SE = .03$) than with normal verbs ($M = .01$, $SE < .01$). There was no significant main effect of prime structure, $F1$ (2, 76) = .52, $p = .596$, $F2$ (2, 140) = .47, $p = .628$, and the effect of prime structure was not dependent on verb type, $F1$ (2, 76) = .06, $p = .938$, $F2$ (2, 140) = .11, $p = .892$. This suggests that the change in procedure did nothing to increase the strength of the priming manipulation, and that the amount of priming did not vary significantly between the normal and theme verbs.

In the previous experiments, a separate theme verb analysis was conducted on the choice data because of the dramatic differences in the rates of passive use between the theme and the normal verbs. While that dramatic difference remains in the current

[22] Entered as a between-subjects factor in the F2 analysis.

experiment, it is obvious from a visual examination of the data, and from the overall analysis that a theme only analysis would not provide any additional insight in the current experiment, so it was not conducted.

Initiation Time. The initiation time data was analyzed in the same way as in Experiment 2 using LMM, except here I used the AR1 covariance structure in the models[23]. Refer to the full explanation of the model parameters in Experiment 1a. As in the previous experiment, constraint was manipulated within subjects. Verb repetition was not manipulated. In the current study, the repeated effects of trial order were assessed using the AR1 covariance structure rather than the Compound Symmetry (CS) covariance structure, as this structure was a better fit for the data (covariance structures were also discussed in the Experiment 1a analysis). The by-subjects random slopes of prime structure, target verb type, and constraint were not significant in the initial model (AIC = 62298.66), and were removed to improve the fit (AIC = 62299.48). Although the AIC did not improve with the removal of these factors, other model fit estimates did indicate that the second model was preferable[24], so this was the final model reported, as it was consistent with previous analysis methods, and results of the various models were equivalent.

The model showed a significant effect of trial order, b = -1.16 , t (220) = -4.91, p < .001, which indicated that over the course of the experiment, trials were, on average,

[23] Initial model fit with CS covariance structure was substantially worse (AIC = 71642.81) and the LMM was unable to converge, so the validity of the model could not be ascertained. Thus, the current experiment required a different covariance structure to model the results of this study. This may have been a consequence of the new testing procedure altering the pattern of residuals across trials. Also see description of alternative covariance structures in Experiment 1a.

[24] Schwarz's Bayesian Criterion (BIC) is a quite strict estimate of model fit which is closely related to the AIC. Using this estimate, the initial model fit (BIC = 62356.33) was improved significantly with removal of the non-significant random factors (BIC = 62337.92).

initiated approximately 1.2ms more quickly than the previous one, for an increase in speed of 167ms. This overall increase in speed over the course of the experiment is consistent with the effects demonstrated in the previous studies in this dissertation, but was particularly robust in the current experiment. This may be a consequence of the new procedure as participants are now only completing a complicated sentence construction task on half of the trials rather than on every trial.

As in the previous experiment, I first assessed the effects of syntactic flexibility on initiation latency. There was a significant main effect of constraint, F (1, 4411) = 5.23, p = .022. Unconstrained target sentences were produced overall more quickly (M = 1082 ms, SE = 38.76 ms) than constrained productions (M = 1131, SE = 33.11), which is inconsistent with the findings of the previous experiments. However, this finding replicates the results from Ferreira's Experiment 3 (1996), is consistent with a noncompetitive account of structural selection, and is consistent with the conclusions drawn from patterns of error rates in this experiment and in the previous experiments.

In this experiment, there were also some interactions with syntactic constraint. There was a marginally significant interaction of target verb type and constraint, F (1, 4162) = 3.28, p = .070 (see Figure 19). First, target sentences containing theme experiencer verbs were produced at about the same speed regardless of whether they were constrained or unconstrained, while sentences containing normal verbs were produced much more slowly in the constrained conditions than in the unconstrained conditions. There was also an interaction of constraint and target structure selected, F (1, 4418) = 8.41, p = .004. The constrained and unconstrained active sentences were both produced quickly, but constrained passive sentences were produced much more slowly

than unconstrained passive sentences (see Table 10). Overall, these results indicate that the slowest initiation time was when passives were required to be produced with normal verbs in the constrained conditions. The fastest initiation time was when active target sentences were produced with normal verbs regardless of whether they were constrained or unconstrained. However, though the pattern is consistent with Ferreira (1996) and with the previous three experiments, the relationship between verb type and target structure/selected did not vary significantly based on constraint, F (1, 4419) = .57, p = .451. Theoretically, these differences should be present in both the normal and theme verbs. The fact that these patterns are not present for the theme verbs is somewhat problematic for a noncompetitive account because it suggests that syntactic flexibility is not easing sentence production.

As in the previous studies, I again also tested whether there was evidence of structural priming and structural competition in the latency data. There was no main effect of prime structure F (2, 4392) < 1, and there were no significant interactions of prime structure, target structure, and constraint. Thus, there was no evidence of facilitation from repeating structures from prime to target as predicted by both accounts. More importantly, there was no evidence of costs from switching structures, as specifically predicted by the competitive account.

Finally, I also assessed how initiation latency was affected by the verb types and the target structures produced. There was a significant main effect of target structure/selected, F (1, 435) = 36.11, p < .001. As in the previous experiments, active target sentences were produced overall more quickly (M = 1035, SE = 33.37) than passive target sentences, (M = 1177, SE = 39.15). But the effect of target

structure/selected on initiation time was also dependent on target verb type, F (1, 4423) = 36.94, $p < .001$ (see Table 10). Consistent with the previous 3 experiments, normal verb sentences were produced much more quickly as actives (M = 970, SE = 33.99) than as passives (M = 1244, SE = 53.22), while theme sentences were produced at about the same speed regardless of structure (active, M = 1100, SE = 34.41; passive, M = 1111, SE = 34.33). No other main effects or interactions were significant.

A separate analysis of the theme verb conditions only showed that the effect of target structure/ selected was not significant, F (1, 35) = .47, p = .499. Otherwise this analysis provided no additional insights.

Comparison to Ferreira (1996). I again considered the results of the current study in relation to the patterns from Ferreira's original study by dropping the priming variable from consideration. This was warranted as there were no significant effects involving this variable in any of the analyses presented above. In this analysis, the overall pattern was again similar to the original experiment (Ferreira, 1996), and to findings of the previous 3 experiments (see Figure 20). The only difference between the findings of the current study and those of Experiment 2 was that unconstrained passives produced with normal verbs were produced more quickly than those in the constrained conditions, perhaps indicating a reduced cost in those conditions, but they were still produced more slowly than either constrained or unconstrained actives produced with normal verbs. Thus, despite that reduction, when participants chose to produce passives with normal verbs, these sentences were still initiated substantially more slowly than any other productions with normal verbs, except for those where they were required to produce a passive. Although this structure was selected very infrequently in the current study, this

still raises questions about why participants might be selecting this option when it appears to be difficult to initiate.

Discussion

Overall, the changes to the procedure to this experiment did not appear to significantly reduce the error rate or provide a more effective priming manipulation. Despite the absence of consistent priming effects, there are still a number of intriguing patterns in the data. First, as in the previous experiments, speakers were very unlikely to choose to produce passives with normal verbs (see also Tables 2 & 3), again suggesting that normal verbs may not be "flexible" in the same way that the theme verbs are, in that they are actually used in both constructions. Secondly, and more importantly, the results of Experiment 3 were different than those of Experiment 2 in one key way: the unconstrained conditions were initiated more quickly in this experiment. In Experiment 2, the influence syntactic flexibility differed for assessments of error patterns and initiation latency. Whereas the latency data were consistent with a competitive mechanism, as the unconstrained conditions were produced more slowly than the constrained conditions, the error data were consistent with a noncompetitive mechanism, as there were more errors in the constrained conditions. However, in the current experiment, both the error data and the latency data were consistent with a noncompetitive mechanism. Unconstrained conditions were produced more quickly and were less error prone. While this was not what I had predicted, it is worth exploring the details from these findings.

Recall that the main motivation for the alterations to the procedures in this experiment was the relatively high error rate in the previous experiments. Yet, the overall

error rate in this experiment was not reduced. For comparison, the error rate for Experiment 2 (using essentially the same design, but previous procedure) was 18.84% (*SD* = 7.94%), whereas here it was 19.77% (*SD* = 7.84%). The error rate for Experiment 1a and 1b was substantially higher than in either Experiment 2 or 3, as was the overall error rate in the original Ferreira (1996) data (see overall discussion from Experiments 1a and 1b). There are a few potential explanations for this difference in the error rates. First, it is possible that the increased error rate in the previous studies was a consequence of the repeated verb conditions (only present in 1a and 1b). Second, it is possible that we had a particularly good group of participants in Experiment 2 which resulted in an atypically low error rate and the new procedure did effectively simplify the task. Third, it is possible that the new procedure did simplify the task by making the prime trials easier to produce, but increased errors on target trials because participants now had to switch tasks between prime and target productions, or because they had less practice over the course of the experiment with the target procedure. In support of the third option, I noted that there were errors made in only approximately 1% of the prime trials in the current study, which means that almost all errors occurred in the targets themselves. By comparison, in Experiment 2, prime trials accounted for just under half of the errors. But, regardless of the explanation, it was more pleasant to participate in the new procedure, at least as indicated by reduced reporting of participant complaining, so it was used again in Experiment 4.

The overall pattern of errors in this experiment was consistent with the previous experiments, as participants were more likely to make an error when producing sentences in the constrained conditions than in the unconstrained conditions. This is again

suggestive of a noncompetitive mechanism driving syntactic formulation in production. Participants started speaking by using whatever information was more available to them. Then, structural choices were resolved naturally based on how the sentence was started. When production was constrained, speakers were more likely to make an error as there is only one option to begin the sentence. If the correct option is not selected first, the only option is to produce an ungrammatical utterance.

Another motivation for the procedure changes to the current experiment was to ensure that the intransitive control condition was an effective baseline for assessing structural priming. However, the current experiment showed no evidence of structural priming, so it is difficult to assess if this new baseline was effective. The take-away message in regards to syntactic choice here is that the prime sentence appeared to have virtually no effect on the choice of the target structure in the unconstrained conditions. This is puzzling given the variety of tasks that have been used in the literature. For example, Pickering and Branigan (1998) presented participants with the initial portions of written sentences and instructed participants to complete the sentences in whatever way they saw fit. Bock and Griffin (2000) displayed drawings of actions and asked participants to describe the actions in the pictures aloud. Both these and other tasks have all seen priming for the transitive construction. It is not clear why those tasks showed structural priming effects whereas my construction task did not. Instead, syntactic choice was most clearly influenced by the target verb type. Normal verbs were strongly predisposed towards being produced as active sentences, while theme-experiencer verbs were produced more evenly as actives and passives, with a slight preference for the passive structure. This finding has been robustly demonstrated in all studies in this

dissertation, and is suggestive of a larger issue related to structural predispositions of different verb types or to a more significant influence of thematic roles and animacy on structural selection. I will address this in the General Discussion.

Finally, the patterns of initiation time were consistent with the error data, with unconstrained target sentences being initiated significantly more quickly than the constrained targets, indicating that the presence of syntactic flexibility eased production. Both of these findings are consistent with a noncompetitive account of syntactic formulation. Yet, this is the opposite pattern of reaction times that was produced in Experiment 2 where, consistent with a competitive view, the unconstrained sentences were produced more slowly. The error patterns across all experiments have supported a noncompetitive account, and here, the initiation times are also consistent with those error patterns. This consistency between the patterns of errors and initiation latency is compelling because there have been so few results that have provided any evidence for a competitive process during syntactic formulation.

Similar to the lack of priming in the choice data, there were no significant effects of the prime structure on the speed of producing the target. This makes it difficult to draw a strong conclusion about the potential role of syntactic competition based on my hypotheses and my assessment of Ferreira's original study (1996). As discussed in relation to the first two experiments, I would not expect to see any costs of switching structures, as a competitive account predicts, when there is no evidence of structural priming. So, despite the fact that the reaction time and choice data seem to support a noncompetitive account of production, it remains entirely possible that competition would be present under the conditions as laid out in the introduction (also see Figure 2).

Specifically, in a situation where the most recently used structure is more available for use in a later sentence (i.e. structurally primed), this is the situation in which I would expect to see costs associated with competition in the form of increased difficulty producing the structural alternative.

Syntactic priming is not the only way in which a certain syntactic configuration can be promoted. Despite the fact that I have so far been unsuccessful in promoting one structure through priming that structure through recent use, I can also promote a structure through promotion of a certain lexical item. Recall from the introduction that in the model of sentence production that I outlined, activation of the words to be used must precede the formulation of the sentence structure. Therefore, promoting activation of sentence ingredients before they are available for sentence formulation may make them more likely to be chosen as sentence subjects and thus also lead to change in target sentence structure. To that end, I employed a lexical priming manipulation to increase the availability of certain words prior to the presentation of the sentence ingredients in Experiment 4. According to a noncompetitive account of syntactic construction, this should influence which structure is produced under syntactically flexible conditions, with the primed item more likely to occur in the subject position of the sentence. According to the competitive account of production, the effects of this lexical priming should also depend on which structure has most recently been used, and the resulting availability of each alternative. Even if the structural priming manipulations still fail to bias choice or reliably affect reaction time, the lexical priming manipulations should independently bias structure and affect initiation time in a similar way based on our lexicalist model of production.

Experiment 4: How does the lexical availability of noun arguments modulate structural selection?

The goal of the final experiment was to build on the first three experiments: to show whether the availability of to-be-produced lexical items influenced structural choice and to illuminate the consequence of this influence. Crucially, here I focus not on the role of the verb, but on other lexical ingredients in addition to the structural manipulations in the previous studies. Combining structural priming and lexical priming will allow me to assess the extent to which grammatical encoding is competitive and when that competition affects formulation. In contrast to the first set of experiments, here I considered the availability of nouns and pronouns, rather than verbs. I again included both normal and theme-experiencer verbs in this experiment, which have demonstrated that they may vary in their overall disposition to the passive (F. Ferreira, 1994). Theme-experiencer verbs have been produced as passives with much greater frequency than the normal verbs, which have resisted being produced in the passive across the first four experiments in this dissertation.

In this experiment, one of the lexical items to be produced in the target sentence was primed prior to the production of that sentence. For example, in both the active and passive structures for the theme-experiencer verb *alarmed*, "John was alarmed by the news" or "The news alarmed John" respectively, there is an agent/experiencer (John) and a theme/patient (news). Priming one of these ingredients essentially primes either the active or the passive structure. Because of the incremental nature of sentence production, if a particular ingredient is more activated, it should be more likely to occur earlier in the sentence, as it will be easier to retrieve. Depending on whether the agent or theme is

primed, this should bias the speaker to produce either a passive or an active structure. Note that the structure that is promoted by the lexical priming manipulations varies based on the target verb type. For example, for normal verbs, priming the agent results in promotion of the active structure, while for theme verbs, priming the agent promotes the passive structure because the two structures place the agent in different sentence locations.

For example, if "news" was primed for the upcoming target containing the theme verb "alarmed" and the sentence components "John/news", "news" holds the subject position in the active construction versus the object position in the passive construction. The priming of "news" should make it more available for selection which in turn should promote the active structure. However, this lexical priming may not be congruent with the structure that was used in the previous production. If the active structure was not produced in the previous production, the lexical and structural priming are at odds with one another. Therefore, biasing the subject selection through this lexical priming process may alter how much influence the activation levels of the relevant structural nodes have in directly determining the structure. The results of this manipulation will illuminate how more general incremental processes in speech production interact with potential competition between structural nodes to ultimately determine sentence structure. In other words, combining these manipulations will allow me to investigate the dynamic of the relationships between words and structures in grammatical encoding. However, the expectations for structural priming manipulations to be effective are low based on the results of the previous experiments. If there is no influence of these structural

manipulations, the lexical manipulations will still provide a different way in which structures can be influenced.

As illustrated, one consequence of the general incremental nature of speech production is that when to-be-produced lexical items are primed, they should be more likely to be mentioned earlier in the sentence. Congruent with this idea, previous research which has used attentional cueing in picture descriptions tasks has demonstrated reliable effects of cueing such that characters that are fixated first tend to be mentioned first in a sentence (Gleitman, Nappa, January, & Trueswell, 2007). Similarly, in an eye-tracking study, Konopka and Meyer (2011) used lexical priming of semantically related objects prior to participants' descriptions of pictured one-character events. However, they demonstrated no effects of agent or patient related priming on structural selection of actives and passives; instead gaze patterns predicted sentence structure selection, similar to the results of Gleitman et al. (2007). However, this result suggests that their lexical priming manipulation may have been ineffective and was overcome by the stronger influence of the gaze patterns. Instead, a stronger or more direct form of lexical priming (such as priming the specific lexical item) will more effectively manipulate subject selection. Additionally, considering dependent variables beyond structural choice (such as initiation latency) will increase sensitivity in detecting the effects of that manipulation. These potentially more robust manipulations and sensitive measurements should allow for a thorough examination of the consequences of lexical availability on structural selection.

Combining these two techniques (structural priming and lexical priming) is potentially revealing regarding the extent to which grammatical encoding is competitive,

as well as at what point in the formulation process competition may occur. Here, I will use a masked priming technique (Trueswell & Kim, 1998) to promote a specific lexical item which will then be produced in the target utterance. Using this technique, Trueswell & Kim (1998) presented groups of "====", one "="for each letter of a word in a sentence to be read that contained an ambiguous complement (e.g. "The photographer accepted the fire could not be put out", p. 102). Participants pressed a button to reveal each successive word, one at a time. As they progressed, the previous words disappeared. At the critical word, the "====" was replaced by a prime word for 39ms immediately followed by the target item. The prime was a verb that either is usually used along with a direct object (e.g. "obtained"), or one usually used with a sentence complement (e.g. "realized"). Trueswell and Kim (1998) found that the type of prime presented influenced both reading times and interpretations of the sentences. When primed with a verb that tended to be used with a direct object, processing difficulty increased in the region of the sentence complement (e.g. "could"), but when primed with a verb generally used with a sentence complement, less difficulty was observed, thus indicating that the priming was effective in activating the argument structures of the verbs.

Here, I will present one of the nouns or pronouns to be used in the target construction prior to the presentation of the verb for that construction. The relation between the prime and target sentence will be varied as in the previous experiments. Together, these manipulations will allow an investigation of how the activation levels of specific lexical items can influence structural selection, but not simply through repetition of that lexical item between productions as in Experiments 1a & 1b where I repeated the verb. Rather, in Experiment 4, first participants will produce a prime sentence, for

example, “The conflict angered Mary” (active). Next, the argument “news” (active subject) or “John” (passive subject) will be subliminally primed, and then participants will be presented with the verb (e.g. “alarmed”) and arguments (e.g. “John” and “news”) for the target sentence. Finally, participants will produce a target sentence such as “John was alarmed by the news” (passive) or “The news alarmed John” (active).

Both initiation latency and syntactic choice will be considered in our analysis of this experiment. Both dependent measures are informative in understanding how the general landscape of structural choices is altered by the priming of the potential subject noun. Furthermore, the choice data from the structural control condition (after an intransitive) will provide a firm idea of the strength of the masked priming manipulation. This information will guide the interpretation of changes in the initiation time, as this can be difficult to interpret in a free choice experiment. Understanding the preferences for syntactic structure based on the priming manipulations will provide a framework for interpreting the initiation latency.

However, target sentences containing normal verbs have been produced as passives in a very low percentage of trials in the previous experiments, and have not seemed to be affected by the structural priming manipulations. It is possible that sentences containing normal verbs may also be immune from lexical priming sources affecting the structures that they are produced in. If this is the case, I will focus on the outcomes for the theme-experiencer verbs only, as the previous studies have indicated that they are more flexible in practice.

Essentially, I predicted that the lexical priming manipulations would influence the structures that participants produced and the initiation latency of the target sentences.

Regardless of whether incremental or competitive processes are dominant, when the structural priming and lexical priming conditions are consistent with one another, such as when the passive structure was primed, and the subject of the passive was made more available, I should see greater likelihood of production of the congruently primed passive structure. Likewise, that structure should be initiated more quickly. However, if the structural priming and lexical priming conditions are contrary to one another, I expect increased competition, if a competitive mechanism is operating in conjunction with more general incremental processes. Critically, if a competitive process is present, this should result in conditions being produced more slowly overall when the lexical and structural influences are at odds with one another. Evidence from syntactic choice data should reveal whether the priming from the structural or lexical manipulations was more effective in determining the final structure as it will provide evidence about whether the lexical or structural priming was congruent with the final structure. If competition is not present, I would expect no difficulty in using the structural alternative, so lexical priming should be more influential in determining the structure of the target utterance.

In sum, I have already demonstrated that different verbs have different basic structural preferences (see Tables 2 & 3) for the active and passive structures. The influence of those preferences should be altered by structural priming manipulations, though we have seen little evidence of this so far in this dissertation. Structural choices may also be affected by lexical priming as implemented in the current study through priming one of the sentence arguments. Finally, choices in the current study may also be affected by the combination of lexical and structural priming. I expect that the combination of structural and lexical influences will affect structural choice and initiation

latency. When structural and lexical manipulations are consistent, sentence production should be faster and less error-prone regardless of whether or not competition is present. Of main importance, however, the competitive account predicts that when the lexical and structural manipulations are inconsistent, sentence production should be slower due to an increase in competition due to the activation of both potential structural options. Under these conditions, the syntactic choice data will be useful in clarifying whether structural or lexical manipulations were more effective in determining the form of the sentence.

Method

Design. The overall design was similar to that in Experiment 1a in that all targets were syntactically unconstrained, but there was no verb repetition in this experiment. Instead, there was subliminal lexical priming of the agent/experiencer or of the patient/theme of the target sentence. The overall design was a 3 prime structure (active, intransitive, passive) X 2 lexical priming (agent/experiencer, patient/theme) X 2 target verb type (normal, theme-experiencer) X 2 block for the syntactic choice data. Target structure selected (active, passive) was also a factor in the analysis of the initiation times in this experiment.

Materials & Apparatus. The apparatus was the same as for previous experiments and the materials were the same as the unconstrained conditions used in Experiment 3. Thus, verb type was no longer blocked based on the constraint factor. Both normal and theme verbs were present in both blocks of the experiment. For the lexical priming manipulation, the presentation of the arguments was fully counterbalanced. Half of the lexical priming words were the proper names or “you” (the agent/experiencer) and half were the noun argument (patient/theme). The arguments were further

counterbalanced such that half were presented on the top half of the screen during the presentation of the sentence ingredients, and half were presented on the bottom. Thus, the primed items were not tied to any specific location during the presentation of the sentence components, and were evenly distributed between promoting the active and passive structure for each verb.

