Lexical Activation Effects on Children’s Sentence Production

by

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Abstract

Sentence production requires the integration of activated words with a syntactic plan; however, there has been little investigation of how the integration process affects children’s productions. Research with adults shows that lexical activation order can influence syntactic planning, placing earlier-activated words in earlier-occurring grammatical roles. It has also been proposed that the relationship between lexical activation and syntactic planning can affect processing ease. When lexical activation order and sentence structure are in conflict, a speaker may need to resolve the conflict prior to speaking, and/or buffer the early-activated word until it is produced late in the sentence. This investigation examined the effects of lexical activation order on sentence structure and processing outcomes for 4- and 7-year-old children, using a semantic priming manipulation.

In Study 1, children described transitive scenes and also completed a primed picture-naming task. The results documented that the children produced active transitives as the default sentence pattern, and that the older children alternated to patient-subject sentences more often than the younger children when pressured to do so by a cloze prompt. The results also documented facilitative effects of semantic priming on lexical activation speed.

Study 2 integrated the semantic primes with sentence production. In one half of the trials, a patient-related prime preceded the scene description. The analyses examined whether patient-subject sentences occurred more often following patient-related primes, and whether early activation of the patient produced negative consequences to sentence onset speed, grammatical integrity, and/or fluency in (agent-subject) active transitive sentences. The results revealed that the patient-related primes did not increase the rate of patient-subject sentential descriptions. However, when children produced active transitive sentences, they
were slower to begin speaking following patient-related primes than control primes. There was no significant effect of the primes on fluency or auxiliary omission rates, no difference in prime effects as a function of age group, and no correlation between prime effects and working memory ability. The results indicate a strong constraint of syntactic preferences on children’s sentence planning, and support the conclusion that conflicts between lexical activation and syntactic planning can negatively affect the speed of children’s sentence planning.
Preface

The research presented in this dissertation conformed to the requirements of the Behavioural Research Ethics Board of the University of British Columbia (certificate #H09-01286, project title: *Finding words and building sentences: Lexical access effects on sentence production*).
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For my father

Luc Pierre Charest

May 14, 1939 – July 9, 2011
Chapter 1: Introduction

1.1 General Introduction

Constructing and producing sentences is a fundamental aspect of human communication. The sentences that a speaker produces reflect the combined influences of the speaker’s linguistic knowledge and the speaker’s solution to the task of accessing, organizing, and expressing that knowledge within the rapid time frame of speaking (e.g., 2.5 to 5 words/second, Levelt, 1989, p. 199). Several decades of process-oriented research in the adult psycholinguistic tradition has provided insight into the nature and organization of the activities that support real-time sentence production. In contrast, the focus in child language research has traditionally placed greater emphasis on questions of knowledge, or ‘competence’, than questions of process (McKee, Rispoli, McDaniel, & Garrett, 2006). Recent years, however, have seen a growing number of child-focused studies that have adapted the methods and insights from the adult processing tradition to expand our understanding of young children’s language knowledge, the organization of the system that expresses that knowledge in early development, and the factors that affect variations in children’s real-time production processing outcomes (e.g., Huttenlocher, Vasilyeva, & Shimpi, 2004; Jerger, Martin, & Damian, 2002; Leonard et al., 2000; McDaniel, McKee, & Garrett, 2010; Stemberger, 1989). The current investigation fits within this growing body of work. It investigates the ways in which the process of coordinating lexical processing with syntactic planning affects children’s sentence production outcomes, and is motivated by theories, models and data generated within the adult psycholinguistic tradition. The literature review therefore begins with an overview of language production processing and relevant observations about lexical and syntactic planning in adulthood, before turning to questions of lexical-syntactic coordination in early development.
1.2 Literature Review

Speaking begins with a thought and ends with an utterance. The task for a speaker is to convert this thought, considered to be non-linear in nature (e.g., Bock, 1995), into a linear, forward-flowing utterance that respects both the speaker’s intended message and the grammatical requirements of the language. Within a given speaking context, the outcome of that task can vary in a number of ways, in terms of the words or sentence structures that are produced (e.g., “The dog licked the cat” versus “The cat was licked by the dog”), and the efficiency and integrity of production (e.g., speed, fluency, grammatical appropriateness).

Language production theories and models provide a framework to understand the ‘computational problems’ (Bock, 1987a) inherent in speaking and their influence on these kinds of variations. They describe the nature of the representations and activities involved in the production process, how information flows within and between them, and how they interact with each other across time (Levelt, 1989). Although these models and theories are not developmental models, they can nonetheless provide a framework for thinking about the potential challenges faced by young children as they construct sentences in real time.

The current investigation focuses on the computational problems inherent in one central requirement of speaking, namely calling up the appropriate words from the available lexicon and arriving at an appropriate ordering of those words via sentence structure (Bock, 1982, 1987a). It addresses questions of how the timing of activation of the major nouns in a sentence influences the developing syntactic plan, how conflicts between lexical processing and syntactic planning affect the ease or integrity of production, and whether these effects change with age in childhood.
Important points of ongoing discovery and debate about the production process exist. Nonetheless, several decades of research into both naturally occurring speech errors (e.g., Garrett, 1975) and experimental outcomes (Bock, 1986a, 1986b; Levelt, Roelofs, & Meyer, 1999; see Bock, 1996 for a review) have led to “reasonable agreement on the broad outline of production processes” (Bock & Levelt, 1994, p. 945). The section that follows will describe aspects of this outline. It focuses on the major components of the language production process, as well as the mechanism of processing and relevant aspects of how the different components are organized relative to each other in time. Broad points of agreement are highlighted and points of debate are acknowledged where necessary, in order to situate the questions of focus in the current investigation.

1.2.1 Language Production Processing: Introduction

The major components of sentence planning and production are broadly divided into message formulation, grammatical encoding, phonological/phonetic encoding, and articulation (Bock, 1995; Bock & Levelt, 1994; Ferreira & Slevc, 2007; Levelt, 1989). As production planning begins, speakers select and organize information relevant to their communicative intent to create a message. The message is a propositional structure that provides the input to grammatical encoding. Grammatical encoding processes elaborate both the lexical and syntactic plan for the sentence. Speakers select words relevant to the message, retrieve their morpho-phonological form representations, assign grammatical roles, and create a serially-ordered syntactic plan. During phonological and phonetic encoding, they encode and syllabify phonological segments in production order. The products of phonological and phonetic encoding guide further output processing.
The nature or mechanism of processing within and among these components is usually conceptualized (e.g., Bock, 1982; Bock & Levelt, 1994; Levelt, 1989) or modeled (e.g., Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Levelt et al., 1999) using the principles of spreading activation. As noted by Goldrick (2007), two connectionist principles have long provided a framework for thinking about language production. First, ‘representations’ are patterns of activation. Second, ‘processing’ is the spreading of activation along weighted connections between units. Activation spreads and decays over time. The amount of activation transmitted between two units is determined by the activation level of the starting unit and the weight or strength of the connection. The activation level of a given unit is determined by the sum of input activations. A third important principle, not always articulated in the production context, is that the weight or strength of connections is determined by experience (Goldrick, 2007).

Importantly, spreading activation principles predict variations in the ease and likelihood of producing any given form, as a function of the current context, prior context, and inherent properties of that form. Whether a particular representation is activated and selected, and how quickly, will depend on its current activation level, the strength and number of input connections, and the timing and amount of activation relative to other potential choices. Experimental studies demonstrate, for example, that previously activated words or sentence structures are more likely to be produced (Bock, 1986b; Potter & Lombardi, 1990) and are produced more quickly (Barry, Hirsh, Johnston, & Williams, 2001; Smith & Wheeldon, 2001; Wheeldon & Monsell, 1992), as

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1 The basic assumptions of activation and spreading activation apply to both localist or symbolic approaches that describe unitary representations, and distributed processing approaches that view representations as patterns of activation over many units, none of which is meaningful on its own (Goldrick, 2007; McNamara & Holbrook, 2003). This distinction will not be further pursued in this study.
are words that are more frequent or earlier acquired (Barry, Morrison, & Ellis, 1997; Ellis & Morrison, 1998; Oldfield & Wingfield, 1965), and words that have rich input support from the semantic context (Griffin & Bock, 1998) and the density of phonological connections (i.e., neighbourhood density, Vitevitch, 2002).

Finally, it is broadly assumed that language production occurs in an incremental and parallel manner (Bock, 1995; Bock & Levelt, 1994; Dell, 1986; Ferreira & Slevc, 2007; Levelt, 1989). Although there is a temporal progression to the activities involved in speaking (i.e., we begin with a message and end with articulation), processing within one component does not have to run to completion for the entire utterance before processing within the next component can begin. A speaker might, for example, initiate grammatical encoding processes as soon as part of the message is formed, while continuing to plan the rest of the message. Or a speaker might begin to articulate the first words of a sentence before the final words have been retrieved.²

Producing even a single sentence thus involves concurrent activation of different representations (from different parts of the sentence and across different levels in the planning process), as well as maintenance of activated representations that have yet to be integrated with

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² While the concept and principles of spreading activation are widely invoked to describe the production process, there is important ongoing debate regarding the direction and timing of activation spreading through the production system. This debate relates to the extent to which activation spreading, and thus the activities of production, occur in a discrete, feed-forward manner (e.g., Bock & Levelt, 1994; Levelt, 1989; Levelt et al., 1999) or in a more interactive manner. Interactive perspectives allow cascading of activation from partially-activated representations and/or feedback of activation from 'lower' to 'higher' level representations (e.g., Dell, 1986; Dell et al., 1997). This debate has been articulated in greatest detail as relates to lexical processing, but in principle can apply to processing at multiple points throughout the production pathway. Detailed discussion of this debate is beyond the current scope, but will be acknowledged as necessary in the sections that follow. Following Ferreira & Slevc (2007, p. 454), the discussions that follow assume that interactive inputs are possible (see also Meyer & Belke, 2007, for the conclusion that, at least where lexical processing is concerned, the weight of evidence supports both cascading and possibly feedback of processing).
further components (Bock, 1982; Bock & Levelt, 1994; Dell, 1986; Levelt, 1989). The importance of this observation is that it highlights the complexity of the task to be accomplished within the constraints imposed by a limited capacity cognitive processing system (Bock, 1982; Levelt, 1989). The concept of capacity limits refers to the fact that there is an upper limit to the amount of cognitive work that any individual can manage within a given unit of time (Johnston, 1994). ‘Capacity’ has been defined and applied to questions of human cognitive activity in different and not necessarily incompatible ways, most notably using metaphors of computational ‘space’, mental fuel or ‘resource’, and processing speed or ‘time’ (Kail & Salthouse, 1994). It is undoubtedly influenced by multiple factors, including domain-general biological limits and efficiency driven by domain-specific experience (Just & Carpenter, 1992; Just & Varma, 2002; Kail & Salthouse, 1994; MacDonald & Christiansen, 2002). The concept of capacity that guides the current work (i.e., the amount of work that can be completed efficiently per unit of time) is compatible with the expectation of multiple potential determinants of capacity.

The capacity limits perspective can be applied to examine how the complexity of language production is managed as successfully as it is within those limits. Relevant questions pertain to the factors that influence individual differences in capacity, which components of the language production process might particularly stress capacity, and which components are most likely to suffer when capacity limits are strained or exceeded. In addressing these kinds of questions, researchers have drawn on concepts of efficiency or automaticity in production (Bock, 1982; Levelt, 1989), flexible trade-offs among different domains of production (Bock, 1982), and the weighting of the relative costs versus the relative information value of a particular

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3 The notion of concurrent processing and maintenance or representations across the sentence applies to both discrete and interactive views of processing.
language form or pattern (e.g., within the Competition Model, Bates & MacWhinney, 1989; Presson & MacWhinney, 2011). All of these concepts are relevant to understanding language production.

The questions in the current investigation are concerned with the architecture and priorities of the production process as it relates to activating words and coordinating those words with syntactic plans, and how that coordination relates to sentence production outcomes within a limited capacity perspective. As noted above, the lexical and syntactic plan is elaborated during grammatical encoding. A more detailed discussion of grammatical encoding is presented in the section that follows.

1.2.2 Lexical and Syntactic Planning During Grammatical Encoding

1.2.2.1 Lexical and Syntactic Processes

Grammatical encoding processes develop the “skeleton of an utterance” (Bock & Levelt, 1994, p. 945). They are guided by the content of the message, including information such as the referents (e.g., who or what entities are involved), actions and states to be expressed, how the different referents are related (e.g., which referent serves the thematic role of agent vs. patient), and prominence relations among the difference elements (Ferreira & Slevc, 2007). With the developing message as the starting point, grammatical encoding processes determine both the lexical content of the utterance and how that content will be expressed within a syntactic structure (Bock & Levelt, 1994).

Two characteristics of grammatical encoding are particularly relevant to this investigation. The first is that grammatical encoding consists of both lexical and syntactic processing streams (i.e., “content” and “structure” subprocesses, Ferreira & Slevc, 2007) that are
to some extent independent of each other. Independence in lexical and syntactic processing makes possible “the sheer expressive power of language” (Ferreira & Slevc, 2007, p. 456), allowing us to combine words and sentence structures in novel ways. The second important characteristic is that these lexical and syntactic processing streams are also to some degree interdependent. Elements of syntactic structure, for example, are represented within the lexical entry (e.g., Levelt et al., 1999; see below). And, most importantly, particular lexical and syntactic activities are assumed to co-occur at different points during the planning process. Finally, the inter-dependent nature of lexical and syntactic processing is observed most readily in the fact that words occur within sentences: Lexical and syntactic processes come together.

Lexical processing during grammatical encoding is a two-step process that involves both selecting the appropriate words to express the message, and retrieving these words’ morphophonological form (Bock & Levelt, 1994; Dell, 1986; Ferreira & Slevc, 2007; Levelt, 1989; Levelt et al., 1999). The lexical representations that are accessed during lexical selection are abstract representations referred to as lemmas. Lemmas are indexed to semantic information from the conceptual (message) level, and represent the word’s syntactic properties (e.g., grammatical category such as noun or verb, argument structure possibilities for verbs, and ‘diacritic features’ such as tense or number; Levelt et al., 1999). The morpho-phonological representations that are retrieved are often referred to as lexemes. Lemma activation is initiated

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4 As noted by Levelt et al. (1999), the term “lemma” in its original use referred to a representation that encoded both the semantic and the syntactic details of a word (e.g., see Levelt, 1989). In later work, (Levelt et al., 1999), the term “lemma” was used in a more restricted manner, referring to a word’s abstract syntactic representation, and the term “lexical concept” was used to refer to a word’s abstract semantic representation. In this division, the lexical concept represents the endpoint of conceptual preparation and directly feeds activation to the lemma. Levelt et al. (p. 66) state that, together, these two “nodes” capture the original concept of a “lemma”. In the current investigation, the term “lemma” will used to refer to the initial, abstract lexical entry that is activated early during grammatical encoding, indexed to both semantic and syntactic information, acknowledging that different sources may describe the semantic and syntactic content of that representation in a more or less unitary manner.
by conceptual (message) inputs, and lemmas in turn spread activation to the word-form level.

Although there is a temporal progression in spreading activation from the conceptual stratum to the lemma to the word form, the principles of interactive activation allow that a lemma’s activation level will ultimately be influenced not only by the conceptual inputs but also by feedback from activation at the level of the word form (Dell, 1986; Dell et al., 1997; but note that this is not possible in strictly discrete accounts of production, e.g., Levelt et al., 1999).

Syntactic processing during grammatical encoding also has a two–step character. It involves selecting the grammatical roles (e.g., subject, direct object) appropriate to expressing the message and creating a hierarchical plan to express these roles and relations among sentence elements in a linear order (Bock, 1995; Bock & Levelt, 1994; Ferreira & Slevc, 2007). In English, this requires retrieving and ordering phrase structures according to the possibilities of the language (e.g., subject before the verb), and creating phrase-internal plans.

Production models assume that lemma selection and grammatical role selection co-occur at a level of processing referred as functional (Bock, 1995; Bock & Levelt, 1994; Garrett, 1975) or selection (Ferreira & Slevc, 2007) processing. Morpho-phonological retrieval and linear ordering are assumed to co-occur during positional (Bock, 1995; Bock & Levelt, 1994; Garrett, 1975) or retrieval (Ferreira & Slevc, 2007) processing. Evidence from naturally occurring

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5 The mappings between lexical and syntactic functions was motivated by observations of the constraints on naturally-occurring speech errors, in particular differences in the patterning of whole-word exchanges and speech sound exchanges (Bock & Levelt, 1994; Garrett, 1975). To summarize, whole word exchanges occur between words of the same grammatical class (e.g., Noun-Noun). They tend to span different phrases, often (though not always) within the same clause. In addition, in whole-word exchanges involving pronouns, the exchanged pronouns take on the case of their new position. The patterning of pronoun exchange errors indicates that these whole-word exchanges involve the mapping between lexical items and grammatical roles, rather than the simple exchange of linear position among items already specified for their morpho-phonological form. Thus, the constraints on these errors relate to grammatical category and grammatical relations. Sound exchange errors, in contrast, tend to occur between adjacent words of different classes, but between similar sounds occupying the same position. Thus, the constraints on these errors relate to sound properties and linear position.
speech errors (Garrett, 1975), as well as some experimental evidence (Meyer, 1996) points to a scope of planning during functional/selection processing that is relatively large, likely clausal, and a smaller scope of planning during positional or retrieval processing, likely phrasal (Bock & Levelt, 1994; see footnote #5 for a summary of the relevant speech error observations).

1.2.2.2 Mapping Nouns to Grammatical Roles: Determinants of Syntactic Structure

Selected lemmas must be linked to the selected grammatical roles (e.g., subject, object) for the serial order of the sentence to be elaborated. During functional/selection processing, the activated lemmas are linked with potential grammatical roles, creating linkages that are assumed to be “temporary” and “labile” until instantiated as serially-ordered phrases (Bock & Levelt, 1994, p. 968). The activated verb lemma serves as an important organizing unit for determining the possible associations between lemmas and grammatical roles, based on its representation of argument structure possibilities (Bock, 1987a; Bock & Levelt, 1994; Pickering & Branigan, 1998).

Given a particular message and verb choice, however, a speaker may nonetheless have options for how to assign lexical elements to grammatical roles. For example, a speaker could describe the same scene as either “The princess is kissing the frog” or “The frog is being kissed by the princess,” a structural alternation that differs (among other ways) in the mapping between the thematic roles of agent and patient and the grammatical roles of subject and object. Certainly, communicative goals, discourse or pragmatic considerations influence these choices. Keeping

These constraints provided an indication of the kinds of information that are simultaneously computed or available (Dell, 1986), and pointed to two important conclusions. First, there is a level of processing that is simultaneously concerned with information about the grammatical categories of words (i.e., lemmas) and the mapping of words to grammatical roles (e.g., subject, object), and a level at which the system is simultaneously concerned with computing word form information and the serial order among words. Second, these patterns of ‘simultaneous computation’ occur over scopes of different size, likely clausal for functional processes and phrasal for positional processes.
with the active/passive example, a speaker may for example wish to either emphasize the patient or de-emphasize the agent (viz. "Mistakes were made"). However, independent of communicative goals, processing dynamics affecting lexical and syntactic availability also influence this choice. As noted by Bock (1987a, p. 338), "... the production system may make a contribution to the formulation of speech that is independent of the propositional content or structure of speakers' intended messages."

The phenomenon of syntactic priming, for example, demonstrates that the activation history of syntactic representations influences moment-to-moment choices among alternative structures, due to residual activation and/or long-term strengthening of input connections to particular structures (see Bock, 1986b; Bock & Griffin, 2000a; Pickering & Ferreira, 2008). Syntactic priming studies demonstrate that speakers tend to repeat sentence structures that they have recently heard or produced (Bock, 1986b, 1989; Bock, Dell, Chang, & Onishi, 2007; Bock & Griffin, 2000a; Bock & Loebell, 1990; Bock, Loebell, & Morey, 1992). For example, hearing or producing a prime sentence in the passive voice such as “The frog is being kissed by the princess” increases the likelihood of producing a subsequent sentence as “The cat is being chased by the dog” rather than “The dog is chasing the cat.” These effects do not depend on overlap in either content words or function words – that is, they are not driven by the activation history within the lexical stream. They demonstrate instead that syntactic activation levels, affected by residual activation and/or input strengths, can influence the mapping between lexical items and grammatical roles.

The current investigation is concerned with the converse influence, namely the potential influences of activation dynamics within the lexical processing stream on syntactic structure.
Bock (1982, 1987a, 1995; see also Ferreira & Dell, 2000; Levelt, 1989) proposed that variations in lexical activation timing can influence syntactic planning, suggesting that:

“… the syntactic structuring of an incipient utterance is sensitive to the accessibility of lexical information…. Where possible, a syntactic alternative is employed so as to place lexical information that has already been formulated ahead of lexical information that has yet to be readied” (Bock, 1982, p. 21).

Bock’s (1982, 1987a) proposal addressed potential effects on sentence structure stemming from lexical ‘readiness’ or availability during both lemma selection and word form retrieval. These effects were referred to by Bock (1987a) as the “conceptual accessibility” and “phonological accessibility” hypotheses. These two hypotheses highlighted effects on word order via grammatical role assignment in the former case and ordering of items sharing the same grammatical role (such as the order of items within a conjoined noun phrase) in the latter.

The current investigation is primarily concerned with the lexical activation effects on grammatical role assignment and sentence structure predicted by the conceptual accessibility hypothesis (Bock, 1987a). As noted above, speech error and experimental evidence (Garrett, 1975; Meyer, 1996) points to a clausal scope of processing during functional/selection processing. Message inputs initiate concurrent activation for all of the major meaning-bearing words within the clause. The activation status of any word may be influenced by the current and prior context (e.g., recent activation, richness of semantic input; Barry et al., 2001; Griffin & Bock, 1998), as well as the lexical-phonological characteristics of the item (e.g., age of acquisition, frequency, neighbourhood density; Barry et al., 1997; Ellis & Morrison, 1998; Oldfield & Wingfield, 1965; Vitevitch, 2002). Activation status will influence the time course of selecting items for further integration within the sentence. Which lemmas are selected, and how quickly, is ultimately influenced in a competitive manner by their activation level relative to
other forms that could potentially be selected (Levelt et al., 1999). Given that multiple lemmas are concurrently processed during grammatical encoding, and that processing is context- and experience-dependent, differences in the time course of processing for these multiple lemmas is to be expected.

The proposal as it relates to lexical activation and selection can be summarized as follows. Consistent with the production model outlined above, the conceptual-lexical perspective assumes “generalized activation” (Bock, 1987a, p. 372) of lemmas\(^6\), and association of lemmas to grammatical roles during functional processing. Also consistent with the general properties of the production system, the proposal assumes that, during this generalized activation, some items will have higher levels of activation and thus will reach a point of “readiness” or “availability” for selection and further processing more quickly. Following from these different activation levels, the association of lemmas to grammatical roles will proceed so that, when possible, the most activated lexical item fills the “highest” (and in English, earliest-occurring) grammatical role first (i.e., the subject role), subject to the constraints of the allowances of the verb (Bock, 1987a). By this view, the choice between potential alternative structures within a given context can follow from the current status of lemma activation. For example, given a message that could be produced as either “The princess is kissing the frog” or “The frog is being kissed by the princess,” the production of the active or passive form may depend on whether lemma-level activation and selection proceeds more quickly for princess or frog.

\(^6\) Bock (1987a; see also Bock, 1986a) does not actually use the term lemmas, but instead refers to, for example, the “ease of retrieving, activating or integrating lexical information during both functional and constituent integration ...” (p. 378). In the terminology used in the current paper, the lexical information accessed during functional (selection) and constituent (positional/retrieval) processing would be, respectively, lemmas and lexemes.
Importantly, the relationship between lexical activation order and sentence structure may have implications for our understanding of processing capacity limits during language production. These implications relate to working memory capacity (WM) and time considerations. WM, defined broadly, refers to the limited-capacity ability, system or “pool of operational resources” (Just & Carpenter, 1992, p. 122) responsible for the activation, processing and temporary maintenance or storage of task-relevant information during complex cognitive tasks (Baddeley, 2003; Just & Carpenter, 1992; Kail & Bisanz, 1982; Shah & Miyake, 1999). As the limits of WM capacity are reached within a task, decrements in the efficiency or sufficiency of performance may be observed. Language planning and production involves concurrent processing and maintenance of representations from different parts of the sentence and different components of the process, and therefore seems to be an ideal candidate to be subject to WM constraints.

According to the proposal put forth by Bock (1982), one potential source of WM processing load during sentence planning may stem from the requirements to buffer or maintain activation of lexical items. If a lexical item reaches a high level of activation and is selected early during sentence planning but is only integrated and produced late in the sentence, then maintaining its activation may come at a cost to WM capacity that might otherwise be available for planning and producing other aspects of the sentence. Such a situation might arise, for example, if the lemma for frog becomes available to the speaker early in the planning process, but is only produced at the end of a sentence such as, “The princess is kissing the frog.” Several factors might lead to early activation and selection, such as if the word has recently received activation, has few competitors (e.g., high name agreement; Bock & Griffin, 2000b; Griffin & Bock, 1998) and/or has numerous and/or strong input connections. In such an instance, the
sentence might be produced, but under the additional pressure of maintaining activation of *frog* as the remaining elements of the sentence are planned and produced.

The relationship between lexical activation order and sentence structure may also have implications for processing efficiency as indexed by time. As noted by Bock (1982, p. 23), any conflicts between lexical activation order and syntactic structure will need to be resolved before the sentence can be produced.

Thus, lexical activation may act as a source of “processing hazard” during sentence planning and production (Bock, 1982, p. 13). One way to minimize the potential processing hazards of lexical activation may be to exploit, whenever possible, syntactic options or alternatives in order to accommodate moment-to-moment variations in lexical availability\(^7\) and make early use of activated items (Bock, 1982; Ferreira, 1996; Ferreira & Dell, 2000). According to Bock (1982):

“... if words are retrieved before the constituent in which they are to appear is scheduled to be produced within a high-level syntactic plan, performance may be impaired by the resulting drain on processing resources. If, however, the formulation system has some flexibility in arranging constituents without distorting the communicative intention, it may be possible for constituents to be scheduled for production in a way that permits some accommodation of lexical information” (p.13).

The proposal of lexical availability effects on sentence production contains two important, and not necessarily inseparable, propositions. The first, relating to the architecture and priorities of the production system, is that lexical activation order can influence the mapping between lemmas and grammatical roles and thus determine syntactic form. The second, related to processing capacity during production, is that the relationship between lexical activation

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\(^7\) It is possible, of course, for words to be ‘available’ or ‘unavailable’ to speaker because they either are or are not present in the speaker’s lexicon. In the current context, ‘availability’ is used to refer to the activation status of known words, indicating that a word within the speaker’s lexicon has been made available to the production system for further processing and integration with the sentence (e.g., Ferreira & Dell, 2000; Streim & Chapman, 1987).
timing and syntax – whether it is one of convergence or conflict – affects the ease or efficiency of sentence production processing. The following sections describe the evidence for these two views in the adult literature, before turning to studies of children’s language production processing.

1.2.2.2.1 Lexical Activation Effects on Sentence Structure

The lexical availability proposal acknowledges that, given the constraints of the grammar, it may not always be possible for syntactic ordering to follow from lexical activation order (Bock, 1982, 1987a). Moreover, this perspective acknowledges that production outcomes will reflect a balance between lexical influences and syntactic preferences. Bock (1987a), for example, noted that two critical factors determining the outcome of grammatical role assignment are the activation dynamics of the lexical items and the strength of activation or accessibility of the alternative grammatical role mappings. However, notwithstanding constraints imposed by syntactic preferences and processing dynamics, there is evidence that activation dynamics within the lexical stream can indeed influence the dynamics of sentence building (Altmann & Kemper, 2006; Bock, 1986a; Bock & Irwin, 1980; Bock & Warren, 1985; Davidson, Zacks, & Ferreira, 2003; Ferreira & Dell, 2000; Ferreira & Firato, 2002; Gleitman, January, Nappa, & Trueswell, 2007). This evidence has come from studies that vary in the naturalness of the production task. They have varied the time course of lexical processing by manipulating the inherent features of the stimuli, the stimulus presentation structure, or the recent lexical context.

Bock (1986a) demonstrated that semantic priming of referents prompted speakers to produce active/passive alternations, placing the primed noun in the subject position. In this experiment, speakers alternated between repeating single words (referred to hereafter as prime
words) and describing pictures of transitive scenes that could be described using either the active or the passive (these activities occurred within a “cover” task designed to mask the experimental manipulation). Importantly, the prime words that preceded the target scenes were semantically related to either the agent or the patient in the scene. For example, prior to seeing a scene of lightning striking a church, the participants heard and repeated either thunder (i.e., related to lightning) or worship (i.e., related to church). The logic of this experiment was that processing the prime word would spread activation along meaning-based connections to the related target in the upcoming scene. When the target picture appeared, residual activation (from the spreading of activation that had occurred during the prime phase) would then facilitate activation and selection of the targeted lexical item. For example, following the worship prime, residual activation along the pathways for church would then facilitate activation and selection of the church lemma. The results revealed that the speakers were more likely to produce a sentence such as “The church is being struck by lightning”, following a prime such as worship, and more likely to produce a sentence such as “Lightning is striking the church” following a prime such as thunder. A particular strength of this demonstration was the fact that the primes were intended to affect processing outside of the speaker’s awareness. The variations in sentence structure were thus more likely to reflect the influence of the “momentary state of the lexical processing system” (p. 583) on grammatical role assignment, than the influence of other communicative or strategic factors.

The results reported by Bock (1986a) also revealed that a manipulation affecting activation of the phonological form of the target words did not produce these alternations in sentence structure. Prime words sharing a rhyme with the target words (Experiment 1, e.g., frightening → lightning; search → church) or sharing the initial onset (Experiment 2, e.g., charge → church)
did not produce a reliable difference in the assignment of referents to the role of sentence
subject. The difference in outcomes between semantic and phonological primes was consistent
with the proposed mapping between lexical and syntactic activities during grammatical
encoding, in which the production system is simultaneously concerned with grammatical role
assignment and lemma selection rather than word form retrieval. Follow-up work (Bock, 1987b),
however, indicated that a stronger manipulation of the phonological relationship could in fact
influence sentence structure decisions. In this study, phonological primes shared both the onset
consonant and the vowel with the targets (e.g., \textit{dot} $\rightarrow$ dog, \textit{cap} $\rightarrow$ cat). With this stronger
manipulation, speakers were more likely to produce a sentence that placed the primed element in
a later-occurring position. This pattern was found for both alternations of the sentence subject in
active and passive sentences, and the linear order of items within a conjoined noun phrase – a
serial ordering decision that did not involve changes in grammatical role assignment. The late
positioning of the primed word was attributed to an inhibitory effect of the phonological primes
on accessibility of the word form. Thus, particularly strong manipulations of word form
processing may indeed influence grammatical role assignment and sentence structure (possibly if
semantic constraints are weak; see Race, 2007). However, more consistent effects on
grammatical role assignment may be expected from manipulations that can more directly
influence lexical processing “higher up” in the planning stream, during lexical selection.\footnote{Two earlier studies reported by Bock and colleagues lend additional support to the hypothesis under investigation. Both studies used written recall as their dependent measure. The results should therefore be interpreted cautiously, given the potential for additional or different constraints related to the written process. In a sentence recall task that included a wide variety of structures, Bock and Irwin (1980) manipulated availability of the different noun constituents within each sentence via the form of the recall prompt. Recall was prompted either by a question that referenced one of the noun constituents or a related word (e.g., \textit{horse} $\rightarrow$ horse or \textit{stallion} $\rightarrow$ horse; Experiment 1), or by a single word that was identical to one of the noun constituents (Experiment 2). In their responses, participants were more likely to produce alternations of the intended structure if it placed the prompted word in an earlier-occurring position. In another sentence recall task, Bock and Warren (1985) demonstrated that the relative imageability of}
In a study employing a less natural method, older adults’ choice of active or passive sentence structures were affected by the order of content nouns presented to them on a computer monitor (Altmann & Kemper, 2006). In this study, two nouns and a verb were presented on a computer monitor, arranged vertically. The speakers’ task was to construct a sentence with the given words. Older, but not younger, adults tended to produce the top-appearing (and presumably earliest-fixated) noun in the subject position, sometimes forcing a syntactic alternation away from the preferred active voice in order to maintain semantic coherence (e.g., “The juice was stirred by the butler”). This study was presented within the framework of lexical activation order effects on grammatical role assignment during functional processing. The results are consistent with a model in which the first available lemma is assigned to the “highest” grammatical role possible (Bock, 1987a). In another study that focused on older adults, speakers produced dative alternations in response to the order of visual fixation for words (Davidson et al., 2003, Experiment 2). Speakers constructed sentences using words that were presented on a computer monitor, and the trials varied in whether or not the lexical stimuli left the speaker free to choose between a double-object dative and a prepositional dative (e.g., “I told the manager a story” vs. “I told a story to the manager;” Davidson et al., 2003, p. 543). Prior to the presentation of the post-verbal nouns (e.g., manager / story; presented simultaneously, side by side), a fixation cross appeared in the position of the leftmost noun. The results revealed that, when the stimuli allowed it, the speakers’ choice of dative structure placed the cued noun in the referents – thought to affect ease of conceptualization and thus lexical processing at the functional stage – influenced recall errors that involved alternations of grammatical role, such as active/passive alternations. In contrast, differences in word length influenced inversions in the serial ordering of words not involving changes in grammatical role assignment, such as the order of nouns within a conjoined noun phrase. Overall, the findings support the expectation that processing manipulations affecting the lexical stream can influence the form of sentence, as well as the expectation that processing effects occurring “higher” up in the planning process are more likely to affect grammatical role assignment (Bock & Warren, 1985).
earlier-occurring sentential position. Finally, in a study that also manipulated the order in which visual attention was directed to the elements in a scene (Gleitman et al., 2007, Experiment 2), participants described scenes using either the active or the passive. Just prior to the onset of the scene, a brief flash occurred in the position of the agent or the patient. The flash was intended to capture the speakers’ attention outside of their awareness. This manipulation affected the speakers’ choice of sentence structure – they were more likely to move away from the preferred active voice and produce a passive when the cue favoured early focus on the patient. In the interpretation of their results, Gleitman et al. pointed to differences in the timing of lemma activation following from differences in the direction of attention, noting the similarity to the presumed mechanism reported by Bock (1986a).

1.2.2.2 Lexical Activation Effects on Processing Efficiency

A handful of studies, then, support the proposal that manipulations of activation timing affecting the lexical processing stream can influence speakers’ choices between alternative sentence structures. These alternations rely on some level of flexibility at the syntactic level to allow structure building to follow lexical activation order. As noted above, however, speakers also often have syntactic preferences or experience syntactic processing constraints that may or may not be compatible with lexical activation order within a given moment. For example, although the timing of noun activation (e.g., early activation of the patient) can override speakers’ strong tendency to prefer active sentence structures (e.g., Altmann & Kemper, 2006; Bock, 1986a; Gleitman et al., 2007), the effect is far from absolute. Even when activation order favours placing the patient in the subject role, speakers nonetheless very often opt for an active structure, assigning the patient to the object role. Costs to processing efficiency, related to time
and WM capacity, may occur in these instances when there is a mismatch or conflict between lexical activation order and grammatical role assignment.

Little research has directly examined the proposal that buffering words during language production draws on WM capacity, taking energy away from other aspects of production. Indeed, relatively few studies have examined the relationship between WM and language production mechanisms at all (but see, for example, Daneman, 1991; Kemper & Sumner, 2001; and a recent proposal by Acheson & MacDonald, 2009, that the same system of knowledge and processing underlies language production and performance on verbal WM tasks). However, in a relevant study, Hartsuiker & Barkhuysen (2006) demonstrated that a WM load incurred from remembering word lists can negatively affect language production processing. In this study, maintaining an added WM load resulted in a higher rate of subject-verb agreement errors relative to a no-load condition, for adult speakers with low (but not high) WM ability. The results of this experiment indicated that the computation of subject-verb agreement was WM-dependent and that the word lists added strain to WM capacity, with negative effects on performance. The lexical maintenance load in this experiment was, of course, externally-induced and processed by the participants with explicit awareness, whereas the proposal put forth by Bock (1982) is more in line with processing load incurred during implicit processing of words. However, the results reported by Hartsuiker and Barkhuysen are at least consistent with the idea that maintaining words in WM can negatively affect language production processing and success.

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9 Agreement errors were elicited in contexts where the sentence subject is singular, but a plural noun intervenes between the subject and verb (e.g., “The cup for the winners ....” – participants then complete the fragment; Hartsuiker & Barkhuysen, 2006, p. 187). Speakers with lower WM spans who had to concurrently remember a list of words produced a higher rate of these errors than those who did not have to manage the additional WM load. In this study, agreement errors were almost non-existent when the intervening noun was also singular (e.g., “The cup for the winner ...”, p. 187), for speakers in both the no-load and WM-load groups.
More direct tests of the relationship between lexical activation order, sentence structure, and processing efficiency are limited and have produced more variable findings. To date, only one study has directly tested the expectation of a relationship between lexical activation order, sentence structure and WM capacity (Slevc, 2011). In this study, speakers were presented with a cue word (Experiment 1) or question (Experiment 2) that allowed them to find a target picture within a group of pictures. The pictures depicted scenes that could be described with dative structures (e.g., “The pirate gave the book to the monk,” or “The pirate gave the monk a book,” Slevc, 2011, p. 1503). The cues made reference to either the theme or goal within the picture (e.g., book or monk), and were intended both to help the speaker locate the relevant stimulus picture and to influence the activation status of the relevant noun. The participants located and described the target picture either under a condition of no WM load, or while maintaining a list of words in memory. The results revealed that WM performance (recall of words after producing the sentence) was better when the dative form chosen for the response placed the cued item in the earlier-occurring position. This effect on WM performance provided direct support for the idea that the relationship between activation order and sentence structure affects WM capacity. However, this effect on performance was only found in Experiment 2, where the cue was given as a question that affected the given-new status of the referents (e.g., “What’s going on with the pirate and the book?”). This cue was interpreted by the author as a particularly “strong manipulation of accessibility” of the cued item (Slevc, 2011, p. 1507). Further evidence regarding WM involvement in production order effects was more challenging to interpret. In particular, the results across several experiments revealed that the effects of the cue on sentence structure were actually stronger in the no-load condition than in the WM-load condition. That is, speakers were more likely to produce the cued noun in the earlier position when the externally
induced WM load was absent. Given the expectation that early placement can help to reduce overall WM processing load – or act as a WM “release valve” (Sleve, 2011, p. 1511) – a higher rate of early placement might be expected when WM capacity is under greater strain – that is, when the WM load is present. The author, however, argued that the interaction between early placement and WM load (however unexpected in its direction) nonetheless indicated a relationship between WM and early-positioning effects. Sleve suggested alternative mechanisms, other than the “release valve” motivation, to account for the relationship between WM load and early placement. The externally induced WM load may have disrupted the maintenance or retrieval of the early-activated item, preventing early placement, or may have interfered with encoding of the cued word in the first place. While the results reported by Sleve provide some support for the expectation that lexical activation effects on sentence structure interact with WM constraints, more research on how these effects are manifested is clearly needed.

Finally, the few studies that have examined other measures of processing efficiency related to lexical activation and sentence structure have produced mixed results. As noted above, Davidson et al. (2003) reported that a visual cue to fixation order influenced speakers’ choices among dative alternatives. Surprisingly, however, measures of reaction time (RT) and dysfluency, taken as indicators of processing difficulty, did not differ between responses in which sentence structure followed the cue manipulation and those in which there was a mismatch. The study reported by Altmann and Kemper (2006), in contrast, provides some evidence in line with the notion that mismatches between lexical activation order and sentence structure may produce RT costs. In one analysis within this study, when the word presentation order favoured the passive, older adults’ speech onset times for active transitive sentences were slower than their onset times for passive sentences in the same presentation context (the authors
did not report within-structure comparisons for different word presentation orders, such as a comparison between active responses in presentation contexts favouring the active versus the passive). One potentially important difference between these two studies may lie in the sentence structures that were studied. In the former, the alternation of interest was between double-object and prepositional datives. The difference between these forms lies in the arrangement of the post-verbal content. In this case, even when the cued element was produced immediately following the verb, it still was produced relatively late in the sentence (and, therefore, possibly created buffering costs earlier in the sentence). In contrast, manipulations involving the active-passive alternation are concerned with the assignment of lexical items to the subject position. In such cases, the choice of sentence structure more clearly affects whether an activated item is produced very early or at the end of the sentence, and may therefore produce greater processing consequences. Finally, it is of interest to note that post-hoc analyses reported by Bock (1987b) indicated that dysfluencies occurred more often when there was a mismatch between word form activation order and production order, in both transitive and phrasal conjunct sentences. Overall, the available literature provides reason to believe that processing costs may be incurred from mismatches between lexical activation order and sentence structure. However, given the variable results and the limited nature of the evidence, more research is needed to understand the nature and manifestation of these costs.

1.2.2.3 Summary

Producing sentences involves a series of activities that are coordinated in time as a non-linear message is elaborated into a linear, forward-flowing sentence. As the sentence plan develops, one task for the production system is to activate, or make available, the words that are
needed to express the content of the message, and assign these words to grammatical roles such as subject and object. One perspective on sentence processing proposes that the order in which words become available to the production system can influence the mapping between words and grammatical roles (Bock, 1982, 1987a; Levelt, 1989). When possible, early-activated words are assigned to earlier-occurring grammatical roles, such as the subject. It has also been proposed (Bock, 1982) that the relationship between activation order and sentence structure has implications for sentence production processing efficiency. When there is a conflict between activation order and production order, time costs may be incurred due to the need to resolve the conflict. As well, the working memory demands associated with producing the sentence may rise, due to the work of maintaining activation of the early-available item until it can be integrated later in the sentence. The resulting strain on processing capacity may have negative effects on the smooth and efficient production of the sentence. Studies examining the effects of lexical activation timing on sentence structure in adults (Altmann & Kemper, 2006; Bock, 1986a; Bock & Irwin, 1980; Bock & Warren, 1985; Davidson et al., 2003; Gleitman et al., 2007) have adopted a range of methods to examine these effects. Overall, they indicate that the time course by which lexical items become available to the production system can indeed influence alternations among potential sentence structure choices. Evidence regarding potential processing consequences of conflicts between lexical activation order and sentence structure is more limited and has been more equivocal. The following sections consider the potential effects of lexical activation timing on children’s sentence production outcomes.
1.2.3 Language Production Processing and Lexical-Syntactic Coordination in Childhood

Given the complexity of the language production process, it is pertinent to ask how production is coordinated and how the process might create challenges for less mature speakers, who are both building their language knowledge base and learning to use that knowledge in the “split-second operations” of speaking (Rispoli & Hadley, 2001, p. 1131). The proposal regarding lexical activation effects on grammatical role assignment and processing efficiency raises interesting questions for our understanding of children’s lexical and syntactic choices and challenges in sentence production. Addressing these questions provides an opportunity to expand our understanding of the real-time lexical and syntactic mechanisms that control children’s sentence structure building: how these processing streams interact, and how these interactions and their effects may vary with development. The following section first provides background on the organization of production planning in childhood, and potential developmental constraints on production ability, before turning to questions of lexical-syntactic coordination.

1.2.3.1 Architecture

To date, there are far fewer process-oriented studies of language production in childhood than adulthood (McKee et al., 2006). However, several studies of speech error and dysfluency patterns point to important similarities between the sentence processing architectures of adults and children (Jaeger, 1992; McDaniel et al., 2010; Stemberger, 1989). Systematic patterns in the nature and scope of naturally occurring speech errors have long provided the basis for insights into the organization of the production system (see Bock & Levelt, 1994; Garrett, 1975). The patterning of speech errors has provided clues about the kinds of information that are “simultaneously computed” or concurrently available at different points during the production
process (Dell, 1986). Although there have been few systematic studies of similar “slips of the
tongue” in children, the evidence that does exist indicates notable similarities between adults and
children in both the kinds of errors that occur and the constraints on those errors (Jaeger, 1992;
Stemberger, 1989). For example, in a diary study of two children followed from ages 1 to 3 and
1 to 6, Stemberger (1989) reported (among other observations) that children and adults showed
the same kinds of similarity constraints on interacting elements. At both ends of the
developmental spectrum, whole-word exchanges tended to occur between words of the same
grammatical class, whereas speech sound exchanges tend to occur between minimally different
phonemes occupying the same syllable position. Moreover, as with adults, when whole-word
exchanges involve pronouns, the exchanged elements are assigned to the grammatical role
associated with their new position, so that the form of the produced word is consistent with the
new role (e.g., “I” produced in the subject position) rather than being produced in error (e.g.,
“me” in the subject position). As with adults, this pattern indicates a process in which
grammatical roles are assigned to abstract word representations, and word forms are retrieved
and produced according to these mappings. Finally, among a number of reported similarities,
Stemberger reported that the high proportion of whole-word exchange errors to sound exchanges
observed in both adult and child speech was consistent with a model (Dell, 1986) in which
“words are selected on the basis of semantic information, and all words in the same clause are
assumed to be accessed at the same time…” (Stemberger, 1989, p. 182). That is, not only do the
speech error patterns of children point to a production system that is organized similarly to that
of adults, many of the noted similarities point to the concurrency of processing that drives
proposals of lexically-guided effects on grammatical role assignment (e.g., concurrency of
processing among lemmas, and between lemma selection and grammatical role assignment).
These similarities indicate that the architecture and literature regarding adult production can provide a relevant framework for questions about the production planning process in children.

1.2.3.2 Developmental Constraints

Although the process by which language forms are activated and coordinated may be adult-like from an early age, children may nonetheless face unique challenges. Children’s productions may be affected by the fact that, at a given point in time, a particular word or sentence structure may not yet have been acquired. And, aside from early gaps in the content of the knowledge base, children’s utterances may be affected by processing capacity limits.

It is well documented that processing capacity (i.e., the amount of cognitive work that can be completed efficiently per unit time) increases with age through early childhood to adulthood (Kail & Salthouse, 1994). Multiple factors may contribute to this increase, including adding representations, adding connections and strengthening connections among existing representations (Kail & Bisanz, 1982). There will be functional gains in processing capacity as processes or access to representations become more automatized (Kail & Bisanz, 1982), and these changes might be observed as general age-related differences, or experience-dependent changes in tasks calling on specific representations. Thus, capacity in language production may be influenced by both domain-general and language specific changes that affect children’s relative computational power within a task. All of these changes may mean that despite an adult-like architecture, young children may nonetheless be vulnerable to some particular processing challenges during production. These challenges may manifest differently for children of different ages, and may be observed with regard to the ease of processing specific representations, and the ease of managing the production task overall.
Turning first to specific representations, children may not yet know all of the forms (e.g., lexical, syntactic, morphological, phonological) that are needed to produce a particular sentence. And, nascent forms, while within a child’s knowledge base, may not be activated and deployed easily in the moment of speaking. This possibility is consistent with the connectionist principle that experience drives connection strengths (Goldrick, 2007). Those forms with which children have relatively less experience may have relatively sparse or weak activation connections, and this may affect the amount of effort that is required to produce them. The likelihood and ease of producing a given sentence may vary with a child’s age and his or her experience with the specific forms that are required. Evidence of this type has been reported with regard to children’s choices and efficiency in producing specific sentence structures (Rispoli & Hadley, 2001; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007). Rispoli and Hadley (2001) demonstrated, for example, that the sentence structures within a young child’s “leading edge” of development, while attempted, are produced with some difficulty. They are produced with a higher rate of disruptions than more familiar forms. Evidence from the syntactic priming literature is also consistent with the notion of changes in the likelihood and ease of activating and producing known forms. This line of research has demonstrated that, like adults, children demonstrate syntactic priming. Although one study indicated that younger children required overlapping lexical items (in the form of pronouns) to demonstrate priming (e.g., Prime: “It got pushed by it”; Target: “It got closed by it”; Savage, Lieven, Theakston, & Tomasello, 2003), other studies have demonstrated syntactic priming effects independent of lexical content, for children aged 3 and older (Huttenlocher et al., 2004; Messenger, Branigan, & McLean, 2011; Miller & Deevy, 2006; Shimpi et al., 2007). Huttenlocher et al. (2004), for example, demonstrated priming of active/passive and dative alternations in 4- and 5-year-old children for prime-target pairs that did
not share lexical content (e.g., Prime: “The flower was watered by the rain;” Target: “The rabbit was chased by the dog”). In addition to providing evidence for the existence of lexically-independent syntactic representations, these priming effects also demonstrated that activation dynamics specific to the syntactic stream can influence children’s choices among structural alternatives. Recently activated syntactic structures were more likely to be produced.

For some young children in some contexts, however, activating and producing “known” forms may not be possible. The children in the Huttenlocher et al. (2004) study demonstrated priming in a variety of conditions – whether they only heard the prime or also produced it, and whether they produced each target immediately after the prime, or heard all primes and then produced all targets as a block. Shimpi et al. (2007) extended the method down to 3-year-old children. In contrast to the more robust effects found for older children, 3-year-olds were sensitive to task parameters. They demonstrated priming effects only when they repeated the prime, and then described the target immediately. When they heard a block of prime sentences with no repetition, then produced a block of targets, they did not. The 3-year-olds required the prime production aspect and/or the short interval from prime to response to demonstrate priming.

In their interpretation, Shimpi et al. (2007) introduced the idea of strength or ease of activation (accessibility) of syntactic representations. The fact that the younger children demonstrated priming indicated that the relevant structures were known to them to some degree. However, some of these structures may still only have been weakly represented, and thus may have required considerable effort to activate and produce. Unless a maximally supportive prior context of activation was provided, they could not be activated easily or quickly enough in the moment of speaking for the influence of the prime to actually be reflected in the chosen structure. This study only compared children at two ages. However, the results are consistent with the idea that
children’s productions may be limited not only by what they know, but also by the strength of or ability to activate that knowledge within a limited-capacity system. The ability to activate known forms in the moment of speaking may pose more of a challenge for younger children than older children, or for less familiar forms relative to more familiar forms.

At a more global level, even where the distribution of speech error and dysfluency phenomena have indicated adult-like production architectures, other patterns have pointed to developmental changes in the capacity to manage the multiple activities and to monitor and make corrections to the appropriateness of the output online (McDaniel et al., 2010; Rispoli, 2003; Stemberger, 1989). For example, although McDaniel et al. (2010) observed many similarities in the speech dysfluency phenomena of 3- to 6-year-old children, 6- to 8-year-old children, and adults, and these similarities supported the conclusion that the organization of the production system is adult-like from a young age, certain patterns in their data also pointed to developmental differences in the ability to effectively operate that system. Among other observations, children were more dysfluent than adults overall, and younger children were more dysfluent than older children. Moreover, the patterning of filled pauses such as uh or um pointed to processing capacity differences. On the whole, adults’ filled pauses clustered at the beginning of sentences. Children, on the other hand, also produced sentence-internal filled pauses, and for the youngest group, sentence-internal filled pauses far outnumbered sentence-initial filled pauses. This pattern of results suggested that young children were less able to plan ahead and “sustain concurrency of processing” (p. 88) during sentence production processing. During sentence production, the younger children appeared to be operating with more restrictive capacity limits.
1.2.3.3 Developmental Considerations for Lexical-Syntactic Coordination

As with adults, the timing of lexical activation may sometimes converge with preferred syntactic structures (e.g., early activation for the agent), and sometimes may not (e.g., early activation for the patient, when an active form is preferred). The noted similarities between adult and child production systems would predict that for children it is at least architecturally possible for grammatical role assignment to follow from the order of lexical activation. Young children may not, however, always have the syntactic ability to flexibly adjust to variations in lexical activation timing, if the relevant sentence structures are not yet known or not yet able to be activated or produced easily. Investigations of lexically motivated alternations in sentence structure, for example, often focus on alternations of the sentential subject to produce passive structures. These are late to emerge in children’s spontaneous speech (Brooks & Tomasello, 1999), possibly difficult to activate (Shimpi et al., 2007), and generally not preferred (see further discussion in the Introduction to Study 1). Although differential timing of lexical activation and potential pressures to make early use of activated items may be a general property of speaking situations, the way in which the production system responds to this pressure may differ according to the potential syntactic alternatives that a context provides and the speaker’s level of control over these alternatives. If placing the early-activated noun in the subject position would require that a child produce an unknown, challenging or infrequently produced sentence structure, he or she may disregard lexical activation order in favour of syntactic constraints. He or she might then have to buffer the early-activated lexical item while remaining lexical items are selected and earlier-occurring constituents are planned and produced. For example, given the intent to communicate a sentence about a princess kissing a frog, if frog happens to receive earlier or greater activation within the sentence-planning context, lexical activation order might
favour the production of the passive form “The frog is being kissed by the princess”. However, if
the passive is not known or not easily produced, the relative costs of attempting the passive form
may be prohibitive – possibly even more prohibitive than the potential costs associated with
lexical buffering. As a result, syntactic constraints may favour disregarding lexical activation
order and producing “The princess is kissing the frog.” In this context, the lexical buffering costs
would be higher than those incurred for the same sentence, if frog did not receive early
activation.

At the same time, the hypothesized relationship between lexical activation order,
syntactic structure, and WM capacity may be particularly relevant in early development. As
noted above, processing capacity increases through childhood to adulthood (Kail & Salthouse,
1994), and young children may operate closer to their capacity limits during speaking tasks. If
sentence production is WM capacity-dependent, and if lexical buffering places extra demands on
WM capacity, then a child’s production capacity limits may be strained or exceeded when there
is a conflict between lexical activation order and syntactic structure. That is, children may have
difficulty absorbing the increased demands related to lexical buffering while continuing to plan
or produce the sentence. In such a situation, capacity limitations may reduce the efficiency or
sufficiency of processing other aspects of the sentence. The following section reviews the
available literature regarding lexical activation and availability effects on children’s syntactic
planning and production.
1.2.4 Lexical Activation Effects on Sentence Production in Childhood

1.2.4.1 Evidence

A handful of studies support the possibility that the order in which words become available during sentence planning may influence young children’s syntactic decisions (Dewart, 1979; Streim & Chapman, 1987; Turner & Rommetveit, 1967, 1968). However, the number of studies is small and the evidence is either indirect, or limited in its applicability to the current question by the methods that were used. Turner and Rommetveit (1967), for example, examined alternations between the active and passive voice produced by children in pre-kindergarten through grade 3 in a picture-scanning task. The participants either viewed the entire scene at once, or viewed elements of the scene in succession through a sliding window. In the latter, “scanning” condition, either the agent or the patient appeared first, and the children were instructed to begin speaking as soon as the first character appeared. Although the children preferred the active, the rate of passive production increased with age. Additionally, more passives occurred in the scanning condition than the free-viewing condition, and more yet when the experimenter modeled the targeted active and passive responses. Consistent with the focus of the study, the higher rate of passives in the scanning condition was presumably due to the trials in which the patient appeared first (although this was not actually reported). Studies have also demonstrated that preschool-aged and young school-aged children are more likely to alternate to a passive sentence in a cued sentence recall task (away from the correct recall of an active transitive sentence) when given a picture of the patient rather than the agent as the recall cue (Dewart, 1979; Turner & Rommetveit, 1968). In these studies, one effect of the recall cue may have been to cause the lexical information for the patient to be highly available relative to the
agent. Of course, the effects of the manipulations in all three of the above studies may have also reflected strategic processes. Both the scanning manipulation (Turner & Rommetveit, 1967) and the recall cues (Dewart, 1979; Turner & Rommetveit, 1968) would have presented a particularly strong cue that the sentence should be “about” the pictured patient. These results, therefore, do not provide a strong indication of whether or not more implicit factors associated with lexical activation order would be equally capable of influencing children’s sentence structure decisions.

In a more direct exploration of some of the hypotheses presented by Bock (1982), Streim and Chapman (1987) provided initial evidence that children may structure their sentences to place early-activated lexical items in an early-occurring sentence role. In this study, 4-, 6-, and 8-year-old children described pictured scenes. In one half of the trials, immediately prior to describing the scene they named a picture of one of the characters. The character appeared exactly as it would appear in the upcoming scene. No picture naming preceded the scenes in the remaining control trials. The results demonstrated that the target characters were named earlier within the sentences that were produced after naming the character in the preceding picture. The picture presentation was intended to influence lexical availability, and the authors interpreted the earlier placement effect as “consistent with … the frequency with which the target appears in the subject position” (p. 62). The results, therefore, at least suggest that lexical availability or activation order can indeed influence children’s sentence structure choices. However, the interpretation of these results is limited in a number of ways. Each picture stimulus depicted multiple characters and several actions, and the stimuli were not constructed to control for the familiarity of referents other than the primed targets or for the range of potential sentence structures and alternations that they might elicit. Perhaps most importantly, although the order effects were interpreted as consistent with an effect on grammatical role assignment, this was not
actually measured. The syntactic forms of the responses were not reported. Instead, the dependent measure of word position was based on counting the number of words that occurred before the target word, and included responses in which the target initially appeared within revised material. It is therefore not possible to conclude whether the repeated word actually appeared as a sentence subject or determine how the sentence structures varied between the control and experimental conditions. Moreover, as with the prior citations (Dewart, 1979; Turner & Rommetveit, 1967, 1968), the explicitness of the manipulation (by exact repetition of the visual image, and by the fact that only the experimental trials required the children to name a picture before describing the scene) also opens up the possibility that responses were influenced by strategic factors (e.g., “talk about the picture you just saw”). Ultimately, Streim and Chapman (1987) concluded that the pattern of results likely represented “the tendency for speakers to topicalize information that has been recently brought to their attention” (p. 63).

Thus, although the effects reported by Streim and Chapman (1987) are certainly suggestive, there is little direct evidence to address whether moment-to-moment variations in the timing of processing within the lexical stream can influence children’s sentence structures via grammatical role assignment. Moreover, to my knowledge, no evidence exists to address the potential processing outcomes associated with conflicts between lexical activation order and sentence structure in children’s productions (e.g., early activation of the patient in an active transitive context). Streim and Chapman (1987) reported an effect of the picture naming manipulation on fluency during sentence production. Lexical access was improved for the target words following naming. However, this analysis did not examine fluency in relation to whether or not the repeated word occurred early or late within the sentence, and therefore does not speak to the question of lexical-syntactic relationships. The following section describes the costs that
might be seen in children’s speech if lexical-syntactic conflicts do indeed create a “processing hazard” during production.

1.2.4.2 Potential Effects of Lexical-Syntactic Conflicts

The available research literature, while providing little direct demonstration of lexical buffering costs to production, points to several effects that might follow from conflicts between lexical activation order and sentence structure. Namely, when a lexical item becomes available early in the planning process but occurs late in the chosen syntactic structure, this conflict may produce costs to time, grammatical integrity, and fluency.

1.2.4.2.1 Time Costs

The first potential effect of lexical-syntactic conflicts on sentence production is a cost to time or speed to begin producing a sentence. This proposed effect is anticipated as an outcome of the need to resolve the conflict before production can happen (Bock, 1982). If the order of lexical activation promotes a grammatical role mapping that cannot be successfully elaborated or is disfavoured enough to not be selected, then the effects of resolving the competition between lexical and syntactic processing priorities might be measurable in reaction time to begin speaking. Thus, for example, speech onset time to produce a sentence such as “The princess is kissing the frog” would be slower in contexts where frog receives early or high activation input than in contexts where the activation timing either favours princess or is neutral between the two lexical items. As noted above, Davidson et al. (2003) reported no effects on RT from conflicts between lexical activation order and dative sentence choice. However, there do not appear to be any studies examining RTs for sentences of similar content and structure that differ in the activation order of words that might serve as the subject.
1.2.4.2.2 Grammatical Morpheme Omissions

Variations in processing costs related to mismatches between lexical activation order and sentence structure may affect the rate of production of grammatical elements such as auxiliary verbs or other bound morphemes or function words. Evidence from both adult- and child-focused research supports this hypothesis. Focusing on adults, Ferreira and Dell (2000) demonstrated that the production or omission of the optional complementizer *that* (e.g., “I know that John is leaving tomorrow” vs. “I know ___ John is leaving tomorrow”) was affected by the activation level of the material that followed the complementizer. Speakers were more likely to omit *that* when the argument that followed it was highly available due to prior mention (e.g., “I knew I missed practice” vs. “You knew that I missed practice”). Ferreira and Dell framed their investigation within the expectation that early or high availability of words that are only produced late in the sentence (e.g., material within the sentential complement) might negatively affect processing efficiency while that word is being maintained in a readied state.\(^{10}\) Rather than focusing on availability-driven alternations in grammatical role assignments and production orders, their results focused instead on production differences within a context of invariant grammatical role assignment. Producing a sentence that omitted the complementizer *that* could allow the activated word to be dispatched sooner. In this study, the sentences that omitted the complementizer were, of course, grammatical. However, the hypothesis of an influence on production versus omission of grammatical elements can be extended to elements that while not necessarily optional may be vulnerable to omission by young children.

\(^{10}\) They also noted that the processing efficiency could be negatively affected if the early activation was lost before the item could be used, requiring re-activation.
A characteristic of language production in early childhood is the omission of various words and obligatory grammatical elements, often related to verb morphology (e.g., Rice, Wexler, & Hershberger, 1998). These omissions are seen in the productions of both typically developing children and children with developmental language impairments (though to different degrees). One perspective on these omissions posits that they reflect the optional selection of non-finite sentence frames during a period when children do not yet know that the use of these morphemes is required (e.g., Rice, Wexler, & Cleave, 1995; Wexler, Schütze, & Rice, 1998). An alternative perspective posits that omissions of various obligatory grammatical elements do not reflect random or optional use. They are instead conditioned by processing capacity constraints, driven by costs incurred from other aspects of the sentence production process (e.g., Bishop, 1994; Leonard et al., 2000; Owen, 2010; Pizzioli & Schelstraete, 2008). According to this perspective, if the total amount of work that is required to produce the sentence exceeds the child’s capacity, one outcome of that processing overload may be failure to produce one of the obligatory morphemes that have so often been shown to be vulnerable to omission.

There are a number of reasons for this vulnerability. These include the fact that many grammatical morphemes may be vulnerable to weak representation due to their surface properties (e.g., relatively brief in duration, often unstressed and often appearing within sentences rather than at the more prominent margins) and the fact that, in English, grammatical morphemes provide relatively less information about the meaning of the sentence than features such as word order (Hsieh, Leonard, & Swanson, 1999; Leonard, Eyer, Bedore, & Grela, 1997; Lindner & Johnston, 1992; see Leonard, 1998 for a discussion). These reasons can be understood within the perspective that capacity allocation decisions in both sentence comprehension and production will be influenced by the relative weighting of factors such as the potential cost of a
form and its information value (e.g., cue cost and cue validity, Bates & MacWhinney, 1989; Presson & MacWhinney, 2011). In English, the properties of grammatical morphemes may cause them to be weakly represented and therefore costly on the one hand, and of less information value than other aspects of the sentence on the other. As processing load rises, these forms may thus be vulnerable.

Studies working within a processing load perspective have demonstrated that variations in presumed sentence production processing costs affect the rate at which children produce or omit grammatical morphemes such as auxiliaries, past tense –ed, and articles. These variations have been manipulated via the complexity of the utterance (Grela & Leonard, 2000; Namazi, 1996; Owen, 2010; Pizzioli & Schelstraete, 2008) and the activation history within the production context (Leonard et al., 2000). These studies were motivated by questions about the production difficulties of children with specific language impairment (SLI), and included children with both typical and impaired language development. In general, these studies have demonstrated that both populations may be vulnerable to omission effects (although not all have shown effects in typically developing children, viz. Namazi, 1996), but they may be more pronounced in younger versus older children, or children with language impairments compared to typically developing children.

Grela and Leonard (2000), for example, reported that children with SLI (M age = 5 years; 3 months) and younger, language-matched peers (M age = 3 years; 10 months) omitted the auxiliary is more often in ditransitive (e.g., “The pig is giving the cup to the mouse”) than transitive or intransitive sentences produced in an elicited production task.11 In this study, no

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11 Interestingly, omissions did not increase when sentences were made longer by the addition of a sentence-final adjunct (e.g., “The pig is giving the cup to the mouse at home”), suggesting that it was complexity rather
effects were observed for typically developing age-matched peers, who never omitted auxiliaries at all. Other research has demonstrated complexity effects on omissions in somewhat older children who, by all theoretical accounts, should be past any period of optional use. In a study of French-speaking children with SLI (\(M\) age = 9;11), age matched peers with typical language development, and language-matched peers (\(M\) age = 5;11), Pizzioli and Schelstraete (2008) demonstrated complexity effects on auxiliary production that were consistent with the findings reported by Grela and Leonard (2000). In other work, Owen (2010) manipulated complexity factors related to sentence type, sentence position, and sentence length in a study of past tense – \textit{ed} production by children with SLI (\(M\) age = 6;7), age-matched and language-matched (\(M\) age = 4;4) peers. The results of this study revealed, among other findings, that past tense –\textit{ed} omissions were more likely in complement than coordinate clauses (the former being more complex). In this study, the difference in complexity between transitive and ditransitive verbs did not influence accuracy in marking the past tense. However, although Owen did not find effects related to verb transitivity (unlike Grela & Leonard, 2000) the overall pattern of results was consistent with the expectation that omissions were more likely as sentence complexity increased.

The above studies were pursued within a framework in which increases to the processing load associated with the sentence may result in children being less likely to produce obligatory grammatical forms. In these studies, the expected rise in processing load was created via changes in sentence complexity. The change in processing load in these studies may have reflected a range of sources, such as the need to access a greater number of lexical items or compute a

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than length per se that drove the effect. A similar finding of no added effect from length was reported by Owen (2010).
greater number of grammatical role assignments (Grela & Leonard, 2000). The focus on lexical activation order pursued in the present study is consistent with a somewhat different expectation. The expectation is that differences in processing load can also occur between two sentences that on the surface appear quite similar in their lexical content and syntactic form, and that these differences can lead to variations in grammatical morpheme use (e.g., “The cat is licking the baby” vs. “The cat ___ licking the baby”). A study of syntactic priming effects on grammatical morpheme production provides support for this expectation (Leonard et al., 2000). In this study, preschool-aged children with SLI and typical language development produced grammatical morphemes more successfully when they were able to re-use a recently produced syntactic frame. Primed and non-primed trials both included the same target sentence structures. Leonard et al. argued that the higher rate of grammatical morpheme production in the primed trials occurred because the prior activation of the sentence frame decreased the demands of syntactic processing. In their study, a manipulation that decreased overall processing costs resulted in grammatical morphemes being more likely to be produced. By the same argument, if overall processing costs increase, then one would predict a lower rate of grammatical morphemes being produced. One source of increase that has yet to be explored is processing costs related to lexical buffering when there is a conflict between lexical activation order and sentence structure.

1.2.4.2.3 Dysfluency

Finally, variations in processing costs related to lexical buffering may also affect production fluency. Dysfluencies may reflect, among other things, difficulties managing the total concurrent processing demands related to the sentence (Bock, 1995; McDaniel et al., 2010). As processing demands increase, speakers may not have the capacity to smoothly manage the
concurrent activities involved in planning and producing language. Overt signs of hesitation may result.

Evidence that processing costs can lead to dysfluencies can be seen in the fact that dysfluencies in children’s speech occur at a higher rate in sentences that are less familiar or at a child’s “leading edge” of development, as well as in those that are longer and/or more complex – and thus, likely to carry higher processing costs – than shorter, simpler sentences (MacLachlan & Chapman, 1988; Ratner & Sih, 1987; Rispoli & Hadley, 2001). Other evidence for a relationship between processing costs, processing capacity, and dysfluencies can be found in the adult-focused literature. In one study (Barch & Berenbaum, 1994) adults spoke extemporaneously under a “no-load” condition or while concurrently engaged in a category monitoring task – that is, with an added WM load. Among the changes to language output that were observed in the dual load condition was a rise in instances of dysfluency, specifically related to filled pauses.\(^\text{12}\) In addition, Daneman (1991) demonstrated that individual differences in WM capacity predict verbal fluency. This study followed the assumption that WM resources are required to manage the multiple concurrent tasks involved in speaking. Participants in this study completed a production span WM task that measured the number of words a speaker could keep in mind while formulating a grammatical sentence for each word. Speakers also spoke extemporaneously for 1 minute on a topic that was provided. The results revealed a significant positive correlation between speaking span (WM) and fluency. The speakers who were able to maintain fewer words in memory while formulating grammatical sentences were also less fluent in their extemporaneous speech. “Fluency” in this study was measured by the number of words produced

\(^{12}\) In this study, a range of dysfluency phenomena were measured. Other dysfluency types also increased in the dual load condition when included within a global measure of dysfluency. However, only filled pauses showed significant dual-task costs on their own.
during that minute. That is, dysfluency phenomena such as pauses and repetitions were not directly measured; however, a likely contributor to the number of words that a speaker produced was how often he or she experienced disruptions in the forward flow of speech.

As noted above, little research has directly examined the occurrence of speech dysfluencies related to lexical activation timing and lexical buffering costs. On the one hand, Davidson et al. (2003) failed to find a rise in dysfluencies when older adults produced dative sentences in which there was a mismatch between the activation order of the post-verbal nouns and their production order. On the other hand, in a study of transitive sentences and sentences containing conjoined noun phrases, Bock (1987b) reported that dysfluencies occurred more often when there was a mismatch between word form activation order and production order. These findings invite further investigation of the relationship between lexical buffering costs and sentence dysfluencies, particularly in the developmental context.

Thus, although the direct evidence regarding lexical activation order and buffering costs is somewhat equivocal, there is support for the expectation that challenges to processing capacity during sentence production produce increases in verbal dysfluencies. The potential costs in the above-cited studies resulted from a variety of sources, such as increases in sentence complexity, as well as externally induced WM load. It also possible that WM costs incurred from conflicts between lexical activation order and sentence structure may negatively affect fluency.