Procedure. The procedure for prime trials was the same as Experiment 3 (see Figure 5). On target trials a subliminal prime was presented prior to the target sentence components (see Figure 6). The rest of the target trial procedure was the same as in Experiment 3. After the participant repeated the prime sentence (e.g. "Mary was angered by the conflict"), and immediately prior to the presentation of the verb for the target production (e.g. "ALARMED" presented in all capital letters), the participants were presented with a row of 9 pound signs as a mask, "#########", for 500ms, then the lexical prime in all lowercase letters for 50ms, followed immediately by the verb presented in all capital letters, then followed by the presentation of the two noun arguments. The verb thus acted as a forward mask (Dehaene, et al., 2001; Enns & Di Lollo, 2000; Forster, 1998; Schiller, 1998). The lexical prime was the lexical item that would be produced as either the theme/patient of the sentence (e.g. "news") or the agent/experiencer (e.g. "john") of the target sentence (e.g. "The news alarmed John"). All lowercase letters were used for the prime even when it was a proper noun. This was done because during pre-testing the procedure, it appeared more visually consistent and participants were less likely to be able to detect the presence of a prime word. Similarly, this was why the verb was presented in all capital letters. It was a more successful second mask for the presentation of the lexical prime word.

Participants. Fifty Lehigh University undergraduate students enrolled in an introductory psychology course participated in the experiment for a research experience credit. All participants were native speakers of English. The experiment took approximately 60 minutes to complete. Ten participants were ultimately excluded from the complete analysis: three participants exceeded the error rate criterion and seven participants did not meet the criteria for rate of passive selection. The data from the remaining 40 participants were fully analyzed.

Results

Scoring and Exclusions. Responses were first coded for accuracy, as in the previous experiments. For all 50 participants, the overall error rate was 9.14% (*SD* = 5.13%). This is comparable to the error rate for the unconstrained productions in Experiment 3 (M = 12.82%), which used a similar procedure. Participants whose error rate was higher than two standard deviations above the mean error rate, 19.39%, were excluded, resulting in three participants being eliminated. The overall rate of passive selection for the 50 participants was 24.37% (*SD* = 15.68%). However, using two standard deviations as the criterion for exclusion resulted in 0% passives produced being acceptable for inclusion in the analysis. This criterion was intended to remove subjects who used very few passives throughout the experiment. To solve this problem, because the results of this experiment will be contrasted with those of Experiment 1a, I chose to use the same criteria as in that experiment and removed participants who produced passives less than 4.7% of the time (or more than 58% of the time). This resulted in seven

additional participants being excluded, all for low rates of passive use[25]. For the remaining 40 participants, the overall error rate for the target sentences was 8.42% (*SD* = 4.18%) and was similar for normal (*M* = 8.54%, *SD* = 4.86%) and theme verbs (*M* = 8.30%, *SD* = 4.68%). The overall rate of passive selection was 26.54% (*SD* = 13.45%), and as in the previous experiments was much higher for theme verbs (*M* = 50.74%, *SD* = 26.15%) than for normal verbs (*M* = 1.77%, *SD* = 2.29%).

Error Rate. In the current study, the overall error rate was lower than in the previous experiments. Most notably, the error rate here was slightly lower than Experiment 3 which used the same updated procedure. The error rate in Experiment 3 did not clearly demonstrate that the new procedure decreased the error rate, in part because there was a mix of constrained and unconstrained targets. The current experiment does show a decrease in errors, and prime errors occurring on less than 1% of trials. It is also possible that the pre-presentation in the lexical priming manipulations of one of the arguments for each target sentence may have also eased production, resulting in overall fewer errors.

Syntactic Choice. Data were analyzed first for syntactic choice in the same manner as Experiment 1a. Figure 21 shows the overall rate of selection for the passive structure for the prime structure and lexical priming condition for each target verb type. Not surprisingly, participants again displayed their unwillingness to produce passive sentences with normal verbs under syntactically flexible conditions (see Tables 2 & 3).

[25] An analysis of passive selection rate was also conducted for the theme verbs separately, but this identified the same 7 participants for removal. Again, the exclusion criteria from Experiment 1a were used, with the lower boundary set at 8.9% for the theme verb analysis.

As in Experiment 1a, I also examined the rates of passive selection over quartiles for normal and theme verbs (see Figure 22). Much like in Experiment 1a, there appears to be little change over time with the normal verbs with low rates of passives being used in all conditions. But the theme verbs do show some variation over time, though the pattern is not as clear as in Experiment 1a. Either the second quarter of the experiment showed a strange drop in passive use which was otherwise consistent over the course of the experiment, or the first quarter of the experiment showed an inflated rate of passive selection, which then dropped to a baseline level and rose consistently across the remainder of the experiment.

A 2 block X 3 (prime structure: active, intransitive, passive) X 2 (target verb type[26]: normal, theme-experiencer) X 2 (lexical priming: agent/experiencer, theme/patient) RM ANOVA was calculated in SPSS 21 for the percent passives produced in each combination of factors. In this analysis, there was no main effect of Block, *F1* (1, 39) = 2.44, $p = .13$, and no significant interactions with block, so that variable was removed to simplify the following analysis. Exclusion of the block variable did not alter the overall pattern of results.

For the main variables of interest, I first looked at whether there was an overall effect of the structural priming manipulations indicating the presence of priming or of syntactic competition. The main effect of prime structure was not significant by subjects or items *F*'s < 1.This indicated that the structural priming manipulations did not bias choice as predicted, and there was no evidence of competition following the use of an alternative structure.

[26] A between-subjects factor in the F2 analysis.

Next, I considered the lexical priming effects. If the lexical priming manipulations made a significant overall impact, I would expect to see an interaction of target verb type and lexical priming because the lexical priming manipulations would promote alternative constructions for each verb type. There was a significant main effect of target verb type, $F1$ (1, 39) = 144.12, $p < .001$, $F2$ (1, 70) = 636.15, $p < .001$. As in the previous experiments, the passive structure was chosen much more often with the theme experiencer verbs than with the normal verbs (see Figure 21, Table 11). However, the interaction with lexical priming was not significant, $F1$ (1, 39) < 1, $F2$ (1, 70) < 1. This suggests that the lexical priming manipulations did not significantly bias structural choice.

I also examined whether the structural and lexical manipulations were dependent on each other and if this depended on the type of verb used in the target. The three-way interaction of target verb type, prime structure, and lexical priming was marginally significant by subjects, $F1$ (2, 78) = 2.44, $p = .084$, though not by items, $F2$ (2, 140) = 1.22, $p = .299$ (see Figure 21). The interaction of prime structure and lexical priming was also marginal by subjects, $F1$ (2, 78) = 2.45, $p = .093$, though again not by items, $F2$ (2, 140) = 1.50, $p = .228$. No other main effects or interactions were significant. These interactions are somewhat difficult to interpret because of the differences between the two types of verbs, but overall this suggests that the effects of the lexical priming manipulations varied based on the structural priming manipulations, and that this pattern differed across the different verb types. However, as shown in Figure 21, for the theme verbs especially, it is obvious that these patterns were not as predicted. I expected that passive primed structural conditions in combination with the agent/experiencer lexical

priming would result in the highest rate of passive production, not those after an active prime. However, as these effects are only marginally significant (and only by-subjects), the lexical and structural priming conditions did not reliably affect what structures participants produced, so the patterns shouldn't be overly interpreted.

Syntactic choice for theme verbs only. In a separate examination of the theme verbs only, no main effects were significant. The interaction of prime structure and lexical priming was marginally significant by subjects, *F1* (2, 78) = 2.57, *p*= .083, but not by items, *F2* (2, 70) = 1.43, *p* = .247 (also see Figure 21). Because of the low overall choice rates for the passive structure with the normal verbs, this second analysis of the theme verbs alone was more informative, and it suggested that there were no reliable influences on syntactic choice on a trial-by-trial basis. Because the structural and lexical priming manipulations did not affect the syntactic choices made by speakers during the formulation of the target sentence, this marginal interaction, and those from the complete analysis will not be discussed further, as they do not seem to be reliable.

Initiation Time. The initiation time data was analyzed the same as in Experiment 3, but with the addition of the lexical priming manipulation. All targets were syntactically flexible. In the current analyses I again used the AR1 covariance structure in the models (CS is reported in a footnote for comparison). The by-subject random slopes for prime structure and lexical priming were not significant in the initial model (AIC = 70879.88), and were removed to improve the fit of the final model (AIC = 70876.48)[27].The random

[27] As with Experiment 3, the initial model fit with CS covariance structure was substantially worse (AIC = 84768.578) but, the MM was unable to achieve convergence, so the validity of the model could not be ascertained. Also see details discussed in the results of Experiment 3.

slope for target verb type was only marginally significant, but was retained in the final model, as removal did not improve the fit (AIC = 70881.97 with slope removed).

The final model showed a significant effect of trial order, b = -1.08, t (41) = -7.00, $p < .001$, similar to the result of the previous experiments reported in this dissertation. This result indicated that over the course of the experiment, each successive trial was, on average, initiated approximately 1 ms more quickly than the previous trial, indicating an overall decrease in latency over the course of the experiment of 156 ms.

First, I assessed whether there were any reliable effects of the structural priming manipulations on reaction time, and I also considered whether these varied by verb type. There were significant main effects of prime structure, F (2, 5037) = 5.29, p = .005, and target structure selected, F (1, 207) = 11.051, p = .001 (see Figure 25 and Table 11). There was a marginally significant interaction of prime structure and target structure selected, F (2, 5043) = 2.65, p = .071, and a significant interaction between prime structure and target verb type, F (2, 5045) = 4.90, p = .008. More importantly however, the three-way interaction of prime structure, target verb type, and target structure selected, F (2, 5047) = 5.83, p = .003, was significant. This suggests that the interaction of target structure selected and prime structure varied across the two types of verbs. As illustrated in Figure 25, there was nothing happening among the theme-experiencer verbs in the current experiment. This may have been a result of the theme verbs having a less marked preference for the active or passive structure, and so target sentences with theme verbs could be initiated equally as quickly, regardless of the priming manipulations. The normal verbs, which showed a large preference for being produced as actives in the choice data, showed a more variable pattern of initiation latency when produced under

various combinations of prime and target structure. Specifically, when normal verbs were produced as passives, they were slower after the passive or intransitive primes, and faster following an active prime. This was not consistent with my predictions that structural repetition would facilitate initiation latency, but it is important to remember that this subsection of the data was quite sparse. Participants rarely produced passive sentences with normal verbs regardless of the priming condition, so it seems prudent not to over interpret this odd finding.

I also considered the influence of the lexical priming manipulations. The main effect was not significant, F <1, but there was a three way interaction of prime structure, target structure selected, and lexical priming, which was marginally significant, F (2, 5059) = 2.58, p = .076 (see Figure 25). This effect was clearly driven by the same differences that caused the previous interaction of prime structure, target structure and target verb type and this result is subject to the same caution. Given the previous concerns and that this effect was only marginal, this finding will not be addressed further.

There were also other effects on initiation latency, mainly for target verb type. As expected, there was a significant interaction of target verb type and target structure selected, F (1, 4458) = 36.06, p < .001. Target sentences with normal verbs were produced more quickly as actives (M = 960ms, SE = 28.27) than as passives (M = 1142ms, SE = 45.08), whereas targets containing theme experiencer verbs were produced somewhat more quickly as passives (M = 1020ms, SE = 28.78) than as actives (M = 1060ms, SE = 28.73). This is consistent with the results of the previous experiments and with the syntactic choice data. Normal verbs show a preference for being produced in the

active structure while theme verbs are more flexible, but show a slight preference for the passive structure in this study.

As in the previous experiment, a separate analysis of the theme verbs only was conducted. However, this analysis did not provide any additional information or clarification from the main analysis. Here, the only effects were of trial order and a main effect of target structure – both indicating the same results as in the overall analysis. Thus, this analysis will not be reported for the interests of brevity.

Comparison to Ferreira (1996). Lastly, I again made a direct comparison to the data from the Ferreira (1996) study (see Figure 26). In this experiment, all target trials were syntactically unconstrained, so data only for those conditions from the original study are displayed along with the corresponding data from the current experiment. As in some of the previous experiments, the basic pattern between the two experiments was very consistent: Normal verbs were produced more slowly as passives than actives and vice-versa for theme verbs. These differences are much less robust in the current study than in the original, as we have also seen in the assessments of the previous studies. However, this comparison does not provide much insight into whether or not a competitive mechanism is operating, as there are no syntactically constrained conditions for comparison in the current experiment. A version of the current experiment which used all syntactically constrained conditions (as in Experiments 1a and 1b) would be a useful comparison. This was not included because it originally appeared that the unconstrained version would provide more useful data considering it also allows for an assessment of syntactic choice in various conditions.

Discussion

Overall, the results of the current study were not in line with the predictions that I made regarding the influence of a competitive mechanism operating in grammatical encoding. We did not see effects of competition in terms of reaction times or in the syntactic choice data or an influence of structural priming, which was again absent as in the previous studies. I have mentioned in the discussion sections previously, that the absence of priming effects results in the inability to draw strong conclusions about the lack of competition. The addition of the lexical priming manipulation was also largely unsuccessful. I thought that pre-exposing participants to one of the lexical items to be used in the target sentences would result in that item being more likely to be used earlier in the sentence, but that did not appear to be the case overall. There were a number of specific issues and results that contributed to these effects being absent in the current study, and I will review those here.

First, the current experiment and Experiment 3 had lower rates of passive use than initial experiments in this dissertation, especially for the normal verbs. It is possible that this was a result of the new procedure combined with the targets being all syntactically flexible, resulting in less practice in formulating the passive in the updated procedure, though the passive is equally represented in the prime sentences. If the passive is the more difficult construction to produce and participants are getting less practice at forming the passive from the sentence components as a result of the updated prime presentation procedure, then it would make sense that they are choosing to use the construction less often. This is especially relevant for the normal verbs, where very little variation was present in the rates of passive production across conditions. For the theme verbs, it

appears that the lexical and structural priming manipulations had little to no influence on syntactic choice. First, in the unprimed control conditions, participants were as likely to produce a passive after either lexical priming manipulation, suggesting little to no independent effect of the lexical priming. Second, there were no clear effects of structural priming in the choice data, suggesting no independent structural effects. The lexical and structural priming manipulations did not interact in a predictable or reliable way, so the effects of each variable were not simply dependent on the level of the other.

The only suggestion that the manipulations may have affected syntactic choice came from the descriptive examination of the passive use over the course of the experiment, regarding the relationship between trial-by-trial priming and more long-term or cumulative priming. In Experiment 1a, I found that the use of the passive increased over the course of the experiment. This suggested that even in the absence of immediate structural priming effects, a more long-term learning mechanism may be working, increasing the passive as experience accumulated. I see a similar pattern here, though it was not a clear as the pattern in Experiment 1a. Taken together, these findings suggest that there are likely multiple sources driving structural priming, one more transient which is absent in this study, and one more long-term (see Pickering & Ferreira, 2008). These processes appear to be dissociable from one another.

As mentioned above, not much can be made of the data that looks at the passive structure for the normal verbs, as the rates of passive selection were extremely low. This is the best explanation for the huge amount of variability seen in the initiation time for passive targets produced with the normal verbs (see SEs in Table 11). For the active targets produced with normal verbs, none of the manipulations seemed to have had much

effect on the initiation time. Again, the normal verbs seem to be immune from structural priming, and here it seems that they were not reliably influenced by the lexical priming manipulations either. It was expected that the normal verbs would be less susceptible to priming than the theme verbs, but not to this extent. I will return to this larger issue in the general discussion.

However, the story wasn't much clearer for the theme verbs. The pattern of results was fairly uninformative overall, as there were only small differences in initiation time across all conditions, and the patterns do not appear to be uniform. The clearest effect was that the passive structure was initiated more quickly for theme verbs than the active structure. This finding was consistent with the previous studies in this dissertation, and as such appears to be quite robust. I will also return to this finding in the general discussion.

Limitations. From a descriptive assessment of syntactic choice over quartiles, it appears that the lexical priming manipulations may have had some influence on syntactic choice for the theme verbs. This may have had some effect in promoting use of the passive structure with the agent/experiencer priming conditions. In further segregating the data, I discovered that this was much more pronounced when the subliminal prime was a proper noun, rather than a pronoun (see Figure 23). This pattern was further supported by the assessment of the presentation order of the items used to construct the target sentence (see Figure 24). When the agent/experiencer (which promoted the passive for theme verbs) was presented on the top of the screen during the presentation of the sentence components, it didn't matter whether a noun or a pronoun was primed; speakers were quite likely to use the passive in constructing their sentences. But, when the

agent/experiencer was primed and then presented on the bottom of the screen the lexical priming was much more effective in promoting the passive when the agent/experiencer was a proper noun rather than a pronoun. In other words, it appears that participants were more influenced by the location on the screen in which the argument was presented than by whether that argument was primed. The exception to this was when proper names were primed and then the theme/patient was presented on top; here participants produced actives and passives about half the time. This suggests that the lexical priming may be more effective when using a proper name than a pronoun, though the effectiveness was still weak especially in comparison to the influence of on screen location.

The finding that proper names primed better than pronouns may be a result of using only a single pronoun throughout those conditions. For example, "you" is the only syntactically flexible singular pronoun in common use. The constant re-use of this same item in all conditions and oftentimes in multiple target sentences in a row may have resulted in confusion or persistent activation across conditions. Future research should consider leaving pronouns out of such an experiment and using only proper nouns, as differences between noun and pronoun primeability are not relevant to the hypothesis of the current study.

Finally, the issue of the location of the items as presented on screen at first appears to be an issue which is relevant for all experiments in the dissertation, and perhaps may be an issue that should be further assessed. However, I do not think that is the case. The location of the presentation of the agent/experiencer and the patient/theme was fully counterbalanced between all conditions in every experiment. Therefore, any influence that the presentation order may have had should be irrelevant in terms of the

hypotheses – half the time it would promote the passive, half of the time it would promote the active. Second, there is no way around this issue – participants will always have to attend to one item or be presented with one item first in preparing a conceptual representation and sentence. In fact, I would suggest that the presentation of the items being just above and just below the center of the screen was an improvement to the original presentation style of Ferreira (1996). In his studies, the items were presented on the left and right of the center of the screen. Because reading in English proceeds in a left to right fashion, it seems much more likely that participants would always attend to the item on the left first. When they are both presented above and below the center, although there may be a bias to attend to the item on top first, this bias should be less strong.

Conclusions. The results of the syntactic choice data in the final experiment revealed no systematic lexical or structural effects on the selection of active or passive forms of a sentence. Again, influence on the selection of active or passive structures was dominated by an effect of verb type, with normal verbs rarely being produced as passives. Although there was some evidence to suggest that the use of the passive structure increased over the course of the experiment for the more syntactically flexible theme verbs, there was still little evidence of trial-to-trial priming effects. This makes it difficult to make an assessment regarding the state of the hypothesis for this study, as in the absence of priming effects I wouldn't necessarily expect to find evidence of syntactic competition. As with the results of the syntactic choice analysis, results from the initiation latency analysis were inconclusive, as there were few consistent effects on reaction time, and none of those effects were directly relevant to or consistent with the predictions of a competitive account of syntactic encoding.

General Discussion

The overarching goal of these experiments was to test whether there is evidence of a competitive mechanism in grammatical formulation. Furthermore, I assessed both lexical and structural influences on grammatical formulation independently, as well as their combined influence in an effort to understand the relative contributions of each. However, I found little reliable evidence for a competitive process in sentence formulation, except for one situation involving direct lexical repetition of the verb. I did not find reliable evidence of structural priming benefits across the entire set of studies, which suggests that if competition affects structural formulation, I was unable to detect it in the majority of these studies. Given this difficulty, I also assessed the data outside of the structural priming manipulations, similar to the original Ferreira (1996) analyses. Overall, the differences in the constrained and unconstrained conditions replicated the patterns in Ferreira's (1996) Experiment 3, generally supporting the noncompetitive account.

The one experiment in which I found significant structural effects was Experiment 1a. Recall that the percentage of passive productions was affected by the structural priming manipulations in conjunction with verb repetition. This pattern supports the predictions of a competitive account, with increased passive production following a passive prime relative to the control, and decreased passive production following an active prime, also relative to a control. However, this pattern was only present in the repeated verb conditions in the first block. In the discussion of Experiment 1a, I suggested an account of competition that would explain why these findings were only found in the repeated verb conditions. Essentially, I propose that syntactic

competition may only be expressed within specific verbs. I only included the verb repetition manipulation in Experiments 1a and 1b, so the results of Experiments 2, 3, and 4 provided little evidence in favor of such an account.

Structural Competition Linked to Specific Verb Lemmas

I propose a verb-specific model of competition based on the model of sentence production that I outlined in the introduction. As illustrated in Figure 1a, the structural nodes that are available for any particular verb are connected to the specific lemma for that verb. First, assume that the strength of the relationship between any particular lemma and the relevant structural nodes is stronger or weaker depending on the structural preferences of that verb and based on cumulative experience or incremental learning. Next, a more weakly associated structural node would have less inhibitory power over the preferred structure for that particular lemma. For example, for a normal verb like "protested," the structural preference is clearly for the active. So, the link between the lemma for "protested" and the active form's structural node is activated and is a strong link, while the link to the passive form, is also activated, but is much weaker. Therefore, the passive node would get overall less activation, and as a result would send less inhibition to the active form. If the structural preferences for that verb were more evenly distributed, such as with a theme verb like "angered," the two structures would engage in more equal competition.

Less competition, as in the "protested" example, would result in decreased initiation latency, as I saw for Experiment 1a for the active target sentences produced with normal verbs, regardless of whether or not the verb was repeated from the prime production. More competition, such as with the "angered" example, would result in less

dramatic structural preferences, as in the choice data, but also in more similar production times for both active and passive structures, also as seen in Experiment 1a. In this way, the preferences of the specific verb might be integral to both syntactic priming effects and to competition. This explanation for competition being relevant only within particular verbs, rather than for more dissociable elements of syntactic structure, requires further experimental examination, but appears to fit the results of the current studies well.

Issues with Structural Priming Manipulations

Overall, the structural priming manipulations that were employed in these experiments did not influence structural selection as expected. I expected that even in the absence of lexical repetition, using a structure in a prime trial would bias the choice of the structure on a target trial so that speakers would be more likely to repeat the same structure. In regards to initiation latency, I predicted that such priming would also facilitate initiation, resulting in speakers beginning their sentences more quickly. However, this second prediction was more tentative, as few studies have examined initiation times (for transitives: Segaert, Menenti, Weber, & Hagoort, 2011; for datives: Corley & Scheepers, 2002). Those studies suggest that not all structures will see facilitation of initiation latency as a form of priming, and that this facilitation may be dependent on repetition of the verb for some structures. For example, active sentences are already initiated more rapidly than passives, so priming actives may not result in any additional benefit to latency, as they are already initiated quickly. Thus, the lack of evidence of structural priming in the latency data is not unprecedented, and does not indicate a problem with the experimental design, manipulations, or materials in themselves.