1.2.5 Summary

The language production literature describes an activation-based system in which multiple representations are processed in a staggered and overlapping manner. Important questions about the production process relate to how the different components interact with each
other and how this process is managed within a speaker’s information processing capacity limits. The proposal for lexical availability effects on grammatical encoding is relevant to both questions. It proposes that lexical availability can influence grammatical role assignment and therefore sentence structure decisions, and that conflicts between lexical activation order and sentence structure produce negative consequences for processing efficiency. While adult-based evidence exists for the first part of this proposal, investigation of the processing consequences of lexical-syntactic conflicts has been much more limited.

Although the range and volume of process-related research addressing children’s language production is smaller than that focused on adults, several studies point to similarities in the organization of production planning in children and adults (Jaeger, 1992; McDaniel et al., 2010; Stemberger, 1989). These similarities indicate that the adult-focused frameworks and literature can be used to guide questions about children’s language production processing. The noted similarities between adult and child production systems would predict that for children it is at the very least architecturally possible for grammatical role assignment to follow from the order of lexical activation. At the same time, children may have more limited language options than adults, and may be particularly vulnerable to strains on processing capacity during production. Moreover, young children may not always have the syntactic ability to flexibly adjust to variations in lexical activation timing via grammatical role assignment. Limitations in syntactic flexibility may result in production situations in which there is a mismatch between lexical activation order and production order. In these situations, costs to the efficiency and sufficiency of production may be observed related to speech onset time, the production of grammatical morphemes, and fluency.
1.3 Overview of Current Investigation

1.3.1 Research Questions and Hypotheses

The purpose of this investigation was to examine the role that the timing of lexical activation and selection plays in determining children’s sentence production outcomes. The methods were designed to keep the message and discourse constraints constant across different lexical activation contexts. They were also designed to control for the relative familiarity of the different referents within the sentence, as well as the range and developmental difficulty of sentence structures that the message was likely to elicit. The questions of interest examined whether the timing of lexical activation can influence the developing syntactic plan, whether mismatches between lexical timing and syntactic plans produce disruptions to sentence production efficiency and integrity, and whether these effects vary with age or WM ability in early development. Specifically, it addressed the following questions:

1. **Can the dynamics of lexical processing, via grammatical role assignment, influence children’s sentence structure decisions?**
   - **Do children produce sentence structure alternations to place early-activated lexical material in early-occurring sentence roles?**
   - **More specifically, given early lemma-level activation for the thematic role of patient, do young children choose sentence structures that place the patient in the subject position?**

This question addressed the architecture and priorities of sentence planning and production. It examined sentence production in the context of transitive scenes that typically elicit active transitive sentences, placing the agent in the subject position and the patient in the
object position (e.g., “The princess is kissing the frog”). Although young children are expected to prefer the active transitive, it was hypothesized that they would overcome this preference (to some extent) in order to assign the early-activated patient to the subject role.

2. Do conflicts or mismatches between lexical activation timing and sentence structure (i.e., lexical production order within the sentence) produce costs to children’s sentence production efficiency and integrity? Do these conflicts lead to:

   • Slower production onsets?

   • Omissions of grammatical morphemes, more specifically the auxiliary *is*?

   • Higher rates of sentence production dysfluency?

These questions addressed the possibility that lexical processing can prove to be a hazard during sentence production (Bock, 1982, p. 13). It was expected that children would sometimes override their preference for the active transitive in order to place the early-activated patient in the subject position. However, it was also expected that they would often disregard the lexical pressure and persist with the active transitive, producing the early-activated patient late in the sentence (e.g., “The princess is kissing the frog”). It was hypothesized that, in these instances, the mismatch between lexical processing and syntactic plans would negatively affect response speed due to the time needed to resolve the conflict, and would negatively affect auxiliary production and fluency due to the increase in WM costs incurred from lexical buffering requirements.

Further questions examined the influence of factors related to age, syntactic context, and WM ability on the answers to the above questions.
3. **Does the likelihood of early placement vary with age or the difficulty of the alternation that would be required?**

This question addressed the effects of knowledge and experience on the ability of lexical activation order to influence sentence structure choices. A common alternation to the active transitive, placing the patient in the subject position, is to produce a passive sentence (e.g., “The frog is being kissed by the princess”). It was hypothesized that older children, relative to younger children, would be more likely to know the passive and/or be able to access the passive structure efficiently in the moment of speaking, and would therefore be more likely to produce these alternations when the patient received early activation. Moreover, it was hypothesized that children would be more likely to produce alternations away from the preferred active transitive if they could rely on a relatively familiar and simple syntactic structure to place the activated patient in the subject position. This question was addressed by examining children’s responses in contexts that would allow the relatively simple agentless intransitive in addition to the passive alternation (e.g., “The apple is being rolled by the monkey” / “The apple is rolling”; see the Introduction to Study 1, below, for further discussion of this distinction).

4. **Do the processing consequences of lexical-syntactic conflicts vary with age or WM ability?**

This question addressed the expectation that the extent to which lexical-syntactic conflicts would prove disruptive would be related to a speaker’s overall level of vulnerability to processing difficulty within the speaking context. Given developmental changes in processing capacity, it was expected that the relative costs incurred from lexical-syntactic conflicts would be greater for younger children who may already be operating closer to capacity limits. It was also
expected that the relative costs of lexical-syntactic conflicts would be negatively related to WM ability.

1.3.2 Research Plan

The questions in this investigation were addressed in two studies, both focused on typically developing 3- and 4-year-olds and 6- and 7-year-olds. In order to externally manipulate lexical activation timing (what is, fundamentally, an internal event), this study followed Bock (1986a) and made use of a semantic priming manipulation, paired with sentential descriptions of transitive scenes. Study 1 examined semantic priming effects in a picture naming task, and examined children’s sentence structure choices in a separate scene description task. The results of Study 1 provided independent evidence regarding the ability of the prime manipulation to influence lexical activation dynamics. It also documented the range of sentence structures that the children in the two different age groups produced, both when they were free to respond with their preferred structures, and when they were compelled to place the patient in the subject position. In Study 2, the semantic priming manipulation was integrated with the sentence production task in order to examine the effects of early activation of the patient (via the prime manipulation) at the sentence production level.

The Introduction to Study 1 that follows provides further background regarding semantic priming as a means to manipulate the timing of lexical activation, as well as further background regarding developmental patterns in the frequency of production for different patient-subject sentence patterns.
Chapter 2: Study 1 Introduction and Method

2.1 Introduction

2.1.1 Purpose

Study 1 addressed two purposes. It provided baseline data regarding children’s preferred sentence patterns when describing transitive scenes, as well as their patterns when pressured to begin with the patient in the subject position. It also provided evidence of the effects of semantic priming on children’s lexical processing as measured by picture-naming reaction time (RT).

2.1.2 Syntactic Alternations of the Sentence Subject for Transitive Scenes

Transitive verbs describe the action of a causal agent on a patient. English speakers have a strong preference to describe transitive scenes using active transitive structures. As noted in the previous chapter, speakers may nonetheless alternate away from this preference in order to place a highly available patient in the subject position (Altmann & Kemper, 2006; Bock, 1986a; Bock & Warren, 1985; Gleitman et al., 2007). Alternations of the sentence subject might be difficult or unlikely with young children, particularly if they require production of passive voice sentences. The following sections describe relevant patterns in children’s use of the passive as well as the agentless intransitive, a structure that may provide an alternative patient-subject solution.

2.1.2.1 The Passive Alternation

2.1.2.1.1 Description

Most transitive verbs can be expressed in the passive voice. Pinker (1989) notes that passivization works best with action verbs having an agent and a patient. The passive places the
focus on the patient (Brooks & Tomasello, 1999), but communicates the same (or very similar) underlying proposition as its active counterpart (Brooks & Tomasello, 1999; Turner & Rommetveit, 1967, 1968). The sentence “The baby is being licked by the cat”, for example, communicates the same underlying event as “The cat is licking the baby”. In addition to the difference in the mapping between thematic roles and grammatical roles, passives differ from actives in their morphological and syntactic requirements, requiring the ‘be’ or ‘get’ verb, the past participle form of the lexical verb, and in the case of full passives, the by preposition heading the by-phrase.

2.1.2.1.2 Developmental Patterns

The passive emerges in production later than the active transitive. Brooks and Tomasello (1999), for example, reported that children do not tend to “produce full passives in their spontaneous speech until 4 or 5 years of age” (p.29). And, elicitation studies focusing on younger children have demonstrated earlier and/or greater success with active than passive forms. In the syntactic priming study reported by Shimpi et al. (2007), for example, the youngest child to produce the full primed active form was 2;6. The youngest child to produce the full primed passive form, in contrast, was 3;5. Moreover, research by Brooks and Tomasello (1999, Experiment 1) demonstrated that more than half of 3-year-old children who had learned a novel verb in a passive frame were able to subsequently produce that verb in an active sentence frame. In contrast, only 12% of children the same age were able to produce a novel passive after learning the new verb within an active frame. When children do produce passives, they produce get-passives far more frequently than be-passives, and also produce a high rate of truncated
passives (e.g., “The cat is getting licked”) (Harris & Flora, 1982; Marchman, Bates, Burkardt, & Good, 1991).

There are a number of reasons that might contribute to the late emergence of the passive in children’s speech, including the fact that it occurs with a low frequency in the speech that children hear, and is a “marked” structure containing forms that are not present in active structures (Brooks & Tomasello, 1999). However, elicitation studies demonstrate that children as young as 3 and 4 years old do produce them when supported by the appropriate discourse/pragmatic conditions and/or processing conditions (Dewart, 1979; Harris & Flora, 1982; Huttenlocher et al., 2004; Marchman et al., 1991; Messenger et al., 2011; Savage et al., 2003; Shimpi et al., 2007; Turner & Rommetveit, 1967; Vasilyeva, Huttenlocher, & Waterfall, 2006). Researchers have elicited the passive from preschool-aged children with prompt questions that highlight the patient (e.g., “What is happening to the [Patient]?”; What is happening? Tell me about the [Patient]”) (Brooks, Tomasello, Dodson, & Lewis, 1999; Harris & Flora, 1982; Marchman et al., 1991). And as noted above, preschool-aged children produce passive sentences following passive primes in syntactic priming studies (Huttenlocher et al., 2004; Messenger et al., 2011; Shimpi et al., 2007).

Elicitation studies demonstrate, then, that even preschool-aged children are capable of producing passive sentences. These studies have also demonstrated that the rate of passive production tends to increase with age from preschool through school age (Brooks et al., 1999; Harris & Flora, 1982; Marchman et al., 1991; Turner & Rommetveit, 1967). For example, Harris and Flora (1982) reported that 8-year-old children ($M$ age = 8;5) were more responsive to prompts that pulled for the passive than young 6-year-olds ($M$ age = 6;1) and 4-year-olds ($M$ age = 4;6). Similarly, Marchman et al. (1991) reported that the rate of passive production following a
patient-focused prompt (“Tell me about the [Patient]”) increased steadily over development from the age of 3;1 to 11;11. At age 3, fewer than 20% of responses took the form of a truncated or full passive. By age 7, that value approached 40%. Although the overall rate of passive use by the 3-year-olds was very low, the majority of children at this age (67%) produced at least one passive during the experiment. Many of the younger children thus “knew” the passive to some extent, but for some reason produced it at a very low rate. Marchman et al. (1991) pointed to age-related changes in the relative strength of the passive structure and its association with the response context. Thus, even when younger children “know” the passive, they may be less able or likely than older children to produce it in a given moment of speaking. This perspective is consistent with the finding reported above that 3-year-olds require more task-structure support than 4-year-olds to demonstrate syntactic priming effects (Shimpi et al., 2007).

Finally, the literature provides evidence that the likelihood or ability to produce a passive response may vary with recent experience. Savage et al. (2003) reported that the rate of production for primed passive sentences increased from the first to the last (fifth) trial in a syntactic priming task (but cf. Huttenlocher et al., 2004; Messenger et al., 2011, who did not observe similar trial order effects). That is, the priming effect “built up” over successive trials. This increase was observed for 4- and 6-year-old children. A similar increase was not observed for primed active transitive sentences, reportedly due to the fact that production of the active transitive was already at ceiling from the start. This pattern of changing use across trials is consistent with the idea that the likelihood of passive production will be affected not only by whether the form is known, but also by the child’s recent and long-term experience with the structure.
In summary, the literature suggests that younger children (e.g., preschool age) will be less likely or less able than older children to produce a passive structure response when pressured to begin with the patient in the subject position. The rate of passive production may be influenced by both gaps in the knowledge base, and (long- and short-term) changes in the strength of or ability to activate available knowledge when needed. It is likely that both older and younger children may be affected by considerations of strength and activation. However, these considerations may exert a greater force on the production patterns of younger children, who can be expected to have relatively less experience with the structure.

2.1.2.2 Anti-causative (Agentless Intransitive) Alternation

2.1.2.2.1 Description

Different verbs offer a different range of syntactic options for alternating to a patient-subject structure. In addition to passive sentences, some transitive verbs can also be used in intransitive (active) patient-subject sentences. These verbs participate in the anti-causative alternation, from an active transitive to an agentless intransitive sentence that places the patient in the subject position. The verb *roll*, for example, participates in the active/passive alternation (e.g., “The monkey is rolling the apple” / “The apple is being rolled by the monkey”) and can also be expressed in an intransitive sentence such as “The apple is rolling.” Transitive verbs that participate in this alternation are those verbs that are “identical in form to an intransitive verb signifying the caused event” (i.e., lexical causatives, Pinker, 1989, p. 48). *Roll*, for example, describes both the action of the agent monkey in the above example, and the consequent action of the patient apple. The anti-causative alternation tends to be possible with contexts and verbs describing extrinsic changes of physical state and motion in a particular manner, produced
through direct physical (causal) contact (Levin, 1993; Loeb, Pye, Richardson, & Redmond, 1998; Pinker, 1989). Importantly, the agentless intransitive sentence structure that is produced in this alternation removes reference to causality or the causal agent. It thus differs somewhat from the active transitive in the propositional content that it expresses. Relative to the passive, however, it has a simple, early-developing structure. For this reason, it may provide a viable option for young children to place a highly available patient in the subject position when the context and the verb choice allows.

2.1.2.2 Developmental Patterns

Less information appears to be available regarding children’s use of the anti-causative alternation. However, several pieces of evidence suggest that the agentless intransitive\(^{13}\) should be easier or more available to young children than the passive. Notably, it requires only the production of a simple intransitive sentence. Elicited production research that has “pulled” for either transitive (agent-subject) or intransitive (patient-subject) sentences with lexical causatives has reported similar performance among 2- to 4-year-old children and adults (Braine, Brody, Fisch, & Weisberger, 1990), as well as similar performance among children with SLI, age-matched, and younger, language-matched peers (Loeb et al., 1998). In the research reported by Loeb et al., typically-developing 2½- to 4-year-old children and 5- to 6-year-old children with SLI used the agentless intransitive equally as often as typically-developing 5- to 6-year-olds. In contrast, they produced the passive, when called for, less often.

\(^{13}\) The term “causative alternation” or “anti-causative” alternation describes the pattern of alternating between a transitive form and an intransitive form that does not reference causation. The term “agentless intransitive” describes the patient-subject structure that is produced within this alternation.
In the above studies, the agentless intransitive structure was elicited via patient-focused questions that emphasized the action of the patient (e.g., “What did [the Patient] do?”; Braine et al., 1990; Loeb et al., 1998). Young children have also been observed to sometimes produce intransitive forms in studies designed to elicit the passive. In the study reported by Harris and Flora (1982), for example, two of the six stimulus items were designed to elicit lexical causative verbs (break, spill). The authors reported that the 4-year-old, but not the 6- or 8-year-old participants sometimes produced the agentless intransitive with these verbs. In this study, children were also observed to substitute lexical causative verbs for target verbs, and use these new verbs in agentless intransitive structures. Harris and Flora (1982) reported that, “… with age the percentage of intransitive responses tended to decrease and the percentage of passive responses with get tended to increase” (p. 308). Moreover, Marchman et al. (1991) suggested that where possible children will use “legal” means to avoid the passive when responding to the conditions that call for a passive. Although they did not examine lexical causative verbs or report on the use of the agentless intransitive form, the available literature suggests that this structure may indeed provide a “legal means” to avoid the passive while satisfying processing pressure or a discourse requirement to place the patient in the subject position.

2.1.2.3 Summary and Predictions

Together, these lines of evidence suggest that the passive and agentless intransitive may present different levels of availability or ease of syntactic alternation for young children. Children may thus be more likely to produce patient-subject sentences when in addition to the passive, the agentless intransitive is also possible. Many of the studies cited above elicited passive and agentless intransitive structures with specific questions that pulled for one or the
other of the structures. In the current investigation, in contrast, the sentence elicitation contexts were designed to create pressure for children to produce patient-initial sentences, but the wording of the elicitation prompts did not pull for any one structure in particular. This study (Study 1) examined children’s syntactic choices when given an explicit cue to begin with the patient, before examining responses to implicit lexical activation pressure in Study 2.

As described above, the second purpose of Study 1 was to provide baseline evidence on the effects of semantic priming on lexical activation speed. Study 1 examined priming effects in a picture-naming task prior to extending the prime manipulation to a sentence production context in Study 2. The following section provides relevant background regarding semantic priming.

2.1.3 Semantic Priming of Lexical Access

2.1.3.1 Description and Rationale

Semantic priming describes the phenomenon in which processing a prime stimulus facilitates the subsequent processing of a semantically-related target stimulus (McNamara & Holbrook, 2003). Semantic priming is observed in a variety of paradigms, and is typically observed as faster or more accurate responding within the primed context. Lexical production studies of semantic priming, for example, demonstrate that speakers name pictures and/or produce words more quickly or accurately when they are preceded by semantically-related pictures or words, relative to when they are preceded by unrelated items (Bajo, 1988; Carr, McCauley, Sperber, & Parmelee, 1982; Huttenlocher & Kubicek, 1983; Lupker, 1988; Sperber, McCauley, Ragain, & Weil, 1979). Importantly, the external or measureable outcomes of priming manipulations are typically attributed to internal changes of activation in relevant pathways or representations (Chapman, Chapman, Curran, & Miller, 1994; Collins & Loftus,
1975). Study 1 will examine semantic priming effects on reaction times (RTs) to name pictures, with the expectation that internal changes of activation will lead to faster RTs in the primed context. Study 2 will seek to harness this internal change as a tool to manipulate the timing of lexical activation and selection during the sentence production process.

The priming paradigm demonstrates a number of features that make it particularly suited to questions of the type that are pursued in this investigation. First, priming does not require conscious or strategic processing. Although expectancy effects can occur when there is a high proportion of related trials, there is also good evidence for an automatic component (Huttenlocher & Kubicek, 1983; see also Sperber et al., 1979).

A second benefit of the priming paradigm is that it allows for a task structure that preserves some of the naturalness of the production process. As noted in Chapter 1, the achievement of methodological control over lexical availability may come at the expense of the naturalness of the production context. One approach, for example, has asked speakers to construct sentences on the basis of printed words presented on computer monitors (e.g., Altmann & Kemper, 2006; Davidson et al., 2003). One potential challenge with methods that pre-specify much of the lexical and/or syntactic content in advance is a risk of changing the fundamental nature of the process under investigation. Picture stimuli, in contrast, allow for some control over the nature of the message that is constructed and thus the likely range of responses, while placing less constraint on how the production process unfolds (Bock, 1996). Priming, when paired with picture-elicited sentences (Bock, 1986a), provides a means to externally manipulate some of the lexical activation dynamics during sentence production without otherwise distorting the planning process.
A final benefit of the priming paradigm is that it is easily adapted to the knowledge and abilities of young children. Production priming studies have often made use of picture prime stimuli and a simple picture naming response (e.g., Bajo, 1988; Carr et al., 1982; Huttenlocher & Kubicek, 1983; Lupker, 1988; Sperber et al., 1979). Pictures have the advantage that they do not require reading ability, and in fact tend to produce more robust priming effects than written word stimuli (Bajo, 1988; Carr et al., 1982; Sperber et al., 1979).

Thus, priming is in many ways ideally suited to examining children’s sentence productions, allowing for some control over the dynamics of lexical processing, while leaving much of the sentence planning process unaffected by strategic decisions or excessive external control.

2.1.3.2 Mechanism

Following from the work of Collins and Loftus (1975) semantic priming effects have long been accounted for in terms of spreading activation mechanisms (McNamara & Holbrook, 2003).\textsuperscript{14} The potential influence of a semantic prime on lexical activation and selection can be understood as the result of spreading activation and residual activation within and between conceptual/semantic and lemma-level networks. Models of lexical access vary with respect to how certain components of these networks are represented, and therefore it is possible to imagine somewhat different routes to the facilitation of lemma activation following a semantic prime.

Within the model of Levelt et al. (1999), for example, concepts are represented in a unitary or non-decomposed manner. Related concepts share connections that index different

\textsuperscript{14} As noted by McNamara & Holbrook (2003) Collins and Loftus’ (1975) conception of spreading activation as the mechanism for priming has become the “canonical” view of priming, even though theories of semantic/conceptual memory have evolved and sometimes diverged considerably from the original theory described by Collins and Loftus.
aspects of their shared meaning, and lexical concepts (a subset of the full range of concepts) connect to lemmas in a one-to-one manner. As a lexical concept receives activation, it spreads the full proportion of activation to its connected lemma. At the same time the activated lexical concept spreads a more limited proportion of its activation to connected concepts, which in turn spread activation to their connected lemmas.\(^{15}\) Within a priming context, residual activation can be expected to facilitate subsequent processing of the concepts and lemmas that had previously received secondary activation.

Within this framework, the priming process during picture naming can be imagined as follows. The prime picture activates the relevant concept, for example the lexical concept CATERPILLAR. Activation from the lexical concept CATERPILLAR spreads in two directions: Activation spreads to the lemma ‘caterpillar’, so that lexical selection can occur (and along the rest of the production pathway, resulting in production of the name \textit{caterpillar}). In addition, some activation spreads from the concept CATERPILLAR to connected concepts, such as BUTTERFLY, and from the concept BUTTERFLY to the lemma stratum. Subsequently, if a target picture of a butterfly is then presented, activation input to the target lemma ‘butterfly’ has a head start due to residual activation along the target pathway. All other things being equal, selection of butterfly should thus occur earlier in a primed context.\(^{16}\)

\(^{15}\) The model described by Levelt et al. (1999) is strictly feed-forward from the lemma level onward during production (i.e., from the lemma to the word form and so on), but allows bidirectional input between the lemma and conceptual levels. Activation can therefore continue to spread from the concept to the lemma, back to the concept and so on.

\(^{16}\) This expectation is specific to the contexts where the prime and target are presented in a non-overlapping manner. In studies of picture-word interference, when a semantically related word is presented very close in advance of (e.g., 150 ms) and overlapping with the target picture, the opposite effect of slower naming is observed (e.g., Schriefers, Meyer, & Levelt, 1990). The negative impact on reaction time is attributed to interference from competition at the lemma level. The issue of how to account for this “paradox” (Bloem & La Heij, 2003; Bock, 1996) of semantic inhibition in some contexts and facilitation in others has yet to be fully resolved. However, the effect of semantic primes is clearly sensitive to the stimulus onset asynchrony (SOA). Researchers have noted that facilitation is the expected outcome in ‘successive stimulation paradigms’ (i.e.,
Within a distributed, interactive activation model, such as that of Dell and colleagues (e.g., Dell, 1986; Dell et al., 1997), the priming process can be imagined as the result of interactive connections between more distributed semantic features and the lemma level. Within these models, semantic meaning is represented as a pattern of activated features rather than a unitary chunk or node, and each feature maps to more than one lemma. When the pattern of semantic features that are relevant for a lemma become activated, activation spreads to that lemma, and some amount of activation also spreads to other lemmas that are also connected to a subset of the activated semantic features (and on through the rest of the production pathway). The activation of these other lemmas then feeds back to relevant features at the semantic level. We can once again imagine that, within a priming context, residual activation will facilitate subsequent processing of the semantic features and lemmas that had previously received activation via their shared relationships with the prime.

Within this framework, the priming process during picture naming can be imagined as follows. The prime picture activates a set of semantic features, for example a set of features related to the meaning of CATERPILLAR (e.g., insect, cocoon). Activation from these features then spreads to the lemma level. The full set of features will activate the lemma ‘caterpillar’. Some features will additionally spread activation to the lemma ‘butterfly’. Activation will them feed back from the lemma ‘butterfly’ (and on through the production system) to the range of semantic features associated with BUTTERFLY, and so on. Subsequently, if a target picture of a butterfly is then presented, activation input to the target lemma ‘butterfly’ has a head start due to

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where the prime and target do not overlap, Bock, 1996) or in studies with 'longer SOAs' (Alario, Segui, & Ferrand, 2000).
residual activation along the target pathway. All other things being equal, selection of butterfly should thus occur earlier in a primed context.

2.1.3.3 **Semantic Priming in Children**

Several studies have demonstrated semantic priming in a picture naming context with young children (McCauley, Weil, & Sperber, 1976; Pellowski & Conture, 2005). McCauley et al. (1976) reported that children in kindergarten and grade 2 were faster to name pictures following semantically-related than unrelated prime pictures. The children named both the prime and the target stimuli, and similar results were obtained with inter-stimulus intervals of both 1 s and 3 s from the onset of the prime response to the onset of the target picture. Pellowski and Conture (2005) reported that typically-developing 3- to 5-year-old children, but not children who stutter, were faster to name pictures following auditory primes that were presented 700 ms before the target picture. These studies demonstrate that children, like adults, demonstrate priming effects.

Although young children demonstrate priming effects, outcomes may be affected by the nature of the prime-target relationship. Priming requires that the relevant relationships be represented in the speaker’s conceptual knowledge base (McNamara & Holbrook, 2003). Different kinds of relationships may be represented and, therefore, amenable to priming. Of particular relevance is the distinction between categorical and thematic relationships. Categorical or taxonomic relations refer to relationships among things of the same kind that share features (e.g., pig/horse; apple/banana; Lin & Murphy, 2001). Thematically-related items, on the other hand, are related by an event schema (Hashimoto, McGregor, & Graham, 2007). Thematic relationships refer to a wider range of connections based on spatial or temporal co-occurrence,
including spatial relationships, functional relationships, causal relationships, and temporal relationships (e.g., *mouse*/*cheese*; *feet*/*shoes*; Lin & Murphy, 2001). There is some evidence to suggest that thematic relationships may produce more reliable priming than categorical relationships in younger or otherwise less cognitively and linguistically advanced children (McCauley et al., 1976; Nation & Snowling, 1999). In the production study reported by McCauley et al. (1976), for example, the primes varied in whether they were categorically related to the targets, thematically related, related both categorically and thematically, or not related at all. The results demonstrated that the nature of the prime-target relationship interacted with the children’s age. The older children demonstrated significant facilitation with both categorically-related and thematically-related primes (independently and together), whereas the younger group demonstrated significant priming effects only when there was a thematic relationship present (with or without a categorical relationship). This finding was consistent with the view that young children’s conceptual organization may include thematically organized connections prior to categorically organized connections. Ultimately, young children do

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17 These kinds of relationships are often also referred to as associative. The term “associative” has been used in different ways by different authors. One meaning of “associate pairs” describes pairs of words generated during word association tasks, where speakers provide the first word that they think of in response to a stimulus word. Associate pairs may include categorically-related items, thematically-related items, or items where the semantic relationship is less obvious (e.g., fish/Wanda, Moss & Older, 1996). In this paper, I will use “categorical” or “thematic” to refer to types of semantic relationships, and “associative” or “verbal associates” to refer to the pairings that are generated during word association tasks.

Lexical production models typically present only limited information regarding the potential range and nature of features and/or relationships that represented at the semantic/conceptual stratum. Schematic illustrations tend to depict categorical relationships, but Rahman and Melinger (2007), for example, have noted that no model makes an explicit distinction between the representation of categorical features or relationships and non-categorical features or relationships (i.e., associative or thematic). Rahman and Melinger note that, theoretically, spreading activation dynamics should lead to activation of both “categorically related concepts and associatively related concepts from different semantic categories” (p. 605).

18 McCauley et al. (1976) actually described their stimuli as “associatively related”, but an examination reveals them to be, in fact, thematically related (e.g., mouse/cheese; iron/shirt).
represent both categorical and thematic relationships (Waxman & Nam, 1997). However, the results from the available priming literature (McCauley et al., 1976; Nation & Snowling, 1999) suggest that thematically-related items may be particularly effective for ensuring priming effects across children of different ages and/or developmental levels.

2.1.3.4 Summary and Predictions

In summary, the facilitating effect of a prime manipulation can be understood as the result of activation spreading and residual activation. Within lemma-based models of production, spread of activation among conceptually related units, and from those units to the lemma stratum can be expected to benefit the speed of lemma activation within a priming context. The available literature supports the expectation that young children will demonstrate priming effects in picture naming, particularly if thematically-related primes are used. In Study 2, semantic priming will be used as tool to influence the dynamics of lexical activation within a sentence production context. The purpose of Study 1 is to provide independent evidence of the effect of the primes on lexical processing dynamics, using a more proximal measure of these effects via picture naming RT.

2.1.4 Summary

In summary, Study 1 will address two purposes. The first purpose is to examine the range of sentence patterns that children produce to describe transitive scenes, both when left free to determine the starting point of the sentence and when compelled to begin with the patient in the subject position. The second purpose is to examine the influence of a selected set of primes on lexical activation dynamics for semantically-related targets, as measured via picture-naming RTs. These two purposes will be addressed in separate Sentence Production and primed Picture Naming tasks. The Sentence Production task will examine children’s sentential descriptions of
transitive scenes in a free response condition and following a cloze prompt that invites completion of patient-subject sentences. In the primed Picture Naming task, children will name pictures of the agent- and patient-role characters from the Sentence Production task stimuli, following primes that are either semantically related to the patient targets or unrelated to either the patient or the agent targets. It is expected that RTs to name the patient-role targets, but not the agent-role targets, will benefit from the patient-related primes.

2.2 Method

2.2.1 Participants

Thirty-two monolingual English-speaking children with typical language development completed the study. Sixteen children participated in each of two age groups, with 8 boys and 8 girls in each group. The participants in the younger group (hereafter also referred to as the 4-year-old group) ranged in age from 3;4 (years; months) to 4;9 ($M = 4;2, SD = 4.9$ months), and the participants in the older group (hereafter also referred to as the 7-year-old group) ranged in age from 6;1 to 7;11 ($M = 6;1, SD = 6.2$ months). The children were recruited through childcare centre teachers or third party contacts. Their language status was confirmed via a parent questionnaire that was included with the consent form. Children were considered to be monolingual English-speaking if English was their first language and the primary language used at home and at school. Typical language development was defined by parent report of no suspected or diagnosed language delay. In addition, no child scored more than one standard deviation below the mean on the Recalling Sentences subtest of either the Clinical Evaluation of Language Fundamentals-Preschool:2 (4-year-old group, Wiig, Secord, & Semel, 2004) or the Clinical Evaluation of Language Fundamentals-4 (7-year-old group, Semel, Wiig, & Secord,
2003), reinforcing parent and teacher judgments of typical language development.\textsuperscript{19} Scaled scores on this measure ranged from 11 to 17\textsuperscript{20} for the younger group ($M = 12.6, SD = 1.96$) and from 7 to 15 for the older group ($M = 11.4, SD = 2.66$). Maternal education, collected as a proxy for socio-economic status, was high and did not differ between the two groups, $p = .7$, Fisher’s Exact Test. One mother reported high school education (younger group), 2 reported college education ($n = 1$ in each age group), 9 reported Bachelor’s level education ($n = 3$ younger group, $n = 6$ older group), and 20 reported graduate level education either completed or in progress ($n = 11$ younger group, $n = 9$ older group).

An additional nine children ($n = 8$ younger group, $n = 1$ older group) completed all or part of the experimental protocol but were not included in the analysis. Of these, seven children did not complete the task ($n = 2$ unable to attend to the tasks, $n = 3$ declined to finish the experimental tasks, $n = 1$ began the session but declined to wear the microphone before beginning the experimental tasks, $n = 1$ unable to complete due to multiple disruptions in the daycare setting). Two children ($n = 1$ from each age group) completed the tasks, but were excluded from analysis because a high number of vocal hesitations ($n = 1$) and naming errors ($n = 1$) left them with fewer than 50\% useable responses in the primed picture naming task.

2.2.2 Materials

2.2.2.1 Sentence Production Task

The materials for the sentence production task consisted of 20, 10-second animated scenes, prepared using Adobe Flash software (Adobe Systems Incorporated, 1993 - 2008). The

\textsuperscript{19} One child in the younger group declined to complete the Recalling Sentences task. This child was included in the study based on teacher and parent judgments of typical language development.

\textsuperscript{20} Average range = 7 to 13 ($M = 10, SD = 3$) (Semel et al., 2003; Wiig et al., 2004).
colour images used in the creation of the animations came from several sources. A number of images were taken from the Rossion and Pourtois (2004) Snodgrass and Vanderwart-like object set, available as freeware from http://www.nefy.ucl.ac.be/faceatlab/stimuli.htm. The remaining images were obtained from publicly or commercially available, royalty-free clip art sites (Microsoft Clip Art Gallery, iclipart.com, clipart.com).