It is more concerning that the structural priming manipulations did not consistently bias choice in the syntactically flexible conditions of the experiments (with the exception of Experiment 1a), as this has been reliably established in many studies. The priming manipulations may not have worked for a number of reasons. For example, the sentence production task used in these experiments may not have lent itself to such effects, as it has not been used to assess priming in the past. However, this seems unlikely given the number and variety of tasks that have shown effects of structural priming (picture description, written and spoken sentence completion, descriptions of movement, in dialogue; see Pickering & Ferreira, 2008 for a review). In the future directions section of this discussion I propose a number of methods that might improve on the method of the current study to more reliably tap into structural priming in the choice data. Because the crux of the predictions in the dissertation were dependent on these manipulations, the fact that they did not effectively appear to bias syntactic choice makes it difficult to draw strong conclusions about the nature of syntactic encoding in the way that was originally intended.

Beyond Priming: Evaluation of Error Patterns and Overall Latencies.

Excluding the structural priming manipulations allowed me to assess syntactic competition based on error rates and initiation latency for syntactically flexible versus inflexible conditions, as done in Ferreira (1996). Across all 5 experiments in this dissertation, the pattern of results was highly consistent with the results of his original study, though the patterns were less dramatic. Ferreira (1996) claimed that if syntactic competition was present, it would make sentence production slower and more error-prone when a syntactic decision is required, and he found this to be the case using the same

basic task as in the current study with both transitive and dative structures. In my experiments, the relative error rates for the syntactically constrained and unconstrained conditions in Experiment 1a vs. 1b, Experiment 2, and Experiment 3 were all consistent with a noncompetitive view of encoding – the unconstrained conditions had a lower error rate. However, the relative speeds of production in the constrained and unconstrained conditions differed in various experiments. Target sentences in Experiment 1a vs. 1b and Experiment 2 were produced more slowly in the unconstrained conditions, which is what is predicted by a competitive account. For the cross-experimental comparison in Experiments 1a and 1b, the difference was small and may have been a consequence of varying skill levels of two different groups of participants, but the comparison in Experiment 2 was within subjects, and was significant. However, I have already noted a few potential issues with the design and procedure of the initial three studies, which were updated in the final two studies. Experiment 3 was a replication of Experiment 2 using the updated procedure and items, and the results of the initiation latency for Experiment 3 was in-line with the results of the error analyses. The unconstrained targets were initiated more quickly, and were less error prone, than the constrained conditions – just as a noncompetitive account predicts.

The fact that the patterns of errors and latency are consistent in Experiment 3 suggests that these results may be the most reliable, considering the issues raised above. I discussed the fact that although it is possible that the errors and latency data may be dissociable, it remains possible that competition may make speech more error prone but not slow initiation. However, it does not seem likely and I am not aware of any evidence to suggest that is the case. Rather, I think that other manipulations in the current

experiments or features of the procedure were responsible for this mismatch in error and speed patterns across Experiments 1a and 1b and in Experiment 2.

In summary, the results of Ferreira (1996) and the majority of the same comparisons in the current studies support a non-competitive account of syntactic encoding. I have never claimed that such an incremental view of syntactic processing is incorrect. Rather, my dissertation posits that a competitive mechanism functions alongside such incremental processing. Including the structural priming manipulation in the design of the study seemed to be the best and most direct way to explore this option. However, this manipulation does not appear to have been effective. Therefore, I am hesitant to conclude that there is no role for a competitive mechanism in syntactic encoding. Rather, I failed to capture conditions in which such a mechanism would be present, so following the standard reasoning concerning inferences from null findings I cannot conclude that it does not exist on the basis of the current studies.

Other Issues in the Current Studies

It is also important to note that other variables that I manipulated in these experiments did affect syntactic choice and the speed and ease of production. I found that the repetition of the verb in Experiments 1a and 1b influenced structural choices, and resulted in decreased initiation latency, although this effect was modulated by the structure that was selected. Other studies have recently demonstrated that the repetition of lexical items, specifically verbs, may be necessary to express structural priming effects, though that interaction was not fully significant in Experiments 1a and 1b reported here (Arai, Nakamura, & Mazuka, 2014; Bunger, Papafragou, & Trueswell, 2013). For example, Bunger et al. (2013) recently looked at how speakers described motion events.

In their experiments, speakers read a prime sentence aloud (as in my Experiments 3 and 4) which varied in syntactic structure and in the degree of overlap with the target conceptually and lexically. Then, they described the motion event that occurred in a dynamic video. Their results suggested that both lexical and conceptual repetition may be required in order for structural priming to occur (Bunger et al., 2013), or that in the absence of lexical repetition, the same conceptual information must be available from the non-repeated lexical items. This finding is not consistent with previous literature, which shows that lexical repetition can increase structural priming, but that it is not a necessary condition. Bunger et al. (2013), however, suggest that many previous studies may require reassessment. In the previous literature, priming may still be due to the repetition of the order of thematic roles in consecutive utterances. For example, in many structural priming studies, the structural choice is essentially the order of mention of sentence components, as in a prepositional, "The princess made a pot of tea for the man," (i.e. theme first, recipient second) or double object, "The princess made the man a pot of tea" (i.e. recipient first, theme second). Based on this suggestion, as well as the previous proposal of verb-specific syntactic competition, it may have been beneficial to retain the verb repetition variable in Experiments 2, 3, and 4 to increase the possibility of influencing syntactic choices. However, I was interested in the "pure" or abstract form of structural priming with these manipulations, which Bunger et al. (2013) discuss as well. In other words, I was mostly interested in being able to assess structural and lexical influences independently of one another, which theoretically should be possible based on the abstract representation of syntax often cited as an explanation for priming effects. However, this may not have been the most effective approach, and if I could do it over

again, I would have included these factors in more than one experiment in order to have a more thorough assessment of influences at both lexical and structural levels.

Structural Preferences for Normal and Theme Experiencer Verbs

I found dramatic differences between the two types of verbs used in the experiments. There were large, consistent differences in the rate of passive structure selection, and the speed at which each structure was produced, for the theme experiencer verbs and the normal verbs across all 5 studies in this dissertation. As mentioned in Experiment 1a, this was expected. Previous research has also shown that normal verbs were unlikely to be produced as passives (Ferreira, 1996). However, the rate of passive use with these verbs was exceptionally low for syntactically flexible targets in the current studies. These verbs seemed to be effectively "immune" from any sort of priming effects; none of the lexical or syntactic manipulations seemed to effectively vary the rates of passive production with normal verbs. In contrast, the theme-experiencer verbs were used much more evenly in both active and passive structures across the course of the experiments. Most of these verbs showed a high degree of flexibility in the rates at which they were produced as passives in each experiment (see Table 2). This shows that the theme experiencer verbs were quite flexible and as such were better suited to the design of the current studies than the normal verbs. This strong preference is most likely related to the preference for putting animate items in the subject position of the sentence. Because all of the sentences in the current study contained one animate, the agent or experiencer, and one inanimate, the theme/patient, item, the two different constructions' structural preferences may have been exacerbated, especially for the normal verbs. Furthermore, the structural preferences of specific verbs are especially relevant given my

previous proposal regarding verb-driven syntactic competition effects. A more thorough assessment of general verb preferences may be integral to understanding syntactic competition in sentence production.

Future Directions

The overall design of the current studies is sound and such a design may yield results in the future. However, there are a number of changes that could be implemented in order to improve the effectiveness of the manipulations and the sensitivity of the response measures. Such changes to the items and procedure could lead to a more successful assessment of the mechanisms of grammatical encoding than the current studies were able to accomplish.

First, dropping the normal verbs from the experiments entirely could be beneficial as they behaved inflexibly under conditions that should have been syntactically flexible. In the current studies, separate analyses were conducted when appropriate to only analyze the theme experiencer verbs. However, the inclusion of the normal verbs in the experiment itself may have promoted the use of the active structure more generally, as the normal verbs were produced in the active voice almost exclusively when a syntactic choice was available. So, the inclusion of these types of items may have had consequences for the performance of speakers in sentences using theme experiencer verbs, especially in the free-choice procedure. The inclusion of the normal verbs was less problematic in syntactically constrained designs, so under those conditions, including normal verbs may still be useful.

However, going one step beyond constraining transitive verbs to the more flexible subtype, would be to use a different category of verb altogether. This change might be an

even more effective update to the materials. In the current studies, I used active and passive monotransitive structures as the critical targets, and used an intransitive sentence as an unrelated control. Previous research has found that structural priming effects using the active and passive transitive alternation are less robust than those using the prepositional object and double-object dative constructions (Bock & Griffin, 2000). However, in English there is a shortage of syntactically inflexible verbs that result in double-object constructions (Ferreira, 1996), and this makes it difficult to find an appropriate baseline comparison for critical items which are produced as double objects with verbs that are syntactically flexible. This lack of inflexible DO verbs was the reason for the choice of the active and passive alternation at the start of this project, as that comparison was critical for a clear assessment of the hypotheses in the current studies. However, using the PO/DO alternation may have been more sensitive to the manipulations, and the PO construction does have an appropriate control since there are flexible and inflexible PO verbs in English.

Relatedly, it may have been more appropriate to use a more unrelated structure for the control condition. Previous research has also used the intransitive as a control condition for the monotransitive alternation (Bock & Griffin, 2000; Segaert, et al., 2011), as I did in the current studies. Though the intransitive is a different construction than the monotransitive, I have noted some potential issues with intransitive sentences being perceived as partial, or truncated, passive sentences. In response to this, I implemented an improved version of the intransitive control condition in Experiments 3 & 4, where I altered the verbs used in the intransitive primes. This was done as a way to decrease participants' interpretation of the intransitives as partial passives, by eliminating the verbs

used elsewhere in the experiment from the intransitives. For example, in Experiments 1a, 1b, and 2, participants may have encountered the verb "angered" in a prime as an intransitive, "He was angered", but later produced that verb as a passive, "He was angered by the conflict." Using the same verbs in these two types of structures may have prompted the participants to interpret the intransitive as a truncated passive. Using items in the intransitive control that were not used elsewhere as actives or passives, for example "The flying saucer landed" should reduce this tendency. Whereas the change that I made to the final two experiments seemed to address this issue, it could be safer to use a more unrelated structure entirely (e.g. dative control for transitive targets).

In addition to potentially changing the control conditions, using a subset of current items, or even making a complete change to the items by using a structure that has been more amenable to priming effects, it is also relevant to consider the role that verb repetition played in this dissertation. As discussed above, the manipulations of verb repetition in this dissertation were limited to Experiments 1a and 1b only. The results from the verb repetition conditions of Experiments 1a were especially interesting as effects of structural priming in terms of the syntactic choice measures, and at least in Block 1, also showed a pattern of results that was consistent with the predictions of a competitive account.

In the discussion of Experiment 1a, and above in the general discussion, I outlined an account of grammatical competition that might be limited to competition between available structures for a specific verb. If this suggestion is correct, that syntactic competition must occur through a lexical filter, then continuing to investigate verb repetition along with the other manipulations in this dissertation would be beneficial. So,

although including verb repetition as a factor should not be integral in seeing structural priming effects more broadly, it is well worth investigating further in the broader context of syntactic competition in sentence formulation.

The repetition of the verb was not the only lexical manipulation that I addressed in this dissertation. In Experiment 4, I also implemented a lexical priming manipulation designed to promote one of the noun/pronoun arguments to be used in the target sentence. By pre-activating this component, I proposed that it should result in that item being more likely to be produced as the subject of the sentence, thus influencing which structure was selected. However, I found little evidence to suggest that this lexical priming was consistently effective. Yet, after the priming of this item, the location of the item on the screen relative to the other noun/pronoun to be used in the target sentence might have had an influence. Although the location on screen was counterbalanced in the current experiment, this finding could be further explored and exploited to improve the lexical manipulations. For example, as in Konopka & Bock (2011) it would be beneficial to implement this manipulation along with an eye-tracking measurement in order to ascertain whether participants were significantly more likely to first fixate on the item presented on the top half of the screen. Or, regardless of whether or not they were more likely to fixate on the top or bottom item first, it would be interesting to simply investigate whether speakers were more likely to include whichever item was first fixated earlier in the sentence using the current task, as previous eye-tracking studies have demonstrated (i.e. Gleitman et al., 2007). This could be used as a more effective lexical priming manipulation than the one used here, and would influence formulation similarly.

It is also worth evaluating whether the procedure as a whole was effective. There was no reason to think that the current procedure would be problematic in terms of structural priming effects, and I still do not have direct evidence to suggest that the sentence formulation task I used was problematic. However, it may be useful to consider using an alternative task, specifically one that has been established in the structural priming literature. For example, many studies that have considered priming have used variations of picture description tasks (Bock, 1986; Bock et al., 2007; Hartsuiker & Kolk, 1998; Hartsuiker et al., 2008; Loebell & Bock, 2003; Saffran & Martin, 1997), including the majority of studies that have assessed structural priming effects on latency (picture descriptions: Segaert et al., 2011; Smith & Wheeldon, 2003; Wheeldon & Smith, 2003; other tasks: Corley & Scheepers, 2002). Such picture description tasks have not been limited to priming studies, but also have been used in studies where the goal is to evaluate how sentences are formulated more broadly (Gleitman, et al., 2007; Griffin, 2001; Konopka & Bock, 2009). Using such a task for the target sentence generation would introduce more variability into the responses, but is a more ecologically valid production task and could lead to increased sensitivity to priming effects. This could be an improved way to assess online sentence formulation processes.

Finally, as mentioned in the Introduction, considering reaction time and syntactic choice in conjunction with one another is a methodological improvement in comparison with the bulk of previous research on structural priming. The majority of the structural priming literature only considers syntactic choice. By combining it with an analysis of initiation latency, the current experiments aimed to give a more complete account of both syntactic choice and production difficulty. Initiation latency does have limits – including

the fact that it cannot account for the effects of ongoing planning during the production of speech. Adding total production time as an additional dependent variable would be wise as it would allow for an assessment of online sentence construction processes. For example, just because a speaker initiates speech quickly, doesn't mean that they will also prepare and produce the complete utterance more quickly. There may be a minor pause at some point during the sentence, or you may speak slightly more slowly while you prepare the rest of your sentence. However, this assessment was not included in the current set of studies, because of the extremely time-intensive nature of the coding necessary for measurement of production time. Perhaps implemented along with the changes described above, containing either a subset of the current items, different structural options, or a more appropriate unrelated control condition, the addition of this dependent measure could be quite helpful as an assessment of online planning processes in sentence formulation.

Conclusions

Based on the results of the current set of studies, it is unclear whether a competitive mechanism exists in structural selection. This is not because all the available evidence points to a non-competitive mechanism, but rather because the key structural priming manipulation in the current studies did not function as planned. Outside of the structural priming manipulations, I assessed the error patterns and initiation latencies as in Ferreira (1996), and largely replicated the results of his study. This suggests that structural selection is a noncompetitive process. However, additional studies are needed in order to assess whether syntactic competition may emerge under other implementations of the conditions targeted in this dissertation. A competitive mechanism

would provide a clear account of a number of effects that have been documented in the literature on grammatical encoding, and understanding exactly how and where such a mechanism may function should continue to be a priority for research on grammatical formulation.

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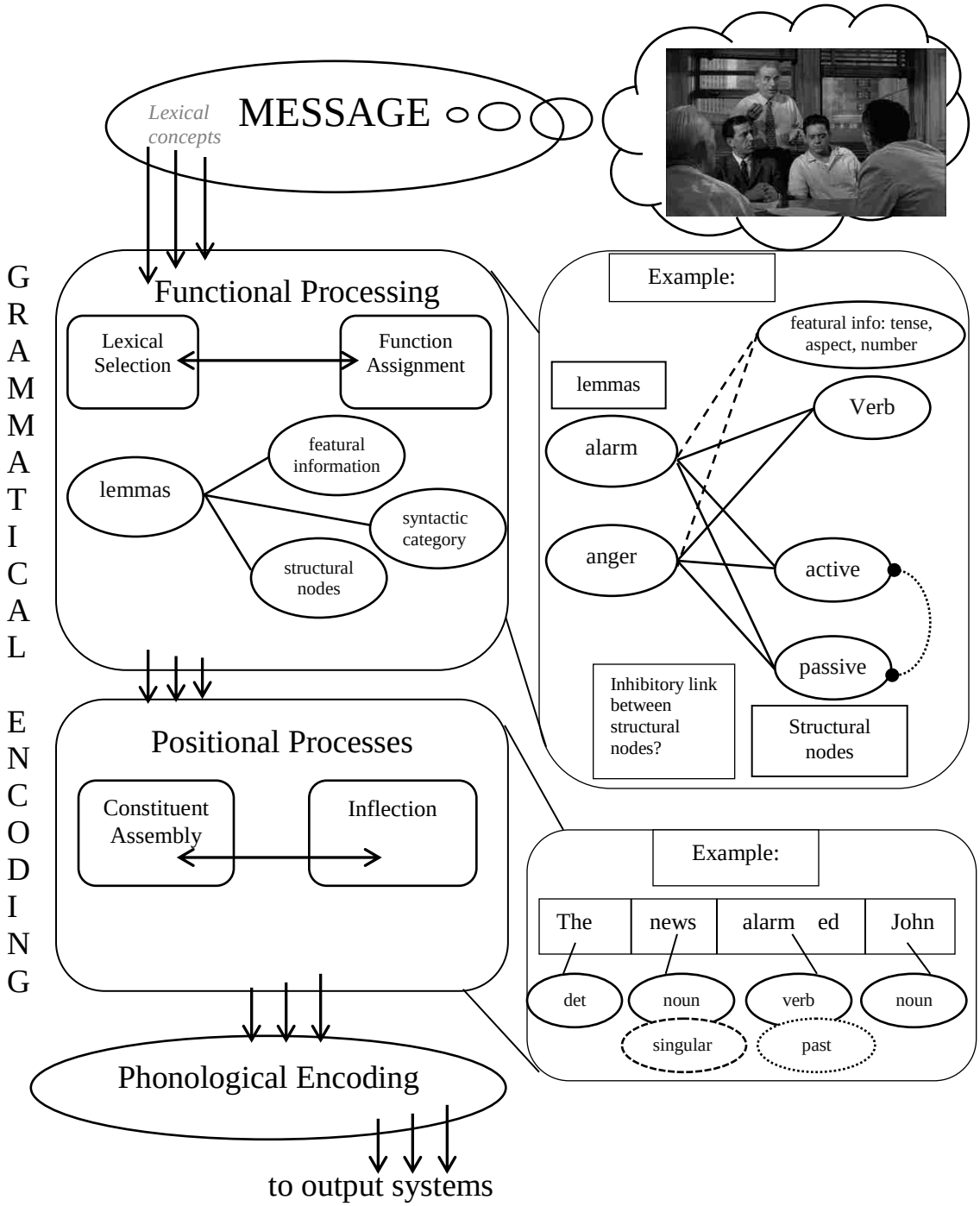

Figure 1. General sentence production model focusing on the pivotal role of the verb in determining structure at the functional level of grammatical encoding. The example shows how structural nodes for active and passive monotransitive structures are linked directly to the lemmas for specific lexical items. Whether an inhibitory link between structural nodes is present is the key question of this dissertation.

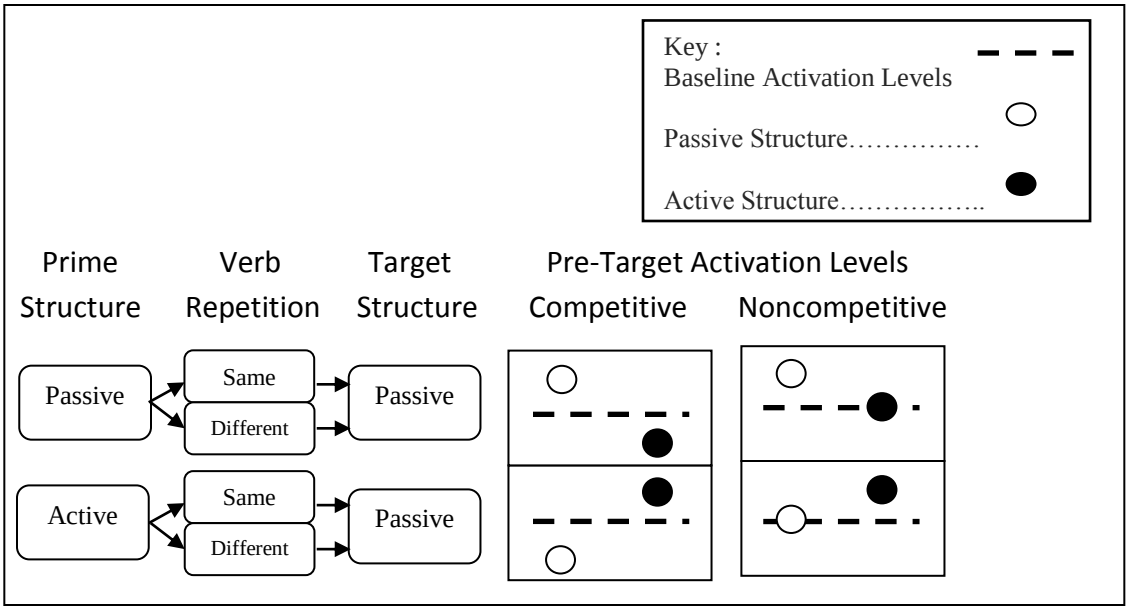

Figure 2: Representation of predicted activation levels for each structure under competitive and noncompetitive accounts.

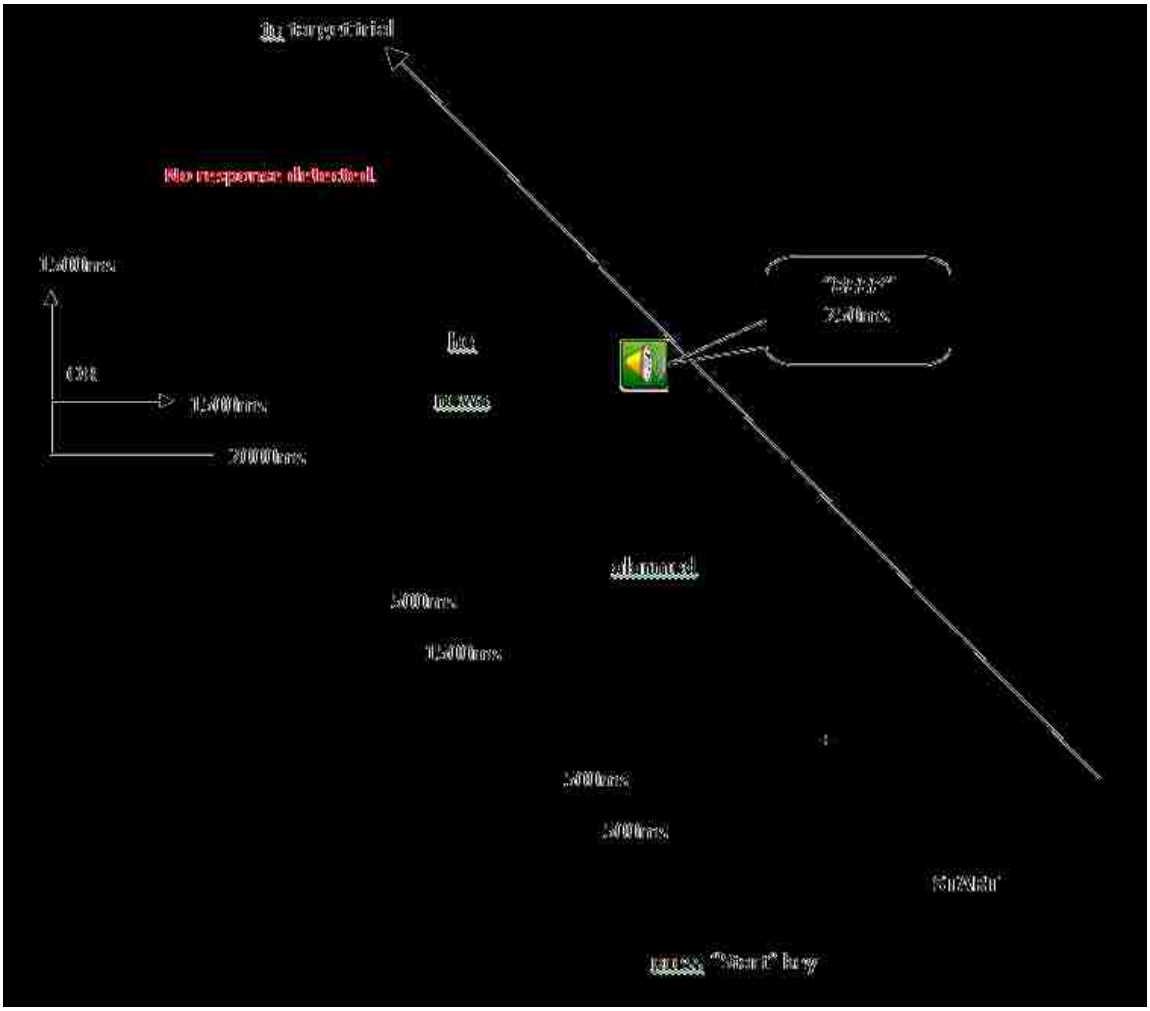

Figure 3. Experimental procedure used for prime trials in Experiments 1a, 1b, and 2. Note that all prime trials in these experiments were syntactically constrained.

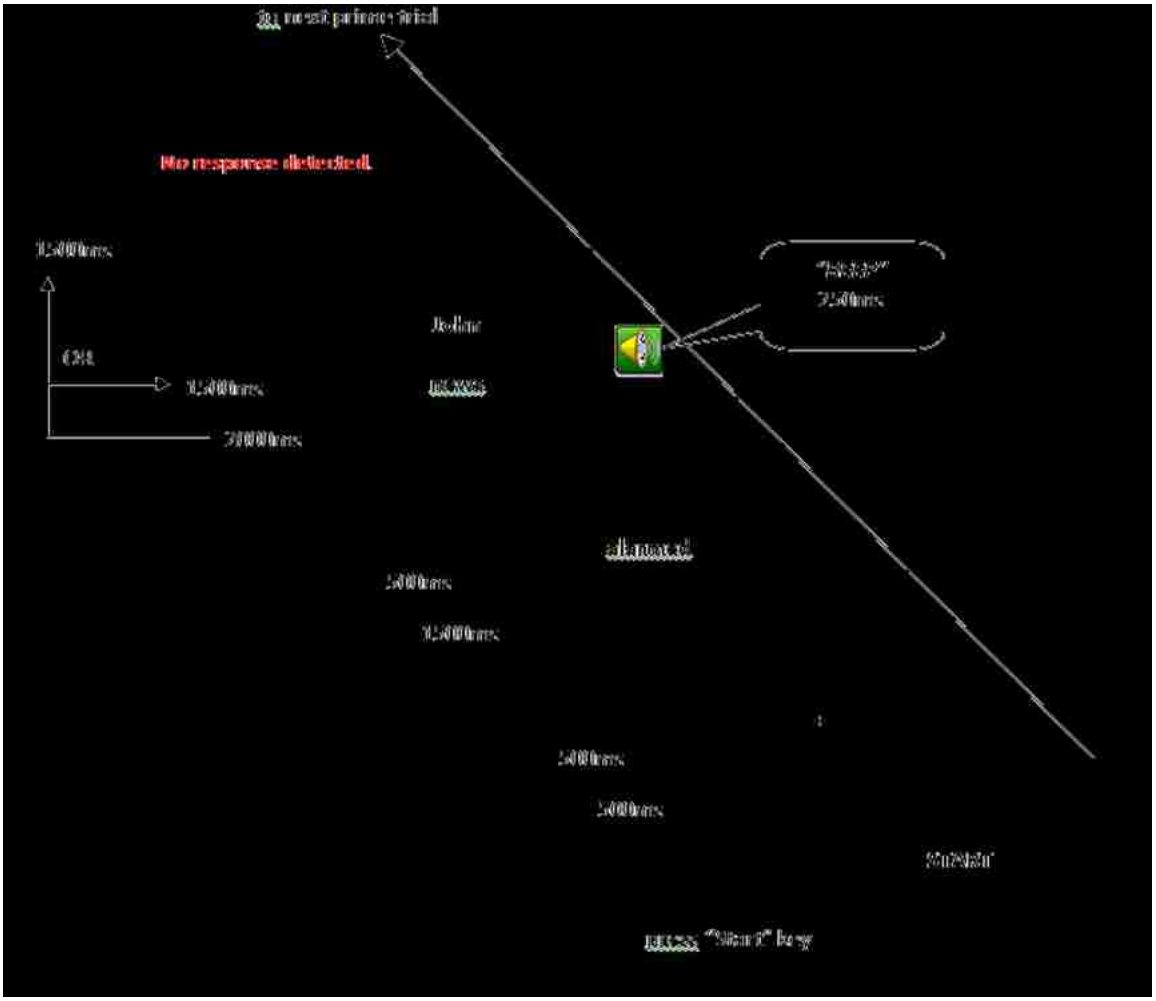

Figure 4. General experimental procedure used for target trials in Experiments 1a, 1b, and 2. Note that Experiment 1a had all unconstrained target trials (‘John” or “you” as agent/experiencer), Experiment 1b had all constrained target trials (“he” or “him” as agent/experiencer), and Experiment 2 had a mix of both types.

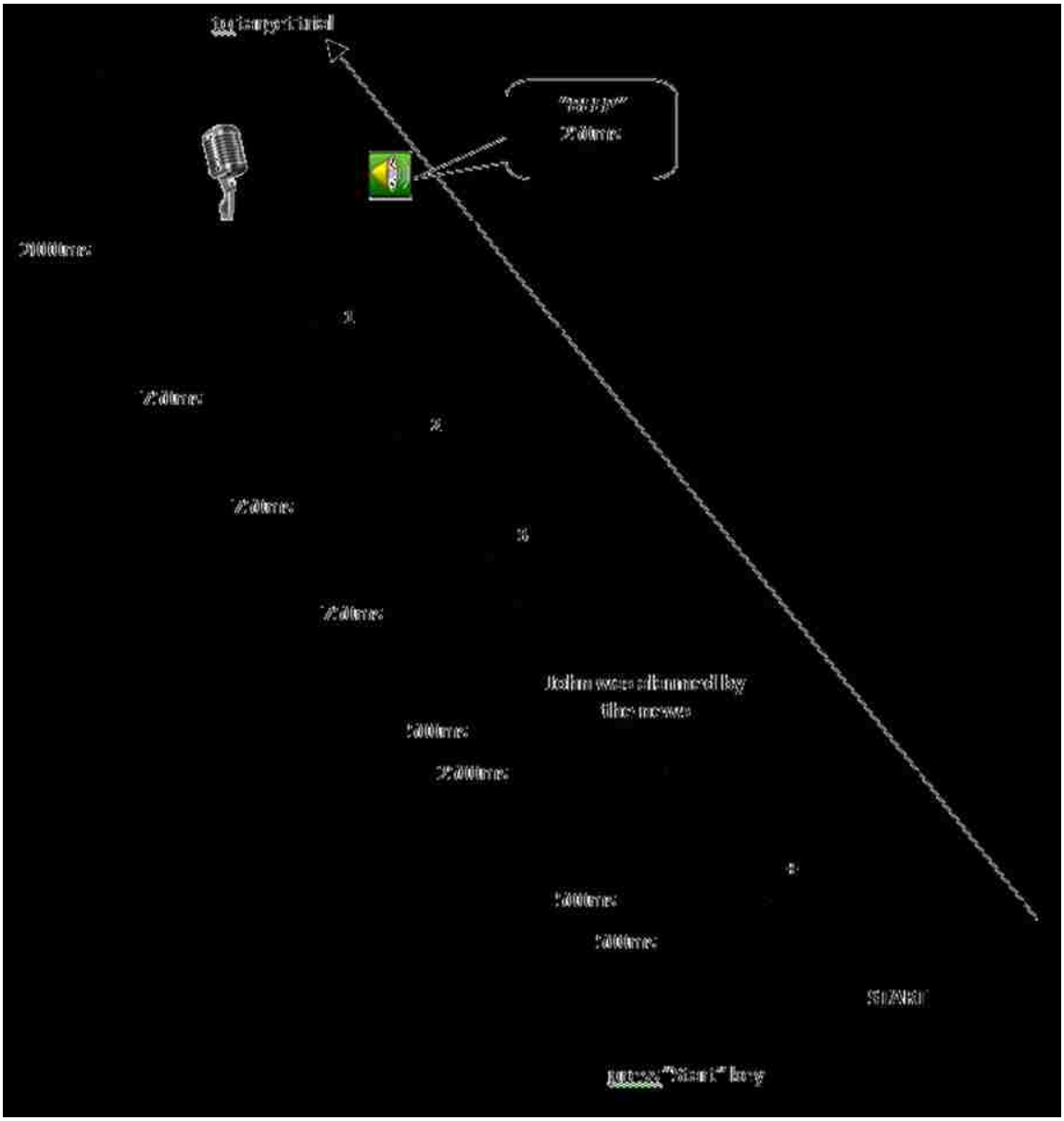

Figure 5. General experimental procedure used for prime trials in Experiments 3 & 4. Note that all prime trials were preconstructed.

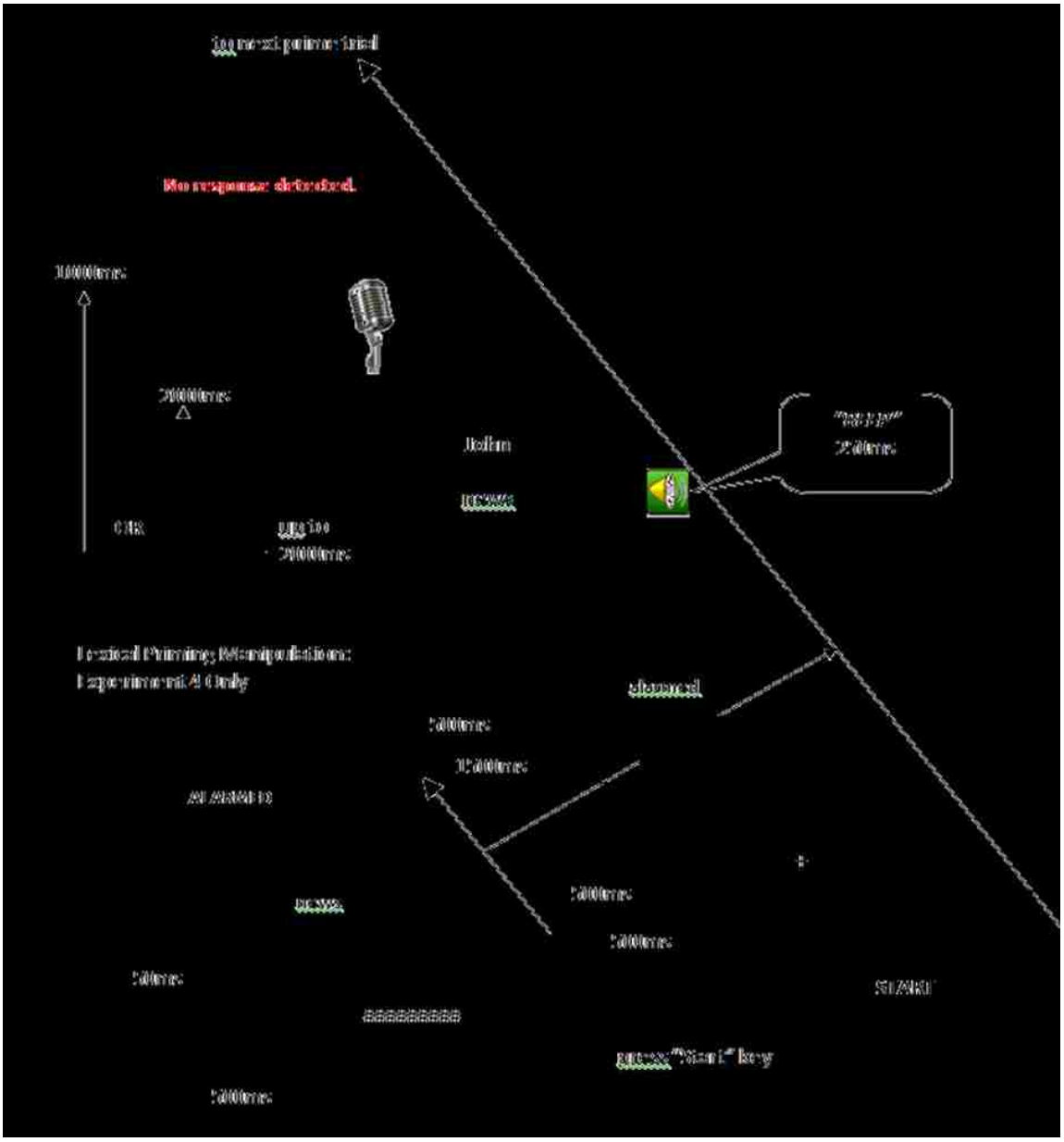

Figure 6. General experimental procedure used for target trials in Experiments 3 & 4. Note that Experiment 3 does not include the lexical priming manipulation, but did contain a mix of constrained and unconstrained targets. The critical verbs in Expeirment 4 were presented in all capital letters to improve their effectiveness as masks for the subliminal prime. Experiment 4 contained all unconstrained target trials.

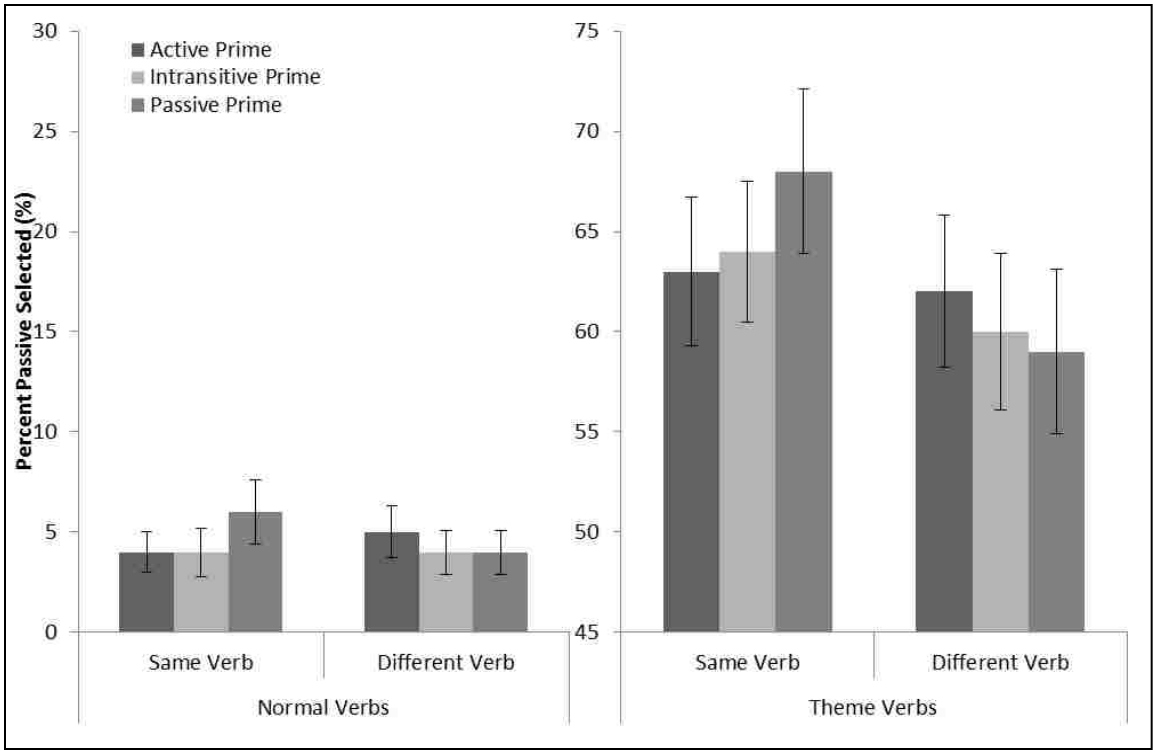

Figure 7. Mean percentage of target sentences produced as passives by target verb type, verb repetition, and prime structure for Experiment 1a.

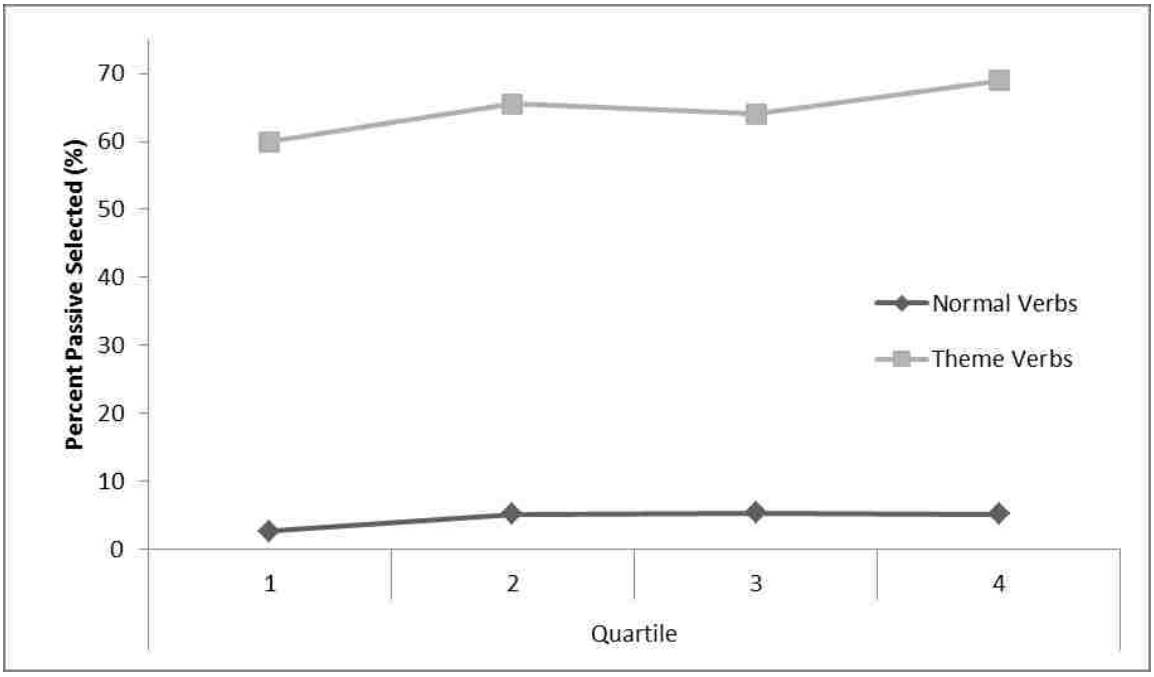

Figure 8. Mean percentage of target sentences produced as passives by target verb type and quartile in Experiment 1a. There is a slight overall increase in passive use over the course of the experiment.

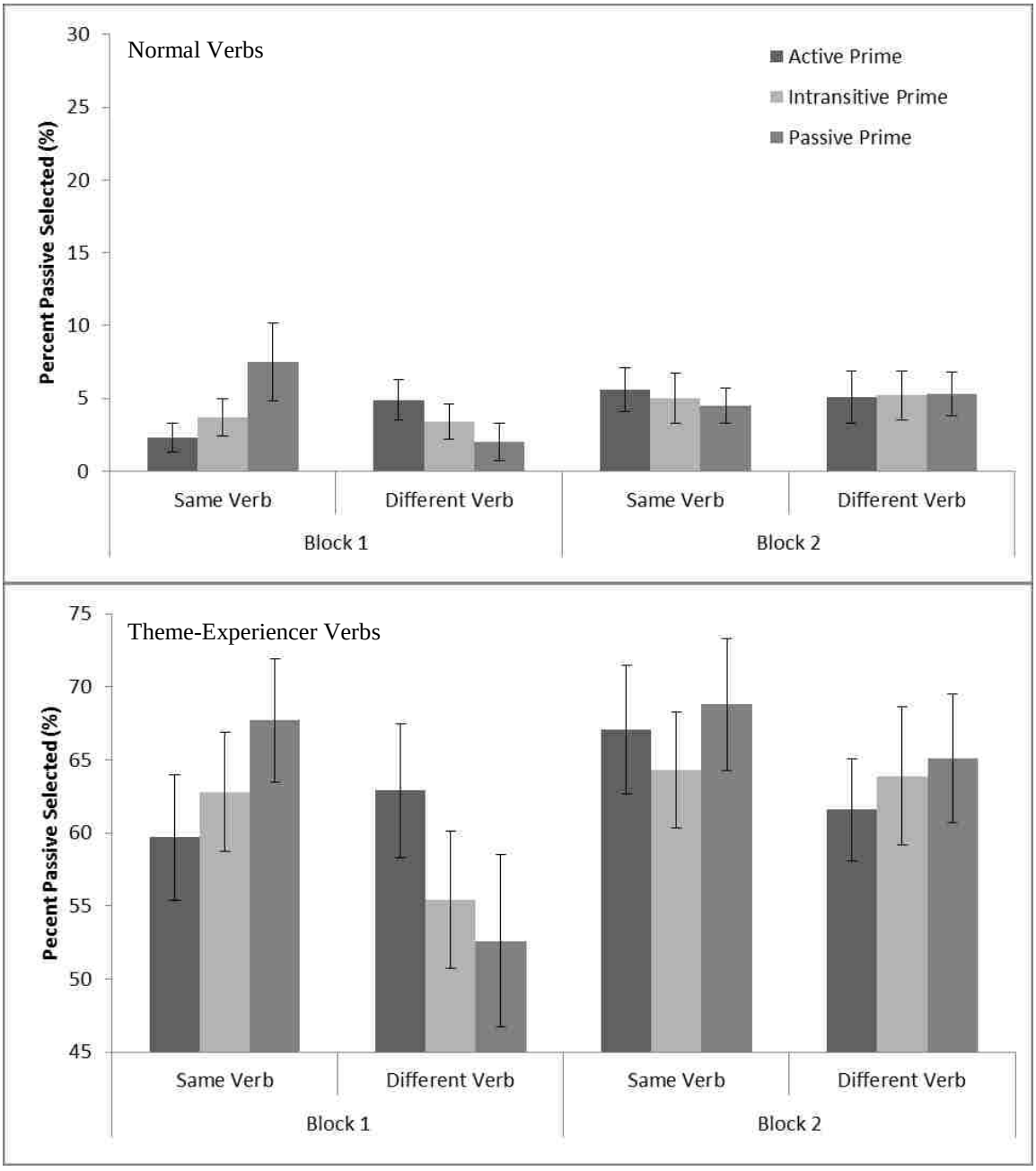

Figure 9. Mean percentage of target sentences produced as passives for normal verbs (top) and theme experiencer verbs (bottom) by block, verb repetition, and prime structure in Experiment 1a.