All 20 of the animations depicted an animate agent acting on an animate or inanimate patient. The animations were designed to elicit transitive verbs and allow description with both an active transitive structure and a passive structure. For 10 (50%) of the items, the depicted action was expected to additionally allow the option of the agentless intransitive to place the patient in the subject position (i.e., verbs that participate in the anti-causative alternation). The two groups of animations were designated 2-option and 3-option scenes, respectively, to reflect the fact that they were expected to provide the children with a different range of syntactic options. The 2-option scenes were designed to elicit verbs that allow both the active and the passive: lick, wash, lift, sting, hit, paint, splash, kick, brush, and push. The actions presented in the 3-option scenes were intended to elicit verbs allowing the active and the passive, and also allowing the agentless intransitive (Levin, 1993). These animations depicted actions involving motion in a particular manner or an extrinsic change of state that could be described using the same verb to express both the agent’s and the patient’s action: bounce, swing, roll, turn, stretch, bend, cook, shake, close, and break. Figure 2.1 provides examples of the animation stimuli, and the relevant syntactic alternations for each scene type.
The number of animate and inanimate patients was equal across the full set of 20 items, with slightly different proportions within each scene type. The 2-option scenes included 6 animate patients and 4 inanimate patients. The 3-option scenes contained 4 animate patients and 6 inanimate patients. This small imbalance reflected the challenge of finding anti-causative alternating verbs that could plausibly take an animate patient. It is difficult, for example, to pair an animate patient with verbs such as close or break. The left-to-right placement of the agent versus the patient was balanced across trials and scene types.\(^\text{21}\)

In order to minimize potential baseline differences in ease or speed of lexical processing, the agents and patients in each scene were selected to be comparable in age of acquisition (AoA), frequency and length of the target name (Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; D'Amico, Devescovi, & Bates, 2001). The primary basis for matching agents and patients was objective AoA, defined as the age in months at which 75% of children are reported to produce the word according to the lexical norms of the McArthur-Bates Communicative Development Inventory (MCDI; Dale & Fenson, 1996), or, where these values were not available, the AoA data provided by Morrison, Chapell, and Ellis (1997) for 75% correct picture naming. MCDI

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\(^{21}\) One 3-option scene (bend) did not have a left-to-right orientation. Instead the patient was superimposed over the agent, as though being held in front.
AoA values were further categorized as very early (<24 months), early (25 – 30 months), or later / not included in the MCDI (>30 months). Agents and patients either fell within the same MCDI age band, or if MCDI values were missing, fell within one 6-month age band of each other in the Morrison et al. norms. Appendix A provides a list of each animation item and the AoA values for the agent and patient stimuli. Agent and patient pairing was further constrained by word frequency and length in syllables. Appendix B presents these values. Agent and patient word length was identical in most cases, and differed by no more than one syllable. Frequency values were obtained from the Grade 1 $U$-values in *The Educator’s Word Frequency Guide* (Zeno, Ivens, Millard, & Duvvuri, 1995). Frequency values in *The Educator’s Word Frequency Guide* are based on written counts drawn from a wide range of texts used within schools; Grade 1 values are based on a total of 584,693 tokens. $U$ is a measure of occurrences per million words adjusted by a measure of dispersion, or the extent to which a particular word tends to occur across a wide range of texts. For the current study, $U$ was summed across the base, plural and possessive form of a given word. Agent and patient frequency values were matched as closely as possible, avoiding pairings from opposite ends of the distribution, subject to the other constraints on item selection. Paired $t$-tests indicated that across the stimulus set there was no statistically significant difference between agents and patients in either frequency, $t(19) = .21, p = .83$, or length $t(19) = 0$. Finally, data regarding concept familiarity and name agreement were available for 15 of the stimulus item pairs (Morrison et al., 1997). Paired samples $t$-tests indicated no statistically significant difference between agents and patients for the values obtained on either measure for the available data. For name agreement, the values for agents and patients were, respectively, 95.7% and 93.4%, $t(14) = .73, p = .48$. For concept familiarity, the values for agents and patients were, respectively 2.6 and 3.0 on a 5-point scale, $t(14) = 1.74, p = .1$. 

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2.2.2.2 Primed Picture Naming Task

The stimuli for the primed Picture Naming task consisted of single pictures of the agents and patients that were used in the construction of the animation stimuli, as well as patient-related prime pictures and control prime pictures. The patient-related and control prime pictures were drawn from the same sources as the agent and patient images. The patient-related primes were selected on the basis of having a semantic association to the relevant patient target that was likely to be relevant to young children. The patient-related primes had no identifiable semantic relations with the agents that were paired within the same stimulus scene. Control primes were selected to have no identifiable semantic relationship to either the agent or patient for a given scene, and to be similar to their corresponding patient-related primes in AoA, frequency and word length in syllables. For example, for the agent-patient pair cat and baby (i.e., A cat licking a baby), the patient-related prime was highchair, and the control prime was firetruck.

Given that thematic relationships (e.g., functional, script, spatial, causal) may be particularly relevant and likely to show priming for young children (McCauley et al., 1976), the patient-related prime-target pairings all had a thematic basis of some kind. Several pairings additionally contained a categorical relationship. Evidence for some degree of verbal association between patient-related primes and patient targets was available for the majority of the pairings, in verbal association studies with either adults or children (Entwisle, 1966; McCauley et al., 1976; Moss & Older, 1996; Palermo & Jenkins, 1964). As previously noted, verbal association pairings are generated by asking speakers to name the first words that come to mind in response to a stimulus word. Although verbal association on its own is not a guarantee of a semantically-based relationship, all verbal associates in the selected stimuli had an evident semantic relationship. No prime-target pairings contained close synonyms that could potentially interfere
with, rather than facilitate, target processing (Wheeldon & Monsell, 1994). In addition, because strong phonological relationships between primes and targets may interfere with lexical processing for the target (Bock, 1987b), phonological relationships between primes and targets were limited as much as possible subject to the semantic constraint. For some items, some degree of phonological overlap was unavoidable. All of the primary, semantically related, verbal associates of king, for example, share the onset /k/ consonant (i.e., queen, crown, castle). Figure 2.2 presents an example of a set of prime and target pictures derived from one animation. Appendix C lists the patient-related and control primes for each agent-patient pair, along with their AoA and frequency values. Additionally, Appendix D provides further information regarding the verbal association data available in the existing literature for the stimulus items.
Figure 2.2 Example of prime and target picture stimuli. Scene = *cat lick baby*.

<table>
<thead>
<tr>
<th>Target Type</th>
<th>Prime Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Agent: Cat" /></td>
<td><img src="image2" alt="Control (Unrelated) Prime: Firetruck" /></td>
</tr>
<tr>
<td><img src="image3" alt="Patient: Baby" /></td>
<td><img src="image4" alt="Patient-Related Prime: Highchair" /></td>
</tr>
</tbody>
</table>

2.2.3 Procedure

2.2.3.1 Overview

The participants completed Study 1 over the course of two sessions of approximately 20-30 minutes, scheduled approximately one week apart ($M = 7$ days, $SD = 1$). During each session, the children completed the Sentence Production task for one of the scene types (i.e., 2-option or 3-option scenes), and the primed Picture Naming task for the other scene type. Each of the tasks within each session was divided into two blocks. The sentence production blocks were divided into a free response block, and a forced patient-subject block that used a cloze technique to
prompt the children to complete a patient-subject sentence. The Recalling Sentences task (Semel et al., 2003; Wiig et al., 2004) was completed at the end of the second session.

The experimental tasks were designed and run using E-Prime 2.0 experimental software (Schneider, Eschman, & Zuccolotto, 2002). For the primed Picture Naming task, the children named each target picture twice, once preceded by the patient-related prime for that item, and once preceded by the control prime for that item. For example, the two target pictures derived from the cat licking baby scene were cat (agent target) and baby (patient target). The prime-target trials created from this scene consisted of highchair → baby (patient-related prime, patient target), firetruck → baby (control prime, patient target), highchair → cat (patient-related prime, agent target), firetruck → cat (control prime, agent target). Agent and patient targets were intermixed within each block, and each target occurred only once per block. In order to create the experimental blocks, two lists were created for each animation type. Within each list, each agent and patient target was assigned to a prime condition in a pseudo-random manner subject to the constraints that there were an equal number of patient-related and control trials, and that the paired agent and patient targets (i.e., taken from the same animation scene) occurred in different prime conditions (e.g., List 1: highchair → baby, firetruck → cat; List 2: firetruck → baby, highchair → cat).

In order to control for order effects on sentence descriptions and naming times, the children were randomly assigned to one of four experimental orders that crossed the assignment of scene type to tasks across days (i.e., Sentence Production for the 2-option scenes and Picture Naming for pictures from the 3-option scenes in Session 1 or vice-versa) and Picture Naming list across blocks (i.e., List 1 or List 2 in Block 1). Children who did not complete the tasks were
replaced, such that the resulting sample contained four children from each age group within each experimental order.

Each session began with the first Picture Naming block of 40 pictures (20 prime-target trials), followed by the free response block of the Sentence Production task. A short play break followed these tasks. Then, Block 2 of the Picture Naming task was completed followed by the forced patient-subject block of the Sentence Production task. The following sections describe the specific procedures for each experimental task.

2.2.3.2 Sentence Production Task

2.2.3.2.1 Detailed Procedure

For the Sentence Production task, each block contained 10 trials, consisting of all 10 items for the relevant scene type. The animations were presented at a comfortable viewing distance on a laptop computer. The order of items within each block was randomized for each child by the experimental software and the trials were advanced manually by the experimenter. Each animation remained on the screen for 10 s.

For the free response block, the experimenter told each participant, “Now we’re going to watch some short movies, and I want you to tell me what’s happening in them.” No demonstration or practice trials were provided. Before the start of each animation, the experimenter asked, “What’s happening / in this movie / in this one / here?” For the first trial only, if the child provided a bare noun (e.g., “cat”), conjoined noun phrase (e.g., “a cat and a baby”) or a bare verb (e.g., “licking”), the experimenter prompted the child for more information (e.g., “Yeah, and what’s happening?” in response to a noun fragment, or “Who is?” in response to a bare verb). The purpose of these additional prompts was to encourage the children to
produce sentence responses for the remaining trials, but no specific request was made for a complete sentence. Otherwise, no feedback was provided on the form or content of responses, and no requests for more information were provided in subsequent trials. The experimenter responded to the children’s utterances with general, neutral encouragement (e.g., “neat”, “how funny” etc.). The children’s responses were recorded for later transcription and coding.

At the beginning of the forced patient-subject block, the experimenter said, “Now we’re going to watch the movies again. And, we’re going to say what’s happening again, but this time we’re going to do it as a team. I’ll start and you finish for me, ok?” At the initiation of each trial, the experimenter asked, “What’s happening / in this movie / in this one? The [patient] ...”, using an intonation that invited the child to complete the sentence. For example, given the scene of the cow washing the bike, the prompt was, “What’s happening in this movie? The baby…” This prompt was intended to be as neutral as possible regarding the syntactic structure of the children’s responses.  

22 For the first trial only, if the child provided an active transitive response (e.g., Experimenter: “The baby…”; Child: “The cat is licking the baby”), the experimenter replied, “Yeah, can you finish for me? The [patient]...” and waited for the child to respond. This second response was elicited to guard against the possibility that some young children would fail to provide patient-subject sentences because they simply did not pay attention to the cloze instructions. As in the free response block, the experimenter’s comments focused on the animations in general and not on the children’s specific utterances (e.g., “neat”, “how funny” etc.). The responses were audio recorded for later transcription and scoring.

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22 As opposed to prompts such as “What is happening to the [patient]”, or “What is the [patient] doing”, which seem to pull for passive and agentless intransitive structures, respectively.
Transcription, Scoring and Reliability

The Experimenter transcribed all responses orthographically and coded all responses. The first stand-alone clause was scored as the response to each trial (e.g., “The pig is scrubbing the rabbit so it can get some things out of its fur”), except in cases in which the child produced only a noun phrase fragment. In such cases, the noun phrase was scored. Each response was categorized as falling into one of four major classes. The first three classes, active transitive, passive and agentless intransitive, captured the major response structures that were expected in the baseline and forced patient-subject conditions. Responses that did not fit into these anticipated categories and trials in which the child did not respond were categorized as other / no response. Although basic present progressive sentences were expected, the children sometimes produced sentences containing past tense forms, elaborated noun phrases or elaborated verb phrases (e.g., “trying to ...”). These responses were included as instances of the major anticipated sentence types (i.e., active transitive, passive, agentless intransitive).

Responses were categorized as active transitive if they contained transitive argument structure. This category included full sentences containing an agent subject, a verb, and a patient object (e.g., “The cat is licking the baby”) as well as responses containing a transitive verb and patient object, but no subject (e.g., “___ licking the baby”), responses missing the auxiliary (e.g., “A cat licking a baby”), and a small number of responses in which the child clearly intended a transitive structure, and began but failed to complete the object phrase (e.g., “The cat is licking the, uh >”). In addition, existential clauses beginning with there’s were scored as transitive if the non-finite clause that followed had transitive structure (e.g., “There’s a cat licking a baby”), based on evidence that the there’s construction serves a performative rather than a structural function (Breivik & Martinez-Insua, 2008). Intransitive responses containing
only an agent subject and a verb were not counted within this category, even if the verb is typically used transitively (e.g., “The cat is licking”). These responses were scored as other / no response.

Responses were categorized as passive if they contained a be or get-verb followed by a passive participle. The vast majority of these responses were produced in the forced-patient condition, which used a cloze format with the experimenter providing the subject patient. There was therefore no requirement that the child actually produce the subject. All passive responses that occurred in the baseline condition did include either a pronominal or a full noun subject. Both full passives containing the by-phrase (e.g., The baby… “is getting licked by the cat”) and bare passives (e.g., The baby… “is getting licked”) were counted within this category, as well as full passives containing a morphological error on the participle (e.g., The clown… “is getting pushing by the lamb”). Responses that contained a morphological error on the participle and no by-phrase (e.g., The chicken … “is getting pushing and bonking”) were considered to be indeterminate between a passive with error and a revision to another, active structure. These responses were coded as other / no response.

Responses were categorized as agentless intransitive if they contained a patient subject and an intransitive verb. As with the passive, the children did not have to produce the subject. The agentless intransitive category included responses containing an anti-causative alternating verb used intransitively (e.g., The apple … “is rolling”), as well as responses containing a general, all-purpose verb and a directional adverb (e.g., The ball … “is going up and down”). On a number of trials, the participants produced an agentless intransitive response followed by a second clause or phrase that referenced the causal agent (e.g., The apple … “is rolling because the monkey is rolling it”). These responses were included within the agentless intransitive
category. Some responses posed a challenge for coding, because they were intermediate between a passive and an agentless intransitive form. These responses contained a causative alternating verb with active, present progressive structure, followed by a by-phrase (e.g., *The frog...“is stretching by the little kid”*). These responses were coded as agentless intransitive based on the structure of the response up to the beginning of the by-phrase. They were scored differently from responses containing both the *get*-verb and the by-phrase (e.g., *The clown...“is getting pushing by the lamb”*), scored as passives as described above.

The final category was *other / no response*. This category contained all responses that did not fit the major categories as described above, and included (but was not limited to) fragments (noun phrases or bare verbs), responses in which part of the verb phrase was gestured rather than spoken, adjectival and locative responses (e.g., “*The king is mad*”; “*The giraffe is by a puddle*”), and responses that did not seem to focus on the target event. This last group included a range of responses, including responses that described an action of the patient unrelated to the major action in the scene (e.g., *The baby...“is moving his eyebrows up and down”*), and a small number of “put” constructions that seemed to focus on a body part of the agent (e.g., “*The squirrel is putting its hand on the chicken*”). This category also included responses containing a frank structural (e.g., *The frog...“is pulling”*) or semantic error (e.g., *The ball...“is bouncing the duck”*). The latter response type was generated exclusively by one child in the 7-year-old group who appeared to be aware of the error, laughing after the responses.

For the purposes of reliability, a trained assistant re-transcribed and coded the sentence production responses for eight (25%) randomly selected transcripts, four from each age group. Reliability for categorizing the responses into the major categories, calculated as the total number of agreements divided by the total number of judgments (agreements + disagreements),
was 94%. Agreement regarding the sentence verb was also assessed, as some of the coding decisions rested on the relationship between the verb and the argument structure that was produced. Agreement was 96%.

2.2.3.3 Primed Picture Naming Task

2.2.3.3.1 Detailed Procedure

Prior to beginning the first block of picture naming in each session, the children were familiarized to the picture stimuli and their names. The 40 pictures were presented in a booklet, 5 to a page. In order to minimize the possibility that children would notice relevant relationships, no paired primes and targets were presented on the same page. The experimenter named each picture, and the child touched each picture as it was named. If a child made an identification error that was not self-corrected, the experimenter presented that item again before moving on to the next page. If the child again failed to correctly identify the item, the experimenter identified it for the child. The total number of errors that were not successfully corrected was extremely low (8/2560 responses).

During the Picture Naming task the children wore a head-mounted microphone connected to the E-Prime Serial Response Box for the purpose of capturing and recording speech onset time. The microphone was positioned approximately 6 cm in front of the child’s mouth. A separate, tabletop microphone and digital audio recorder recorded the content of the responses.

In the instructions for the Picture Naming task, the experimenter informed each child that the purpose of the activity was to learn about “how quickly people can think of the words for things.” The experimenter further told each child “you will see pictures on the computer. When you see a picture, I want you to say what it is right away as soon as you know it.” The Picture
Naming task began with three demonstration trials in which the experimenter modeled the desired, bare noun response format, followed by four practice trials. Neither the demonstration nor the practice trials contained items that appeared in the experimental trials. The practice trials were repeated if the child appeared to not understand the task. The first block of 20 experimental prime-target trials began immediately following the practice trials.

The order of trials within each block of 20 was randomized by the experimental software, with the constraint that agent and patient targets associated with the same animation could not appear in adjacent trials. For example, a trial containing the agent target cow could not follow a trial containing its paired patient target bike. An encouragement screen stating “Great job!!” appeared after every 10 pictures (5 prime–target trials).

Each trial began with an orienting cue (“+”) presented in the centre of the screen for 1 s, followed by the prime picture. The prime picture remained on the screen until the child named it, or for a maximum of 5 s. When the voice key registered the onset of the child’s response to the prime picture, the picture disappeared from the screen. The “+” sign appeared again 1 s after the onset of the prime response, and remained on the screen for 1 s, followed by the target picture. The total interval between the onset of the child’s response to the prime picture and the appearance of the target picture was 2 s. The target picture remained on the screen until the child named it, or for a maximum of 5 s. Again, the picture disappeared when the voice key registered the onset of the response. At the completion of each prime–target trial, the experimenter recorded any noise artifacts, early voice key triggers or failures of the voice key to trigger, as well as obvious lapses of attention (e.g., the child turning to look elsewhere in the room just as a trial began). The experimenter advanced the program manually to the next trial when the child was paying attention. Pausing between trials was possible if needed, but it was not possible to pause
between the prime and target within a trial. If there were no lapses in a child’s attention, the trials progressed in a near-continuous manner with no attention called to the pairing of primes and targets. The RT for each response was recorded by the E-Prime software, and responses were audio recorded for later transcription.

### 2.2.3.3.2 Transcription, Scoring and Reliability

The experimenter transcribed all prime and target responses orthographically. Responses were scored as correct if the child produced the target response, a synonym or a near synonym. Variations such as *bike/bicycle, hamburger/burger, alligator/crocodile, cat/kitty, and mouse/rat* were scored as correct. Trials were scored as incorrect and excluded from further analysis if they contained a frank naming error in either the prime or target portion, if the child produced no response or was off-task during either the prime or the target presentation, if the child spoke between the prime and target presentations (including revisions of their prime response), and if the target response began with a false start, or an extraneous vocalizations such as *uh, um* or a determiner.

For the purposes of reliability, a trained assistant re-transcribed all prime and target responses for six (18%) randomly selected transcripts, three from each age group. The calculation of reliability focused on agreement regarding whether or not a response was produced, the word that was produced (i.e., the orthographic transcription), the presence of extraneous sounds at the beginning of the target response, and the presence of speech between the prime and target. Reliability, calculated as the total number of agreements divided by the total number of judgments (agreements + disagreements) was 97%.
Chapter 3: Study 1 Results and Discussion

3.1 Study 1 Results

The first set of analyses in Chapter 3 examined outcomes from the Sentence Production task. The purpose of this task was to determine children’s sentence structure preferences for the animations when the starting point of the sentence was unconstrained and also when the children were constrained to begin with the patient, as well as to examine potential differences by age and scene type in the overall number of patient-subject responses in the forced patient-subject condition. These analyses focused on the frequency with which the participants produced the targeted active transitive, passive, and agentless intransitive structures.

The second set of analyses examined outcomes from the primed Picture Naming task. The purpose of this task was to determine whether, as expected, the patient-related primes facilitated naming of the patient- (but not agent)-target pictures taken from the animations. In order to address this purpose, the analyses examined RTs to name the agent and patient-role target types following the patient-related and control primes.

For all analyses, an alpha level of .05 was used as a guide for statements of statistical significance. Significance values just above the cutoff (i.e., .05 - .06) were considered to be approaching statistical significance and worthy of further investigation. For each analysis, exact p-values are stated (except where p is very small, p < .001), along with effect size estimates.
3.1.1 Sentence Production Task

3.1.1.1 Primary Analysis

3.1.1.1.1 Overview and Structure

The analyses for the Sentence Production task examined the range of syntactic structures that the participants used to describe the animation stimuli, first for the free response condition (Block 1) and then for the forced patient-subject conditions (Block 2). The analysis of the free responses examined the expectation that both scene types would elicit active transitive descriptions as their predominant or default pattern when the sentence starting point was not constrained. The analyses of the forced patient-subject responses in Block 2 asked how the use of each of the targeted structures varied by age and scene type. These analyses asked whether, as expected, the younger participants produced fewer passive but not fewer agentless intransitive responses than the older participants. These analyses also asked whether, as expected, the younger participants produced fewer successful patient-subject responses than the older children overall, and whether they produced a greater number of patient-subject responses to describe the 3-option scenes (i.e., when they could produce a successful patient-subject response using either a passive or the relatively simple agentless intransitive).

The inferential analyses in the following sections report factorial ANOVAs with age group as the between-subjects independent variable, and scene type as the within-subjects variable. The analysis for the free response condition focused on the frequency of production of active transitive sentences as the dependent measure. For the forced-patient subject condition, separate analyses were conducted with the frequency of passive responses and the frequency of
agentless intransitive responses as the respective dependent measures. For several analyses of sentence structure, the data violated the ANOVA assumption of normality, and in some cases, homogeneity of variances. Given the fact that ANOVA is noted to be relatively robust to such violations (Howell, 1992), the planned parametric tests on means were retained in order to be able to examine interactions as well as main effects.  

3.1.1.1.2  Free Response Condition (Block 1)

Prior to turning to the analysis of sentence structure, a preliminary analysis examined the types of verbs that the children produced in the free response condition. The purpose of this analysis was to determine whether the intended distinction between the two scene types was valid, that is, whether the two scene types elicited transitive verbs with a different range of patient-subject argument structure allowances. Specifically, this analysis asked whether the 3-option scenes but not the 2-option scenes elicited verbs that can be produced within agentless intransitive structures (e.g., verbs such as roll, break, etc.). On average, only 1.6% of descriptions ($SD = 2.2\%$) of the 2-option scenes in the baseline condition contained a lexical verb that permits the agentless intransitive structure (e.g., moving, shaking). In contrast, 73.4% ($SD = 15.7\%$) of descriptions of the 3-option scenes contained this type of verb. These values indicate that the different scene types did indeed elicit transitive verbs differing in their sentence structure possibilities.

The next analysis asked whether, as expected, the stimuli elicited active transitive sentences as the default or preferred response structure. Figure 3.1 presents a 100% stacked

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23 In order to further evaluate whether or not the parametric outcomes were unduly influenced by the assumption violations, repeat analyses examined the main effects using non-parametric Wilcoxon Signed-Ranks tests. For all analyses, the parametric and non-parametric tests returned the same pattern of results.
graph showing the distribution of major response types in the baseline condition, by age and scene type. As can be seen in Figure 3.1, active transitive responses dominated for both scene types, for both the 4-year-old group ($M = 81.9\%, SD = 23.2$) and the 7-year-old group ($M = 94.1\%, SD = 6.4$). Somewhat surprisingly, Figure 3.1 points to higher use of the passive by the younger children than the older children. However, rather than reflecting an overall trend for the group, this pattern reflects the data from one participant who described almost all of the animations, in both conditions and in both sessions, using the passive voice. As expected, there was virtually no difference in the overall rate of active transitive descriptions between the 2-option scenes ($M = 87.5\%, SD = 19.3$), and the 3-option scenes ($M = 88.4\%\%, SD = 20.3$).
The reliability of these patterns was examined in a 2 (Scene Type) x 2 (Age Group) ANOVA conducted on the number of active transitive responses (out of a maximum of 10 per scene type) that the children produced. The results revealed that the main effect of age group approached statistical significance, $F(1,30) = 4.095, p = .052, \eta_p^2 = .12$. Neither the main effect of scene type, $F(1,30) = .093, p = .76, \eta_p^2 = .003$, nor the interaction between scene type and age group, $F(1,30) = .51, p = .48, \eta_p^2 = .017$, was statistically significant. These results indicate that,
as expected and as seen in Figure 3.1, the preferred sentence pattern for both scene types was the active transitive. And, although the results indicated a lower overall rate of production of active transitive responses by the 4-year-old group than the 7-year-old group\textsuperscript{24}, the fact that the vast majority of responses conformed to this expected pattern at both ages indicates that this was indeed the preferred pattern.

3.1.1.3 Forced Patient-Subject Condition (Block 2)

The analyses for the forced patient-subject block asked whether there were differences by age group and scene type in the number of passive responses produced, the number of agentless intransitive responses produced, and the total number of successful patient-subject responses produced. Figure 3.2 presents a 100% stacked graph showing the distribution of major response types in the forced patient-subject condition, by age and scene type.

\textsuperscript{24}This difference appeared to be driven by a combination of the contribution of the single participant in the younger group who produced passive responses almost exclusively, and a potential difference by age in the tendency to either not respond or produce a non-target response. As can be seen in Figure 3.1, the younger participants produced a somewhat higher rate of responses that were categorized as no response / other. A follow-up analysis, conducted to examine whether this difference was statistically significant, however, indicated that it was not, $F(1, 30) = 2.16, p = .15, \eta^2_p = .067$. 

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In comparison to the similarities that were observed across age groups and scene types in the free response condition (see Figure 3.1), Figure 3.2 reveals a pattern of differences in the forced-patient subject condition. The children produced both passive and agentless intransitive sentences to describe the animations. And notably, almost one quarter of the 4-year-old group’s responses in the forced patient-subject condition maintained the active transitive structure ($M = 23\%, SD = 31$, collapsing across scene types), despite initial instructions to complete the sentence following the experimenter’s prompt, repeated instructions if the child failed to do so.
on the first trial, and the use by the experimenter of an intonation pattern that invited completion with a patient-subject sentence. Thirteen of the 16 participants in the 4-year-old group produced at least 1 active transitive response in the forced patient-subject condition, and 5 produced active transitives as their dominant response for at least one of the forced patient-subject blocks. This pattern of response was virtually non-existent in the responses produced by the older children \( M = 0.95\%, SD = 2 \).

An analysis of passive responses addressed whether these responses were produced less often by the younger than older participants, and less often in response to the 3-option scenes than the 2-option scenes. The patterns in Figure 3.2 point to the expected differences by age group and scene type. Even though all of the trials presented a potential context for a passive sentence structure, the 4-year-old group produced passives in slightly less than half of the trials overall \( M = 45.7\%, SD = 36.7 \). The 7-year-old group, in contrast, produced passive responses in almost three-quarters of the patient-subject trials \( M = 73.5\%, SD = 32.8 \). And, collapsing across the age groups, a passive response was provided in 68.8\% \( SD = 37.9 \) of trials for 2-option scenes, and in 50.3\% \( SD = 45.1 \) of trials for 3-option scenes.

The reliability of these differences was examined in a 2 (Age Group) x 2 (Scene Type) ANOVA on the number of passives produced (out of a maximum of 10 per scene type). The results of the ANOVA revealed significant main effects of both age group, \( F (1,30) = 4.91, p = .03 \), \( \eta_p^2 = .14 \), and scene type, \( F (1,30) = 8.32, p = .007 \), \( \eta_p^2 = .22 \). The interaction between age group and scene type was not statistically significant, \( F (1, 30) = .002, p = .961 \), \( \eta_p^2 < .001 \).

These results are consistent with the expected developmental difference in the frequency of passive production, namely a lower rate of production for the younger group. The results also show that, as expected, the range of argument structure possibilities afforded by the scene type
affected the rate of passive production. When another option was available, the frequency of passive production was lower.

The second analysis examined whether the rate of production of agentless intransitive responses was greater for the 4-year-old group than the 7-year-old group, and whether they were produced more often in response to the 3-option scenes than the 2-option scenes. Returning again to Figure 3.2, the patterns point to the expected differences. For both age groups, the production of agentless intransitive responses was almost completely localized to the 3-option scenes. And, the younger children produced slightly more agentless intransitive responses ($M = 38.1\%, SD = 42.2$) than the older children, ($M = 28.8\%, SD = 45.9$). The reliability of these patterns was examined in a 2 (Age Group) x 2 (Scene Type) ANOVA on the number of agentless intransitives produced (out of a maximum of 10 per scene type). The results of the ANOVA revealed a significant main effect of scene type only, $F (1,30) = 15.699, p < .001, \eta^2_p = .34$. The main effect of age group was not statistically significant, $F (1,30) = .362, p = .55, \eta^2_p = .01$, nor was the interaction between scene type and age group, $F (1,30) = .91, p = .35, \eta^2_p = .03$. These results indicate that, in contrast to the outcomes observed for the passive, there was no reliable effect of age on the frequency with which the participants produced agentless intransitive responses.

Turning to the significant main effect of scene type, the scene types were constructed to preclude the production of agentless intransitive responses for the 2-option scenes, and indeed only $4.4\%$ ($SD = 9.1$) of these trials contained agentless intransitive responses. The majority (10/13, 76%) of these trials were produced with the general verbs go or move (e.g., The piano… “is going up because the kangaroo is kicking it”). For the remaining three, the children selected a verb that allows the agentless intransitive (shaking, shivering, floating), and marginally described the action in the scene (e.g., The piano… “was shivering”, describing a jitter motion each time
the piano was kicked). In contrast, 29.1% (SD = 38.6) of 3-option scenes were described with an agentless intransitive sentence, and only 14% (13/93) of these responses relied on the general verbs go or move.

Thus, when pressed to begin with the patient, some children made use of the agentless intransitive. And, the fact that this structure was almost exclusively restricted to the 3-option scenes suggested a high degree of adherence to the semantic and syntactic allowances of the context. It is important to note, however, that this analysis failed to capture a small number of relevant responses. In a small number of contexts, the children produced responses that were agentless intransitive in structure but contained a frank error (e.g., “The star is painting”, n = 3); or described the action of the patient in an active voice, but did not focus on the central action involving the agent’s effect on the patient (e.g., “The rabbit is moving its ears”, n = 11). The majority of these occurred in response to 2-option scenes, and were coded within the no response / other category. Although these responses contained either a frank error or an “error” of focus, it could be argued that they represented valid attempts to produce a patient-subject response, and that they patterned much more closely with the agentless intransitive than the passive. The analysis was therefore repeated with these responses included, in order to guard against the possibility that excluding them had overestimated the extent to which agentless intransitive use was constrained by scene type. The analysis again revealed a large and statistically significant effect of scene type, $F(1,30) = 12.897, p = .001, \eta_p^2 = .30$. Thus, although it may arguably be easier for children to produce an active, intransitive sentence than a passive, these results

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25 Additionally, and as discussed in the Method section, one participant in the older group consistently produced active transitive responses with the agent in the direct object position, producing a frank semantic error. This child seemed to be well aware of the error. While this strategy may very well have reflected an inability to generate a grammatical response to the prompt, this child’s responses were felt to be different from the active structures discussed here, which were produced with no sign of uncertainty. As such, this child’s responses were not included in this analysis.
indicated that the participants were by and large only willing to make use of this simpler option when it was both semantically and syntactically appropriate.

The results of these analyses indicated that the two different scene types elicited verbs with different argument structure possibilities, and elicited different overall sentence structure patterns. Although all of the scenes could have been described using a passive sentence structure, the children chose this option less often when the scene also allowed the agentless intransitive. Indeed, for the 3-option scenes, the agentless intransitive structure accounted for almost one third (28%) of patient-subject responses (i.e., passive + agentless intransitive) produced by the 7-year-old participants, and more than one half (54%) of those produced by the 4-year-old participants. The results of these analyses also revealed different developmental patterns in the frequency of use of the two sentence types. Only the passive response pattern revealed a significant difference between the age groups, with fewer passives produced by the younger than the older children. In contrast, the younger children produced more agentless intransitive responses than the older children, although this difference was not statistically significant.

The final analysis in this section asked whether the differences in the argument structure possibilities afforded by the two scene types led to differences in the rate at which the children in the two groups produced patient-subject responses overall. This analysis examined the overall rate of completion of patient subject sentences as a function of age group. For this analysis, passive and agentless intransitive responses were summed to create a total score for child. This analysis addressed the expectation that, overall, the younger participants would produce fewer patient-subject structures than the older participants, and that the participants would produce fewer patient-subject sentences when the passive was the only possible patient-subject response, that is in response to the 2-option scenes. Returning to Figure 3.2, as can be seen, the evidence
for an age group difference in the total number of patient-subject responses was much stronger than the evidence for a difference by scene type. The average number of patient-subject sentence structures was higher for the participants in the 7-year-old group ($M = 87.8\%$ of all trials, $SD = 25.6$) than for the participants in the 4-year-old group ($M = 64.7\%, SD = 30.1$) in the forced patient-subject condition. Active transitive responses were produced only by the younger group. Contrary to expectations, this response type occurred to a similar degree for both scene types. Across the two age groups, the absolute difference between the two scene types in the overall production of patient-subject sentences was small. On average, the participants produced patient-subject sentences in 73% of trials for the 2-option scenes ($SD = 35.2$) and 79% of trials for the 3-option scenes ($SD = 31.1$).

Consistent with these observations, the results of the 2 (Age Group) x 2 (Scene Type) ANOVA, conducted for the number of patient-subject sentences, revealed a statistically significant main effect of age group only, $F (1,30) = 5.47, p = .026, \eta^2_p = .15$. There was no statistically significant main effect of scene type, $F (1, 30) = 1.50, p = .23, \eta^2_p = .05$, and no interaction between scene type and age group, $F (1,30) = 1.22, p = .28, \eta^2_p = .04$. Even though the 3-option scenes offered a relatively simple patient-subject strategy, the availability of this strategy did not increase the likelihood that the participants would complete the cloze prompt with a patient-subject sentence structure.

3.1.1.2 Secondary (Follow-up) Analyses: Order Effects

Post-hoc analyses were conducted to examine the effect of within-task experience on the rate at which the participants produced the targeted patient-subject sentence structures in the forced patient-subject blocks. For these analyses, experience was operationalized as trial order.
The purpose of these analyses was to explore the expectation that the children’s responses might be influenced not only by whether or not the relevant structures were known to them, but also by experience-driven variations in the ease of activation for these structures. These analyses were intended to provide further insight into the factors affecting children’s syntactic flexibility. They asked whether or not the number of times that each of the target structures was produced was correlated with trial number. These analyses first examined the children’s use of passive responses, and then examined their use of agentless intransitive responses.

Figures 3.3 and 3.4 present the total number of passive and agentless intransitive responses respectively, summed across children, by age group and trial number. In these figures, the data are presented for both sessions, in order to capture variation both within and across days. Trials 1-10 correspond to the forced patient-subject trials that the children completed during Session 1, and Trials 11-20 correspond to the analogous trials that they completed during Session 2. As such, the data are collapsed across the two scene types. Each trial corresponds to a 2-option scene trial for half of the children, and a 3-option scene trial for the remaining half.
Figure 3.3 Total number of passive responses by age group and trial in the forced patient-subject condition

Figure 3.4 Total number of agentless intransitive responses by age group and trial in the forced patient-subject condition
Consistent with the means-based analyses in Section 3.1.1.1, Figure 3.3 presents clear evidence for an age group difference in the overall frequency of production of passive responses. In addition, these figures reveal opposite trends for the two sentence types. For passive responses, Figure 3.3 reveals that the production of these responses increased across trials and sessions, for both groups. There was a large, statistically significant positive correlation between trial number and the total number of passives that were produced, $r (18) = .94, p < .001$. This relationship remained statistically significant after controlling for session in a partial correlation, $r (17) = .79, p < .001$. In contrast, Figure 3.4 reveals a negative trend in the use of agentless intransitives, for both age groups. There was a large, statistically significant negative correlation between trial number and the total number of agentless intransitives that were produced, $r (18) = -.88, p < .001$. However, after controlling for session, this relationship no longer reached significance, $r (17) = -.36, p = .13$.