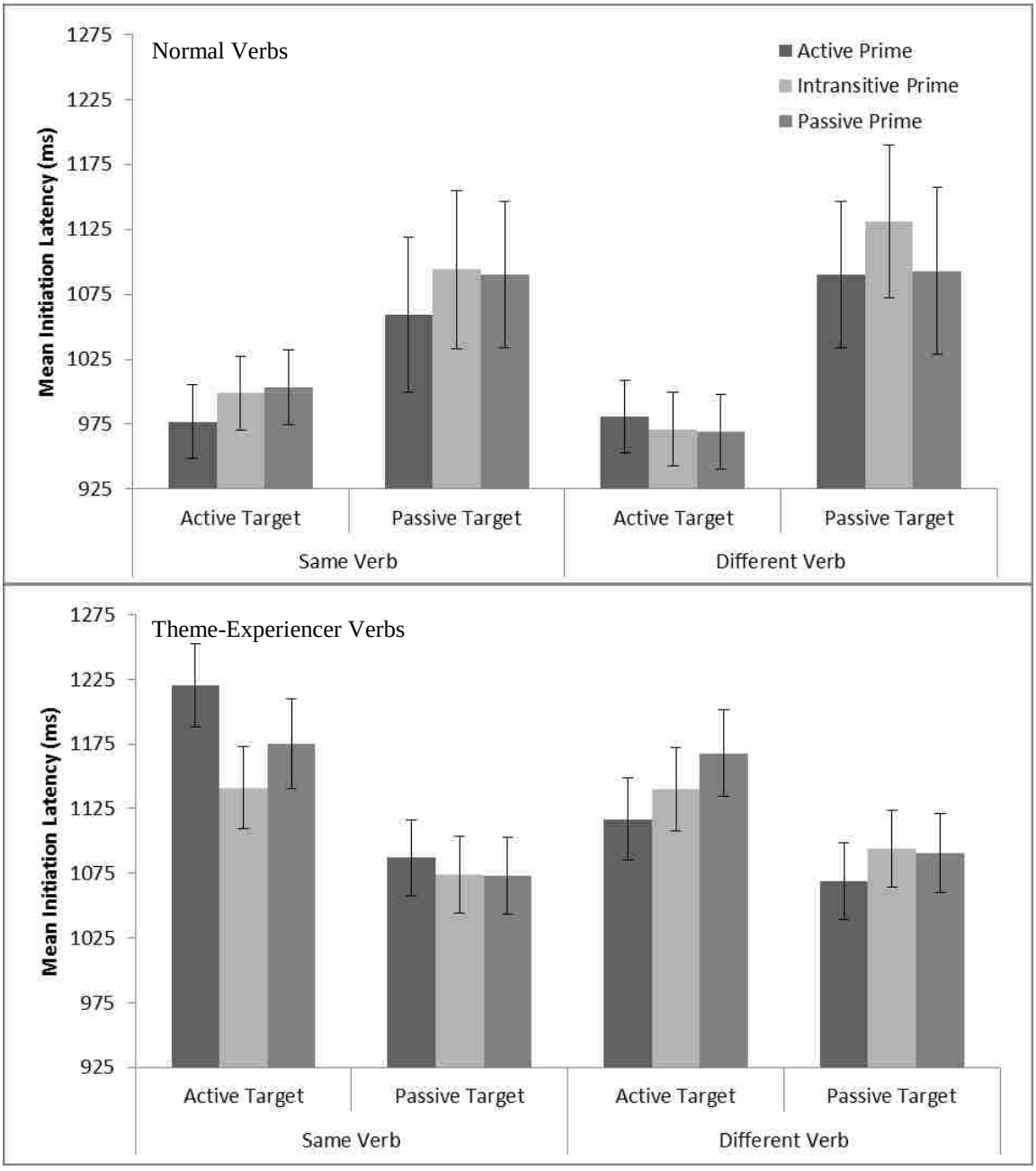

Figure 10. LMM estimated marginal mean initiation latency for normal verbs (top) and theme experiencer verbs (bottom) by verb repetition, prime structure, and target structure selected for Experiment 1a.

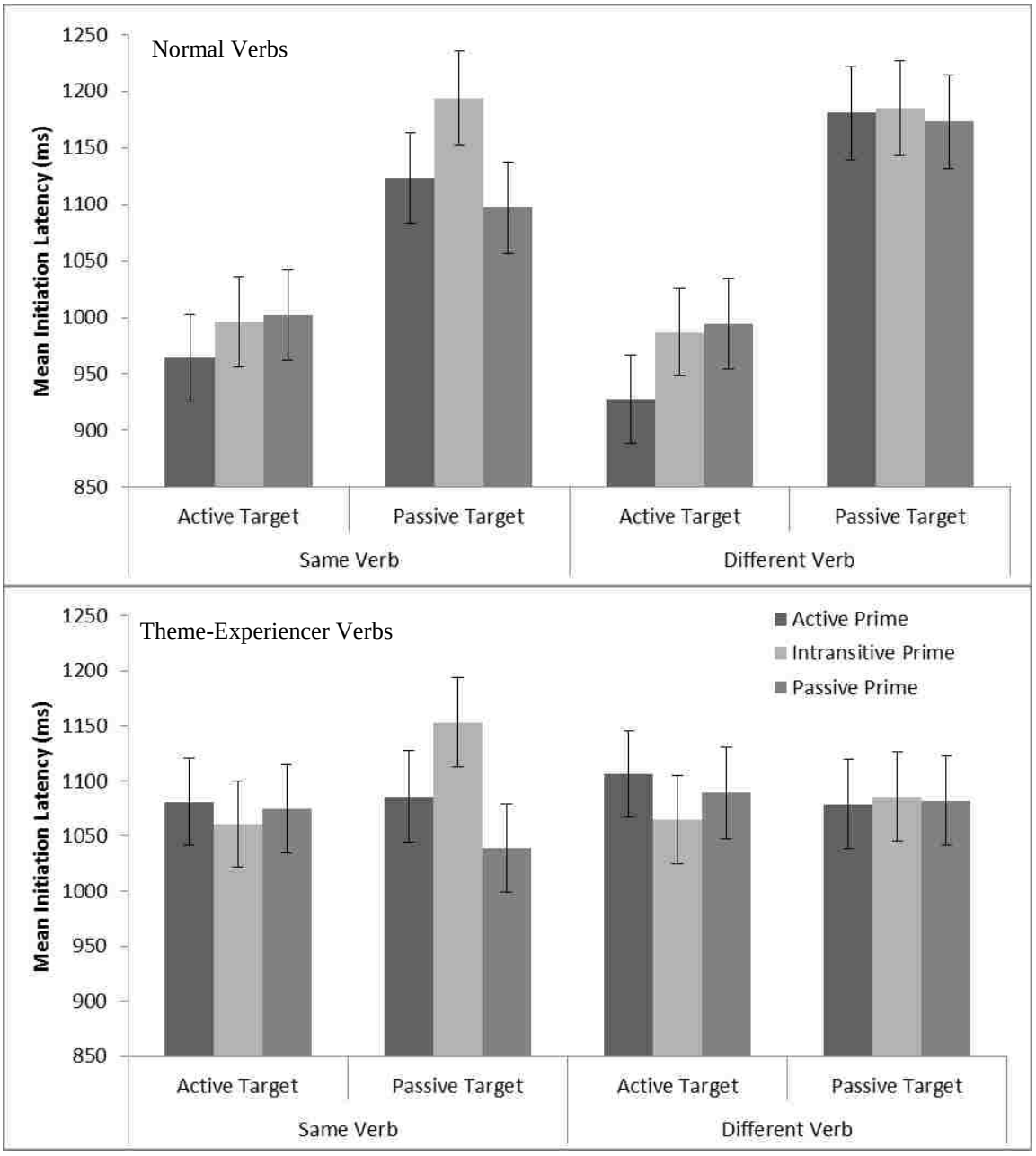

Figure 11. LMM estimated marginal mean initiation latency for normal verbs (top) and theme experiencer verbs (bottom) by verb repetition, prime structure, and target structure selected for Experiment 1b.

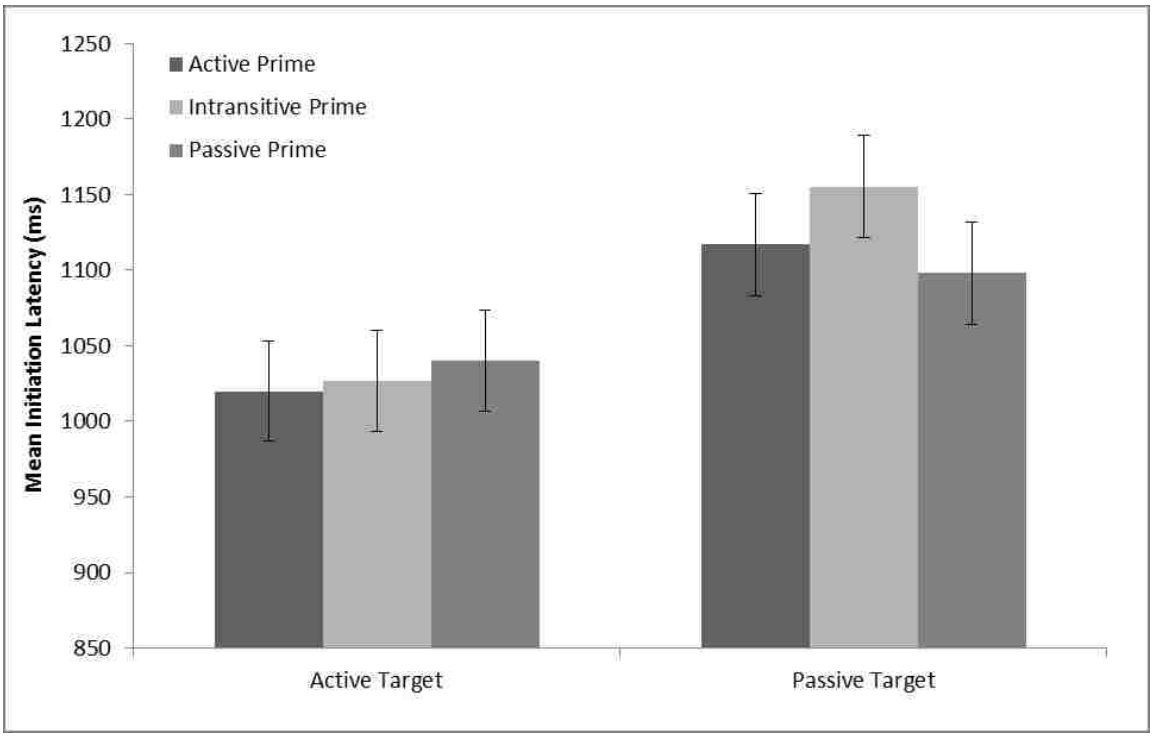

Figure 12. LMM estimated marginal mean latency for active and passive targets by prime structure for Experiment 1b.

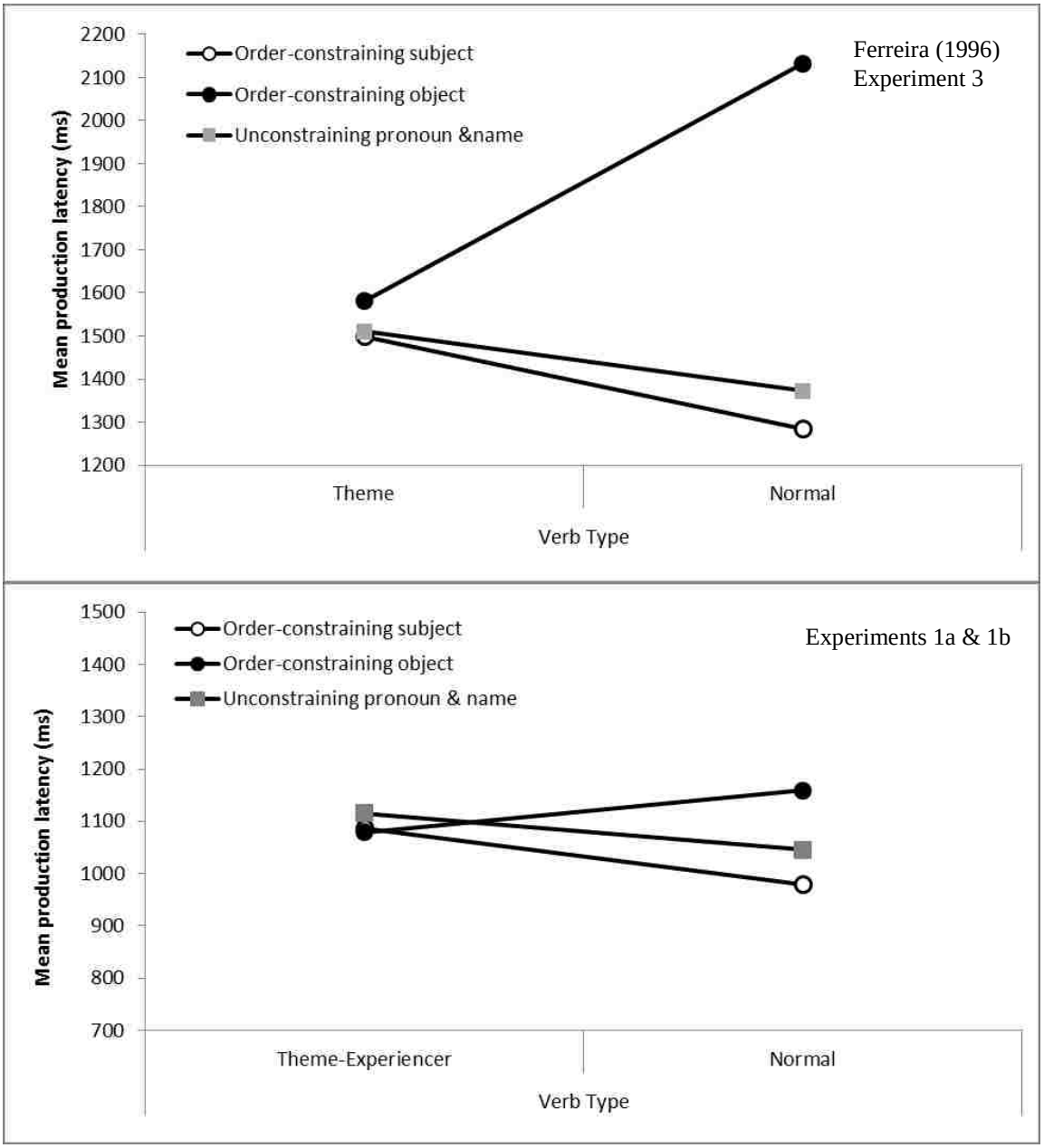

Figure 13. Latency data from Ferreira (1996) Experiment 3 resegregated from original data (approximation), collapsed across unconstraining pronoun and name (top) and corresponding LMM model estimates for Experiments 1a and 1b: mean production latency by verb and argument type. Data from Ferreira (1996) is an approximation because I do not have an exact record of the criteria used for data trimming in the original study. However, this estimate was derived from the complete original data set.

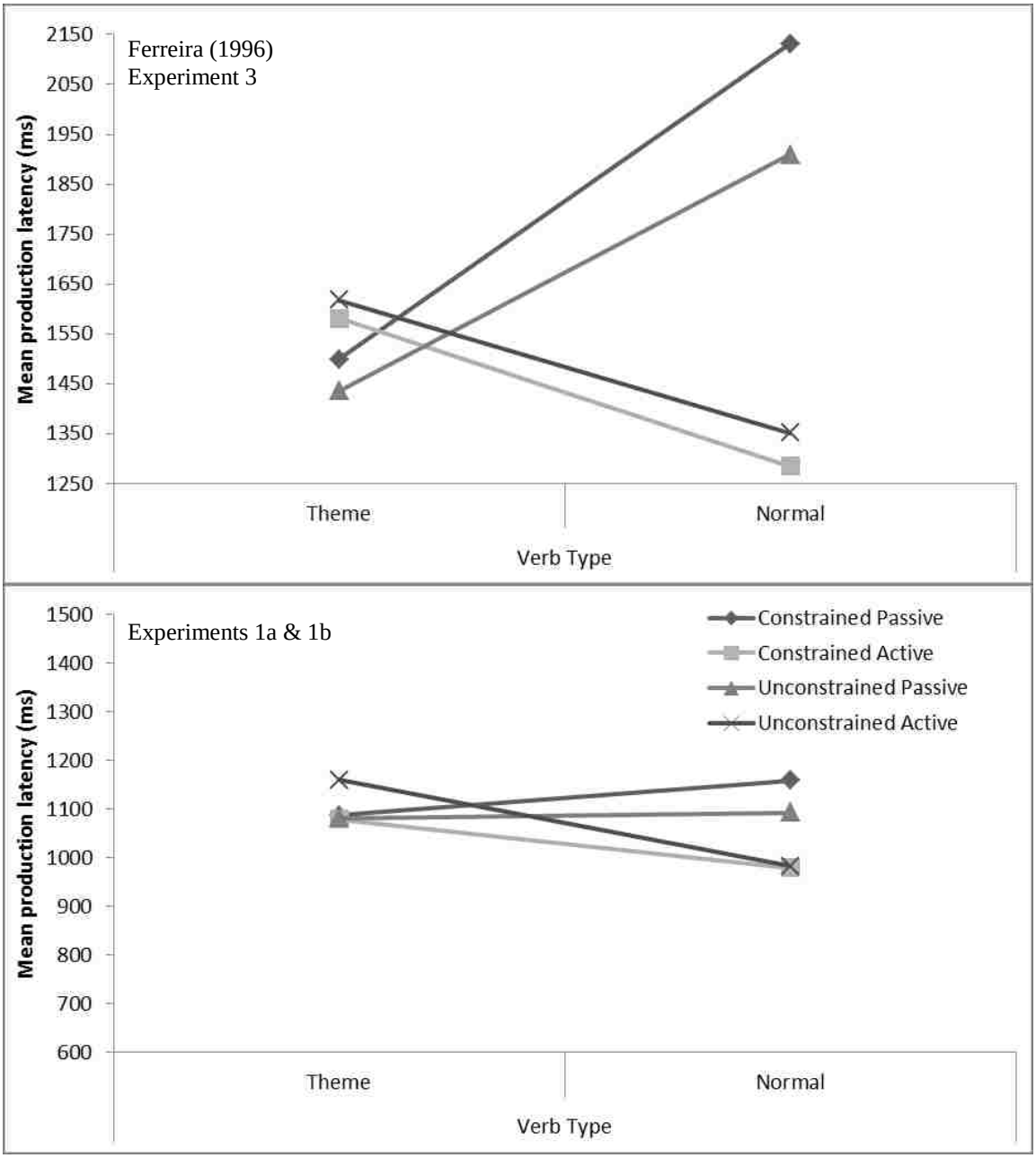

Figure 14. Latency data for Ferreira (1996) Experiment 3 (top) resegmented from original data (approximation), and LMM model estimates for corresponding data from Experiments 1a and 1b (bottom): mean production latency by constraint, verb type, and target structure. Data from Ferreira (1996) is an approximation because I do not have an exact record of the criteria used for data trimming in the original study. However, this estimate was derived from the complete original data set.

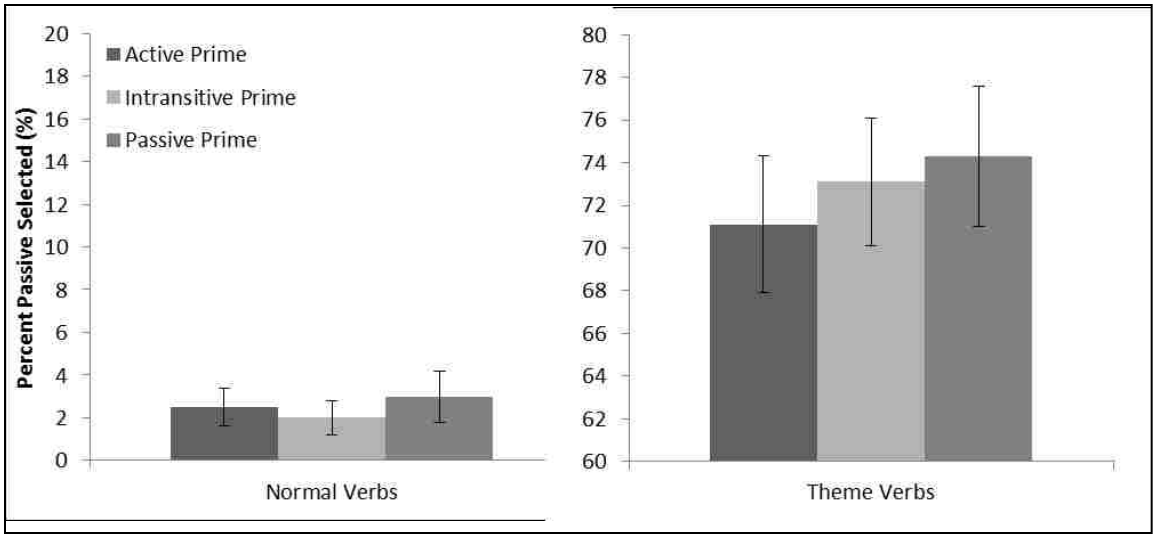

Figure 15. Percentage of passive structures selected in the unconstrained target productions by prime structure and target verb type for Experiment 2.

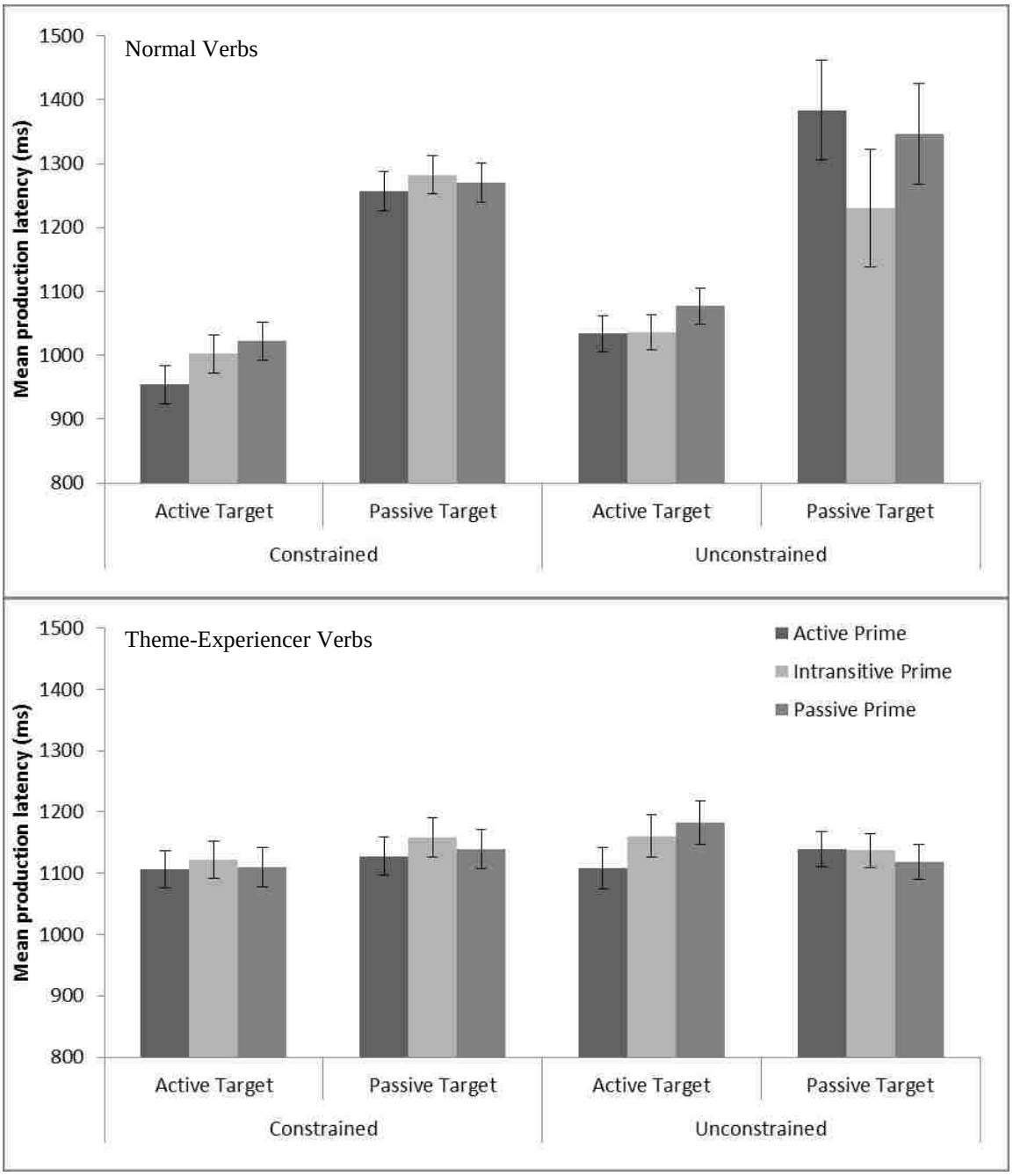

Figure 16. LMM estimated marginal mean latency for constraint, target structure/selected, and prime structure for normal (top panel) and theme-experiencer verbs (bottom panel) for Experiment 2.

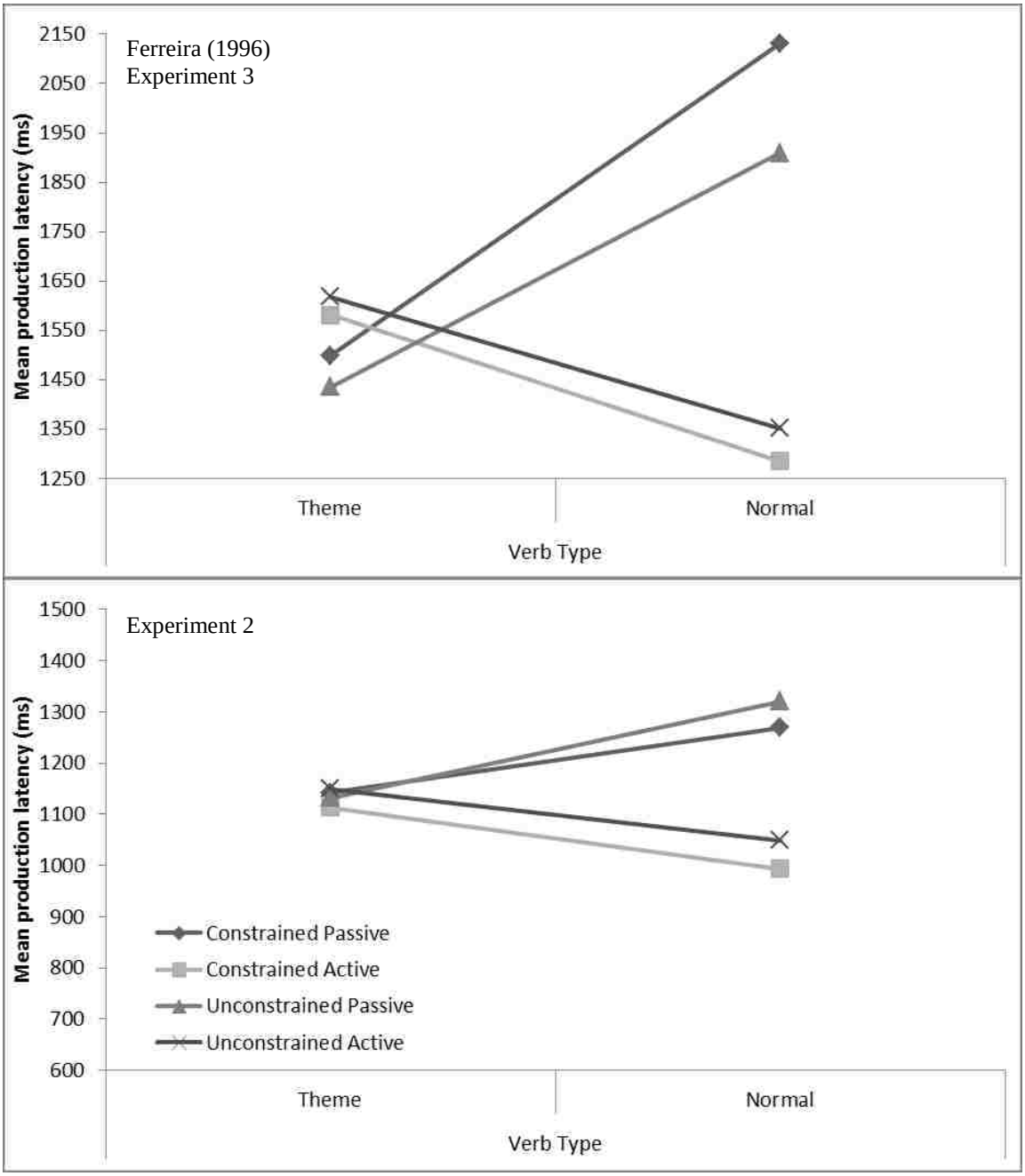

Figure 17. LMM estimated marginal mean latency for Experiment 2 by constraint, verb type and target structure (bottom panel). Data from Ferreira's (1996) Experiment 3 (top panel).

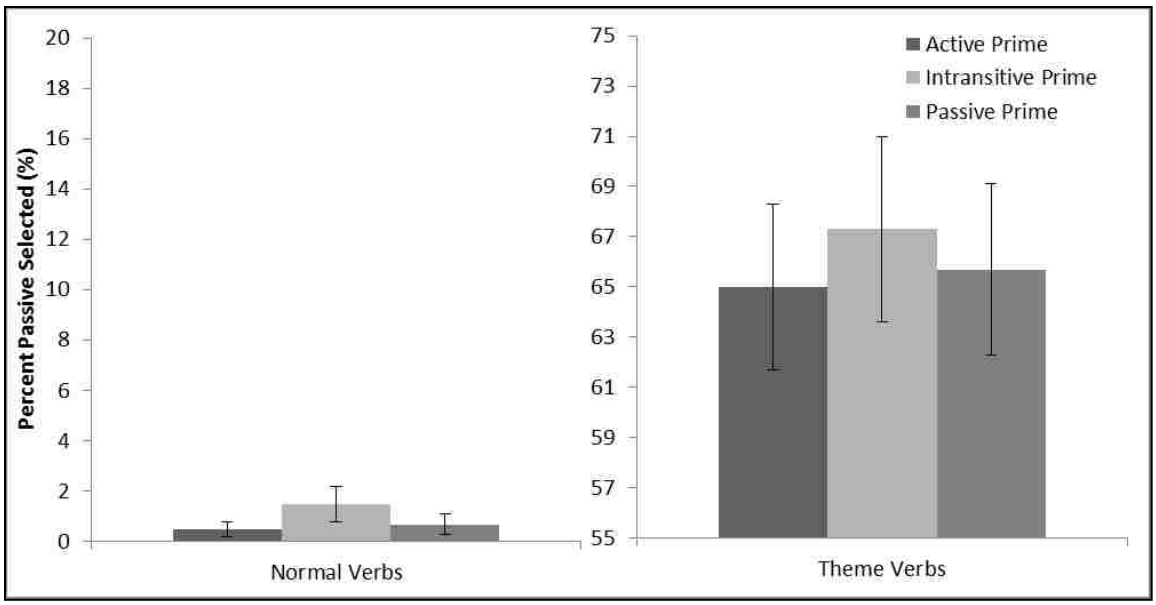

*Figure 18***.** Percentage of passive structures selected in the unconstrained target productions by prime structure and target verb type for Experiment 3 with SEs.

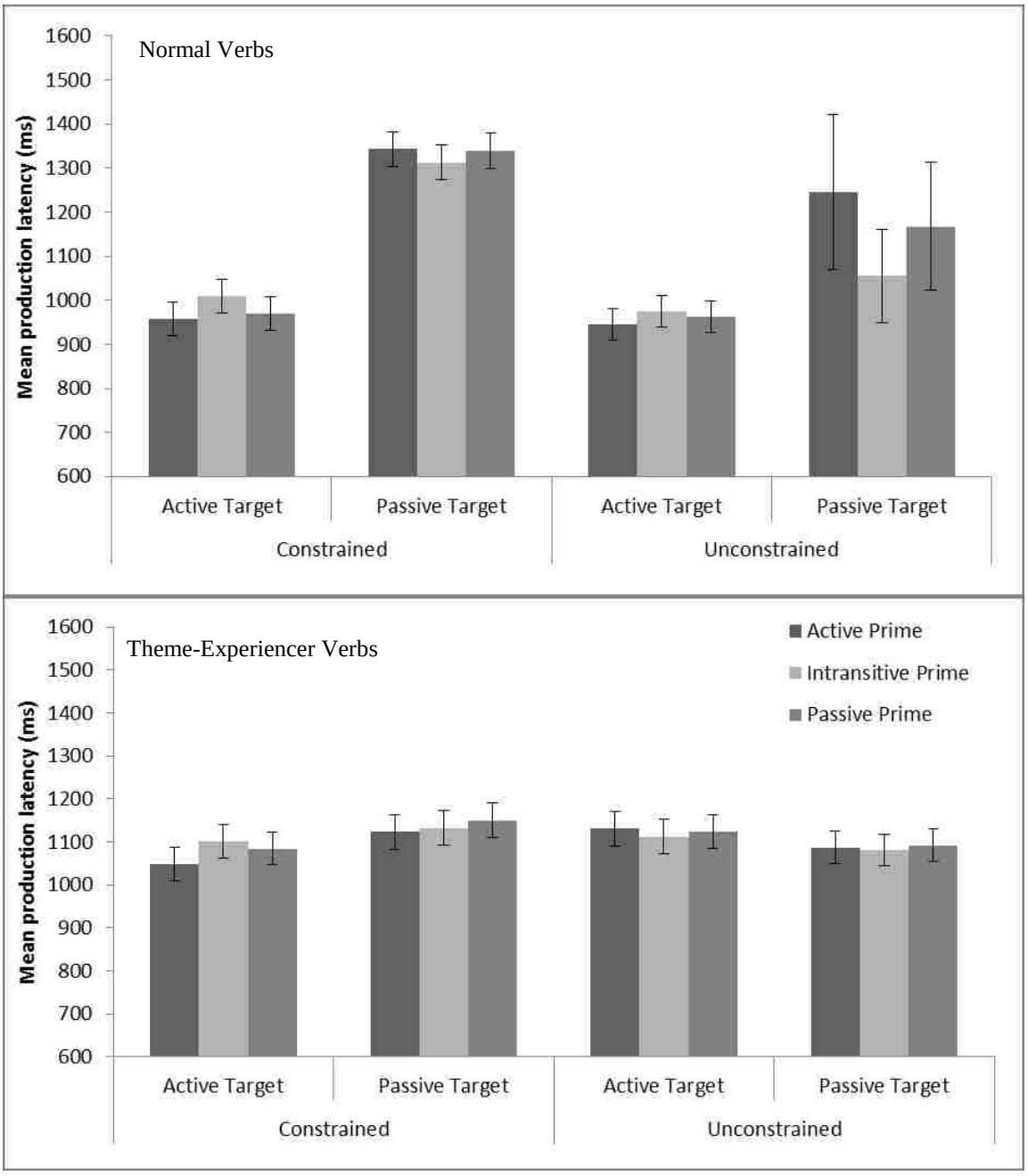

*Figure 19***.** LMM estimated marginal mean latency for constraint, target structure/selected, and prime structure for normal (top panel) and theme-experiencer verbs (bottom panel) for Experiment 3.

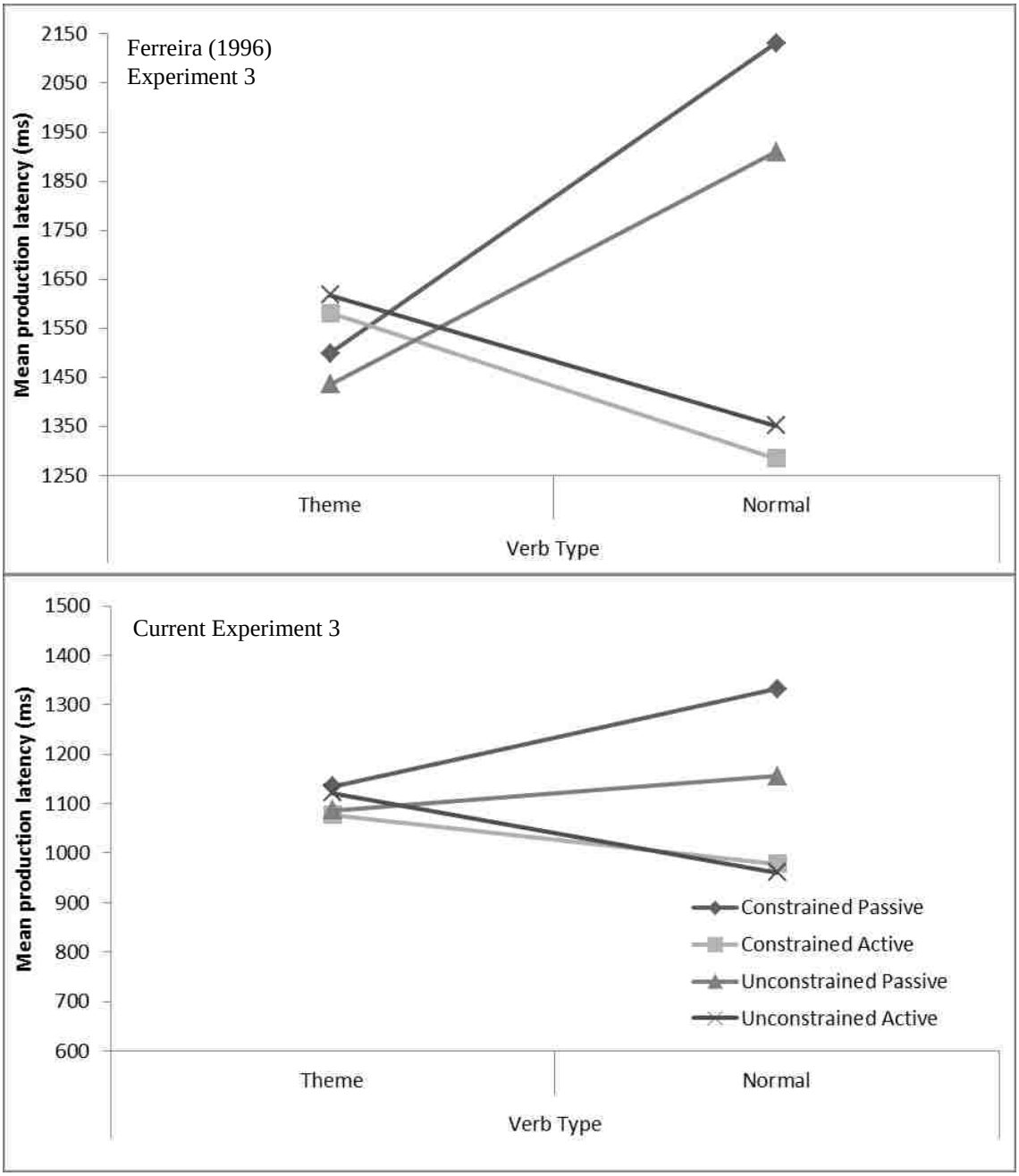

Figure 20. Latency data for Ferreira (1996) Experiment 3 re-segmented from original data (approximation – untrimmed) (top panel), and LMM model estimates for Experiment 3 (bottom panel): mean production latency by constraint, verb type, and target structure/selected.

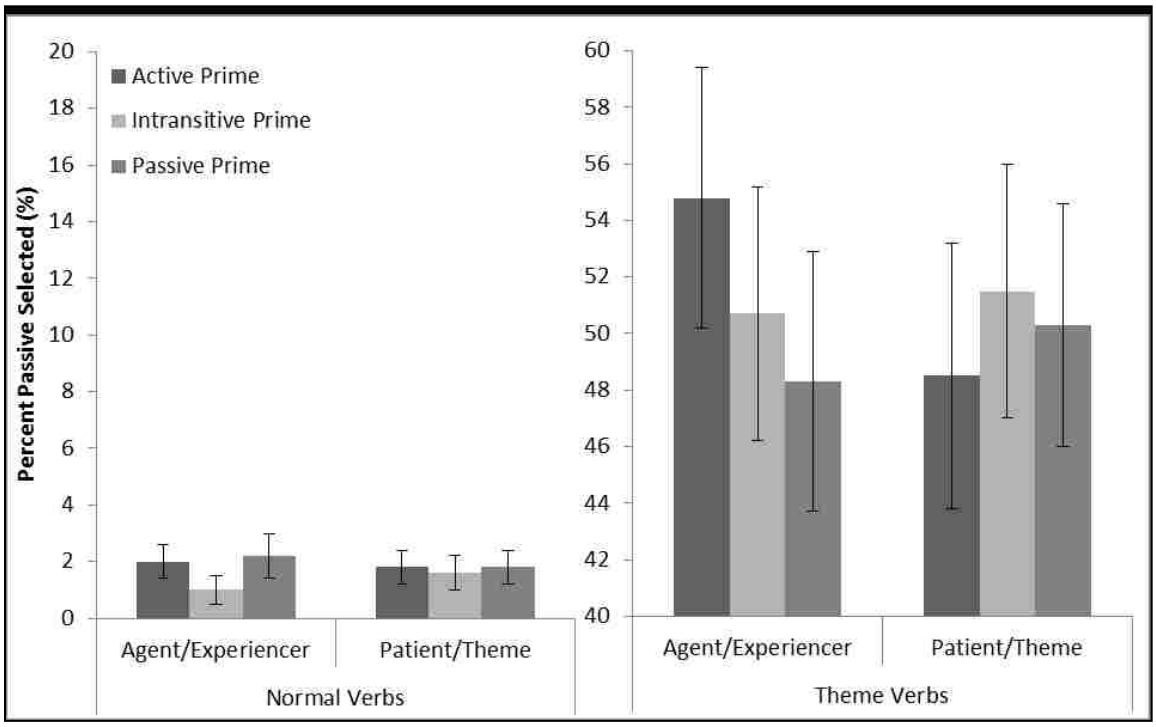

Figure 21. Percentage of passive structures selected in the unconstrained target productions by prime structure, lexical priming condition, and target verb type for Experiment 4.

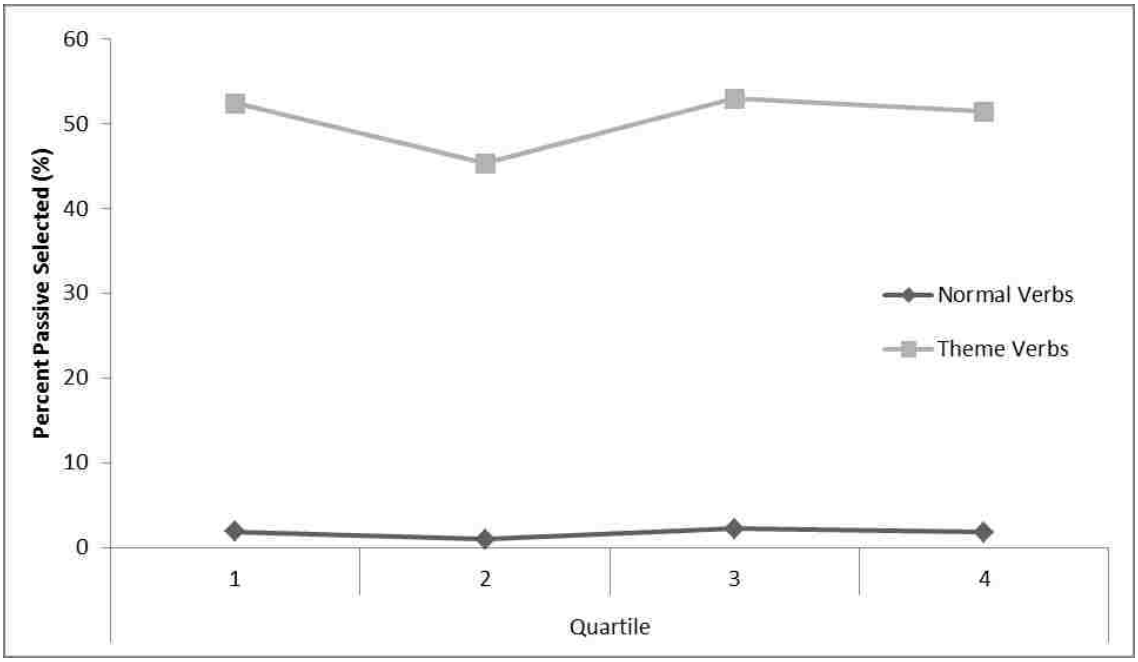

Figure 22. Percentage of passive structures selected in the target productions over quartiles for each verb type in Experiment 4.