### 3.1.1.3 Sentence Production Task Summary

The analyses of the children’s sentence responses in the free response condition demonstrated that both scene types elicited active transitive sentences as the dominant response. Although the difference between the 7-year-old and the 4-year-old children in the mean number of active transitive responses that were produced approached significance ($p = .052$), both age groups produced a high rate of this structure overall. When pressed to begin with the patient in the forced patient-subject condition, the children produced a broader range of responses. Both age groups produced passive responses and agentless intransitive responses, and the choice between these two options respected the semantic and syntactic restrictions of the scenes and the verbs that they elicited. There was a significant difference between the age groups in the
frequency of passive use, but no significant difference in frequency of use of the agentless intransitive. Finally, a striking aspect of the data was that children in the 4-year-old group sometimes persisted with active transitive responses, a pattern that was not seen for the older group.

The results of the follow-up analyses by trial suggested that the children’s willingness or ability to produce the different possible structures changed as a function of their experience across both trials and sessions. For both age groups, passives and agentless intransitives demonstrated opposite trends. The overall rate of production of passive responses increased with experience in the task, and the production of agentless intransitive responses decreased with experience in the task. The two sentence types differed with respect to the strength of evidence for systematic change within rather than across sessions.

Overall, the results of the analyses of sentence responses suggested differences between the two age groups in the ability to flexibly alternate to a patient-subject sentence structure. The implications of these results for our understanding of children’s sentence production and for the questions of interest in Study 2 will be addressed in the Discussion below. The following section examines the outcomes for the primed Picture Naming task.

3.1.2 Primed Picture Naming Task

The analyses for the primed Picture Naming task examined the effects of the prime pictures on RTs to name target pictures representing the agents and patients from the animation stimuli. The purpose of these analyses was to confirm that the set of patient-related primes facilitated speed of processing for the patient targets and had no systematic effect on the agent targets. In order to address this purpose, picture naming RTs were analyzed as the dependent
measure in 2 x 2 x 2 ANOVAs with Prime Type (patient-related, control) and Target Type (agent-role characters, patient-role characters) as the within-participants independent variables, and age group as the between-participants variable. For these analyses, an interaction between prime type and target type was anticipated, reflecting the presence of a difference in RTs between the two prime conditions for the patient-role targets only.

3.1.2.1 Analysis, Full Data Set

3.1.2.1.1 Usable Trials and Outlier Trimming

Trials in which the child provided no response or named the prime or target picture in error, was off task, hesitated or included extraneous content in the target response (e.g., a determiner), and trials containing a noise artifact or voice key error in the target response were excluded as unusable. In total, 691 unusable trials were removed from the data set, leaving 1,869 or 73% usable target trials. Overall, 20% of responses were excluded due to error in the form or content of the prime or target response, no response, or lapses of attention, and 7% were excluded due to early or late trigger of the voice key.

A 2 (Prime Type) x 2 (Target Type) x 2 (Age Group) ANOVA examined the distribution of unusable responses across cells. The results revealed statistically significant effects of prime type, $F(1, 30) = .6.15, p = .02, \eta^2 = .17$, and age group, $F(1, 30) = 9.58, p = .004, \eta^2 = .24$ on the mean number of unusable trials. A greater number of unusable trials occurred with patient related primes ($M = 29\%, SD = 13.3$), than unrelated primes ($M = 25\%, SD = 10.95$), and in the responses of the younger children ($M = 32.5\%, SD = 11.28$) than the older children ($M = 21.5\%, SD = 8.69$). Neither the main effect of target type, $F(1, 30) = .06, p = .80, \eta^2 = .002$, nor the
two-way interaction between prime type and target type, $F (1, 30) = .68, p = .42, \eta_p^2 = .02$, was statistically significant, and there were no other significant effects (all $ps > .1$).

The observed higher rate of unusable trials in the patient-related condition was unexpected, but ultimately resulted in an average difference of only 1.5 usable trials across the entire stimulus set. Nonetheless, further analyses were conducted to explore the nature of this difference. A trial containing a patient-related prime could be scored as unusable due to an error related to the prime response portion of the trial, the target response portion, or both. If the effect of prime type on the error rate were due to a high rate of target naming errors in this condition, this would be an indication that the primes had an unintended (and problematic) negative effect on responding. The previous analysis identified which trials were unusable, but did not identify which portion of the trial, the prime or the target response, was in error. A second ANOVA was therefore conducted only on errors occurring during the target-naming portion of the trials, and examined whether the two different prime types differentially affected the participants’ ability to name the targets that followed. The 2 (Prime Type) x 2 (Target Type) x 2 (Age Group) ANOVA revealed a significant main effect on the number of unusable trials of age group only, $F (1, 30) = 15.4, p < .001, \eta_p^2 = .34$. As in the previous analysis, the younger group produced a greater mean number of unusable responses than the older group. There were no other statistically significant effects. The participants’ ability to name the target was not reliably affected by prime condition, target type, or any interactions among prime type, target type, and age group (all $ps > .1$). Thus, although there were slightly fewer usable trials within the patient-related prime condition, these results indicate that the two different prime types did not differentially affect the participants’ ability to name agent and patient targets successfully.
Following the removal of unusable trials, suspected outlier values were removed from the set of usable responses prior to completing further analyses. The procedure for outlier trimming followed the procedure used by Miller and colleagues (Miller, Kail, Leonard, & Tomblin, 2001; Miller et al., 2006). The mean RT was calculated for each child and condition. Any RT that was greater than two times the mean was removed and the mean was recalculated. This was repeated until no outliers remained. In the trimming procedures used by Miller and colleagues, minimum values of 350 ms (Miller et al., 2001) and 300 ms (Miller et al., 2006) were applied to identify low-value outliers; in the current data set all RTs below this range had already been flagged as early triggers or noise artifacts, and none remained in the data set. Using the M x 2 criterion, 2.7% of the useable responses were removed as outliers. The number of outliers did not differ reliably as a function of prime type, target type, age group, or any of the interactions (all ps > .1). Following the removal of unusable and outlier responses, 1,818 responses (71% of trials) were available for analysis.

3.1.2.1.2 Prime Effects on RTs

Table 3. 1 presents the mean picture naming RT as a function of prime and target type. As noted above, faster RTs following the patient-related targets were expected for target pictures representing patients only, with no significant priming effect expected for the agent targets. In line with this expectation, responses to patient targets were, on average, 47 ms faster following patient-related primes than control primes. Responses to agent targets were, on average, only 6 ms faster following patient-related primes than control primes.
Table 3.1 Mean RT in ms (and standard deviation) as a function of prime condition and target type

<table>
<thead>
<tr>
<th>Prime Type</th>
<th>Target Type</th>
<th>Agent (e.g., <em>cat</em>)</th>
<th>Patient (e.g., <em>baby</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-Related (e.g., <em>highchair</em>)</td>
<td></td>
<td>898 (153.95)</td>
<td>883 (151.6)</td>
</tr>
<tr>
<td>Control (e.g., <em>firetruck</em>)</td>
<td></td>
<td>904 (159.2)</td>
<td>930 (179.8)</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>-6 ms</td>
<td>-47 ms</td>
</tr>
</tbody>
</table>

The reliability of these patterns was examined in a 2 (Prime Type) x 2 (Target Type) x 2 (Age Group) ANOVA. Contrary to expectations, the results revealed that the interaction between prime type and target type was not statistically significant, $F(1, 30) = 2.26, p = .14, \eta^2_p = .07$. The main effect of age group approached statistical significance, $F(1, 30) = 4.12, p = .051, \eta^2_p = .12$, as did the two-way interaction between age group and target type, $F(1, 30) = 4.03, p = .054, \eta^2_p = .12$. Overall, the 4-year-old group demonstrated slower RTs ($M = 954$ ms) than the 7-year-old group ($M = 854$ ms). There were no other statistically significant main effects or interactions (all $ps > .1$).

Even though the omnibus ANOVA did not reveal a statistically significant interaction between prime and target type, planned comparisons of the effect of prime condition on RTs for each target type were conducted based on the *a priori* prediction that significant priming effects would appear for patient targets only. This analysis examined the effects of the prime pictures on naming RTs in 2 (Prime Type) x 2 (Age Group) ANOVAs conducted separately for agent and patient target pictures.
For targets representing the agents from the animation stimuli, the main effect of prime type on RT did not approach statistical significance, $F(1, 30) = .08, p = .78, \eta^2_p = .003$. Although RTs were slower for the 4-year-old group ($M = 939$ ms) than the 7-year-old group ($M = 864$ ms), the main effect of age group was also not statistically significant, $F(1, 30) = 2.15, p = .15, \eta^2_p = .07$, nor was the interaction between age group and prime type, $(1, 30) = .37, p = .55, \eta^2_p = .01$.

In contrast, and as expected, the effect of prime type on RTs for patient targets was statistically significant, $F(1, 30) = 4.59, p = .037, \eta^2_p = .13$. For patient targets, the main effect of age group was also statistically significant, $F(1, 30) = 6.09, p = .02, \eta^2_p = .17$. Mean RTs were slower for the younger group ($M = 969$) than the older group ($M = 844$). The interaction between prime type and age group was not statistically significant, indicating that the effects of the prime on naming RTs did not differ between the younger and the older children, $F(1, 30) = .17, p = .68, \eta^2_p = .006$. This analysis of prime effects repeated over items was not statistically significant $t(19) = 1.56, p = .14, \eta^2 = .11$.

These results indicate that, as expected, semantic relatedness did facilitate naming RT for the patient targets only. However, the overall priming effect was relatively modest, and the analysis over items suggested that it may have been due to a limited subset of the stimuli. The goals of Study 2 require greater certainty that the set of primes will produce a facilitation effect for the patient targets. As such, individual items were further examined for their suitability for use in Study 2.
3.1.2.2 Selection of Items for Study 2

The goal of this selection procedure was to identify a stimulus set for Study 2 that retained as many stimulus items as possible while removing those primes that showed no evidence of any facilitative priming effect for the patient targets.

3.1.2.2.1 Selection Strategy

The first step in identifying prime items to retain for Study 2 was to identify those primes that produced RT effects in the anticipated direction and those that did not, based on the mean RT for each cell averaged across all children. Of the 20 prime-target sets, 13 produced faster mean RTs for the patient targets following patient-related than control primes ($M$ difference = 80 ms, $SD = 58.99$). These items were: hammer/nail (agent/patient), bat/ball, frenchfries/hamburger, caterpillar/butterfly, egg/chicken, highchair/baby, wheel/car, moon/star, man/lady, pie/apple, pond/frog, cheese/mouse, and helmet/bike. Seven items produced slower mean reaction times for patient targets following patient-related primes than unrelated primes ($M$ difference = 60 ms, $SD = 54.5$). That is, based on the cell means, there was no evidence of facilitation. These items were: clam/shell, carrot/rabbit, music/piano, house/window, circus/clown, corn/scarecrow, and crown/king.

Prime items were provisionally designated for Study 2 retention based on the above categorization. As a second step towards selecting prime items for Study 2, item cell means were re-examined excluding three children who seemed to be particularly inhibited in patient-target naming following patient-related primes. An examination of the mean prime effect for individual

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26 All discussions of mean priming effects at the item or participant level above and in section 3.1.2.2 are descriptive in nature, with a prime condition RT difference of 0 designated as the classification cut-off point. Any prime-patient target set or individual participant that showed a mean difference between prime conditions that was greater than zero was designated as showing faster responding in the primed condition.
children (across the entire stimulus set of patient targets) had revealed a wide range of values, from a difference score of 375 ms in the direction of faster naming following patient-related primes to a difference of 169 ms in the direction of slower naming following patient-related primes. While most of the participants demonstrated varied responses to the individual items, a small number of children appeared to consistently name the patient more slowly following the prime – that is, to be inhibited. This raised the possibility that relatively weaker but nonetheless present facilitative trends for a particular item in the larger group might be muted or masked by general inhibitory effects seen for these children. As such, the designation of primes as likely or not likely to have some facilitative effect was re-examined with these three children removed.

For the smaller group of \(N = 29\) children, all 13 primes originally identified as having a facilitative effect continued to show this expected direction of relationship. In addition, six of the seven items demonstrating slower mean RTs following the patient-related prime continued to do so. One item, crown/king changed to show a shorter mean reaction time for king following crown (patient-related target, \(M = 858\) ms) than chain (unrelated target, \(M = 885\) ms).

Based on these outcomes, the 6 items that demonstrated no priming facilitation for the patient target in either the full or reduced participant group were removed from the set of stimuli to be used in Study 2. In the interest of maintaining as large a stimulus set as possible, all of the remaining items were retained (i.e., no other minimum criterion was imposed). Crown/king was retained based on the fact that it revealed a facilitative effect in the smaller group, and on the fact that there is evidence for verbal association between crown and king among children (Palermo & Jenkins, 1964). The analysis in the following section examines the priming outcomes for the set of retained items, calculated across the full set of 32 participants. This analysis retained the three participants (described above) who responded particularly slowly following patient-related
primes for the full set of stimuli. These participants were in included in this analysis on the basis that their response patterns reflected part of the continuum of outcomes that were observed, from a much faster mean RT in the patient-primed condition to a much faster mean RT in the control condition. It is possible that in any sample of children, some might fail to show any facilitation from a prime manipulation. The goal with respect to Study 2 was to retain a set of prime items that would be likely to produce an overall facilitative effect despite the fact that for some children lexical activation might not benefit from the primes.

### 3.1.2.2 Priming Results for the Reduced Item Set

Table 3.2 presents the mean RT per prime/target cell, calculated across the full sample of 32 participants, for the smaller stimulus set containing 14 agent and 14 patient targets. With this data set, the patient prime effect for participants ranged from 222 ms faster naming following patient-related primes to 153 ms slower naming, 95% CI = 36 to 144 ms. Of the 32 participants, 26 demonstrated a mean RT for patient targets that was faster following patient-related than control primes.

#### Table 3.2 Mean RT in ms (and standard deviation) by prime and target type, reduced stimulus set

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Target Type</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agent</td>
<td>Patient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(e.g., cat)</td>
<td>(e.g., baby)</td>
<td></td>
</tr>
<tr>
<td>Patient-Related</td>
<td>902 (161.9)</td>
<td>844 (135.4)</td>
<td></td>
</tr>
<tr>
<td>(e.g., highchair)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>888 (157.6)</td>
<td>933 (198.4)</td>
<td></td>
</tr>
<tr>
<td>(e.g., firetruck)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>14 ms</td>
<td>-89 ms</td>
<td></td>
</tr>
</tbody>
</table>
The analysis of prime effects on naming RTs was repeated for this smaller set of items, but a preliminary analysis was first conducted to rule out any influence of the repetition of items between experimental blocks (due to each picture being presented twice). Although block was not intended as an independent variable, it was important to ensure that the conclusions regarding this smaller data set reflected the intended semantic priming effect rather than any unintended effect of repetition priming. Picture Naming Block 2 contained 52 fewer usable trials than Block 1. This difference was statistically significant, \( F(1, 30) = 6.38, p = .02, \eta_p^2 = .18 \). However, for the number of usable trials, the main effect of block showed no interactions with either prime type or target type (all \( ps > .1 \)). Moreover, an analysis for RTs indicated no main effect of block and no interactions between block and any other factors (all \( ps \geq .1 \)). The analysis is therefore reported collapsed across experimental block.

A total of 1,281 data points, or 71.5% of trials, contributed to the analyses conducted on this smaller stimulus set. As Table 3.2 reveals, responses to patient targets were, on average, 89 ms faster following patient-related primes than unrelated primes. For agent targets, in contrast, RTs were on average 14 ms slower following patient-related than unrelated primes. A 2 (Prime Type) x 2 (Target Type) x 2 (Age Group) ANOVA was again conducted to examine the reliability of these patterns, and the results revealed the expected outcomes. The interaction between prime and target type was statistically significant, \( F(1, 30) = 8.63, p = .006, \eta_p^2 = .22 \), and qualified the significant main effect that was observed for prime type, \( F(1, 30) = 4.54, p = .04, \eta_p^2 = .13 \). The ANOVA also revealed a statistically significant main effect of age group, \( F(1, 30) = 4.60, p = .04, \eta_p^2 = .13 \). RTs were faster in the older group (\( M = 841 \) ms), than in the

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27 This analysis was conducted for \( N = 27 \) participants who had a minimum of 3 trials per cell following the divisions of cells by experimental block.
younger group \((M = 943 \text{ ms})\). The main effect of target type was not statistically significant, \(F(1, 30) = .15, p = .70, \eta^2_p = .005\), nor were the interactions between prime type and age group, \(F(1, 30) = .15, p = .70, \eta^2_p = .005\), target type and age group, \(F(1, 30) = .199, p = .17, \eta^2_p = .06\), or prime, target and group, \(F(1, 30) = .84, p = .37, \eta^2_p = .03\).

In order to examine the significant interaction between prime type and target type, simple main effects analyses were conducted to examine the effect of prime type on RTs for each target type. For patient targets, the effects of faster naming following patient-related than control primes was statistically significant, \(F(1, 30) = 10.48, p = .003, \eta^2_p = .26\). For agent targets, the effect of prime condition on RTs was not statistically significant, \(F(1, 30) = .37, p = .55, \eta^2_p = .01\).

The analysis repeated over items also revealed a significant effect of age group, \(F(1.13) = 41.18, p < .001, \eta^2_p = .76\), as well as the expected significant interaction between prime and target type, \(F(1, 13) = 8.78, p = .01, \eta^2_p = .40\). Simple main effects analyses indicated that RTs were significantly faster following patient-related primes than control primes for patient targets, \(F(1, 13) = 12.86, p = .003, \eta^2_p = .497\). For agent targets, the difference between prime conditions was not statistically significant, \(F(1, 13) = 1.35, p = .27, \eta^2_p = .09\). There were no other statistically significant effects (all \(ps > .1\)).

The above analysis indicates that, overall, the participants were faster to name the patient targets following the patient-related primes than the control primes. Targets such as *baby*, for example, were named more quickly following primes such as *highchair* than following primes such as *firetruck*. In contrast, there was no reliable effect of the primes on RTs to name the agent targets. Targets such as *cat* were not named reliably more quickly following primes such as *highchair* than primes such as *firetruck*. Looking ahead to Study 2, these results suggest that
when children view the animation stimuli preceded by the prime stimuli, activation for characters such as *baby* (patient) will be faster in the patient-related than control prime condition. However, these results do not indicate whether speed of processing for patient-role characters such as *baby* will differ reliably from speed of processing for agent-role characters such as *cat*. The goals of Study 2 assume that when children view an animation of a cat (agent) licking a baby (patient) preceded by the *highchair* (patient-related) prime, activation and selection of *baby* will be faster than activation of *cat*, and that when they view the same animation preceded by the *firetruck* (control) prime, neither *cat* nor *baby* will have a reliable processing advantage. In order to further examine this assumption, the final analysis in this section re-examined the significant interaction between prime type and target type on picture naming RTs, comparing RTs to name patient versus agent targets within each of the prime conditions. For example, this analysis compared RTs to name *baby* (patient) versus *cat* (agent), first following *highchair* (patient-related prime, i.e., *highchair* → *baby* vs. *highchair* → *cat*) and then again following *firetruck* (control prime, i.e., *firetruck* → *baby*; *firetruck* → *cat*). In the control prime condition of the Picture Naming Task, patient targets were named more slowly on average than agent targets ($M_{\text{Difference}} = 45$ ms). This difference approached statistical significance, $F (1, 30) = 3.69, p = .06, \eta^2_p = .11$. In the patient-related prime condition, in contrast, patient targets were named more quickly than agent targets ($M_{\text{Difference}} = 58$ ms). This difference was statistically significant, $F (1, 30) = 5.83, p = .02, \eta^2_p = .16$.

### 3.1.2.2.3 Follow-up Analysis: Further Predictors of Priming Outcomes

Finally, a series of post-hoc analyses were conducted to explore whether the magnitude of the priming effect was related to any other participant characteristics. These analyses
examined the relationship between priming outcomes for the patient targets and participants’
gender, general language proficiency as indexed by *CELF-P:2* (Wiig et al., 2004) or *CELF-4*
(Semel et al., 2003) Recalling Sentences score, and baseline response speed for the patient
targets as indexed by their RTs in the control prime condition. These results demonstrated that
the priming outcomes were not related to gender, \( t (30) = .14, p = .89 \), or general language
proficiency, \( r (29) = .18, p = .34 \). The magnitude of priming facilitation, however, was positively
correlated with RT to name the patients in the control prime condition. The children who were
slower overall to name the patient targets demonstrated greater benefit from the prime, \( r (30) =
.46, p = .01 \).

### 3.1.2.3 **Picture Naming Task Summary**

The analyses in section 3.1.2 examined the influence of the prime manipulation on RTs to
name pictures of the agent and patient targets that appear together within the animation stimuli.
For these analyses, a priming effect was expected for the patient, but not the agent, target
pictures. The results for the full stimulus set were broadly consistent with this expectation.
Planned comparisons revealed a statistically significant difference in RT between the prime
conditions for patient targets only. However, the overall priming effect was relatively modest
and was not statistically significant by items. In anticipation of the goals of Study 2, the items
that showed no evidence of any facilitative prime effect, based on means across participants,
were removed from the stimulus set. The RT analysis repeated for this selected set revealed the
anticipated interaction between prime type and target type. There was a large and statistically
significant effect of the prime manipulation of RTs to name patient targets. Patient-role targets
were named more quickly following patient-related primes than control primes. The secondary
follow-up of the interaction also revealed that the patient-role target pictures were named more quickly than the corresponding agent-role target pictures following the patient-related primes.

3.1.3 Overall Summary of Study 1 Results

Study 1 examined the syntactic patterns that 4- and 7-year-old children used to describe animation stimuli depicting transitive scenes. It also examined the RTs to name pictures of the agent- and patient-role characters from these animations following patient-related and control primes. The results from the free response condition of the Sentence Production task indicated that, for both age groups and both scene types, the participants preferred to describe the animations using active transitive sentences. When forced to begin with a (non-preferred) patient subject, more striking differences emerged by age and scene type in the frequency with which different sentence structures were produced. Overall, the children in the 4-year-old group produced fewer successful patient-subject responses than the children in the 7-year-old group, sometimes persisting with active transitive responses. Turning to the targeted patient-subject structures, the younger children produced fewer passive but not fewer agentless intransitive responses than the older children. As expected, the participants’ selection of passive versus agentless intransitive responses was influenced by scene type, with agentless intransitive responses almost completely localized to the 3-option scenes. However, summing across passives and agentless intransitives, the total number of patient-subject responses did not differ between the scene types. Thus, even though the 3-option scenes offered a relatively simple option for producing a patient-subject sentence, the availability of this option did not increase the likelihood that the participants would complete the cloze prompt with a patient-subject sentence structure. Finally, results of the follow-up analyses by trial order indicated that within-
experiment experience influenced the children’s response patterns. There was an increase across trials in the rate of production of passive responses, and a decrease over all trials in the rate of production of agentless intransitive responses.

The results of the primed Picture Naming task revealed a modest priming effect for patient-role targets for the full stimulus set. A subset of 14 prime items was retained for use in Study 2, excluding 6 prime items that demonstrated no evidence of priming facilitation. After trimming the data set to exclude these 6 items, the analysis across participants revealed a large and statistically significant effect of the prime manipulation for patient-role targets. Patient-role targets were named more quickly following patient-related primes than control primes. As expected, there was no systematic effect of the prime manipulation on RTs to name agent-role targets. Importantly, neither the analysis for the full data set nor the analysis for the reduced data set revealed any interaction between the prime effect and age group. These analyses indicated similar effects of the prime manipulation on RTs for both the younger and the older participants.

3.2 Study 1 Discussion

The purpose of Study 1 was to establish baseline data relevant to the broader goal of examining lexical activation effects on young children’s sentence production outcomes. The results from the Sentence Production and Picture Naming tasks will inform the predictions for Study 2 and the interpretation of its results. With regard to the goals of Study 2, the most important findings of Study 1 are the observations of a high reliance on active transitive descriptions in the free response condition of the Sentence Production task and age group differences in the rate of production of patient-subject sentences in the forced patient-subject condition, as well as the documentation of facilitating prime effects in the Picture Naming task.
The discussion that follows will first address these outcomes, and then address the effects of within-task experience on children’s sentence production outcomes.

3.2.1 Primary Implications: Syntactic Patterns and Semantic Priming

3.2.1.1 Age Group Similarities in Preference for an Active Transitive Default

The first question of interest in Study 1 addressed children’s sentence patterns in the free response condition of the Sentence Production task. In this condition, the eliciting prompt pulled for a description of the action in the scene but otherwise left the children relatively free to respond naturally. Based on prior reports of children’s baseline patterns (Shimpi et al., 2007; Turner & Rommetveit, 1967) and the noted general preference in English, active transitive responses were expected to dominate. As anticipated, the vast majority of children’s responses indeed took the form of an active transitive sentence, accounting for more than 80% of responses across both age groups and both scene types.

The observed active transitive dominance is important because it predicts a relatively stable baseline pattern of syntactic planning against which to examine the effects of a manipulation of lexical activation patterns in Study 2. As noted by Bock (1996), an important challenge in production research is to maintain the naturalness or the integrity of the production process as much as possible while minimizing the problem of “exuberant responding” – that is, the production of utterances that “have uncertain bearing on the questions of interest” (p. 407). With young children, the possibility of “exuberant responding” in a sentence production task is certainly present. In a baseline condition that preceded their syntactic priming study, for example, Shimpi et al. (2007) observed that 64% of 4- and 5-year-olds’ sentences were active transitives – and 36% were fragments or otherwise not codeable as one of the structures of
interest. Among the 3-year-old group in that study, a full 76% of baseline descriptions were fragments or did not conform to the targeted structures. The questions of interest in Study 2 are concerned with the rate at which children produce alternative sentence structures. These questions require the production of sentences containing a hierarchy of grammatical roles rather than noun- or verb-phrase fragments. Moreover, the questions of interest assume that the facilitation of processing for the patient will introduce a conflict between the processing priorities of the lexical stream and children’s syntactic priorities. These questions rest on the assumption that syntactic priorities will naturally favour the active transitive. In Study 1, active transitive responses dominated in the absence of any specific instruction, modeling or feedback (other than on Trial 1) regarding the form of children’s responses. For the targeted age range and with the current stimuli, the needs and assumptions with regard to Study 2 seem to be met. The current set of stimuli and the prompt structure were relatively successful in eliciting a stable default active transitive pattern.

It is important to acknowledge that although both groups of children demonstrated a strong preference for active transitive descriptions, they did not actually produce this form to quite the same extent. As noted above, there was a mean difference between the age groups of 12% in the rate of active transitive production, and this difference approached statistical significance \( (p = .052) \). This difference suggests that the two age groups may be expected to function with a somewhat different baseline in Study 2. The more important observation in the current study is the high overall rate of active transitive responses produced by the two groups. It is also worth noting that the difference between the two age groups in the current study partly reflected the contribution of the one 4-year-old child who responded to almost all free response trials with a passive sentence. This pattern was unusual and there is no reason to expect a similar
pattern to occur to any large extent in a new sample of children. With this one unusual pattern excluded, the difference between the age groups in the rate of active transitive responding is reduced to 8%, a difference that is not statistically significant \((p = .07)\). Overall, the results provide reason to expect more similarity than dissimilarity in children’s default preferences across the age range of interest.

Finally, although the two age groups were very similar in their preference for an active transitive default, the children’s responses demonstrated one feature that is relevant to the question of default form and was not captured by the set of analyses reported in the Results section. The category of active transitive responses included sentences that were produced with full nouns as well as those containing pronominal forms and, to a lesser extent, sentences with a null subject. Consistent with prior evidence (Bloom, 1990), pronominal and null forms were observed to a greater extent for agents than patients \((t (31) = 2.65, p = .012)\), and in the responses of 4-year-old than 7-year-old participants \((t (30) = 2.33, p = .027)\). On average, the children in the 4-year-old group produced pronominal or null forms for 19% of the agent/patient nouns in their transitive responses, whereas for the 7-year-olds this value was 5%. Because this investigation’s broader questions about lexical activation effects relate to the priming of noun lemmas, it will be important to encourage the use of full lexical nouns rather than pronominal forms in Study 2. The age group difference in the use of pronominal forms also has another potentially interesting interpretation. One perspective on language production suggests that pronominal forms may be selected because they require less cognitive effort than selecting a specific full noun, and that null forms may similarly occur for reasons related to processing load.

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28 Included in this count were the relatively few responses that contained an agent and an optionally or obligatorily transitive verb, but no patient. For the analyses in the Results section, these responses were coded as other rather than active transitive.
(Bloom, 1990). By this argument, the higher rate of pronominal and null forms produced by the 4-year-olds may indicate that even though the two age groups both naturally favoured active transitive sentences, they differed in their ability to manage the total work of producing these sentences. The younger children may have resorted more often to (less costly) pronominal forms in order to manage the production task within their overall more limited capacity. This possibility would be consistent with the expectations that capacity is more limited in younger children and that experience influences capacity in sentence production. Although the active transitive is preferred and occurs frequently, the children in the 4-year-old group nonetheless had approximately 3 years’ less experience with this structure and the requisite lexical items. The processing-load based interpretation of these patterns is necessarily speculative. However, if true, these patterns would provide additional support for the expectation that in Study 2, 4-year-olds will operate with greater strain on their capacity than 7-year-olds when producing active transitive sentences, particularly if producing full lexical nouns. They may therefore be relatively more prone to difficulty managing any rise in total processing demands (e.g., such as demands incurred from early activation of a late-produced lexical item).

3.2.1.2 Age Group Differences in Syntactic Flexibility

The second question of interest in Study 1 addressed the sentence patterns that the children produced when pressed to begin with the patient in the subject position. This question asked whether the 4-year-old participants would produce patient-subject structures less often than the 7-year-old participants. This question is relevant to the broader expectation that younger children have less flexibility in syntactic planning than older children and, therefore, in general will be less likely or less able to accommodate variations in lexical activation timing via
alternations of sentence structure. In the current study, the expectation of differences in syntactic flexibility was examined with a focus on the rate at which children produced alternations to the default active transitive. The cloze prompt in this study was chosen to provide a relatively strong or compelling cue to begin with the patient. Even with this relatively strong cue, the results supported the expectation of differences in syntactic flexibility. The children in the 4-year-old group produced patient-subject sentences in just under two-thirds of the trials, whereas the children in the 7-year-old group did so in almost 90% of the trials.

As discussed in sections 3.1.1.2 and 3.2.1.1, the difference between the two age groups in the rate of production of active transitive forms in the free response condition approached significance when all participants were included in the analysis. It is important to ask whether the conclusion that the younger group demonstrated more limited syntactic flexibility holds despite the difference that was observed in the free response condition. The evidence for a difference in flexibility was provided by the fact that the 4-year-old participants produced fewer patient-subject sentences than the 7-year-old participants in the forced patient-subject condition. Given that they also produced fewer active transitives in the free response condition, it could be argued that the observed difference in the rate of patient-subject sentences reflects a more general difference between the two age groups in the tendency to produce any of the targeted sentential responses, rather than a specific difference in the likelihood of alternating between active transitive and patient-subject sentence structures. There are several reasons to reject that argument. First, if the observed difference in the rate of patient-subject responses simply reflected a more general age-related difference in the likelihood of producing a sentential response at all, then one might expect the 4-year-old group to produce a higher rate of unscorable responses than the 7-year-old group in both blocks of the Sentence Production task. This was not
the case, and in fact the rate of unscorable responses was virtually identical between the two
groups in the forced patient-subject condition, at approximately 12% each. Instead, the
difference between the two age groups in this condition stemmed primarily from the fact that
almost one quarter of responses produced by the children in the younger group maintained the
default active transitive pattern. As noted in the Results section, 13 of the 16 children in the
younger group produced at least one active transitive response in the forced patient-subject
condition. In contrast, only 3 of the 16 children in the older group did so (1 trial each). Moreover,
more than one third (n = 6) of the children in the 4-year-old group maintained the same syntactic
structure across a majority of both the free response and patient-subject trials during at least one
session.29 The younger children appeared to be either unwilling or unable to alternate to a
patient-subject structure on some trials (and for some children, across an entire block of trials),
despite the fact that adherence to the active transitive forced them to disregard the pragmatic
requirement of the task. In contrast, even though the older children clearly also preferred the
active transitive, the requirement to alternate to a different form did not appear to pose a
problem.

In Study 1, the most important question regarding syntactic flexibility was the question
of whether two the age groups differed in the overall ease or likelihood of alternating to a
patient-subject structure. The research questions in Study 1 also asked whether children’s
demonstrated syntactic flexibility would differ as a function of scene type. Based on the prior
literature (Harris & Flora, 1982; Marchman et al., 1991; Turner & Rommetveit, 1967), it was
expected that the 4-year-old group would produce fewer passive responses than the 7-year-old

29 This includes the one child who adhered to the passive across almost all trials of the Sentence Production
task, and five who adhered to the active transitive during at least one session.
group. It was also expected that the 3-option scenes would provide an arguably easier alternative to the passive, allowing children to produce a simple intransitive structure while still describing the central action in the animation (e.g., “The apple is rolling”). Based on the prior literature, it was expected that the younger children would produce the agentless intransitive form at least as often as the older children (Braine et al., 1990; Loeb et al., 1998) and possibly more often if they had a greater need to rely on it in compensation for difficulty alternating to the passive. It was therefore anticipated that syntactic flexibility (as measured by the rate at which children produced either of the anticipated patient-subject responses) would be higher in response to the 3-option scenes, certainly for the younger group and possibly for the older group. Many of the expected patterns occurred: The 4-year-old children indeed produced fewer passive responses than the older children. In addition, the two scene types resulted in a different range of responses, with the 3-option scenes eliciting a mix of passive and agentless intransitive sentences. Agentless intransitive sentences accounted for 29% of responses overall to the 3-option scenes in the forced patient-subject condition. This pattern demonstrated that when the scene semantics and the argument structure possibilities of the verb allowed it, the children did make use of the agentless intransitive option. And finally, the younger children produced agentless intransitive forms at a higher rate than the older children, albeit to an extent that was not statistically significant. There was little support, however, for the expectation that children’s overall willingness or ability to produce a patient-subject structure would be higher in response to the 3-option scenes, or that the age difference in syntactic flexibility would be minimized in the responses to these scenes. The rate at which the younger children persisted with the active transitive did not differ significantly between the scene types, nor did the overall rate of production of patient-subject sentences.
This pattern of results suggests that although the agentless intransitive certainly provided one descriptive option, other potentially more powerful constraints may have helped to maintain the difference in flexibility that was observed between the two groups. In particular, even though the agentless intransitive provides a relatively simple syntactic option to place the patient in the subject position, using this form may come at a cost to message fidelity. As noted above, one of the defining features of the agentless intransitive is that it removes reference to the agentive or causal aspect of the scene. Such a change does not occur in the alternation between the active and the passive. Even the truncated passive implies that the patient was acted on by some (unnamed) agent, rather than acting volitionally. With respect to this difference, it is of interest to note that almost half (44%) of responses that were agentless intransitive in form also referenced the causal agent in another phrase or clause. These references took a variety of forms (e.g., *The ball… “is bouncing from the duck”; The ball… “is bouncing because the duck’s bouncing it”; The clown… “is moving and the sheep is pushing it”; The frog… “is stretching and the person’s making it stretch more”; The hamburger … “is cooking by the crocodile”). These patterns suggest that the children were often unwilling to deny or ignore the causal or agentive aspect of the message. On balance, then, although the agentless intransitive may have an advantage over the passive in terms of ease of syntactic production, this advantage may be nullified if a child is particularly sensitive to the need to express the causal aspect of the message.