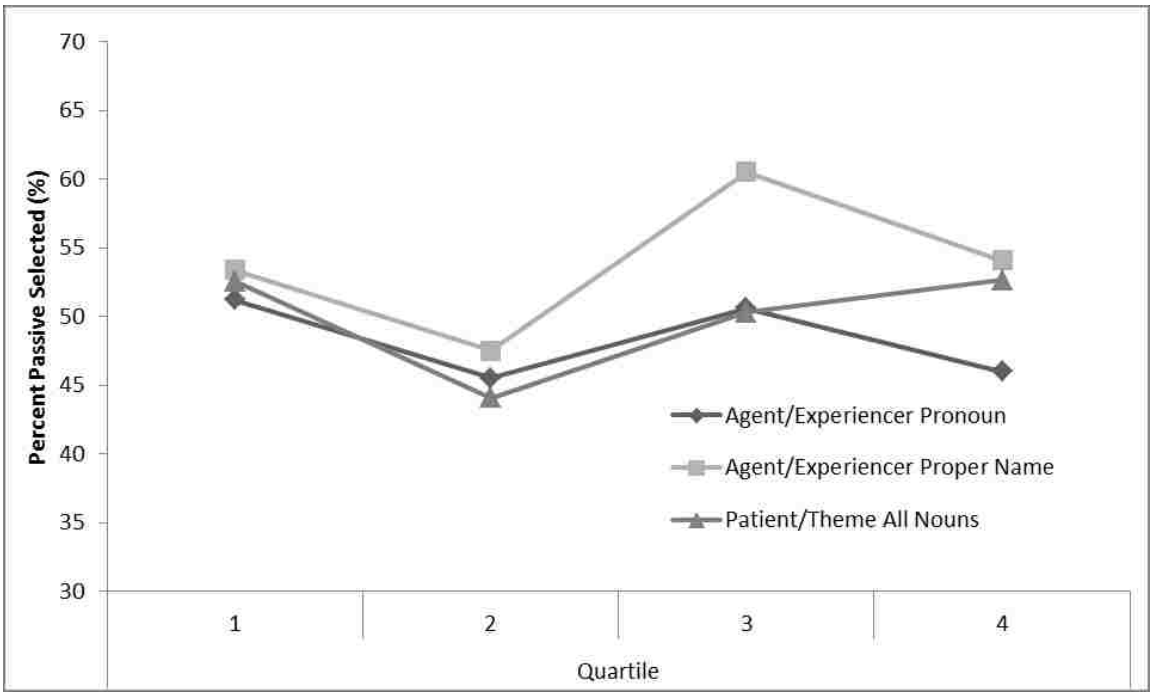

Figure 23. Percentage of passive structures productions by lexical prime type for theme verbs over quartiles in Experiment 4.

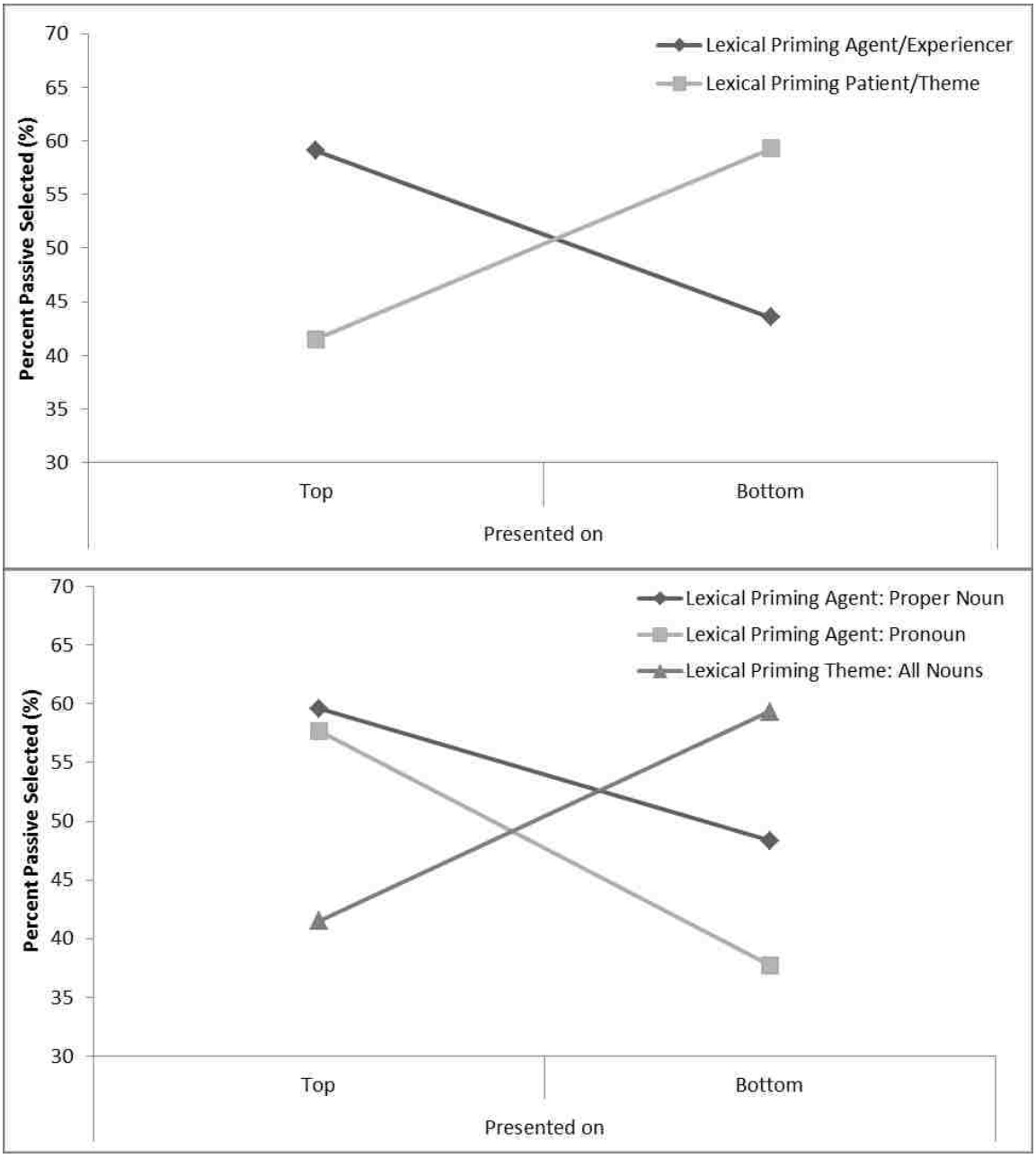

Figure 24. Percentage of passive structures selected for theme-experiencer verbs in the target productions by lexical prime type and screen position of primed item (top panel) and by agent priming type (pronoun, proper noun) (bottom panel) for Experiment 4.

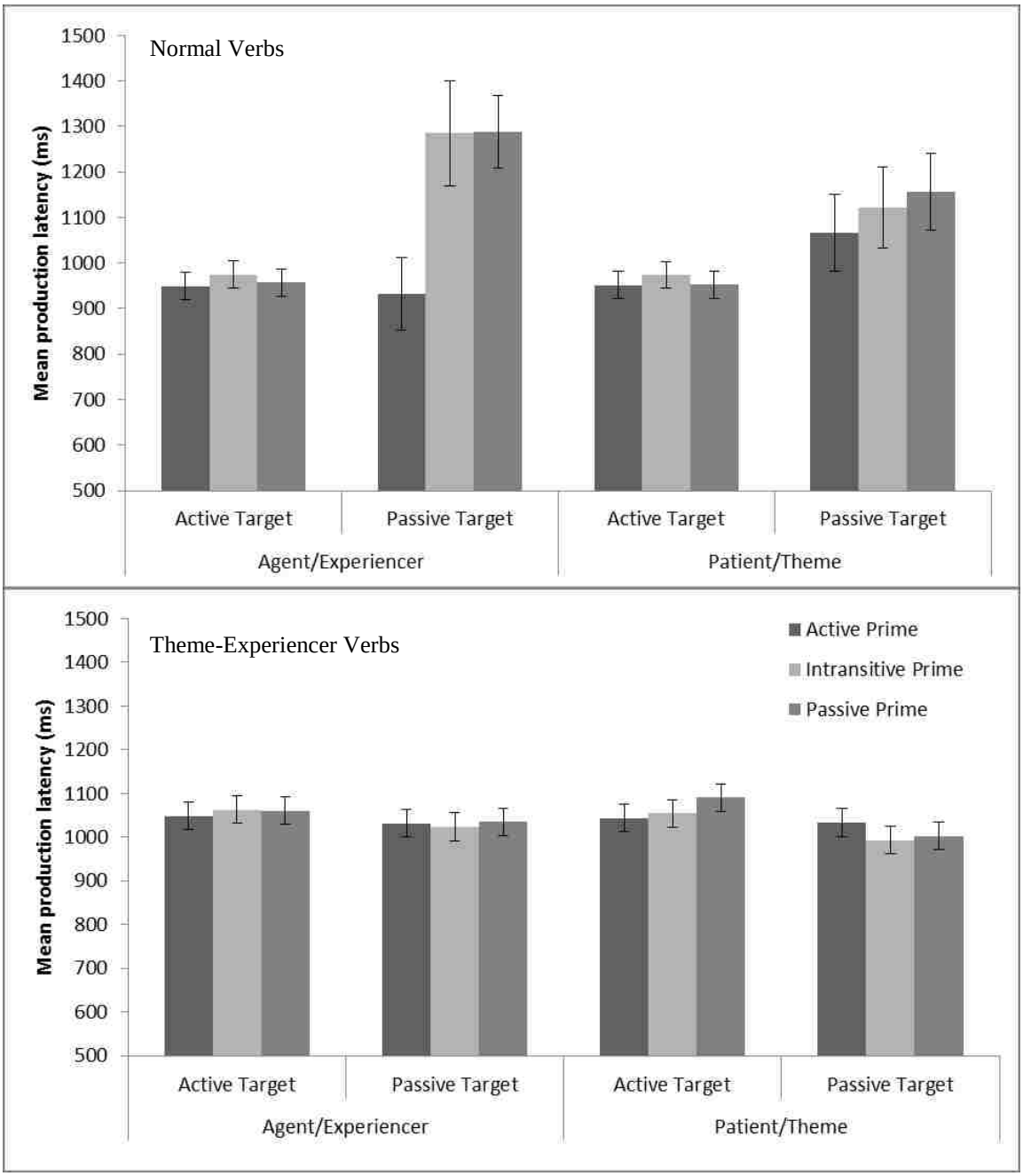

Figure 25. LMM estimated marginal means for target initiation latency by lexical priming condition, target structure selected, and prime structure for normal (top panel) and theme-experiencer verbs (bottom panel) for Experiment 4.

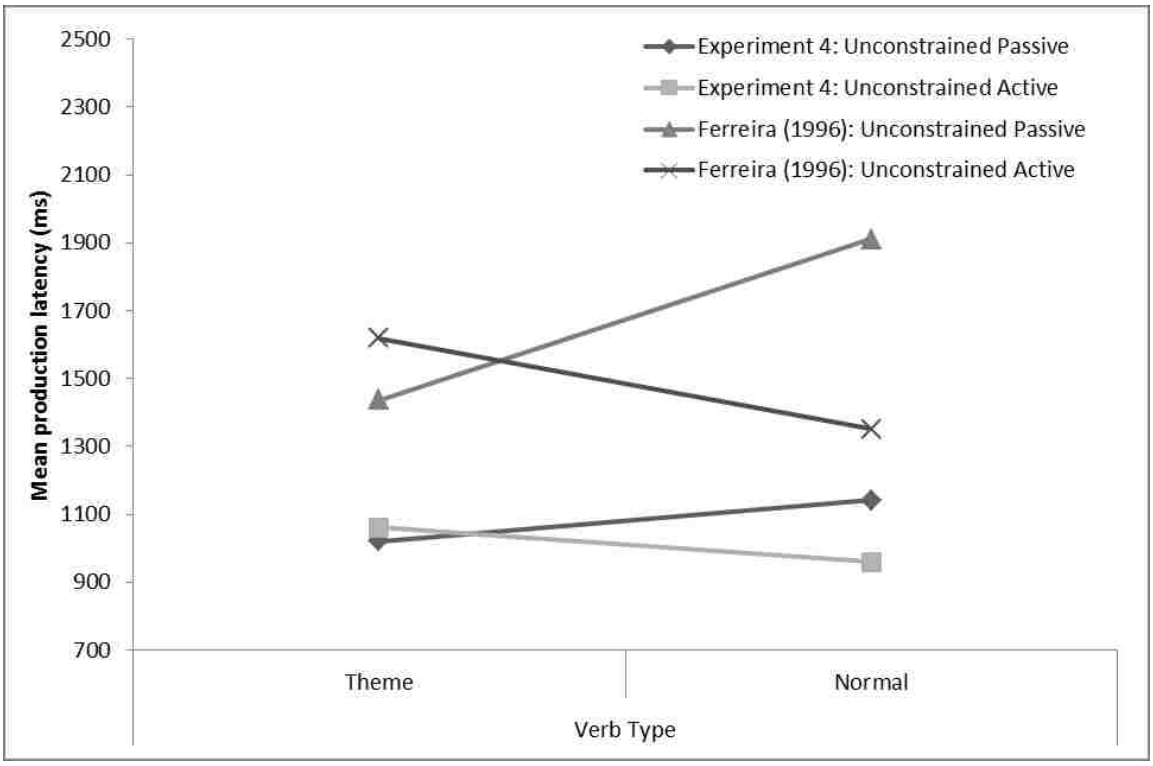

Figure 26. Mean initiation latency for Ferreira (1996) Experiment 3 estimated from original data (approximation) and data from Experiment 4 for all syntactically flexible conditions by verb type and target structure selected.

Table 1. Verb pairs and arguments from Ferreira (1996) Experiment 3. Changes for the current study are marked with a strikethrough and updated items are displayed. Item sets marked with an asterisk were used as practice in Experiments 1a, 1b, & 2.

#	Theme Experiencer Verb	Normal Verb	Theme 1	Theme 2
1	angered	protested	conflict	proposal
2	alarmed	suppressed	news	screams
3	aggravated	bellowed	insult	command
4	relaxed	requested	massage	~~cigarette~~ tea
5	confused	rejected	affair	story
6	soothed	enjoyed	lullaby	sunlight
7	tempted	decorated	sundae	invitation
8	troubled	examined	evidence	assignment
9	frightened	watched	lightning	bomb
*10	entertained	applauded	jokes	performance
11	irritated	recommended	hairstyle	manuscript
12	terrified	dreaded	thunder	earthquake
13	disturbed	prevented	theft	accident
14	haunted	scrutinized	image	movie
15	worried	ordered	layoffs	attacks
16	shocked	loathed	slayings	carnage
17	pleased	wrapped	gift	chocolates
18	alerted	sounded	sirens	horn
19	scared	explored	cave	forest
*20	distracted	ignored	television	conversation
21	guided	consulted	map	script
22	bored	~~xeroxed~~ copied	textbook	article
23	enticed	devoured	cheesecake	brownie
24	encouraged	appreciated	praise	comments
25	stunned	mourned	tragedy	death
26	impressed	ensured	profits	victory
27	demoralized	disregarded	defeat	setback
28	excited	misplaced	prize	treasure
29	appalled	detested	crime	ritual
*30	thrilled	feared	fireworks	adventure
31	annoyed	despised	delay	roadwork
32	amused	purchased	toy	~~Nintendo~~ game
33	enraged	noticed	profanity	graffiti
34	challenged	solved	puzzle	problem
35	captivated	criticized	mystery	artwork
36	disgraced	fabricated	scandal	editorial
37	intrigued	analyzed	~~phenomenon~~ event	illusion
38	embarrassed	avoided	blunder	mistake
39	disgusted	refused	anchovies	caviar
*40	offended	repeated	rumors	speech

Table 2. Theme Verbs: Percentage produced as passive by items in all unconstrained conditions

Theme Verbs	E1a	E2 Unconstrained trials	E3 Unconstrained trials	E4	Mean % Passive (SD)
impressed	0.86	0.94	0.95	0.69	0.86 (0.12)
embarrassed	0.79	0.92	0.90	0.74	0.84 (0.09)
stunned	0.88	0.96	0.92	0.56	0.83 (0.18)
shocked	0.87	0.91	0.81	0.71	0.83 (0.09)
disgusted	0.92	0.89	0.87	0.60	0.82 (0.15)
frightened	0.77	0.88	0.97	0.57	0.80 (0.17)
demoralized	0.83	0.93	0.79	0.50	0.76 (0.18)
pleased	0.68	0.93	0.85	0.56	0.76 (0.17)
excited	0.66	0.90	0.87	0.53	0.74 (0.17)
intrigued	0.53	0.97	0.86	0.58	0.73 (0.22)
worried	0.61	0.94	0.88	0.51	0.73 (0.21)
captivated	0.58	0.94	0.83	0.58	0.73 (0.18)
troubled	0.88	0.71	0.84	0.49	0.73 (0.17)
confused	0.47	0.94	0.92	0.56	0.72 (0.25)
appalled	0.55	0.79	0.90	0.62	0.71 (0.16)
tempted	0.48	0.97	0.84	0.50	0.70 (0.24)
disgraced	0.63	0.80	0.67	0.56	0.66 (0.10)
scared	0.46	0.83	0.78	0.58	0.66 (0.18)
terrified	0.63	0.80	0.56	0.55	0.63 (0.12)
soothed	0.49	0.85	0.70	0.44	0.62 (0.19)
annoyed	0.78	0.72	0.41	0.49	0.60 (0.18)
alerted	0.44	0.69	0.81	0.42	0.59 (0.20)
disturbed	0.80	0.61	0.54	0.39	0.59 (0.17)
enraged	0.56	0.67	0.53	0.53	0.57 (0.07)
guided	0.63	0.54	0.62	0.42	0.55 (0.10)
angered	0.82	0.50	0.34	0.47	0.53 (0.20)
enticed	0.75	0.41	0.48	0.49	0.53 (0.15)
amused	0.76	0.47	0.46	0.43	0.53 (0.15)
aggravated	0.68	0.60	0.35	0.44	0.52 (0.15)
irritated	0.60	0.52	0.49	0.43	0.51 (0.07)
alarmed	0.76	0.43	0.26	0.52	0.49 (0.21)
haunted	0.68	0.66	0.32	0.28	0.48 (0.21)
bored	0.49	0.55	0.33	0.39	0.44 (0.10)
challenged	0.47	0.35	0.44	0.45	0.43 (0.05)
encouraged	0.31	0.36	0.40	0.30	0.34 (0.05)
relaxed	0.17	0.48	0.44	0.22	0.33 (0.16)
MEAN	0.65	0.73	0.67	0.50	0.64 (0.14)

Table 3. Normal Verbs: Percentage produced as passive by items in unconstrained conditions

Normal Verbs	E1a	E2 Unconstrained trials	E3 Unconstrained trials	E4	Mean %Passive (SD)
ensured	0.25	0.03	0.03	0.11	0.11 (0.10)
scrutinized	0.14	0.07	0.00	0.04	0.06 (0.06)
purchased	0.14	0.03	0.03	0.00	0.05 (0.06)
appreciated	0.08	0.07	0.05	0.00	0.05 (0.03)
recommended	0.02	0.10	0.03	0.03	0.04 (0.04)
sounded	0.02	0.11	0.00	0.05	0.04 (0.05)
wrapped	0.13	0.03	0.00	0.00	0.04 (0.06)
prevented	0.08	0.03	0.03	0.01	0.04 (0.03)
decorated	0.07	0.04	0.00	0.04	0.04 (0.03)
ordered	0.09	0.06	0.00	0.00	0.04 (0.04)
suppressed	0.07	0.03	0.00	0.02	0.03 (0.03)
copied	0.00	0.04	0.06	0.01	0.03 (0.03)
criticized	0.00	0.00	0.06	0.04	0.03 (0.03)
mourned	0.07	0.00	0.00	0.03	0.03 (0.03)
devoured	0.09	0.00	0.00	0.00	0.02 (0.05)
consulted	0.02	0.08	0.00	0.00	0.02 (0.04)
protested	0.03	0.03	0.03	0.00	0.02 (0.02)
disregarded	0.09	0.00	0.00	0.00	0.02 (0.04)
solved	0.00	0.03	0.00	0.05	0.02 (0.03)
dreaded	0.00	0.06	0.00	0.01	0.02 (0.03)
misplaced	0.01	0.00	0.00	0.05	0.02 (0.03)
despised	0.05	0.00	0.00	0.01	0.02 (0.02)
avoided	0.03	0.00	0.00	0.03	0.02 (0.02)
loathed	0.03	0.00	0.00	0.03	0.02 (0.02)
requested	0.03	0.03	0.00	0.00	0.02 (0.02)
fabricated	0.03	0.00	0.00	0.03	0.01 (0.02)
examined	0.05	0.00	0.00	0.00	0.01 (0.03)
noticed	0.01	0.03	0.00	0.00	0.01 (0.02)
detested	0.03	0.00	0.00	0.01	0.01 (0.01)
rejected	0.01	0.00	0.00	0.03	0.01 (0.01)
explored	0.03	0.00	0.00	0.00	0.01 (0.02)
refused	0.03	0.00	0.00	0.00	0.01 (0.01)
analyzed	0.00	0.00	0.00	0.00	0.00 (0.00)
bellowed	0.00	0.00	0.00	0.00	0.00 (0.00)
enjoyed	0.00	0.00	0.00	0.00	0.00 (0.00)
watched	0.00	0.00	0.00	0.00	0.00 (0.00)
MEAN	0.05	0.03	0.01	0.02	0.03 (0.02)

Table 4. Experiment 1a Unconstrained: LMM Estimated Marginal Mean latency (ms), standard error (ms), and percentage of each structure selected (by subjects) for each Target Structure by condition.

	Verb Repetition	**Same Verb**				**Different Verb**				
Verb Type	*Prime Structure*	**Active**	**Intransitive**	**Passive**	Total	**Active**	**Intransitive**	**Passive**	Total	TOTAL
Theme Experiencer	**Active**									
	M	1220	1141	1175	1179	1117	1140	1168	1142	1160
	SE	(32.30)	(31.78)	(34.44)	(28.60)	(31.79)	(31.85)	(33.64)	(28.43)	(27.42)
	% selected	.363	.365	.322	.350	.378	.387	.365	.377	.363
	Passive									
	M	1087	1074	1073	1078	1069	1094	1091	1084	1081
	SE	(29.50)	(29.32)	(29.50)	(27.23)	(29.53)	(29.63)	(30.44)	(27.40)	(26.73)
	% selected	.637	.635	.678	.650	.622	.613	.635	.623	.637
	Total									
	M	1152	1106	1122	1128	1092	1115	1126	1113	1119
	SE	(27.84)	(27.63)	(28.48)	(26.66)	(27.70)	(27.74)	(28.49)	(26.66)	(25.75)
Normal	**Active**									
	M	977	999	1003	993	981	971	969	974	983
	SE	(28.15)	(28.37)	(278.86)	(26.82)	(28.14)	(28.14)	(28.89)	(26.79)	(26.41)
	% selected	.960	.954	.943	.952	.951	.958	.960	.956	.954
	Passive									
	M	1059	1094	1090	1081	1090	1131	1093	1104	1093
	SE	(59.58)	(61.08)	(56.19)	(40.58)	(56.52)	(58.70)	(64.03)	(41.12)	(34.71)
	% selected	.040	.046	.057	.048	.049	.042	.040	.044	.046
	Total									
	M	1024	1158	1054	1037	1040	1054	1040	1039	1045
	SE	(37.19)	(37.82)	(35.99)	(30.24)	(35.94)	(36.79)	(39.14)	(30.41)	(27.75)
TOTAL	Mean									
	M	1088	1082	1088	1086	1066	1085	1083	1078	1082
	SE	(28.66)	(28.81)	(28.31)	(25.98)	(28.22)	(28.51)	(29.47)	(26.03)	(25.30)
	--									

Table 5. Experiment 1b Constrained: LMM Estimated Marginal Mean latency (ms) and standard error (ms) for each Target Structure by condition.