Overall, the results of the Sentence Production task were consistent with the expectation that 4-year-old children are less flexible than 7-year-old children in their descriptions of transitive scenes. They are less likely to alternate away from the preferred active transitive structure. In Study 1, this difference was observed when children were pressed to alternate with a relatively strong and explicit cue. This difference in flexibility is expected to carry over to Study
2, which will examine children’s sentence productions following a much more implicit lexical activation pressure to alternate to a patient-subject sentence. The results of Study 1 do not support the expectation that children will be more responsive to the lexical activation pressure in the context of 3-option scenes than 2-option scenes. However, Study 2 provides an opportunity to observe whether the two scene types elicit a similar range of structures with the more implicit task structure.

3.2.1.3 Independent Evidence of Facilitative Prime Effects

The research questions in Study 1 also addressed the effect of the selected semantic primes on RTs to name pictures of the agents and patients taken from the animation stimuli. In Study 2, semantic priming is used as a methodological tool to manipulate lexical activation during sentence planning and production, and the measures of interest focus on the secondary effects of this activation on sentence production variables. The interpretation of any sentence-level effects rests on an assumption that the semantic primes are in fact likely to facilitate lexical activation for the patient. With this assumption in mind, the most important outcome of the Picture Naming task was the fact it allowed for the establishment of a set of primes that can reasonably be expected to produce such facilitation.

With the full set of stimuli, a statistically significant priming effect was observed for patient targets. However, the modest nature of this overall effect and the fact that it was not reliable across items underscores the importance of generating independent evidence of priming outside of the sentence production context. Study 2 will examine secondary or more distal effects of the prime, as lexical activation interacts with other influences on sentence planning. It is likely that these effects might be relatively harder to observe than the more proximal effect on picture-
naming RT, and even more difficult to observe if the overall strength of the primes is too modest. The more robust facilitative priming effects observed with the reduced set of stimuli lend greater confidence to the expectation that the priming manipulation will have the expected effects on patient processing in Study 2.

The set of stimuli that were retained for Study 2 produced an average facilitating effect of 89 ms for the patient targets and had no reliable effect on naming times for agent targets. Although these values certainly contain some amount of measurement error, they nonetheless provide support for the expectation that the set of primes will be capable of selectively promoting patient (and not agent) activation within the sentence production context. In the absence of relevant data it is not possible to specify or predict how much lexical facilitation is necessary or sufficient to influence sentence planning. Bock’s (1986a) report of semantic priming in sentence production, for example, did not report any independent measures of the strength of the prime stimuli. Moreover, research into the time course of sentence planning and production in young children is extremely limited. One relevant study, however, reported average speech onset RTs of approximately 1500 ms for typically developing preschoolers producing simple active transitive sentences (Anderson & Conture, 2004). A variation of 89 ms in the time course of lexical planning does not seem insignificant within that time frame.

Lexical processing data from the adult literature also provide insight into the potential importance of the observed magnitude of facilitation. Based on a review of the existing literature, Indefrey and Levelt (2004) provided estimates for the time course of the different components of lexical processing. Indefrey and Levelt estimated a median time course of 250 ms (Range: 150 – 350 ms) from the onset of a picture to lexical (lemma) selection. This value reflected median estimates of 175 ms for accessing a lexical concept (Range: 150 – 200 ms) and 75 ms for lemma
selection (Range: 0 - 150). These values should be interpreted cautiously as they relate to the current study. In particular, the relevant time frames for children can be expected to be longer than those reported for adults. Indefrey and Levelt, for example, provided an estimate of 600 ms from picture onset to speech onset. In contrast, the mean picture-naming RTs for the children in the current study were in the range of approximately 900 ms, or 1.5 times longer than the adult estimate. Accordingly, we can expect that the time course specific to lexical selection was also longer than the adult estimate. If we extend the time estimates accordingly we can imagine that, for children, lexical selection requires somewhere in the range of a median of 375 ms (Range: 225 – 525). This estimated time frame is of course only speculative. However, 89 ms of facilitation again does not seem insignificant within such a time frame.

Even with the smaller and more robust set of primes, however, a small number of children (n = 6 out of 32) did not show the expected facilitation. Given room for measurement error, 26/32 is an estimate of the true number of children who were primed. However, given the fact that priming outcomes rest on both knowledge structures and activation dynamics, it is also possible that some children may fail to show priming for systematic reasons (see for example Pellowski & Conture, 2005, for a demonstration of different priming outcomes for typically developing children and children who stutter). Although the current study was not designed to systematically investigate the causes of individual difference in priming, the results of the follow-up analysis in section 3.1.2.2.3 did reveal that neither age group, gender, nor general language proficiency were significantly related to priming outcomes, whereas there was a statistically significant correlation between children’s response speed for patient targets in the control condition and raw magnitude of priming. The children who named the patient targets more slowly in the control condition demonstrated greater raw benefit from the patient-related
primes. This correlation is consistent with prior observations that overall slowness and the magnitude of priming tend to be positively related (Chapman et al., 1994). However, the interpretation of this relationship is not entirely straightforward. Chapman et al. argued that differences in the raw magnitude of priming between individuals with different baseline response speeds may simply reflect general differences in performance rather than differences in activation specific to the prime. In the current context, it remains an open question whether the possibility of a greater raw magnitude of lexical priming for individuals with slower responses might translate into greater effects of the prime on outcomes at the sentence level.

The most important implication of the potential relationship between response speed and priming effects relates to potential differences as a function of age group. As noted by Chapman et al. (1994) the relationship between priming and speed predicts that the raw magnitude of priming will differ between different age groups. Children, for example, are slower to respond than adults (across a variety of tasks) and are also likely to show a greater raw magnitude of priming than adults. In Study 1, the 4-year-old children were slower to name the target pictures than the older children. There was no interaction, however, between age group and the priming effect. It was not the case that the younger group showed reliably more priming than the older group. This lack of a difference between the age groups also remained when the magnitude of priming was re-analyzed using proportional scores that controlled for participants’ response speed in the control prime condition \( t (30) = .64, p = .52 \). This pattern of results lends further support to the expectation that the selected primes will have a facilitating effect on lexical activation for the patient stimuli, and that this effect will be similar for the two age groups of interest.
3.2.2 Secondary Implications: Within-Task Experience Influences Sentence Outcomes

A secondary focus of the research questions in Study 1 examined the effects of experience on the rate at which children produced the targeted patient-subject sentence structures in the Sentence Production Task. In this study, it was expected that the 4-year-olds would produce fewer passives than the 7-year-olds in the forced patient-subject condition, and this expectation was borne out. Because passives are late to develop, one possible source of this age group difference could reflect a knowledge gap on the part of some of the younger children. Of the 16 children in the 4-year-old group, 5 never produced a passive response on any trial. For these children, it is possible that the passive was not yet known or was not yet part of their productive repertoire. However, the perspective on language production that guides this research is also consistent with the possibility that the rate of passive production was influenced by children’s ability to activate and produce that structure within their capacity limits. This perspective is consistent with the view that experience (both long- and short-term) will influence the processing demands associated with producing a targeted form. Even if a child knows a form to some extent, he or she may not be able to successfully activate and produce it in the moment of speaking if his or her total experience with that form is limited. Based on the prior literature, it was expected that experience, and its relationship to activation strength, would affect children’s rate of production of the passive, particularly for the younger participants (Savage et al., 2003; Shimpi et al., 2007). Experience was operationalized as trial order in this study, and the results were consistent with expectations. The total number of passives that the children produced increased across trials within the forced patient-subject blocks of the Sentence Production task. Strikingly, the 7-year-old and the 4-year-old groups demonstrated very similar effects of trial
order. The younger group, however, consistently produced fewer passives than the older group. The correlation between trial number and passive production indicated that as children accrued experience in the task, they became either more willing or more able to produce the passive. This result is consistent with the effect of experience on passive production reported by Savage et al. (2003). In the context of Study 2, this result suggests that some children will be unable to alternate to the passive in a less supportive context (e.g., one in which passive production contexts are intermixed with other structures rather than blocked together), even if they do know the form.

Among the potential explanations for the trial order effects, a less interesting possibility would be to attribute the observed changes to strategic factors or task discovery. By this account, what would have changed across trials would not be children’s ability to activate and produce the passive due to trial-by-trial experience or functional gains in capacity as they became more familiar with the task, but rather their realization that the passive was expected. This account would predict that once a child caught on to the expectation, he or she would then produce the passive with no systematic variations in difficulty. Several factors argue against this interpretation and argue instead for more implicit changes in the activation of the passive in the moment of speaking.

First, as noted in the Method section, children were given no feedback on either the structure or content of their responses other than on the very first trial. They were given no consistent indication that their responses either were or were not meeting some expectation. Anecdotal observation provided no indication that the children were particularly aware or concerned about the form or content of their responses. They often commented after producing their descriptions, but these comments tended to focus on the animations, not their responses.
(e.g., “Do you think the cat and the baby are friends?”; “That duck shouldn’t play in the road” etc.). The lack of models or feedback regarding expected responses argues against a strategic or explicit source of the change in children’s responses.

A second observation that is more in line with implicit changes relates to the opposite direction of effects that were observed for agentless intransitive and passive responses. While the rate of passive responses increased across trials, the rate of agentless intransitive responses decreased. The change in the rate of agentless intransitive production appeared to occur across sessions rather than across trials within a session (in contrast to the rate of passive production, which increased both within and across trials; refer to Figures 3.3 and 3.4). Children were more likely to produce agentless intransitive structures to describe the 3-option scenes during Session 1 than Session 2. This pattern can be explained with recourse to the implicit learning view of syntactic priming (Bock & Griffin, 2000a). By this view, experience with a syntactic structure creates long-lasting changes in the production system via changes in connection strengths to the relevant syntactic pathways. As children gained experience producing passives to describe the 2-option scenes in Session 1, long-lasting changes to the strength of the mapping to the passive would lead to a greater likelihood of being able to activate it again in the second session, and a lesser likelihood of selecting the alternative agentless intransitive.

Finally, observations of several children’s productions point to gradual changes over trials in the ability to successfully activate and produce the passive. Tables 3.3 and 3.4 provide relevant examples from two children.
Table 3.3 Responses to 2-option scenes, Trials 1-10, Participant A

<table>
<thead>
<tr>
<th>Trial #</th>
<th>(Cloze prompt) … “Child’s Response”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(The star) … “is painting. Ooh, it looks yellow”.</td>
</tr>
<tr>
<td>2</td>
<td>(The lady) … “is there by the puddle and the giraffe splashing at her”.</td>
</tr>
<tr>
<td>3</td>
<td>(The rabbit) … “is [pause] brushed. A pig's brushing it”.</td>
</tr>
<tr>
<td>4</td>
<td>(The clown) … “is (push*) getting pushing by the lamb”.</td>
</tr>
<tr>
<td>5</td>
<td>(The chicken) … “is beating because the squirrel's patting it”.</td>
</tr>
<tr>
<td>6</td>
<td>(The piano) … “is getting kicked. On its bum”.</td>
</tr>
<tr>
<td>7</td>
<td>(The bike) … “is getting washed by the cow”.</td>
</tr>
<tr>
<td>8</td>
<td>(The king) … “is getting poked by the bee”.</td>
</tr>
<tr>
<td>9</td>
<td>(The car) … “is getting lift up by the [pause] horse”.</td>
</tr>
<tr>
<td>10</td>
<td>(The baby) … “is getting licked by the cat”.</td>
</tr>
</tbody>
</table>

Table 3.4 Responses to 2-option scenes, Trials 1-5, Participant B

<table>
<thead>
<tr>
<th>Trial #</th>
<th>(Cloze prompt) … “Child’s Response”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(The king) … “is surprised”</td>
</tr>
<tr>
<td>2</td>
<td>(The car) … “is being lifting up. Or it's lifting up from the horse”.</td>
</tr>
<tr>
<td>3</td>
<td>(The rabbit) … “is getting brushed”.</td>
</tr>
<tr>
<td>4</td>
<td>(The bike) … “is getting sprayed by water”.</td>
</tr>
<tr>
<td>5</td>
<td>(The star) … “is getting painted by the dragon to look nice”.</td>
</tr>
</tbody>
</table>

Patterns such as these suggest that the children knew the passive structure, but that the ability to successfully activate and produce it built up gradually through repeated attempts.

Recall that these changes occurred in the absence of feedback regarding the adequacy of children’s sentences. A potential explanation for these kinds of changes can be found in the literature on the phenomenon of “conduite d’approche” demonstrated by individuals with conduction aphasia. In conduite d’approche, speakers with aphasia demonstrate gradual improvements in lexical access with repeated attempts. With regard to successive improvements towards success, Franklin, Buerk, and Howard (2002) noted that “an obvious mechanism for successful self-correction would be repeated activation proceeding from the lexical to the
phonological level, refreshing and adding information.” Although the lexical phenomena in
*conduite d’approche* and the syntactic phenomena in the current study certainly differ in many
ways, the notion of repeated attempts at activation along a particular pathway leading to
incremental additions of information seems to be relevant. In the current context, the pathway of
repeated activation might include levels concerned with determining the relevant functional
mappings, elaborating those mappings during positional processing, and elaborating those
mappings with the appropriate morphology (e.g., the past participle of the verb rather than the
progressive form) and including the agentive *by*-phrase. As children achieved success with one
aspect of the sentence on a given trial, that aspect may have subsequently been produced with
greater ease on future trials, allowing greater capacity to “sort out” other aspects of the sentence.
The syntactic priming literature currently points to two potential mechanisms for changes in
activation with syntactic repetition: residual activation along relevant pathways and
strengthening of relevant connections (e.g., Bock, 1986b; Bock & Griffin, 2000a). The patterns
observed in the current study are potentially compatible with both mechanisms. They lend
support to the view that syntactic knowledge is not “all or nothing” but instead varies in strength
with experience in the moment and across development. And, they invite further research into
the mechanisms of change in syntactic knowledge and performance.

3.2.3 Conclusions: Looking Forward to Study 2

The results of Study 1 provided important baseline information for the pursuit of the
questions of interest in Study 2. Study 2 will examine the influence of patient-related semantic
primes on the frequency of production of patient-subject sentences. In Study 2, it is expected that
the animation stimuli will elicit active transitive descriptions as the default preference. It is
further expected that the patient-related primes will facilitate early activation and lexical selection for the patient-role characters, and that given this early activation, the participants will, on some trials, overcome the active preference to produce a patient-subject sentence. It is expected that younger (4-year-old) children will do so less often than older (7-year-old) children. Study 2 will also examine the negative processing consequences that might ensue when an active transitive sentence is produced following a patient-related prime. It is anticipated that the potential negative consequences for active transitive productions will be relatively greater for the younger than the older participants.
Chapter 4: Study 2 Introduction and Method

4.1 Introduction

The purpose of Study 2 was to examine the effects of lexical activation order on children’s sentence production outcomes. This study paired the prime stimuli with children’s descriptions of the animation stimuli within the same task. It asked whether the facilitative effect of the patient-related primes on the patient targets would influence the syntactic form, efficiency, and/or integrity of the children’s sentences. More specifically, this study examined whether children would be more likely to produce patient-subject sentences following the patient-related primes, whether the patient-related primes would produce costs to speech onset speed, auxiliary use or fluency in active transitive sentences, and whether these outcomes would vary with children’s age or working memory ability.

4.2 Method

4.2.1 Participants

None of the participants in Study 2 had participated in Study 1. Forty-eight monolingual English-speaking children with typical language development completed Study 2. There were 24 children in each age group. The participants in the younger, 4-year-old group (13 boys and 11 girls) ranged in age from 3;4 (years; months) to 4;9 ($M = 4;1$). The participants in the older, 7-year-old group (6 boys and 18 girls) ranged in age from 6;4 to 7;11 ($M = 7;1$). The participants were recruited through their schools or childcare centres, or through third party contacts. The criteria for considering children to be monolingual and typically developing were the same as in Study 1. As in Study 1, no child scored more than 1 $SD$ below the mean on the Recalling
Sentences subtest of the CELF-P:2 (Wiig et al., 2004) or the CELF-4 (Semel et al., 2003). Scaled scores on this measure ranged from 7 to 19\textsuperscript{30} for the younger group ($M = 12.9$, $SD = 2.76$) and from 7 to 15 for the older group ($M = 12.0$, $SD = 2.26$). Maternal education was high overall, and did not differ between the two age groups, $p = .36$, Fisher’s Exact Test. Two mothers reported high school plus additional training (1 in each group), 3 reported college education ($n = 1$ younger group, $n = 2$ older group), 18 reported Bachelor’s level education ($n = 12$ younger group, $n = 6$ older group), and 24 reported graduate education or an advanced degree (e.g., MD; either completed or in progress) ($n = 10$ younger group, $n = 14$ older group).\textsuperscript{31}

An additional 11 children ($n = 10$ younger group, $n = 1$ older group) completed part or all of the experimental protocol but were not included in the analysis. One child in the older group was excluded for being strongly bilingual. Among the children in the younger group, 5 did not complete the experimental task ($n = 1$ attentional lapses left fewer than 50\% usable trials, $n = 2$ declined to finish the experimental tasks, $n = 2$ began the session but declined to wear the microphone before beginning the experimental tasks). Two children participated in the sessions, but were excluded from analysis because they did not achieve the required response pattern of naming the prime, then providing a sentence description of the animation without additional prompting. An additional two children were excluded because of response strategies that used “pretend” words and alternative labels that were not possible to code. Finally, 1 child was excluded due to an age error (outside the age range).

\textsuperscript{30} Average range $= 7$ to 13 ($M = 10$, $SD = 3$) (Semel et al., 2003; Wiig et al., 2004).

\textsuperscript{31} Maternal education information was unavailable for 1 participant in the older group.
4.2.2 Materials

4.2.2.1 Sentence Production Task

The materials in the primed Sentence Production Task consisted of fourteen stimulus item sets, retained for inclusion in Study 2 as described in the Results section of Study 1. Each item set consisted of an animation scene, a patient-related prime picture and a control prime picture. There were seven 2-option scenes (lick, wash, lift, sting, hit, paint, splash), and seven 3-option scenes (bounce, swing, roll, turn, stretch, bend, cook). For the item paint, the agent dragon was replaced with sheep in Study 2 because the data from Study 1 suggested that the patient-related prime moon also facilitated naming the agent target dragon, to an even greater extent than the patient target star. Although this most likely represented a spurious result (there is no obvious systematic relationship between moons and dragons), the agent was replaced in order to minimize this potential confound. Across the set of 14 stimulus items in Study 2 there was no statistically significant difference between agents and patients in AoA (calculated as described in Study 1, Dale & Fenson, 1996; Morrison et al., 1997), $t$ (13) = .865, $p = .403$, frequency (Zeno et al., 1995), $t$ (13) = .112, $p = .912$, or length in syllables $t$ (13) = 1.0, $p = .336$. The balance in left and right positioning of the agent and patient was also preserved in this stimulus set.\(^{32}\)

4.2.2.2 Working Memory Task

The Working Memory (WM) task was a modification of a storage and processing task used previously by Moser and Johnston (Moser, 2003; Moser & Johnston, 2004), which in turn

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\(^{32}\) As in Study 1, one item (bend) had a front-to-back orientation rather left-to-right. Among the remaining items, for 2-option scenes, the patient appeared on the left in 3 items and the right in 4. For the 3-option scenes, the patient appeared on the left in 3 items and on the right in 3 items.
was originally based on the work of Montgomery (2000). The task (to be described below) required the children to recall lists of words. As they recalled each word, they made a judgment about the size of its real-world referent, classifying each word according to whether or not the referent would fit into a box that was present on the table throughout the activity. The stimuli consisted of 26 monosyllabic words, their corresponding colour drawings, and a plastic box measuring 17.5 cm (l) x 10.5 cm (w) x 11.5 cm (h). The stimulus words consisted of animals, foods, body parts, clothing, household articles and nature items. One half of the words designated real-world referents that would be small enough to fit in the box, whereas the remaining half of the items designated real-world referents that would be too large to fit in the box. For each small item that would fit in the box (e.g., “mouse”), there was a corresponding item, drawn from the same object category, that was too large to fit in the box (e.g., “cow”). All of the words included in the WM task were intended to be familiar to the participants, having an age of acquisition of 30 months or younger according to the production norms of the MCDI (Dale & Fenson, 1996). Each stimulus word was represented by a coloured line drawing on a 6 cm x 6 cm card. The images for the drawings were taken from several sources, including the Rossion and Pourtois (2004) Snodgrass and Vanderwart-like object set and publicly or commercially-available, royalty-free clip art sites (Microsoft Clip Art Gallery, iclipart.com, clipart.com). Appendix E provides the list of the WM memory stimuli.
4.2.3 Procedures

The participants completed the activities in Study 2 over the course of two sessions, scheduled on separate days. During the first session, they completed the primed Sentence Production task. During the second session they completed the WM task and the Recalling Sentences task (Semel et al., 2003; Wiig et al., 2004). Each session lasted approximately 20 – 30 minutes. The children participated in the sessions at their home, at the University of British Columbia, or in a quiet room at their school or childcare centre, according to the parent’s preference.

4.2.3.1 Sentence Production Task

4.2.3.1.1 Detailed Procedure

The procedure for the experimental task in Study 2 differed in an important way from the tasks in Study 1. In Study 2, the participants named the prime pictures and described the animated scenes within the same task. Each trial contained one prime picture and one animated scene. In one half of the trials, a patient-related prime picture preceded the animation; in the other half of the trials the corresponding control prime preceded the animation. Each child described each of the 14 animations two times, once in each prime condition, for a total of 28 prime-animation trials.

The participants completed the 28 trials in two blocks, each block containing one presentation of each of the 14 different stimulus scenes. Scene type (i.e., 2-option scenes, 3-option scenes) and prime type were intermixed within block. Within each block, one half of the

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33 For one child, scheduling constraints required that both sessions be completed on the same day, several hours apart.
trials presented patient-related primes and one half presented control primes. In order to create
the experimental blocks, two lists were created by assigning each of the fourteen items to a prime
condition in a pseudo-random manner, with the constraint that there was an even number of
patient-related and control prime trials in each list, and that the distribution of prime and control
trials within each list was balanced across the scene types. Assignment to receive either List 1 or
2 in the first block was counterbalanced within each age. Within each block, the order of trials
was randomized by the E-Prime software.

The Sentence Production task began with a familiarization phase, in which the
participants pointed to pictures of the agent, patient, and prime stimuli after the experimenter
named them. The pictures were randomly arranged seven to a page and were blocked by
category (i.e., agents, patients, primes) in order to avoid drawing attention to prime-target
pairings. During familiarization, the experimenter told the participants that the “people, animals
and things” on the pages would re-appear in the “pictures and movies” in the computer game to
follow. Identification errors were very rare and were always corrected, either spontaneously or
with prompting. The Sentence Production task immediately followed familiarization.

The children sat a small table at a comfortable distance facing a laptop computer. They
wore a head-mounted microphone connected to the E-Prime Serial Response Box for the purpose
of recording speech onset times. The participants’ responses were audio recorded for later
transcription.

The experimenter introduced the Sentence Production task as a talking game on the
computer. The instructions indicated that the child would see pictures and movies alternating on
the computer, “going picture-movie, picture-movie, back and forth just like that”. The
instructions further indicated that, “when you see a picture, you say what it is as soon as you
know it, and when you see a movie, you say what’s happening in the movie as soon as you
know”. There was no further instruction to speak quickly or provide a speeded response. The
instructions were designed to encourage children to respond in a timely manner, but not before
they had determined the content of the animation. The instructions further emphasized the
importance of being quiet between the pictures and movies so as not to “confuse the computer”.

The task began with three demonstration trials. In order not to draw explicit attention to
the sentence structures used during the demonstration, the experimenter told the child, “I’ll go
first, to show you what I mean about going picture-movie, picture-movie.” During the
demonstration, the experimenter modeled naming the prime picture with a bare noun, then
describing the animation with a full sentence beginning with the definite article and containing
full lexical nouns (e.g., “The girl is closing the window”). The experimenter described each
demonstration animation using a different syntactic structure, one active transitive, one full
passive, and one agentless intransitive. The order of the demonstration trials was randomized by
E-Prime, so that the order of sentence structures varied. Following the demonstration trials, the
participants completed two practice trials. The demonstration and practice trials were repeated if
the child did not demonstrate understanding of the task structure (i.e., naming response →
sentence response) during the first practice round.

The experimenter initiated each trial when the child appeared to be ready. At the onset of
each trial, the Experimenter repeated the prompt, “What is the picture and what is happening (in
At the onset of the trial, a “+” sign appeared as an orienting cue in the centre of the screen for 1 s. The prime picture then appeared for a maximum of 5 s (no child needed the maximum prime exposure). The onset of the child’s prime naming response triggered the voice key, and the prime disappeared. The orienting sign again appeared 1 s after the onset of the prime response. It remained on the screen for 1 s, and then the animation began, producing a total interval of 2 s between the onset of the prime response and the onset of the animation. The child described the animation as soon as he or she was ready. The animation remained on the screen for 10 s, regardless of when the child began or finished speaking. As long as the child maintained attention, the trials progressed with little pausing in between.

During a trial, if a lip pop or other extraneous sound caused the prime picture to be removed early and the child did not immediately name the prime, and also in a small number of trials in which the child named the prime in error, the experimenter provided the prime for the child to repeat. This occurred in 5% of retained trials, occurred more frequently for the younger children than the older children ($p < .05$), and for the younger children only, occurred more often in patient-related prime trials than control prime trials ($p < .05$). Otherwise, no further prompts were given during a trial. Breaks were provided between trials as needed. Feedback was limited to general comments of interest and encouragement that were not contingent on the form or content of the children’s sentences (e.g., “neat”; “wow”; “that’s funny”). At the completion of Block 1, a short play break ensued. When the child was ready to return to the task, the experimenter reminded him or her to “say what the picture is as soon as you know it, and what is happening in the movie as soon as you know.”

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34 The prompt varied slightly for the sake of naturalness, sometimes including the phrase “in the movie” and sometimes not.
At the conclusion of the Sentence Production task, the experimenter asked each participant a short series of questions designed to explore whether or not he or she was aware of the prime-target relationships and used this awareness strategically (i.e., consciously aiming to identify which character the prime was related to, and talk about that character). These questions were: (1) “How did you know what to say about each movie? How did you decide? Did you use any tricks or strategies?” (2) “You know how it went picture-movie, picture movie? Did the picture that came right before the movie help you to decide?” and (3) “How?” (if the child responded affirmatively to Question 2). None of the children in the younger group responded in a way that indicated awareness or strategic responding. Seven of the older children gave some indication of some degree of awareness that relationships existed among some items, although very few were able to clearly articulate this awareness. Only four children identified any prime-target relationships.

4.2.3.1.2 Transcription, Scoring and Reliability

The experimenter transcribed all sentence responses. Prior to transcription, the project assistant isolated the digital audio record of each utterance from its preceding prime and saved it to an individual file with a randomly designated file number. Transcriptions were based on these de-identified utterances. As such, during transcription, the experimenter was blind to the prime condition and placement of the trial within the session. The project assistant transcribed all of the prime responses based on the original, complete audio files.

The experimenter transcribed the responses orthographically. For every response containing an obligatory context for the auxiliary is, the presence or absence of the auxiliary was coded. Additionally, all instances of filled pauses (e.g., uh/um), repetitions of sounds, words or
phrases, and revisions of sounds, words or phrases were coded.\textsuperscript{35} In instances where revised material contained other dysfluencies, only the revision was counted. The measure of dysfluencies also included silent pauses. Coding and scoring of silent pauses was completed in two steps, and followed the criteria established by McDaniel et al. (2010). During the initial transcription, the experimenter noted any apparent silent pauses in each utterance. The experimenter then measured each potential pause in Adobe Soundbooth (Adobe System Incorporated, 2006-2010), using both the auditory and visual signals to determine the beginning and end of the pause. Following McDaniel et al., pauses that were 500 ms or longer in duration were retained. In order to account for differences in pause length, each 500 ms interval of silence was scored as an instance of silent pausing. Thus, for example, a pause measuring 2.5 seconds counted as five pauses in the final tally.

Each utterance was further coded for response type. The children produced a variety of verbs to describe the actions in the scenes, and coding of responses was not contingent on the children using the intended or modal verb. The major response categories included active transitive, passive, agentless intransitive, other, and unscoreable. Independent clauses that followed the primary response (e.g., “The cat is licking the baby and the baby’s eyebrows are going up”) were not coded.

Utterances were coded as active transitive if they had an agent subject and described an agent acting on a patient. All active transitive responses were coded in this category, including responses that varied structure of the verb phrase (e.g., conjoined clauses with a null subject in

\textsuperscript{35} Initially, prolonged sounds and words were also transcribed. However, it proved to be very difficult to reliably identify prolongations, and inter-rater reliability for this measure was very low (60%). It was therefore not included in the measure of dysfluency.
the second clause, such as “The elephant is twirling and lifting the butterfly”), and responses that contained adjunct information after the patient (e.g., “The duck is bouncing the ball on the street”). Responses that omitted the subject and auxiliary, but contained a transitive verb and patient (e.g., “__ licking the baby”) were also coded as active transitive utterances. Additionally, utterances that included a false start with the patient but ultimately were produced as an active transitive were also coded within this category. Patient false starts included a variety of forms, including bare noun false starts (e.g., “Frog > The boy is stretching the frog”) and determiner + noun combinations (e.g., “The frog > The boy is stretching the frog”), as well as a small number of false starts that were revised after the initiation of the verb phrase. A patient false start was credited if the child produced the initial segment or more of the expected patient target (e.g., “F > The boy is stretching the frog”). Active transitive responses that contained a patient false start were double-coded for both the active transitive structure and the false start.

The categories of patient-subject responses were passive and agentless intransitive. In theory, both full and truncated passives were acceptable. However, all instances of passives that the children produced included the by-phrase containing the agent. The agentless intransitive code was assigned to active utterances that contained the patient in the subject position followed by a verb used intransitively. This code included utterances that lacked an auxiliary and other functional elements (e.g., “apple rolling”), as well as utterances constructed with a general, all purpose verb and directional modifiers (e.g., “The mouse is going back and forth”).

The other code was applied to responses that did not fit into any of the above categories, including agent-subject intransitives (e.g., “The crocodile is cooking”) and noun phrases (e.g., “crocodile” with no further response). In addition, two utterances were scored within an ad-hoc
category of patient-subject other because they contained the patient in the initial position, but did not fit cleanly into the major sentence categories (“For the car, it’s going up”; “Apple with a monkey rolling it around”).

Finally, the following types of responses were categorized as unscoreable: utterances in which the child spoke between the prime and the animation, or was off-task at the animation onset, responses in which the child addressed a question to the researcher (rather than describing the picture), as well as a small number of responses containing experimenter error, and a small number of responses in which the child made a prime naming error that was not corrected.

Reliability for the different measures was computed as follows. A linguist who was familiar with the general aims of the study but also blind to prime condition re-transcribed all 28 utterances for 12 (25%) randomly-selected participants (6 at each age). For these 12 transcripts, the experimenter again coded auxiliary use and instances of dysfluency other than silent pausing, for which reliability was computed separately. Reliability was computed as a point-by-point comparison between the original and re-transcribed responses. Reliability for the presence or absence of the auxiliary, computed as the total agreements divided by the sum of agreements and disagreements, was 98%. Reliability for instances of dysfluency (other than silent pauses), calculated in the same way, was 91%. In order to calculate reliability for silent pauses, the project assistant re-listened to all 28 utterances of 10 randomly-selected participants (21%). Using the experimenter’s original transcript in which potential pauses were marked, the assistant measured and coded every potential pause and also noted any that the experimenter had missed. Reliability was computed based on the code ultimately given to a potential pause (i.e., 0 if under 500 ms, 1 if 500 – 1000 ms, 2 if 1000 – 1500 etc). Reliability for the coding of silent pauses was
92%. Finally the project assistance re-coded each utterance in 10 randomly selected files (21%), according to the major response categories (active transitive (+/- false start), passive, agentless intransitive, other, unscoreable). Reliability, calculated as the total number of agreements divided by the total number of utterances, was 98%.

4.2.3.2 Working Memory Task

4.2.3.2.1 Detailed Procedure

The children completed the WM task at the beginning of the second session. This task also began with a familiarization phase. During familiarization, the picture cards depicting the stimulus words were laid out on the table in a random order, in two groups of 13. The child pointed to each picture after the experimenter named it. Again, pointing errors were extremely rare and always corrected either spontaneously or with prompting.

Following familiarization, the children were introduced to and given practice with the categorization procedure that would be used in the memory task, to ensure that they understood and were capable of the processing requirement. The experimenter placed the box on the table, and starting with the picture of the mouse, said, “See this? It’s a picture of a mouse. Now, imagine a real life mouse. Do you think that if I had a real live mouse, I could put it in this box? Would it fit?” If the child hesitated or seemed otherwise uncertain, the experimenter encouraged him or her to “show” how big a mouse would be, using his or her hands, then try to place his or her hands in the box. Once the child had responded that a mouse would indeed fit in the box, the experimenter showed the picture of the cow, and repeated the same steps. After the child had responded that the cow would not fit in the box, the experimenter gave the child the remaining
cards to sort independently. For the items that would fit in the box, the child placed the picture inside the box. For the items that would not, the child placed the pictures in a pile on the table, labeled with an X. All sorting errors were identified and resolved through discussion. In all cases, the children accepted the experimenter’s suggestion (i.e., corrected their sorting response). Many of the discussions stemmed from questions about the specific nature of the item (e.g., a whole cake versus just a piece). The average number of sorting errors (or uncertainties resolved through discussion) for the younger group was 1.8 (range: 0 – 6). The average number of errors / uncertainties for the older group was 1.2 (range: 0 – 3). After the participant finished sorting the pictures, the experimenter said, “That’s great! Now you know all the things that fit in the box, and all the things that don’t.” The experimenter then listed the items within each pile, beginning each list with, “Here are the things that do / do not fit.”

Both the box and the X card (indicating the pile for items that would not fit) remained on the table throughout the WM task. The pictures of the referents were out of sight of the child. At the beginning of the WM task proper, the experimenter told the child that she would say lists of words and that the child’s task was to listen to the words and then repeat them back, categorizing each word according to whether or not its referent would fit inside the box. The experimenter told the child that, “if it’s something that would fit in the box, when you say the word, you touch the box, just like you’re putting it in. If it’s something that wouldn’t fit in the box, you touch the X.”

Prior to beginning the test trials, the participant viewed a demonstration trial (many

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36 This aspect of the task differed from the original task used by Moser (2003), in which the participants recalled the test words, re-ordering them to first name all of the items that would fit and then name the items that would not fit. It was felt that this would be too challenging (and possibly confusing) for the younger group in this study, who were considerably younger than the children studied by Moser. Instead, the requirement to touch the box was intended to make the task more concrete, while the categorization requirement preserved the processing component. Observation of the children’s performance indicated that
children spontaneously participated with the experimenter during the demonstration), and completed a practice trial, for both single-word and two-word lists. The experimental trials began at a Span Level of 2. There were five 2-word lists at this level. If, however, the child demonstrated any uncertainty at the 2-word level during the practice, the experimental trials began at a span level of 1 to ensure that they understood the task before moving on.

During the test trials, the experimenter spoke each word in a trial list clearly, separated by an interval of approximately 1 s. There were no minimal pairs within a list, and to the extent possible, no repetition of a semantic category within a list. Beyond a span of 5 words per list, some categories repeated. However, very few children reached this level. In lists containing an even number of words, there were an equal number of items that would and would not fit in the box; for lists with an odd number (i.e., Spans 3 and 5) the number of small and large items differed by 1. The order of lists and order of words within lists was constant across all participants.

4.2.3.2.2 Scoring and Reliability

To receive credit for a word, the participant had to recall it and categorize it correctly. However, the participants were not required to recall the words within each list in the same order in which they had been presented. Children occasionally self-corrected categorization errors. When this happened, they were credited with a successful categorization.

There were five lists at Span Levels 2 and 3, and four lists at Span Levels 4, 5, 6, and 7. If the participant succeeded on at least 3 lists at a given span level, correctly recalling and sorting

---

they indeed did think about the categorization decisions. The children often spoke slowly, at times hesitating or correcting the course of their pointing response.
each word within the list, he or she progressed to the next level. Testing ended when a
participant succeeded on fewer than three lists at a given level. However, to ensure that the task
captured each child’s maximal performance, if a child passed only two lists at a given level, the
experimenter presented the first list at the next level. If the child did not pass this list, the task
ended. If, however, the child did succeed with this list, the task continued. Each child received a
score based on the total number of words successfully recalled and categorized across the entire
task.

Reliability was obtained during live coding by the project assistant for eight participants
(17%). The assistant sat off to the side, and recorded the child’s response and categorization for
every word. Agreement between the two experimenters was calculated on a word-by-word basis
and was very high at 99%.
Chapter 5: Study 2 Results and Discussion

5.1 Results

5.1.1 Main Analysis: Prime Effects on Sentence Production

5.1.1.1 Overview of Analysis Plan

5.1.1.1.1 Preliminary Data Treatment

The expectation in Study 2 was that the patient-related primes would facilitate lexical processing for the patients in the animations, and that this facilitation would in turn affect sentence production outcomes related to sentence structure, reaction time, auxiliary production, and dysfluency. Following from this expectation, preliminary analyses explored whether there was a relationship between the strength of lexical priming in Study 1 and the prime effects on the dependent measures in Study 2. Of particular interest was whether items that exerted only a weak lexical priming effect in Study 1 continued to exert a weak effect in Study 2. Ultimately, the four items with the weakest Study 1 prime effects were excluded from the analysis set in Study 2 (see pp. 148-149).

Because RT data were available for both the Picture Naming task in Study 1 and the Sentence Production task in Study 2, the first analysis compared the influence of the individual patient-related primes on the RTs obtained in these two tasks. Based on the hypotheses of this study, the patient-related primes were expected to have opposite effects in the two studies, promoting faster naming for patient-role targets in Study 1, and slower onsets for agent-subject, active transitive sentences in Study 2. That is, a negative relationship between Study 1 and Study
2 RTs was expected at the item level. If such a relationship were found, this would lend support to the idea that there was a systematic relationship between the strength of a prime’s ability to facilitate naming for the patient and its effects in sentence production outcomes.

Figure 5.1 presents the scatterplot of the relationship between the patient-related primes’ effects on patient naming RTs in Study 1 and their effects on RTs for agent-subject sentences in Study 2. In this scatterplot, each data point represents the RT outcomes for a different patient-related prime. Negative (leftward) values on the X-axis indicate faster naming of the patient target following patient-related primes in Study 1. On the Y-axis, negative values (lower on the axis) indicate faster sentence onsets in Study 2 following the same patient-related primes, and positive values (higher on the axis) indicate slower sentence production onset RTs.

**Figure 5.1 Relationship between effect of patient-related primes on patient naming RT in Study 1 (X) and sentence onset RT in Study 2 (Y)**
Although not all items showed the anticipated effect in Study 2 of a slower mean RT in the patient-primed condition, the data in Figure 5.1 do reveal a negative relationship between the RT outcomes of the two studies. With the exclusion of the notable outlier in the bottom left quadrant – the item “cook” – there was a moderate, statistically significant negative correlation between the item-wise RT values obtained in Study 1 and Study 2, $r (11) = -.53$, $p = .03$ (1-tailed).\textsuperscript{37} In contrast, and as would be expected based on the hypotheses of the study, there was no evidence of a relationship between the patient-related primes’ influence on agent naming in Study 1 and sentence production RTs in Study 2, $r (11) = -.08$, $p = .79$. These results point to a systematic, although not perfect, item-level relationship between the strength of patient priming in Study 1 and effects on sentence production RTs Study 2.

In order to further explore the relationship between prime strength and outcomes, a second, descriptive, analysis examined the prime condition effects on the dependent measures in Study 2 for item sets composed of relatively stronger and weaker lexical primes. For this analysis, the lower margin of the 95% CI for the priming effect in Study 1 was used as the pre-determined cut-point for designating primes as relatively weaker or stronger (95% CI, 36-144 ms). In Study 1, four items demonstrated mean prime condition difference scores that either fell below or right at the lower margin of the 95% CI for the prime effect calculated across participants. These items were: \textit{bat/ball} (\textit{bounce}; \textit{M} Study 1 prime effect = 6 ms), \textit{hammer/nail} (\textit{bend}; \textit{M} prime effect = 26 ms), \textit{moon/star} (\textit{paint}; \textit{M} prime effect = 36 ms), and \textit{crown/king} (\textit{sting}; \textit{M} prime effect = -32 ms indicating slower naming following the patient-related prime).

\textsuperscript{37} This correlation was conducted across the entire set of usable trials in Study 2. The same analysis, repeated over only those children who produced a sufficient number of trials to be included in the participants-wise analysis, returned a similar result, $r = -.630$, $p = .01$ (1-tailed).
Table 5.1 presents the condition means for each of the primary dependent variables in Study 2, calculated separately for the 4 weakest lexical primes and the remaining 10. The difference scores in Table 5.1 indicate the prime condition effects, calculated by subtracting the control prime condition means from the patient-related prime condition means. The hypotheses of the study predicted a positive value for each of these difference scores, reflecting a greater proportion of patient-subject sentences as well as a higher rate of auxiliary omissions, slower RTs, and higher rates of dysfluency for active transitive sentences in the patient-primed condition. As can be seen, for three of the four primary dependent variables (sentence subject, auxiliary omissions, RT), the set of weaker primes shows a difference score that is either closer to zero than that of the set of stronger lexical primes or runs opposite to the hypothesized direction of effect. These differences between the sets of stronger and weaker primes suggest that the relatively weak effects of these primes on naming in Study 1 carried over to weaker sentence-level effects in Study 2. Although some of the differences may appear small, they nonetheless suggest that the influence of the prime manipulation on sentence production outcomes in Study 2 will depend on the strength of the lexical activation effect of the prime. In order to minimize the potential noise created by primes that have only small lexical facilitation effects (or indeed, effects that may run counter to expectations for some children, *viz.* crown/king), the 4 items in the “weak priming” set – sting, bend, bounce, and paint – were excluded from further analysis.
Table 5.1 Study 2 condition means (and standard deviations) for weaker and stronger sets of lexical primes

<table>
<thead>
<tr>
<th>Item set</th>
<th>Prime Condition</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaker Primes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>1.6 (6.1)</td>
<td>1396 (543)</td>
</tr>
<tr>
<td>Control</td>
<td>1.7 (6.9)</td>
<td>1506 (782)</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.1</td>
<td>-110</td>
</tr>
<tr>
<td>Stronger Primes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>1.7 (4.3)</td>
<td>1569 (703)</td>
</tr>
<tr>
<td>Control</td>
<td>1.1 (3.3)</td>
<td>1471 (561)</td>
</tr>
<tr>
<td>Difference</td>
<td>0.6</td>
<td>98</td>
</tr>
</tbody>
</table>

*Calculated across all active transitive sentences not containing a patient false start or a voice key artifact

5.1.1.2 Analysis Plan

For the main analyses, the primary independent variables were prime condition and age group. Separate analyses were conducted for each dependent variable (i.e., sentence structure, RT, auxiliary use, fluency) using omnibus ANOVAs with prime condition as a within-participants variable and age group as a between-participants variable. The analyses in sections 5.1.2.2 and 5.1.2.3 (sentence structure and auxiliary omissions) were computed on arcsine-
transformed proportion scores.\textsuperscript{38} Although the scores were transformed, the data nonetheless violated the ANOVA assumption of normality, and for some analyses, homogeneity of variances. As in Study 1, the planned parametric tests were retained.\textsuperscript{39} An alpha level of .05 was used as a guide for statements of statistical significance. Significance values just above the cutoff (i.e., .05 - .06) were considered as approaching statistical significance and worthy of further investigation. For each analysis, exact $p$-values are stated (except where $p$ is very small, $p < .001$), along with effect size estimates. In addition, for main effects involving prime condition, 95% confidence interval estimates for the mean difference are provided.

As in Study 1, preliminary analyses were conducted to examine whether the prime condition effect was influenced by the repetition of items across blocks. Although experimental block was not intended as an independent variable, it was important to determine whether this aspect of the study design affected the results in a consistent manner. These analyses indicated a limited influence of the block repetition on outcomes, affecting only the RT analysis and a secondary analysis of order of mention. There was no interaction between prime condition and experimental block for measures of sentence structure, auxiliary omissions, or overall dysfluency (all $F$s < 1). In the sections that follow, repetition effects will be addressed in the relevant sections for only those variables that revealed an influence of experimental block. Where preliminary analyses indicated no influence, the analyses are reported collapsed across blocks.

\textsuperscript{38} Proportion scores were transformed using the formula $y = 2 \cdot \text{arcsine} \sqrt{x}$ (Cohen, 2003).

\textsuperscript{39} As in Study 1, in order to further evaluate whether or not the parametric outcomes were unduly influenced by the assumption violations, repeat analyses examined the main effect of prime condition using non-parametric Wilcoxon Signed-Ranks tests. Once again, for all analyses, the parametric and non-parametric tests returned the same pattern of results.
5.1.1.3 Unusable Responses

Responses that were categorized as unscoreable (as described in Section 4.2.3.1.2) were excluded from all analyses. The number of unscoreable trials was identical for the two prime conditions, but did differ by age (4-year-old group > 7-year-old group), $t(46) = 3.059, p = .005$. For some analyses, additional exclusions were made. These exclusions are further described at the end of section 5.1.1.2.2 and in section 5.1.1.3.

In a small number of utterances, the children referred to either the agent or the patient with a pronoun or made a lexical selection error. These utterances were included in the analyses. The rate of occurrence of pronouns and lexical selection errors did not differ between prime conditions ($F < 1$), but did differ between the age groups (4-year-old group > 7-year-old group), $F(1,46) = 4.34, p = .05$. The overall rate of pronoun use and lexical selection errors, however, was very low. The children in the 7-year-old group did not produce any pronominal forms. The children in the 4-year-old group produced pronominal forms in 4% of trials. More than half of the lexical selection errors were in fact close synonyms of the target (e.g., chicken $\rightarrow$ rooster). Lexical selection errors occurred in 1% of the trials for the 7-year-old group and 2.8% of trials for the 4-year-old group.

5.1.1.2 Sentence Structure

5.1.1.2.1 Primary Analysis

The first analysis addressed the hypothesis that lexical activation order can affect sentence structure via the assignment of the early-activated element to the sentence subject function. This analysis examined whether the children produced a greater number of patient-
subject sentences in the patient-related prime condition than the control prime condition, and whether the tendency to produce patient-subject sentences differed by age group or scene type.

Table 5.2 presents the mean percentage of utterances in the analysis set that had a patient subject, as a function of age, scene type, and prime condition. Overall, the total number of patient-subject sentences was very low, reflecting an overwhelming preference for active transitive responses. Indeed, of the 48 children who completed the study, only 8 produced any patient-subject sentences.

Table 5.2 Percentage (and standard deviation) of patient-subject sentences in analysis set

<table>
<thead>
<tr>
<th>Age group</th>
<th>Scene Type</th>
<th>Prime Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Patient</td>
</tr>
<tr>
<td>4-year-old</td>
<td>2-option</td>
<td>2.5 (7.0)</td>
</tr>
<tr>
<td></td>
<td>3-option</td>
<td>1.7 (6.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>7-year-old</td>
<td>2-option</td>
<td>0.8 (4.0)</td>
</tr>
<tr>
<td></td>
<td>3-option</td>
<td>1.7 (6.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>M</strong></td>
</tr>
</tbody>
</table>

The effects of prime condition, age group and scene type on the proportion of patient-subject sentence responses was investigated in a 2 x 2 x 2 ANOVA computed on the arcsine-transformed proportion scores. The results revealed no statistically significant main effects or interactions. There was no significant difference in the production of patient-subject sentences as
a function of prime condition, $F(1,46) = 1.00, p = .32, \eta^2_p = .021$, age group, $F(1,46) = .06, p = .82, \eta^2_p = .001$, scene type $F(1,46) = .07, p = .79, \eta^2_p = .002$, or the interactions between prime condition and scene type, $F(1,46) = .11, p = .74, \eta^2_p = .002$, prime condition and age group, $F(1,46) = 1.00, p = .32, \eta^2_p = .021$, or prime condition, scene type and age group, $F(1,46) = .98, p = .33, \eta^2_p = .021$.

These results indicate that the participants were not reliably more likely to produce patient-subject sentences following the patient-related primes than control primes. Moreover, and consistent with the results of Study 1, the tendency to produce patient-subject sentences did not differ between scenes that did and did not allow the agentless intransitive as an alternative to the passive.

5.1.1.2.2 Secondary (Follow-up) Analysis: Patient First-Mentions

The above analysis indicated that the prime manipulation did not influence the order of mention of the agent and patient when measured in terms of sentence structure alternations. In order to further explore whether or not the prime manipulation had any effect on early mention of the patient at all, a follow-up analysis examined the number of responses that mentioned the patient first in each condition – whether or not the patient was ultimately retained as the subject of the sentence. This analysis combined patient-subject sentences and patient false starts within a single measure of patient first-mention.

Preliminary analyses indicated that the effect of prime condition on patient first-mentions interacted with experimental block, and block was therefore included in this analysis as a within-subject variable.
A 2 (Prime Condition) x 2 (Block) x 2 (Age Group) ANOVA on the arcsine-transformed scores was conducted for the mean proportion of responses within the analysis set containing a patient first-mention. The results revealed that there was a statistically significant interaction between prime condition and age group, $F (1,46) = 4.65, p = .036, \eta^2_p = .092$, and between prime condition and block, $F (1,46) = 4.26, p = .045, \eta^2_p = .085$. The main effect of prime condition was not statistically significant, $F (1,46) = .486, p = .489, \eta^2_p = .01$, nor were the main effects of block, $F (1,46) = 1.26, p = .28, \eta^2_p = .027$, age group $F (1,46) = .04, p = .85, \eta^2_p = .001$, the 2-way interaction between block and age group, $F (1,46) = 3.08, p = .086, \eta^2_p = .063$. or the 3-way interaction between condition, block and age group, $F (1,46) = .009, p = .93, \eta^2_p < .001$.

Follow-up analyses were conducted to examine the statistically significant interactions between prime condition and age group, and between prime condition and experimental block.

Simple main effects follow up of the two-way interaction between prime condition and age group revealed that there was a statistically significant effect of prime condition for the younger group $F (1,46) = 4.07, p = .05, \eta^2_p = .08$, 95% CI = 0.5% to 9.2%. Patient first-mentions occurred more frequently in the patient-primed condition ($M = 8.9\%, SD = 13.32$) than in the control prime condition ($M = 3.8\%, SD = 6.52$). For the older group, although the mean percentage of patient first-mentions was somewhat higher in the control condition ($M = 5.9\%, SD = 5.88$) than the patient-primed condition ($M = 4.6\%, SD = 8.36$), this difference was not statistically significant, $F (1,46) = 1.06, p = .31, \eta^2_p = .023$, 95% CI = -.5.7% to 2.9%.

Simple main effects follow up of the two-way interaction between prime condition and block revealed a statistically significant effect of prime condition on the percentage of responses containing patient first-mentions in Block 1, $F (1,46) = 4.07, p = .05, \eta^2_p = .08$, 95% CI = 0.3%
to 11.0%. The mean percentage of responses containing patient first-mentions was higher in the patient-primed condition ($M = 7.8\%, SD = 16.88$) than the control prime condition ($M = 2.2\%, SD = 6.72$). In Block 2, however, the difference in patient first-mentions between the patient-primed condition ($M = 4.8, SD = 10.54$) and the control prime condition ($M = 6.9, SD = 11.05$) was not statistically significant, $F (1,46) = 1.53, p = .22, \eta^2_p = .032, 95\% CI = -6.4\%$ to 2.1\%\(^{40}\).

The results of the primary analysis in this section indicated that the participants were not more likely to produce patient-subject sentences following the patient-related primes than the control primes. However, although syntactic alternations were rare, the results of the secondary analysis indicated that the prime manipulation did influence order of mention of agents versus patients, measured more inclusively. Although the main effect of prime condition was not significant for this variable, the follow-up analyses to the interactions indicated that the 4-year-old children produced a greater number of patient first-mentions in the patient-primed than the control condition, and that collapsed across age groups, a similar result was observed in the first block of the experiment. The results of these follow-up analyses need to be interpreted cautiously given that multiple comparisons were made and that the significance values sit right at, rather than below, .05. Moreover, it is important to note that the overall rate of patient first-mention responses was relatively low ($M = 5.8\%$ of responses, $SD = 6.9\%$), placing limits on the extent of interpretation that can be applied these outcomes. Bearing in mind these cautions, the results

\(^{40}\) As noted in section 4.2.3.1.1, there was a higher rate of experimenter-provided primes in the patient-primed condition for the younger participants. To ensure that the outcomes of the patient-first mention analysis were not unduly influenced by uncontrolled differences in the dynamics of these trials, this analysis was repeated with these trials excluded. With these trials excluded, the results revealed a similar pattern in Block 1 as in the original analysis, $F (1, 46) = 4.34, p = .043, \eta^2_p = .09$. With these trials excluded, the results for the younger group no longer reached significance but revealed a similar trend as in the original analysis, $F (1, 46) = 3.36, p = .066, \eta^2_p = .07$, suggesting that the results were not inordinately influenced by this subset of trials.
support the view that the patient-related primes likely did produce the intended effects on
activation of the patient. The implications of the fact that these activation effects did not produce
a greater number of syntactic alternations will be addressed below, in the Discussion section.

The analyses that follow in Sections 5.1.1.3 to 5.1.1.5 turn to examine the effects of early
activation of the patient on the production of the preferred active transitive structures. These
analyses addressed the hypothesis that conflicts between lexical activation order and the
preferred or ultimately selected sentence structure increase processing costs and, therefore, have
a negative effect on production outcomes. For these analyses, in addition to the exclusions
described above, the analysis set excluded all patient-subject sentences (i.e., passives, agentless
intransitives, patient-subject other) as well as agent-subject responses that did not have a
transitive structure (e.g., intransitive sentences, “The crocodile is cooking”). The RT analysis
additionally excluded any responses in which the time measurement was likely disrupted (see
below).

5.1.1.3 Reaction Time

This analysis addressed the hypothesis that resolving the conflict between lexical
activation order and sentence structure would create processing costs related to RT. The analyses
examined the effects of the prime condition and age group on latencies to begin production of
active transitive sentences that did not contain a patient false start. In addition to the general
exclusions noted in section 5.1.1.3, this analysis excluded trials containing a voice key error in
the prime portion of the trial that required the experimenter to provide the prime for the child to
repeat, as well as trials containing a voice key error in the animation portion of the trial. The
presence of voice artifacts was confirmed by the project assistant, who examined the auditory
and visual records of each response. As a group, and despite instructions regarding the
importance of being quiet between responses, the children produced many extraneous noises
between the prime and the animation, causing voice key errors during the animation portion \( (n =
325, \text{ or } 29\% \text{ of potentially usable trials}) \). The number of trials excluded for voice key problems
did not differ between prime conditions \( (t < 1) \).

5.1.1.3.1 Potential Block Effects: Data Analysis Plan

Preliminary analyses indicated an interaction between experimental block and the prime
effect on RTs. This interaction can be seen in Table 5.3, which presents the mean RTs, calculated
across all usable trials, per condition and block. Although the mean RT is slower for the patient-
primed condition than the control prime condition in both blocks, the magnitude of difference is
considerably larger in Block 1. Table 5.3 also reveals that RTs appear to be faster overall in
Block 2 than in Block 1.

Table 5.3 Mean RT (and standard deviation) as a function of prime condition and block

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Block</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Block 1</td>
<td>Block 2</td>
<td></td>
</tr>
<tr>
<td>Patient Prime</td>
<td>1697 (723)</td>
<td>1437 (543)</td>
<td></td>
</tr>
<tr>
<td>Control Prime</td>
<td>1522 (573)</td>
<td>1410 (543)</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>175 ms</td>
<td>26 ms</td>
<td></td>
</tr>
</tbody>
</table>

In order to address this potential interaction, experimental block was included in an
analysis of RTs by items, below. It was not possible to include block in the analysis by
participants due to the fact that splitting the data set by block would result in very few data points
per cell for many children. Participants were retained for the RT analysis if, after the removal of trials with voice key errors, they produced a minimum of four usable RTs in each of the prime conditions. Twenty-eight children (n = 14 from each age group) met this criterion. However, with the additional division of usable trials into separate cells by block very few children continued to meet this minimum criterion, and this line of analysis was therefore not pursued for the subject-wise analysis. Collapsing across participants left a suitable number of usable data points per item to allow the inclusion of block in an analysis by items.

5.1.1.3.2 Participant-Wise Analysis

For the 28 children who were included in the RT analysis, there were a total of 181 usable trials in each condition (M = 6.5 per participant). The number of usable trials did not differ by age group (F < 1). As in Study 1, outlier trimming followed the procedures reported by Miller et al. (2001; 2006). Responses with an RT that was more than two times a given participant’s condition mean were removed and condition means were recalculated. This procedure removed five additional data points, three from the patient-primed condition and two from the control condition. Table 5.4 presents the mean RTs for each combination of prime condition and age group, calculated across only those participants retained for the participants-wise analysis. As can be seen in Table 5.4, for both the younger and the older children, the mean RTs in the patient-primed condition were slower than RTs in the control prime condition.

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41 As in Study 1, it was not necessary to additionally trim responses that were faster than the minimum criterion of 350 ms, as these had all previously been identified as trials containing noise artefacts.
Table 5.4 Mean RT (and standard deviation) as a function of age and prime condition, participants-wise analysis (collapsing across block)

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Age Group 4-year-olds</th>
<th>Age Group 7-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-Related</td>
<td>1610 (419)</td>
<td>1502 (313)</td>
</tr>
<tr>
<td>Control</td>
<td>1505 (362)</td>
<td>1385 (266)</td>
</tr>
<tr>
<td>Difference</td>
<td>105 ms</td>
<td>117 ms</td>
</tr>
</tbody>
</table>

These RT values were analyzed in a 2 (Prime Condition) x 2 (Age Group) ANOVA. The results of the ANOVA revealed that the main effect of prime condition on RTs was statistically significant, $F(1,26) = 4.30, p = .048$, $\eta^2_p = .14$, 95% CI = 3.17 to 217.74. The main effect of age group was not statistically significant, $F(1,26) = .925, p = .345$, $\eta^2_p = .001$, nor was the interaction between age group and prime condition, $F(1,26) = .013, p = .909$, $\eta^2_p = .001$.

A follow-up correlation examined whether the magnitude of the prime condition difference score was correlated with children’s control condition (baseline) response speed. Recall that in Study 1, the magnitude of facilitative priming in the Picture Naming task was positively correlated with children’s RTs in the control condition: Children who were slower to name the patient-target pictures in the control condition demonstrated a greater raw magnitude of priming. The current analysis examined the correlation between children’s sentence-onset RTs in the Study 2 control condition and their prime condition difference score. It asked whether the children who were slower to respond in the control prime condition also demonstrated relatively greater negative effects on RT in the patient-primed condition. This correlation was not statistically significant, $r(26) = -234, p = .23$. 

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5.1.1.3.3 Item-Wise Analysis

For the item-wise analysis, RTs that were more twice the mean for each Item x Age Group X Condition cell mean were removed as potential outliers. This resulted in the removal of eight data points, five from the patient-primed condition and three from the control prime condition.\(^42\) Given the fact that there was no interaction between prime condition and age group in the prior analysis \((F = .013)\), the items-based analysis was conducted collapsed across both age groups. This allowed for the inclusion of a greater number of data points per Item x Condition x Block cell. Table 5.5 presents the mean item-wise RTs for each prime condition and experimental block. As can be seen in Table 5.5, sentence onset RTs were slower following patient-related than control primes in Block 1. In Block 2, sentence-onset RTs were somewhat faster following patient-related than control primes.

Table 5.5 Mean RT (and standard deviation) as a function of prime condition and experimental block, item-wise analysis (collapsing across age group)

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-Related</td>
<td>1616 (226)</td>
<td>1365 (175)</td>
</tr>
<tr>
<td>Control</td>
<td>1510 (224)</td>
<td>1398 (190)</td>
</tr>
<tr>
<td>Difference</td>
<td>106 ms</td>
<td>-33 ms</td>
</tr>
</tbody>
</table>

\(^42\) Outliers were trimmed in this way rather than by re-using the data set by trimmed participants because there was considerable variability in overall RTs between participants.Trimming was done in this way in order to ensure that the mean score per item was as representative of the overall pattern for that item as possible, and minimize the influence of individual children’s scores. However, although this method resulted in a slightly different data set, and slightly different mean scores, the analysis repeated with outliers trimmed by subjects returned the same pattern of results.
These RT values were analyzed in a 2 (Prime Condition) x 2 (Block) ANOVA. The results revealed a statistically significant interaction between prime condition and block, $F(1,9) = 7.01, p = .027, \eta^2_p = .44$, and a statistically significant main effect of block, $F(1,9) = 12.85, p = .006, \eta^2_p = .59$. The average response latencies were 181 ms faster in Block 2 than in Block 1. The main effect of prime condition was not statistically significant, $F(1,9) = .56, p = .47, \eta^2_p = .06$.

Simple main effects contrasts conducted to follow up the significant interaction indicated that the difference in RT between the patient-related and control prime conditions was statistically significant for Block 1, $F(1,9) = 5.45, p = .044, \eta^2_p = .38, 95\% CI = 3.30$ to 207.9. In this block, response latencies were slower in the patient-primed condition than the control prime condition. In Block 2, although mean response latencies were actually somewhat faster in the patient-primed condition than the control prime condition, this difference was not statistically significant, $F(1,9) = .27, p = .61, \eta^2_p = .03, 95\% CI = -110.32$ to 176.72.

As anticipated, the results of the analyses in this section revealed that the participants were on average 110 ms slower to begin speaking when producing active transitive sentences following patient-related primes than control primes. Although the analysis over items indicated that this difference was stronger in Block 1 and was not maintained with the repetition in Block 2, it is important to note that the effect on RT was strong enough to produce a statistically significant main effect of prime condition in the subject-wise analysis, even when collapsing across Block 2.
5.1.1.4 Auxiliary Omissions

This analysis addressed the hypothesis that processing pressures created by early activation of the patient would contribute to the omission of obligatory grammatical elements. It examined whether the children omitted auxiliaries more often when producing active transitive sentences following patient-related primes than control primes. The analysis set included all active transitive sentences, including those containing a patient false start. For this analysis, the percentage of omission was calculated by dividing the number of omitted auxiliaries by the number of obligatory contexts for each child. The mean number of obligatory contexts was 9.3 for each condition (range = 6-10). The younger children produced slightly fewer obligatory contexts ($M = 8.9$) than the older children ($M = 9.6$).

Table 5.6 presents the mean percentage of auxiliary omissions in active transitive sentences as a function of prime condition and age group. As can be seen, the 4-year-old children omitted a higher percentage of auxiliaries than the 7-year-old children. Additionally, for both age groups there was a small difference between the prime conditions in the rate of auxiliary omissions, with a greater rate of omission occurring in the patient-primed condition.

<table>
<thead>
<tr>
<th>Prime Condition</th>
<th>Age Group</th>
<th>$M$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-Related</td>
<td>40.8 (42.0)</td>
<td>21.4 (36.1)</td>
</tr>
<tr>
<td>Control</td>
<td>38.7 (43.2)</td>
<td>18.6 (34.8)</td>
</tr>
<tr>
<td>$M$</td>
<td>39.8</td>
<td>20.0</td>
</tr>
</tbody>
</table>
The effects of prime condition and age group on auxiliary omissions were analyzed in a 2 x 2 ANOVA conducted on the arcsine-transformed proportion scores. The results of the ANOVA revealed that the main effect of prime condition was not statistically significant, \( F(1,46) = 3.03, p = .09, \eta^2_p = .06, \) 95% CI = -0.15 to 5.1%, nor was the interaction between prime condition and age group, \( F(1,46) = .39, p = .54, \eta^2_p = .008. \) The main effect of age group approached statistical significance, \( F(1,46) = 3.38, p = .06, \eta^2_p = .075. \)

5.1.1.5 Dysfluency

The final analysis in this section addressed the hypothesis that processing pressures created by early activation of the patient would contribute to instances of dysfluency throughout the utterance. It examined the effects of the prime condition and age group on the children’s mean overall rates of dysfluency in active transitive sentences. The inclusion set was identical to that in the auxiliary omission analysis. For this analysis, the mean number of dysfluencies per utterance for each child was computed, taking into account all instances of dysfluency across the entire sentence (i.e., silent pauses, filled pauses, repetitions, false starts and other revisions). Table 5.7 presents the mean number of dysfluencies per utterance for each prime condition and age group.
Table 5.7 Mean number (and standard deviation) of dysfluencies per utterance, by age group and prime condition

<table>
<thead>
<tr>
<th>Prime condition</th>
<th>4-year-olds</th>
<th>7-year-olds</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-Related</td>
<td>1.79 (.94)</td>
<td>.85 (.55)</td>
<td>1.32</td>
</tr>
<tr>
<td>Control</td>
<td>1.53 (1.26)</td>
<td>.88 (.64)</td>
<td>1.21</td>
</tr>
<tr>
<td>M</td>
<td>1.66</td>
<td>.86</td>
<td></td>
</tr>
</tbody>
</table>

The values in Table 5.7 demonstrate that the 4-year-old children produced a greater number of dysfluencies than the 7-year-old children. The effect of prime condition on dysfluencies trended in opposite directions for the two age groups and was small overall. In line with these observations, the results of a 2 (Prime Condition) x 2 (Age Group) ANOVA on the mean number of dysfluencies per utterance revealed a statistically significant main effect of age group, $F (1,46) = 14.130, p < .001, \eta^2_p = .24$. There was no statistically significant main effect of prime condition, $F (1,46) = .580, p = .45, \eta^2_p = .012, 95\% \text{ CI} = -.18 \text{ to } .41$, or the interaction between prime condition and age group, $F (1,46) = .964, p = .331, \eta^2_p = .021$. These results indicate that, contrary to expectations, overall dysfluency was not higher in the patient-primed than the control prime condition.
5.1.1.6 Summary

The results of the main analyses revealed that activation of the patient following the patient-related prime did not produce the anticipated alternations of syntactic structure. However, the analyses of the active transitive responses revealed that on the whole, children were slower to begin speaking following patient-related primes than control primes. These results are in line with the expectation that early activation of the non-preferred sentence subject would produce processing costs during production. Not all of the anticipated effects of prime condition on sentence processing, however, were observed. Neither the analysis of auxiliary omissions nor the analysis of sentence dysfluencies revealed a significant effect of the prime manipulation. The analysis of sentence dysfluencies, in contrast, revealed a large and statistically significant effect of age group. The analyses in section 5.1.2 explore the relationship between the participants’ working memory ability and their outcomes on these measures.

5.1.2 Correlations with Working Memory

Following Bock (1982), the questions of interest in this study derived from the expectation that early lexical activation creates processing pressures that may in turn influence production outcomes. Given the expectation that lexical maintenance creates costs to WM capacity, the anticipated effects of the prime manipulation on production outcomes may be more likely or more pronounced in speakers with more constrained WM capacity. The analyses in section 5.1.2.2 address this possibility, followed by analyses in section 5.1.2.3 that address the more general question of the relationship between WM and overall measures of production. For the analyses that follow, the combined patient first-mention score (i.e., sum of patient-subject sentences and patient false starts) was used as the measure of patient versus agent order of
mention. The family-wise alpha level for each set of correlations was set to .05. Two children in the 4-year-old age group (the youngest two participants in the study) did not understand the WM task, failing to sort items correctly even at the 1-item list level. These two children were not included in the WM analyses.