	Verb Repetition	**Same Verb**				**Different Verb**				
Verb Type	*Prime Structure*	**Active**	**Intransitive**	**Passive**	Total	**Active**	**Intransitive**	**Passive**	Total	TOTAL
Theme Experiencer	**Active**									
	M	1081	1061	1075	1072	1106	1065	1089	1086	1079
	SE	(39.57)	(38.91)	(40.01)	(34.24)	(39.12)	(39.79)	(41.05)	(34.43)	(32.85)
	--									
	Passive									
	M	1086	1153	1039	1092	1079	1086	1082	1082	1087
	SE	(41.16)	(40.59)	(39.96)	(34.67)	(40.83)	(40.20)	(40.72)	(34.67)	(33.03)
	--									
	Total									
	M	1083	1107	1057	1082	1093	1076	1085	1084	1083
	SE	(35.84)	(35.50)	(35.63)	(32.62)	(35.62)	(35.63)	(36.13)	(32.67)	(31.86)
Normal	**Active**									
	M	964	996	1002	987	928	987	994	970	979
	SE	(38.60)	(39.69)	(40.01)	(34.22)	(38.91)	(38.99)	(39.72)	(34.13)	(32.76)
	--									
	Passive									
	M	1123	1194	1097	1138	1181	1185	1173	1180	1159
	SE	(40.01)	(41.43)	(40.53)	(34.73)	(41.40)	(41.93)	(41.56)	(35.10)	(33.17)
	--									
	Total									
	M	1044	1095	1049	1063	1054	1086	1084	1075	1069
	SE	(35.26)	(35.96)	(35.79)	(32.63)	(35.73)	(35.92)	(36.01)	(32.71)	(31.87)
TOTAL	Mean									
	M	1063	1101	1053	1072	1073	1081	1085	1080	1076
	SE	(33.31)	(33.41)	(33.39)	(31.77)	(33.37)	(33.43)	(33.59)	(31.81)	(31.38)
	--									

Table 6. Experiment 2: LMM estimated marginal mean latency (ms), standard error (ms), and percentage selected in each target structure (for unconstrained) for each target structure by condition.

	Constraint	**Constrained**					**Unconstrained**				
Verb Type	*Prime Structure*	**Active**	**Intransitive**	**Passive**	Total		**Active**	**Intransitive**	**Passive**	Total	TOTAL
Theme Experiencer	**Active**					**Active**					
	M	1106	1122	1110	1113	*M*	1108	1161	1182	1150	1131
	SE	(30.30)	(30.52)	(31.54)	(27.20)	*SE*	(33.72)	(33.92)	(35.66)	(28.76)	(25.35)
						%selected	.289	.269	.257	.271	--
	Passive					**Passive**					
	M	1128	1158	1139	1142	*M*	1139	1137	1119	1132	1137
	SE	(31.52)	(31.67)	(32.34)	(27.51)	*SE*	(28.62)	(28.36)	(28.57)	(26.21)	(24.82)
						%selected	.711	.731	.743	.729	--
	Total					Total					
	M	1117	1140	1125	1127	*M*	1123	1148	1150	1141	1134
	SE	(27.85)	(27.99)	(28.40)	(25.93)	*SE*	(27.91)	(27.91)	(28.45)	(25.86)	(24.07)
Normal	**Active**					**Active**					
	M	954	1002	1022	993	*M*	1034	1036	1077	1049	1021
	SE	(29.60)	(26.65)	(29.76)	(26.57)	*SE*	(28.00)	(27.95)	(28.31)	(26.23)	(24.51)
						%selected	.975	.980	.970	.975	--
	Passive					**Passive**					
	M	1257	1282	1270	1269	*M*	1384	1231	1346	1320	1295
	SE	(30.80)	(29.97)	(30.36)	(26.89)	*SE*	(78.58)	(92.12)	(78.85)	(52.68)	(33.67)
						%selected	.025	.020	.030	.025	--
	Total					Total					
	M	1106	1142	1146	1131	*M*	1209	1134	1212	1185	1158
	SE	(27.36)	(27.14)	(27.32)	(25.50)	*SE*	(45.09)	(51.07)	(45.19)	(34.02)	(26.43)
TOTAL	*M*	1111	1141	1135	1129	*M*	1166	1141	1181	1163	1146
	SE	(24.52)	(24.48)	(24.66)	(23.46)	*SE*	(30.37)	(32.66)	(30.59)	(26.03)	(23.57)

Table 7. Prime sentences used for active and passive primes containing theme-experiencer verbs in Experiments 3 & 4. These sentences are comprised of the same items as in Experiments 1a, 1b, & 2, but now were not limited to he/him to constrain form, which increased variability among items.

Pair #	Theme Verb	Prime Sentence Example (Active form// some examples of Passive form – using argument one)
1	angered	The conflict angered Pat// Pat was angered by the conflict
2	alarmed	The news alarmed the reporter//The reporter was alarmed by the news
3	aggravated	The insult aggravated Chris//Chris was aggravated by the insult
4	relaxed	The massage relaxed Gordon//Gordon was relaxed by the massage
5	confused	The affair confused her//She was confused by the affair
6	soothed	The lullaby soothed her
7	tempted	The sundae tempted Jessica
8	troubled	The officer was troubled by the evidence
9	frightened	The lightning frightened the boy
10	irritated	The hairstyle irritated Amanda
11	terrified	They were terrified of the thunder
12	disturbed	The theft disturbed Jenny
13	haunted	The image haunted Jordan
14	worried	The employee was worried about the layoffs
15	shocked	The slayings shocked the reporter
16	pleased	The gift pleased William
17	alerted	The girl was alerted by the sirens
18	scared	The cave scared the pirate
19	guided	The script guided the actor
20	bored	Rachel was bored by the article
21	enticed	The brownie enticed Dominic
22	encouraged	The comments encouraged Justin
23	stunned	They were stunned by the death
24	impressed	The victory impressed them
25	demoralized	The setback demoralized Kate
26	excited	The pirate was excited by the treasure
27	appalled	The ritual appalled Rachel
28	annoyed	The roadwork annoyed the driver
29	amused	Lauren was amused by the game
30	enraged	The graffiti enraged them
31	challenged	The problem challenged the student
32	captivated	Mike was captivated by the artwork
33	disgraced	The editorial disgraced the employee
34	intrigued	The illusion intrigued her
35	embarrassed	Dominic was embarrassed by the mistake
36	disgusted	The caviar disgusted Mike

Table 8. Prime sentences used for active and passive primes containing normal verbs in Experiments 3 & 4. These sentences are comprised of the same items as in Experiments 1a, 1b, & 2, but now were not limited to he/him to constrain form, which increased variability among items.

Pair #	Normal Verb	Prime Sentence Example (Active form// some examples of Passive form – using argument two)
1	protested	The committee protested the proposal//The proposal was protested by the committee
2	suppressed	Jenny suppressed the screams//The screams were suppressed by Jenny
3	bellowed	Brian bellowed the command//The command was bellowed by Brian
4	requested	Dana requested tea//The tea was requested by Dana
5	rejected	The editor rejected the story//The story was rejected by the editor
6	enjoyed	Alex enjoyed the sunlight
7	decorated	The bride decorated the invitation
8	examined	The assignment was examined by Brian
9	watched	Lauren watched the bomb
10	recommended	They recommended the manuscript
11	dreaded	The earthquake was dreaded by Alex
12	prevented	She prevented the accident
13	scrutinized	The critic scrutinized the movie
14	ordered	The attacks were ordered by Chris
15	loathed	They loathed the carnage
16	wrapped	Abby wrapped the chocolates
17	sounded	The horn was sounded by her
18	explored	The girl explored the forest
19	consulted	The explorer consulted the map
20	copied	The textbook was copied by Jack
21	devoured	Jack devoured the cheesecake
22	appreciated	Tim appreciated the praise
23	mourned	The tragedy was mourned by them
24	ensured	Allison ensured the profits
25	disregarded	The boxer disregarded the defeat
26	misplaced	The prize was misplaced by Allison
27	detested	The officer detested the crime
28	despised	She despised the delay
29	purchased	The toy was purchased by the boy
30	noticed	Erin noticed the profanity
31	solved	Kyle solved the puzzle
32	criticized	The mystery was criticized by Erin
33	fabricated	The editor fabricated the scandal
34	analyzed	The professor analyzed the event
35	avoided	The blunder was avoided by Kelly
36	refused	Kelly refused the anchovies

Table 9. Prime sentences used for intansitive control conditions in Experiments 3 & 4. These sentences are comprised of different items than found elsewhere in the study to reduce possible contaminiation from production of the same verbs as actives and passives elsewhere in the experiment. Items marked with an asterisk were selected from Bock & Griffin (2000); others were constructed from common intransitive verbs.

Item #	Intransitive Verb	Intransitive Prime Sentence
1	landed	The flying saucer landed*
2	struggled	The new television network struggled*
3	agreed	The opposing lawyers agreed
4	appeared	The feast suddenly appeared
5	sighed	The unhappy artist sighed*
6	giggled	The two clerks giggled*
7	arrived	The long awaited guest arrived
8	collapsed	The gigantic sandcastle collapsed
9	whispered	The duck hunters whispered*
10	blundered	The real estate agent blundered*
11	collided	The sports cars collided
12	died	The beautiful houseplant died
13	retired	The successful businessman retired*
14	shaved	The young man shaved*
15	drilled	The careful dentist drilled
16	disappeared	The ink stain disappeared
17	multiplied	The company's problems multiplied*
18	gambled	The old woman gambled*
19	emerged	The answer finally emerged
20	existed	The fabled treasure existed
21	crashed	The old computer crashed*
22	cried	The lost child cried*
23	knocked	The persistent salesman knocked
24	lied	The sneaky criminal lied
25	survived	The resourceful campers survived*
26	fell	The tightrope walker fell*
27	responded	The angry debater responded
28	rotted	The wormy apple rotted
29	shone	The full moon shone*
30	broke	The university went broke*
31	sat	The obedient dog sat
32	laughed	The audience members laughed*
33	smiled	The movie star smiled*
34	danced	The ballerina danced*
35	galloped	The graceful thoroughbred galloped*
36	steamed	The hot spring steamed
37	sneezed	The bus driver sneezed*
38	shattered	The delicate vase shattered*
39	escaped	The kidnapped child escaped*
40	mumbled	The shy kid mumbled*
41	stood	The vigilant officer stood
42	swam	The colorful fish swam
43	dozed	The hardworking nurse dozed*
44	vanished	The expert magician vanished
45	yelped	The dentist's patient yelped*
46	waited	The angry mother waited
47	slept	The overworked receptionist slept*
48	leaked	The ruined container leaked*

Table 10. Experiment 3: LMM estimated marginal mean latency (ms), standard error (ms), and percentage selected for each target structure (for unconstrained) for each target structure by condition.

	Constraint	**Constrained**					**Unconstrained**				
Verb Type	*Prime Structure*	**Active**	**Intransitive**	**Passive**	Total		**Active**	**Intransitive**	**Passive**	Total	TOTAL
Theme Experiencer	**Active**					**Active**					
	M	1048	1101	1084	1078	*M*	1131	1112	1124	1122	1100
	SE	(38.38)	(38.17)	(38.21)	(35.67)	*SE*	(40.07)	(40.28)	(40.08)	(36.46)	(34.41)
	--					%selected	.350	.327	.343	.340	
	Passive					**Passive**					
	M	1123	1132	1150	1135	*M*	1087	1081	1092	1087	1111
	SE	(39.99)	(39.98)	(40.40)	(36.34)	*SE*	(37.35)	(37.22)	(37.32)	(35.32)	(34.33)
	--					%selected	.650	.673	.657	.660	
	Total					Total					
	M	1086	1117	1117	1107	*M*	1109	1097	1108	1105	1106
	SE	(36.51)	(36.42)	(36.54)	(34.80)	*SE*	(36.17)	(36.21)	(36.17)	(34.69)	(33.56)
Normal	**Active**					**Active**					
	M	958	1009	970	979	*M*	945	975	963	961	970
	SE	(37.92)	(38.00)	(38.05)	(35.51)	*SE*	(36.34)	(36.33)	(36.32)	(34.99)	(33.99)
	--					%selected	.955	.985	.993	.991	
	Passive					**Passive**					
	M	1343	1313	1339	1332	*M*	1245	1055	1168	1156	1244
	SE	(39.65)	(40.14)	(40.41)	(36.37)	*SE*	(176.07)	(106.33)	(145.46)	(88.89)	(53.22)
	--					%selected	.005	.015	.007	.009	
	Total					Total					
	M	1150	1161	1155	1155	*M*	1095	1015	1065	1058	1107
	SE	(36.27)	(36.42)	(36.54)	(34.78)	*SE*	(93.02)	(60.98)	(78.66)	(53.38)	(39.17)
TOTAL											
	M	1118	1139	1136	1131	*M*	1102	1056	1087	1082	1106
	SE	(33.95)	(33.99)	(34.04)	(33.11)	*SE*	(54.57)	(41.81)	(48.62)	(38.76)	(34.39)

Table 11. Experiment 4: LMM estimated marginal mean latency (ms), standard error (ms), percentage of targets produced as active and passive for each Target Sentence by condition.

	Lexical Prime	**Agent/Experiencer (promotes passive for Theme, active for Normal)**					**Patient/Theme (promotes active for Theme, passive for Normal)**				
Verb Type	*Prime Structure*	**Active**	**Intransitive**	**Passive**	Total		**Active**	**Intransitive**	**Passive**	Total	TOTAL
Theme Experiencer	**Active**					**Active**					
	M	1049	1063	1061	1058	*M*	1044	1054	1090	1063	1060
	SE	(32.19)	(31.80)	(31.64)	(29.39)	*SE*	(31.77)	(31.88)	(31.80)	(29.37)	(28.73)
	%selected	.452	.493	.517	.487	%selected	.515	.485	.497	.499	.493
	Passive					**Passive**					
	M	1032	1024	1035	1031	*M*	1033	993	1003	1009	1020
	SE	(31.54)	(31.86)	(32.01)	(29.40)	*SE*	(32.06)	(31.80)	(31.84)	(29.43)	(28.78)
	%selected	.548	.507	.483	.513	%selected	.485	.515	.503	.501	.507
	Total					Total					
	M	1041	1044	1048	1044	*M*	1039	1023	1046	1036	1040
	SE	(29.48)	(29.46)	(29.46)	(28.18)	*SE*	(29.50)	(29.46)	(29.45)	(28.17)	(27.84)
Normal	**Active**					**Active**					
	M	949	975	957	960	*M*	951	974	953	959	960
	SE	(29.84)	(29.87)	(29.88)	(28.59)	*SE*	(29.90)	(29.88)	(29.94)	(28.60)	(28.26)
	%selected	.980	.990	.978	.983	%selected	.982	.984	.982	.982	.983
	Passive					**Passive**					
	M	932	1285	1289	1169	*M*	1066	1121	1157	1114	1142
	SE	(79.47)	(115.62)	(80.05)	(58.83)	*SE*	(83.93)	(89.10)	(83.85)	(54.83)	(45.08)
	%selected	.020	.010	.022	.017	%selected	.018	.016	.018	.018	.017
	Total					Total					
	M	940	1130	1123	1064	*M*	1008	1047	1055	1037	1051
	SE	(46.52)	(62.66)	(46.76)	(37.84)	*SE*	(48.45)	(50.69)	(48.41)	(36.31)	(32.72)
TOTAL	*M*	991	1087	1085	1054	*M*	1023	1035	1051	1036	1045
	SE	(33.10)	(39.22)	(33.19)	(29.91)	*SE*	(33.78)	(34.62)	(33.80)	(29.44)	(28.28)

ALEXANDRA KATE FRAZER
CURRICULUM VITA

Department of Psychology, Lehigh University,
27 Memorial Drive West, Bethlehem, PA 18015
Email: akf207@lehigh.edu

EDUCATION

2016 **PhD in Psychology,** Lehigh University
Dissertation: *Lexical and Syntactic Influences on Structural Selection in Language Production*
Advisor: Padraig G. O'Seaghdha, Ph.D.
Committee Members: Barbara Malt, PhD., Almut Hupbach, PhD., & Kiri Lee, PhD.

2007 **Masters of Arts in Psychology,** Northern Arizona University
Thesis: *Positive and Negative Events, Gender, and the Use of the Active and Passive Voice*
Advisor: Michelle D. Miller, Ph.D.

2005 **Bachelor of Arts in Psychology,** Northern Arizona University
Extended Major: Psychology

PUBLICATIONS

Frazer, A.K., O'Seaghdha, P.G., Munoz-Avila, H., & Roessler, N. (2014). Competitor activation and semantic interference: Evidence from combined phonological and semantic similarity. In P. Bello, M. Guarini, M. McShane, & B. Scassellati (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp.1108-1113). Austin, TX: Cognitive Science Society.

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Frazer, A.K. & Miller, M.D. (2009). Double standards in sentence structure: Passive voice in narratives describing domestic violence. *Journal of Language and Social Psychology, 28*(1), 62-71.

PAPERS IN SUBMISSION AND PREPARATION

O'Seaghdha, P.G. & **Frazer, A.K.** (2015). *Consequential form preparation in word production.* Manuscript under revision.

Frazer, A.K. & O'Seaghdha, P.G. (2015). *Consequences of consonance: When sound similarity increases semantic interference.* Manuscript in preparation.

Frazer, A.K. & O'Seaghdha, P.G. (2015). *Does phrase structure priming exist?* Manuscript in preparation.

Frazer, A.K., O'Seaghdha, P.G., & Rehrig, G.* (2015). *Syllable variation in form preparation.* Manuscript in preparation.

* denotes undergraduate collaborator

CONFERENCE PRESENTATIONS

Frazer, A.K., O'Seaghdha, P.G., & Rehrig, G.* (November, 2014). *Structural variation does not prevent form preparation in word production: Support for an attentional account*. Poster accepted for presentation at the 55th annual meeting of the Psychonomic Society, Long Beach, CA, USA.

Frazer, A.K., O'Seaghdha, P.G., Munoz-Avila, H., & Roessler, N.* (July, 2014). *Competitor activation and semantic interference: Evidence from combined phonological and semantic similarity*. Paper presented at the 36th Annual Conference of the Cognitive Science Society. Quebec City, Canada.

O'Seaghdha, P.G., Packer, D., **Frazer, A.K.**, Preusse, K.*, Hatalis, K., Munoz-Avila, H., & Hupbach, A. (November, 2013). *Does mere co-activation drive semantic interference?* Paper presented at the 54th annual meeting of the Psychonomic Society, Toronto, Ontario, Canada.

Preusse, K.*, **Frazer, A.K.**, & O'Seaghdha, P.G. (November, 2013). *Semantic interference in word production: Insights from remote associates in problem solving.* Poster presented at the 54th annual meeting of the Psychonomic Society, Toronto, Ontario, Canada.

Preusse, K.*, Lewis, J.*, Prieto, C.*, **Frazer, A.K**., & O'Seaghdha, P.G. (March, 2013). *Exploring phonological preparation and semantic interference in word production.* Poster presented at the annual meeting of the Eastern Psychological Association, New York, NY.

Frazer, A.K. & O'Seaghdha, P.G. (July, 2012). *Does phrase structure priming exist?* Poster presented at the 7th International Workshop on Language Production, New York, New York.

O'Seaghdha, P.G. & **Frazer, A.K.** (November, 2011). *A goal-setting theory of preparation for word production*. Paper presented at the 52nd annual meeting of the Psychonomic Society, Seattle, WA.

Frazer, A.K. & O'Seaghdha, P.G. (July, 2011). *Phrase structure priming across sentences: Facilitation or reconfiguration?* Poster presented at the 33rd Annual Conference of the Cognitive Science Society, Boston, MA.

Frazer, A.K. & O'Seaghdha, P.G. (November, 2010). *Flexible planning in word production*. Poster presented at the 51st annual meeting of the Psychonomic Society, St. Louis, Missouri.

Frazer, A.K., Knicely, J.L., & O'Seaghdha, P. G. (July, 2009). *Expect the unexpected: Robust planning processes in speech production*. Poster presented at the annual meeting of the Cognitive Science Society, Amsterdam, Netherlands.

Frazer, A.K., Knicely, J.L., & O'Seaghdha, P. G. (March, 2009). *The best laid plans: Consequences of form preparation in speech production*. Paper presented at the annual meeting of the Eastern Psychological Association, Pittsburgh, PA.

Frazer, A.K. & Miller, M.D. (April, 2007). *Gender of attacker and victim affects sentence structure in descriptions of interpersonal violence*. Paper presented at the annual meeting of the Rocky Mountain Psychological Association, Denver CO.

Frazer, A.K. & Miller, M.D. (April, 2005). *Male-on-Female Versus Female-on-Male Violence: Gender and Verb Voice in Newspaper Stories*. Poster presented at the annual meeting of the Rocky Mountain Psychological Association, Phoenix AZ.

POSITIONS HELD

2014-current **Visiting Instructor, Muhlenberg College, Allentown, PA**

2013-14 Adjunct Instructor, Muhlenberg College, Allentown, PA

2013-14 Introductory Lab Instructor, Lafayette College, Easton, PA

PROFESSIONAL SERVICE

2014-15	Cognitive Science Society Annual Conference Submission Reviewer
2015	EuroAsianPacific Joint Conference on Cognitive Science (EAPCogSci) Submission Reviewer
2014	Ad-hoc Textbook Reviewer for Sinauer Associates, Inc., Publishers Principles of Psychology, by Marc Breedlove
2014	Ad-hoc Textbook Reviewer for Sage Publications Inc. Cognitive Psychology, by Dawn M. McBride and J. Cooper Cutting
2011	2011 LVAIC Undergraduate Research Conference Session Chair & Poster Session Judge
2010	2010 EPA Annual Conference Submission Reviewer – Cognitive Area
2010	2010 LVAIC Undergraduate Research Conference Poster Session Judge
2009	2009 EPA Annual Conference Submission Reviewer – Cognitive Area
2008	2008 LVAIC Undergraduate Research Conference - Session Chair

TEACHING INTERESTS

General: Introduction to Psychology, Introduction to Cognitive Science, Statistics for the Social Sciences, Experimental Research Methods, History of Psychology
Content Specific: Cognitive Psychology, Language, Learning and Memory, Attention, Language and Society, Social Psychology,

RESEARCH INTERESTS

Cognitive Psychology: Language production and comprehension, psycholinguistics & sociolinguistics, memory, knowledge and representation, attention, language and the media

PROFESSIONAL AFFILIATIONS

Cognitive Science Society
Women in Cognitive Science
Eastern Psychological Association