5.1.2.1 Working Memory Performance

WM scores were higher for the older group \((M = 52.9 \text{ words}, SD = 10.41)\) than the younger group \((M = 38.4, SD = 10.24)\). The results of an independent samples t-test confirmed that this difference was statistically significant, \(t(44) = 4.75, p < .001, \eta^2 = .34.\)

5.1.2.2 Correlations Between Working Memory and Prime Condition Effects

The first set of correlation analyses examined whether the influence of prime condition on the sentence production measures varied according to the children’s WM ability. Table 5.8 presents the results of these analyses in the first column of data. Although not the focus of the current analysis, the correlation values for the entire matrix, including correlations between dependent measures, are included for further information. As the correlation values in Table 5.8 demonstrate, there were no statistically significant correlations between WM scores and the influence of the patient-related prime on sentence production outcomes. A visual inspection of the scatterplots for each WM relationship confirmed that the distributions were consistent with the low correlation values, and did not reflect any undue influence of outliers. The lack of significant correlations also did not appear to be caused by excessive restriction in the range of difference scores (Patient first-mention, Range = -20% to 33%; RT, Range = -450 ms to 981 ms; Auxiliary omissions, Range = -20% to 27%; Dysfluencies per utterance, Range = -3.18 to 3.38).
Table 5.8 Correlations between WM scores and prime condition difference scores

<table>
<thead>
<tr>
<th></th>
<th>WM score (words)</th>
<th>Patient First-mention</th>
<th>RT (ms)</th>
<th>AUX omit (%)</th>
<th>Dysfluencies per Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>Sig. (^a) (N)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient First-mention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>Sig. (^a) (N)</td>
<td>-.234</td>
<td>.104</td>
<td>.046</td>
<td>-.063</td>
</tr>
<tr>
<td>RT (ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>Sig. (^a) (N)</td>
<td>.111</td>
<td>-.114</td>
<td>-.114</td>
<td>-.114</td>
</tr>
<tr>
<td>AUX omit (%)(^43)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>Sig. (^a) (N)</td>
<td>-.019</td>
<td>.025</td>
<td>.541</td>
<td></td>
</tr>
<tr>
<td>Dysfluencies per Utterance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>Sig. (^a) (N)</td>
<td>-.131</td>
<td>.121</td>
<td>.301</td>
<td>.121</td>
</tr>
</tbody>
</table>

\(^a\) 2-tailed.

These analyses provided no evidence for an association between WM ability and the effects of the prime manipulation on sentence production outcomes. Follow-up analyses examined whether children’s WM performance was correlated with overall measures of patient first-mention, RT, auxiliary omission, or dysfluency, collapsed across prime conditions.

5.1.2.3 Correlations Between Working Memory and Overall Scores on Dependent Measures

The final set of correlations asked whether the children’s overall scores on the dependent measures, collapsed across prime conditions, varied according to their WM ability. Table 5.9 presents the correlations between WM score and the production measures collapsed across prime

\(^43\) For this analysis, the arcsine-transformed values were used for the auxiliary and patient first-mention variable, as in the analyses in sections 5.1.1.2.2 and 5.1.1.4. However, correlation analyses repeated on the original, non-transformed proportion scores returned the same pattern of results.
conditions.\textsuperscript{44} As in the prior analysis, although relationships among the different dependent measures were not the focus of the current analysis, the entire matrix of correlations is presented for further information.

As Table 5.9 indicates, there was a moderate, statistically significant negative correlation between WM score and overall dysfluency, indicating that children with lower WM scores were more dysfluent. Figure 5.2 presents this relationship, with data points for the 4- and 7-year-old participants labeled separately. The most extreme point in the lower left quadrant represents the scores for a 4-year-old participant who, contrary to the overall trend, had both a very low WM score and a very low overall rate of dysfluency. It is noteworthy that this participant also had the lowest mean length of utterance of all the participants, suggesting perhaps that fluency was obtained by producing very short utterances. Given that the mean scores for both overall fluency and WM differed between the age groups, a follow-up analysis examined the partial correlation between WM and dysfluency controlling for age, in order to observe whether or not evidence for the relationship remained after accounting for age differences. The participant with the very short MLU was excluded from this analysis. The results of the partial correlation again indicated a statistically significant relationship between WM and overall fluency, \( r (42) = -.326, p = .031 \).

Figure 5.3 presents the scatterplot of the relationship between WM score and overall auxillary omissions\textsuperscript{45}. Although this correlation was statistically significant, the distribution in this scatterplot provides little indication of a linear relationship. The remaining correlations were

\textsuperscript{44} As in the previous analysis, the arcsine-transformed proportions were used for the auxiliary and patient first-mention variables. The results returned the same pattern as an analysis conducted over the original, untransformed, proportion scores.

\textsuperscript{45} For ease of interpretation, the scatterplot presents the original, untransformed proportion scores. The scatterplot containing these scores and the arcsine-transformed scores are very similar in distribution, differing primarily in the unit of measurement on the \( Y \)-axis.
not statistically significant, and the relevant scatterplots showed no evidence suggesting a relationship.

**Table 5.9 Correlations between WM scores and overall scores for dependent measures**

<table>
<thead>
<tr>
<th></th>
<th>WM score (words)</th>
<th>Patient First-mention</th>
<th>RT (ms)</th>
<th>AUX omit (%)</th>
<th>Dysfluencies per Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.$^a$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient First-mention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r$</td>
<td>.217</td>
<td>.147</td>
<td>.082</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.$^a$</td>
<td>.170</td>
<td>.147</td>
<td>.082</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>46</td>
<td>46</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>RT (ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r$</td>
<td>-.230</td>
<td>-.334</td>
<td>.164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.$^a$</td>
<td>.238</td>
<td>.082</td>
<td>.403</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>AUX omit (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r$</td>
<td>-.427</td>
<td>-.033</td>
<td>.164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.$^a$</td>
<td>.003</td>
<td>.789</td>
<td>.403</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>46</td>
<td>46</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Dysfluencies per Utterance</td>
<td></td>
<td>-.445</td>
<td>.041</td>
<td>.011</td>
<td>.285</td>
</tr>
<tr>
<td></td>
<td>Sig.$^a$</td>
<td>.002</td>
<td>.789</td>
<td>.955</td>
<td>.055</td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>46</td>
<td>46</td>
<td>28</td>
<td>46</td>
</tr>
</tbody>
</table>

$^a$ 2-tailed
Figure 5.2 Scatterplot of relationship between WM score (X) and overall dysfluency (Y)

Figure 5.3 Scatterplot of relationship between WM score (X) and overall percentage of auxiliaries omitted (Y)
5.1.3 Overall Summary of Study 2 Results

Overall, the results of Study 2 revealed three important patterns. First, patient-subject sentences were very rare, and did not occur to a statistically significant degree more often in the patient-primed condition than the control prime condition. The results, however, did reveal evidence for an effect of the prime on processing efficiency. Among the analyses of processing outcomes for patient-primed active transitive sentences, the prime manipulation affected RT, but not auxiliary use or overall dysfluency. Third, the extent to which the prime manipulation affected children’s sentence production outcomes was not correlated with their score on the WM task. In contrast, children’s overall rate of dysfluency did show a relationship to WM ability. There was a statistically significant negative correlation between WM score and overall dysfluency, collapsed across prime conditions. The strength of evidence for, and implications of, these patterns for our understanding of children’s sentence planning and production are discussed in the following section.

5.2 Study 2 Discussion

Study 2 examined questions about the influence of lexical activation order on sentence structure, production efficiency and integrity, and also examined questions about the relationship of age and working memory capacity to sentence production outcomes. The results of Study 2 provide insight into the priorities of the language production system during sentence planning and extend our understanding of language production mechanisms within a limited capacity perspective. The discussion that follows will address each of the major research questions in
turn. Later sections of the discussion will address limitations, caveats, and secondary implications.

### 5.2.1 Primary Outcomes

#### 5.2.1.1 Can Lexical Activation Order Influence Children’s Sentence Structure?

The first question in Study 2 asked whether lexical activation order can influence the mapping of a referent to the subject position in children’s sentences and, in consequence, influence sentence structure. In order to address this question, this study examined whether or not children would alternate away from the preferred (agent-subject) active transitive following semantic priming of the patient. The stimuli provided a context to produce an active transitive sentence, a passive sentence, or, in some trials, an agentless intransitive. It was anticipated that active transitive responses would dominate overall, but that the rate of patient-subject sentences would increase in the patient-primed condition. Moreover, given the evidence in Study 1 for age-related differences in syntactic flexibility, it was expected that the rate of patient-subject responses in the primed condition would be higher for the 7-year-old participants than the 4-year-old participants. The results of Study 2, however, did not support either prediction. On average, the children produced patient-subject sentences in 2% or fewer of their responses. For the 7-year-old group, the rate of patient-subject sentences was virtually identical between the patient-primed and the control condition. For the 4-year-old group, the rate of patient-subject sentences was descriptively higher in the patient-primed condition (2.1 vs. 0.8%). This difference, however, was not statistically significant.
There are several potential explanations for the fact that exposure to the patient-related primes did not lead to sentence structure alternations. Of these, the least interesting explanation would be to assume that the primes failed to influence sentence structure because they failed to influence lexical activation dynamics. The sentence-based analyses in Study 2 rested on the assumption that the primes were capable of facilitating lexical activation for the patient. If this assumption was not met, the participants would have produced similar sentence structures in both the patient-primed and control conditions simply because both conditions presented similar, neutral lexical activation contexts.

An admitted challenge in the current work is that it is not possible to directly observe the inner workings of lexical activation when the prime is presented. However, there are nonetheless several good reasons to believe that on the whole, the primes did in fact produce changes to lexical activation dynamics for the patient targets. First, Study 1 documented that as a group, the set of primes produced reliable facilitation when priming was measured more directly via picture-naming RT. For the 10 prime-target pairs that contributed to the Study 2 analyses, the average patient-target facilitation in Study 1 was 105 ms, calculated across participants. Although Study 2 examined a different group of children, the two groups were similar in their age ranges, were both composed of monolingual, typically developing children, and demonstrated similar overall profiles of maternal education as well as general language ability as measured by CELF-P:2 (Wiig et al., 2004) and CELF-4 (Semel et al., 2003) sentence repetition scores. Although there was some dissimilarity in the gender distribution between the two studies, the results of Study 1 gave no evidence that priming facilitation was dependent on gender ($p = .89$). Based on the results of Study 1, it is reasonable to assume that a relatively small number of
children in Study 2 would not have been sensitive to the primes’ influence on lexical activation (i.e., at a descriptive level, 6 children in Study 1 demonstrated no RT facilitation in the primed condition). However, the results of Study 1 also support the expectation that for the greater majority, the set of primes would have a facilitative relationship to the patient targets.

Although the participant characteristics of the two studies were very similar, the priming context did differ in an important way – in Study 1 the children viewed the target pictures in isolation, whereas in Study 2 they viewed the patient targets within an animated action scene that also contained the agent target. This difference could have introduced unique processing dynamics and priorities during initial visual analysis and lexical activation that could have in turn altered or muted the facilitative effect of the prime on patient activation. In research that manipulated the order of visual scanning (Gleitman et al., 2007), for example, the order in which adult speakers fixated the different characters in the scene influenced the order of mention. In the current study, the prime’s effects may have occurred against the backdrop of visual scanning dynamics that may have either helped or interfered with the prime’s effects on lexical activation order. Future work would benefit from methods to either control the order of visual scanning or measure it on a trial-by-trial basis. However, even though the visual context was more complex in Study 2, the results of the analysis of patient first-mentions (see section 5.1.1.2.2) support the view that the primes nonetheless did provide a processing advantage for the patient targets. Although the primes did not reliably influence children’s ultimate choice of sentence structure, the patient first-mention results revealed a tendency for children to name the patient (in full or in part) prior to naming the agent more often following patient-related than control primes, either within a patient-subject sentence or as a false start. This tendency was observed for the younger
children across the full experiment, and for the full sample of children when Block 1 was considered on its own. As noted in section 5.1.1.2.2, the overall rate of patient first-mentions was too low to warrant extensive interpretation. Despite this caution, however, the pattern of patient first-mentions coupled with the patient-target priming results from Study 1 supports the view that the primes likely did provide activation benefit during the Sentence Production task. This activation benefit, however, did not translate into reliable effects on sentence structure. This pattern is interesting in light of the results reported by Streim and Chapman (1987). Recall that in Streim and Chapman’s investigation, repetition priming (i.e., naming a picture of the target referent immediately before it appeared in a target scene) resulted in the earlier appearance of the primed referent within children’s descriptions. The results were interpreted as suggestive of an effect on syntactic organization and assignment of the primed element to the subject position, but this was not actually measured. The results thus left open the question of whether early activation truly promotes structural alternations in children’s speech. The current results are consistent with the view that children may feel pressure to make early mention of early-activated lexical items, but that this pressure may not translate into an effect on decisions regarding the syntactic organization of the sentence.46

The inability of lexical activation to influence syntactic organization in the current study stands in contrast to other effects on syntactic structure that are observed within the same age range. As previously described, children as young as three and four years old show an increase in the rate of production of passive and agentless intransitive sentences following discourse or pragmatic pressure from patient-focused questions (Braine et al., 1990; Brooks et al., 1999;

46 Here, as with any other references to “decisions” or “choices” within the syntactic or lexical stream, there is no assumption that these “choices” are made at a conscious level.
Harris & Flora, 1982; Loeb et al., 1998; Marchman et al., 1991). Syntactic priming studies also demonstrate that children show a higher rate of passive responses when syntactic activation dynamics support this structure (Huttenlocher et al., 2004; Messenger et al., 2011; Shimpi et al., 2007). The current results suggest that lexical activation dynamics, however, do not have a comparable ability to motivate the production of passive sentences. There are two possible interpretations for this difference. The first is that lexical-syntactic interactions of the kind sought in the current experiment are somehow not possible within the architecture of young children’s language production systems. That is, the lack of alternations to passive or agentless intransitive structures may reflect a general restriction on this type of communication between lexical and syntactic planning processes. This account would suppose that there is no available mechanism within the organization of the production system for lexical activation timing to influence structural decisions. With respect to this possibility, it is interesting to note that a number of the younger group’s patient false starts seemed to point to a lack of integration between the primed noun and the sentence planning process. When the children in the 4-year-old group produced patient false starts, they often produced a bare noun or part of a bare noun rather than the determiner phrases that typically initiated their sentences (e.g., “Ba > The kitty’s licking the baby”). Bare nouns (or partial production of bare nouns) accounted for almost half (48%) of the patient false starts produced by this group. This was not, however, the pattern observed for the 7-year-old children, who produced a bare noun (or part of a noun) in only 11% of their patient false starts. The bare noun false starts produced by the younger group suggests the possibility that, in some trials, they were not attempting to produce the primed patients as sentential subjects, but
instead named them in isolation (“blurted then out”) before returning to the task of sentence planning.

The characteristics of some responses thus suggested a possible separation between early naming of the primed item and syntactic planning processes. These responses aside, however, there is little empirical basis on which to assume that it should be architecturally impossible for lexical activation dynamics to influence the syntactic stream during grammatical role assignment in children’s sentence planning. From the perspective that these kinds of interactions are possible in adults’ speech, there is reason to believe that they should be possible in children’s speech, too. As discussed in the Introduction chapter, studies of speech error and dysfluency phenomena point to greater similarity than dissimilarity between adults’ and children’s production architectures (Jaeger, 1992; McDaniel et al., 2010; Stemberger, 1989). We can be less certain that these similarities apply when children are just beginning to produce sentences: There is evidence that syntactic representations and syntactic planning may undergo qualitative changes in early childhood (Tommasello, 2000; Wijnen, 1990). However, these considerations are typically expected to apply to children younger than 3 years of age – that is, younger than the focus within the current study. Moreover, the current study only examined one sentential context, using one strategy to manipulate lexical activation. It remains possible that children would demonstrate syntactic alternations involving other structures (e.g., the dative alternation) or using a stronger manipulation of lexical activation. And, looking beyond the current focus, it is also possible that children would demonstrate lexically-influenced alternations of linear order that do not involve grammatical role assignments or major structural alternations (e.g., linear order within a conjoined noun phrase).
A more likely account for the current results appeals to the dynamic balancing or weighting of the different priorities of the production system within the moment of speaking. That is, a more likely account is that it is architecturally possible for lexical activation to influence children’s sentence structure, but that the lexical pressure in the current study was not ultimately able to overcome other, competing, priorities. Within an approach such as the Competition Model (Bates & MacWhinney, 1989; Presson & MacWhinney, 2011), production decisions can be viewed as a dynamic process of conflict resolution that takes into account the relative strength or validity (e.g., information value, goodness-of-fit to the communicative goals, strength of activation connections) versus the relative costs of different priorities or forms. This perspective is also consistent with Altmann and Kemper’s (2006) conclusion that “sentence production is best described as a probabilistic, constraint-satisfaction process in which a number of constraints compete to influence sentence structure choice …” (p. 351). In the current context, the relevant constraints appeared to be the communicative intent or meaning, syntactic constraints, and lexical activation pressures. The following paragraphs consider how each of the constraints might have favoured or disadvantaged the different potential syntactic options.

An active transitive response was valid on all trials, maintaining high fidelity to the message and allowing the use of a frequent, familiar syntactic form. In patient-primed trials, producing this form became arguably more costly and arguably less valid due to its conflict with lexical activation order. However, despite becoming a less ideal choice than in the control prime condition, the status of the active transitive as a relatively basic or default form may have carried more weight in the determination of the ultimate outcome. As suggested by Bates and Devescovi (1989), “… frequent use may increase the candidacy of a structural type to the point where it
sometimes is chosen under non-optimal conditions, in place of a form that is higher in cue validity, but also higher in costs” (p. 252). This interpretation is consistent with the observation that, by approximately 3 years of age, English-speaking children adhere to a canonical agent-action-patient schema in their interpretation of noun-verb-noun sequences (Slobin & Bever, 1982).

As noted, the alternatives to the active transitive also came with costs. The passive retains a high degree of message fidelity. In the patient-primed condition, it also retains better fidelity to the order of lexical activation, and therefore, arguably presents fewer costs associated with lexical buffering. However, the processing costs associated with activating and producing the relatively infrequent passive structure are arguably high. As demonstrated in Study 1, young children may need a maximally supportive context to produce the passive, which Study 2 did not provide. The agentless intransitive, in turn, may carry fewer production processing costs with regard to structure (i.e., a simple intransitive), but may be less valid in terms of message validity due to the lack of explicit or implied reference to the causal agent. As the various costs and benefits associated with different courses of action competed, it would seem that the children in this study (and Study 1) prioritized satisfying constraints related to maintaining message fidelity and minimizing syntactic structure costs.

The relative strengths of the active transitive versus the relative weaknesses or costs of potential alternatives can also account for the fact that, even in studies with adults that demonstrate sensitivity to lexical activation order, lexical activation effects are far from absolute and active transitive responses tend to dominate overall (Altmann & Kemper, 2006; Gleitman et al., 2007). Given that young children have less ability with the passive than do adults, the
adherence to the active transitive in the current study is not entirely surprising. However, it should be noted that the results were not a foregone conclusion. If attempts to make early use of the activated lexical item are sensitive to processing pressures, the relative processing capacity limitations of young children could have made them more likely to attempt to do so, potentially with compromises to structural accuracy. Altmann and Kemper (2006), for example, observed that older adults but not younger adults alternated their sentence structures in response to lexical availability. Altmann and Kemper interpreted this difference with respect to general capacity limitations that may have given the older adults greater need to make early use of the activated lexical item. By the same argument, children may also have a relatively strong need to make early use of available items. This possibility is in line with the fact that the tendency to mention the patient first in the primed condition was more consistent for the younger (and presumably more capacity-constrained) group than the older group. However, they did not tend to elaborate a sentence frame from this starting point.

Overall, the results of the current study are in line with the conclusion that although children may feel pressure to make use of early-activated lexical items, syntactic considerations exert a stronger influence on children’s ultimate syntactic decisions. A promising direction for future research will be to examine the limits of the syntactic stream’s dominance on sentence organization, and to explore the conditions under which planning becomes more flexible. The following sections consider the processing consequences of pressure from early activation of the patient on active transitive sentence productions.
5.2.1.2 Can Lexical Activation Create a “Processing Hazard” in Sentence Production?

As noted in the Introduction, the potential processing consequences of lexical-syntactic conflicts have received less empirical investigation than the potential influence of lexical activation order on sentence structure alternations. Studies in the adult literature have paid more attention to the ability of lexical stream processing dynamics to dictate syntactic structure than the consequences that might occur when they fail to do so. However, these potential consequences are also centrally important to understanding sentence production within a limited capacity perspective.

The second major question in Study 2 asked whether conflicts or mismatches between lexical activation timing and sentence structure produce costs to children’s sentence production efficiency and/or integrity. This question addressed the possibility that lexical activation may act as a source of processing hazard during sentence planning and production (Bock, 1982). According to the perspective guiding this investigation, lexical activation may negatively affect sentence production processing when lexical activation order and sentence structure are in conflict, due to the need to resolve the conflict as well as the need to buffer the early-activated lexical item as the rest of the sentence is planned and produced. The current investigation examined the negative consequences of lexical-syntactic conflicts with a focus on speech onset time (RT), auxiliary production and production fluency. Consistent with the expectation regarding conflict resolution, speech onset time (RT) for active transitive responses was negatively affected in the patient-primed condition. Children were slower to begin speaking when the primed word was produced later in the sentence. This result is consistent with the conclusion that lexical activation can indeed create a processing hazard during sentence planning.
and production. The remaining predictions regarding processing consequences, however, did not receive support. In particular, the results did not reveal reliable changes in auxiliary omission rates or the number of dysfluencies per utterance following the patient primes. And, given the expectation that younger children produce sentences with greater capacity limitations than older children, it was anticipated that the negative consequences of lexical-syntactic conflicts would be relatively greater for the 4-year-old children than the 7-year-old children. This expectation was not borne out. The following sections will first discuss the positive evidence for lexical activation as a processing hazard, and then will further consider the outcomes related to auxiliary use, fluency, and age.

5.2.1.2.1 Consequences for Speech Onset Speed (Reaction Time)

Turning first to the results of the RT analysis, the patient-related primes demonstrated opposite patterns of effects in Study 1 versus Study 2. For the 10 items that contributed to the analyses in Study 2, RTs to name pictures of the patient-target pictures in Study 1 were on average 105 ms faster following patient-related primes. RTs to name agent pictures were 22 ms slower following patient-related primes, but this difference was far from statistically reliable ($p = .40$). In Study 1, exposure to the patient-related primes facilitated activation of the patients and was neutral with regard to the agents. In Study 2, in contrast, the patient-related primes produced negative consequences for sentence onset speed. RTs to begin producing active transitive sentences were on average 110 ms slower following patient-related primes than control primes. Although the magnitude of this effect varied over the course of the experiment (as seen in the interaction with experimental block), the overall pattern calculated across participants was of
slower responses in the patient-primed trials. This result is consistent with the conclusion that early activation of a late-occurring word indeed has negative consequences on sentence processing. It indicates that the priorities of both the lexical and syntactic streams affect the sentence planning process, and is consistent with the prediction (Bock, 1982) that a mismatch between lexical activation order and syntactic planning sets up a conflict that must be resolved before the sentence can be produced. In the current study, this conflict resolution consistently respected syntactic planning constraints.

The RT results stand in some contrast to the results reported by Davidson et al. (2003) for older adults. As noted in the Introduction, Davidson et al. reported no difference in RT or dysfluencies for dative sentences that either maintained or were in conflict with lexical activation order (as determined by a cue to visual fixation for the stimulus words). The current study examined a different population and used a different method to manipulate lexical activation order, and so there may be several reasons for the difference in outcomes. One potential account of this difference, however, rests on the difference between the current study and that of Davidson et al. (2003) in the sentence structures under investigation. As previously noted, transitive and dative alternations differ with respect to whether the alternation affects the starting point of the sentence versus the arrangement of post-verbal material (e.g., “The cat is licking the baby / The baby is licking the cat” vs. “The boy is giving the dog a treat / The boy is giving a treat to the dog”). Manipulations affecting the relative activation level of agent versus patient referents may produce more notable consequences for speech onset RT. The current results support that possibility. In addition, as previously noted, Altmann and Kemper (2006) reported evidence that older adults were faster to initiate passive sentences than active sentences when the
lexical presentation context favoured the passive. The number of passive sentences in the current study was too few to allow a similar comparison, but the two studies are nonetheless consistent in demonstrating that speech onset RT is affected by the relationship between lexical activation order and the starting point of the sentence.

Finally, the current results point to a time-dependent process of conflict resolution, but do not reveal exactly how or where within the sentence planning process this occurred. The need for conflict resolution could have occurred at the initial point of assigning the thematic roles of agent versus patient to the subject versus object grammatical role (i.e., functional role mapping), or at the point of attempting to elaborate that initial assignment into a more detailed, serial plan during positional processing. Differences in the frequency of occurrence of active and passive sentences could potentially lead to differences in activation strength at both the functional and positional levels of planning. Bock (1987a), for example, proposed that during functional processing, different forms of a verb “marked for the functional relations” (p. 372, e.g., active and passive functional mappings) receive activation, and the relative activation levels of these representations will influence whether or not a lexical item is ultimately mapped to the subject function (see Tanaka, Branigan, McLean, & Pickering, 2011, for a related view). More recent work (Pickering & Branigan, 1998; Pickering, Branigan, Cleland, & Stewart, 2000) is also consistent with the general spirit of this proposal, demonstrating that lemma-level processing during sentence production involves the activation of a verb lemma and also the activation of units or nodes representing combinatorial possibilities. Within this approach, combinatorial representations are linked to and shared between different verbs. Pickering and colleagues’ studies (Pickering & Branigan, 1998; Pickering et al., 2000) focused on lemma-level activation of combinatorial
nodes related to alternative dative forms (i.e., double-object versus prepositional datives), but the same activation principles presumably apply for alternations such as the active/passive. Within the current study, initial attempts to map the early-activated patient to a weakly activated passive (patient-first) “functional mapping” or “combinatorial node” representation, instead of a more strongly activated active (agent-first) representation, may have produced time costs. Costs related to conflict resolution could also arise from positional level considerations, if difficulties elaborating the initial functional mapping forced a revision of the initial plan (Bock, 1987a) or, possibly, fed back to prevent the mapping from occurring in the first place within a context of cascading and feedback of processing. The former possibility would be consistent with children making an initial mapping of the patient to the subject function, then failing to elaborate that mapping sufficiently to begin speaking. Further investigation of the locus of conflict and conflict resolution is a topic for future research. For the current purposes, the most important observation is the documentation that this conflict resolution has real-time implications for sentence planning outcomes. This observation invites further investigation of how this conflicts occurs and is resolved, factors that predispose an individual speaker to resolving conflicts more or less efficiently, and implications (if any) of the time costs for other aspects of sentence processing and communication success.

5.2.1.2.2 Consequences for Auxiliary Production Invite Further Investigation

Within the framework that guided this investigation, it was expected that early activation of the patient would add to working memory load during sentence planning and production, and that this increase in processing load would have a negative effect on auxiliary use. This increase was expected to occur as a result of the added work needed to buffer or maintain activation of the
primed patient until the patient could ultimately be produced at the end of the sentence. Contrary to expectations, the results did not reveal a reliable effect of the primes on auxiliary production within children’s active transitive responses. This outcome stands in contrast to prior studies that have demonstrated that children’s omissions of vulnerable morphemes are determined at least in part by processing capacity constraints (Grela & Leonard, 2000; Leonard et al., 2000; Namazi, 1996; Owen, 2010; Pizzioli & Schelstraete, 2008). In consideration of this outcome, a closer inspection of the data in current study suggested that the participants fell into three different groups with respect to their auxiliary use. Across the entire sample of children, 10 \((n=7\) younger group, \(n=3\) older group) produced sentences containing no auxiliary in 90\% or more of trials in each condition. Another group of 17 children \((n=5\) younger group, \(n=12\) older group) never omitted the auxiliary in either condition. A third group of 21 children \((n=12\) younger group, \(n=9\) older group) demonstrated rates of auxiliary use that fell between these extremes. These three groups invite different explanations for the patterns of auxiliary use that were observed in this study.

Turning first to the group of children who omitted 90\% or more of auxiliaries in each condition, it is possible that some of these children did not have sufficient mastery of the auxiliary to produce it within the performance constraints of the current study (although this explanation seems unlikely to account for the performance of the older children in this group). It is also possible that these children did not view the task as creating an obligatory context for a tense-bearing utterance. That is, despite the prompts that were given, they may have viewed the task as requiring essentially a labeling response (e.g., \((There’s) \text{ “A cat licking a baby”}\)). The
measurement of auxiliary omissions requires that the task create an obligatory context for auxiliary production. For this group of children, it may be that this did not occur.

Turning next to the group of children who never omitted the auxiliary, these children’s outcomes point to two potential interpretations. The lack of variability within this group may indicate that early activation of the patient does not add strain to capacity in the manner that was expected. It is also possible that lexical maintenance does produce capacity costs, but that for these children, mastery of auxiliary production was so complete (and demanding little capacity investment) that these costs did not lead to omissions. The success demonstrated by these children is perhaps not surprising, as the sentence context was relatively simple and typically-developing children within the age range of the current study do not omit auxiliaries very frequently within their spontaneous or elicited speech (Rice et al., 1998). In the absence of an extraordinarily challenging production context, then, the range of variation that could be anticipated was limited.

Turning finally to the group of children who demonstrated auxiliary use falling between these extremes, 14 children within this group demonstrated a higher proportion of omissions in the patient-primed condition, 4 demonstrated a higher proportion of omissions in the control prime condition, and there were three ties. The effect of the prime manipulation on auxiliary use also failed to reach significance in this smaller group, \( t(20) = 1.93, p = .07 \). However, the fact that the outcomes for more children patterned in the direction of the hypothesized effect rather than in the opposite direction suggests that this line of inquiry remains promising for future investigation. With methodological changes to allow participation of children with less advanced language skills, and to encourage a more obligatory context for auxiliary production, future work
might reveal more consistent effects of lexical-syntactic integration dynamics on grammatical integrity. Section 5.2.1.4.1, below, describes potential methodological changes for future work.

5.2.1.2.3 No Reliable Consequences for Production Fluency

The measure of dysfluency captured all instances of silent pausing, hesitation, repetition and revision following speech onset. Contrary to expectations, there was no reliable effect of prime condition on the children’s overall level of dysfluency in active transitive sentences. This result adds weight to the suggestion that early activation of the patient either did not reliably increase the pressure on children’s sentence production capacity once production had begun, or that it did not increase it sufficiently to disrupt the productions of the current group of children.

The results of the dysfluency analysis support some findings and differ from others within the (adult) literature. They are consistent with Davidson et al.’s (2003) report of a lack of a fluency effect for dative sentence productions that did and did not follow the order of activation for the post-verbal material. The results, in contrast, are not consistent with post-hoc analyses reported by Bock (1987b). In that study, adults’ dysfluencies occurred more often when there was a mismatch between word form activation order and production order, in both transitive and phrasal conjunct sentences. Several factors may account for the difference in outcomes. In the study reported by Bock (1987b), the manipulation of word-form activation was in the form of phonological inhibition. It is possible that manipulations that facilitate versus inhibit lexical availability will have different effects on sentence fluency. It is also possible that activation manipulations having their effects more directly at the lemma versus word-form level may produce different effects in situations of conflict with syntactic planning. It may be the case that conflicts at the lemma-level are more likely to lead to revisions before speech onset (e.g., causing
longer RTs, as observed in the current study), whereas conflicts at the word-form level are likely to additionally lead to dysfluencies after speech onset. That is, a speaker may sometimes create an initial plan based on conceptually-driven lemma activation and a preference for a particular structure (e.g., an active transitive), only to revise or hesitate after speech is initiated but before producing, for example, the subject noun. Bock (1987b, p. 134), for example, noted that the pattern of dysfluencies was consistent with speakers attempting active transitive responses only to run into difficulty retrieving the phonological form of the subject noun. A close reading of Bock (1987b) also indicates that the measure of dysfluency may have overlapped with both the RT and dysfluency measures in the current study, rather than distinguishing between onset latencies and post-onset dysfluencies. In that study, the post-hoc measure of dysfluency included filled pauses, revisions and “unusually long hesitations preceding the production of each description” (p. 128, no further details were provided). Given this possibility, and because the current study did not systematically vary either facilitation versus inhibition or lemma-level activation versus word-form activation, further conclusions regarding the difference in outcomes are not possible.

A striking feature of the dysfluency analysis was the large and statistically significant difference that was observed as a function of age group. This outcome was consistent with the findings reported by McDaniel et al. (2010) for children within the same age range. In the McDaniel et al. study, the age-related difference in dysfluency rate was observed in productions of complex sentence structures that were likely to be relatively new or weakly represented for the younger group. In that study, participants produced both long and short subject- and object-relative sentences. In the current study, in contrast, the children produced relatively simple active
transitives. The children in both groups had been familiarized to the names of the characters within the scenes, and Study 1 demonstrated that, for these stimuli, the active transitive was the default preference for both age groups. Yet, despite these facts, the 4-year-old children in Study 2 demonstrated greater challenges with the smooth planning and execution of these sentences, as evidenced by the dysfluency measure. This observation lends support to the conjecture in the Study 1 Discussion that the younger children were under greater capacity constraint even when producing the relatively familiar and preferred active transitive (see section 3.2.1.1, regarding age–related differences in the rate of pronominal and null forms in active transitive responses). It is consistent with McDaniel et al.’s (2010) conclusion that there are developmental changes in sentence production capacity, particularly in the ability to sustain the necessary concurrency of processing.

A promising avenue for future research relates to further understanding of the nature or source of age-related differences in production fluency and their relationship to processing capacity. One source might have to do with relative experience specific to the active transitive and the lexical items that were needed. As noted above, Rispoli and Hadley (2001) documented that young children’s dysfluencies tend to occur more frequently in structures that are at children’s “leading edge” of development. It seems unlikely that for the children in the current study, simple active transitives would represent the outer edge of their productive knowledge base. It is possible, however, that for some of the younger children, the active transitive was still within the range of structures that the child controls productively but that still require relatively greater or more consistent capacity investments – particularly in a non-familiar context such as in the experimental task – in comparison to even simpler and/or more practiced structures (and in
comparison to the 7-year-old group for whom simple transitive sentences may be so well-practiced as to place minimal demands on capacity). If so, it is possible that other, simpler, structures would not have revealed the same age-related difference. The current study did not examine other structures and therefore cannot speak further to this possibility.

However, it is possible that the dysfluency results were also affected by more general, age-related differences in the ability to sustain concurrency of processing, related to age differences in overall language experience (rather than specific ability with the transitive) or some more domain-general influence. With regard to the question of more general versus structure-specific determinants of capacity in this task, it is interesting to note how performance did and did not change across Study 2. Prior research (Bock & Loebell, 1990) has suggested that repeated experience with a particular sentence structure within an experiment leads to greater fluency with that structure. This is consistent with the expectation that the processing demand that a given structure places on capacity will vary with the speaker’s experience with that form. The item-based RT analysis in Study 2 (section 5.1.1.3.3) revealed a statistically significant effect of experimental block on children’s speech onset latency. Children were faster to begin speaking in Block 2, suggesting that some aspect of the initial planning benefitted from prior experience within the experiment. For the dysfluency measure, in contrast, there were no significant main effects or interactions involving experimental block (and the analysis therefore disregarded block). Experiment-specific experience with the relevant lexical items and the active transitive structure did not lead to reliably greater fluency or a reduction in the 7-year-olds’ fluency advantage over the 4-year-olds. This pattern suggests that even though the repeated experience within the experiment benefitted efficiency, this benefit did not necessarily translate
into improved ability to smoothly coordinate production activities once production had begun. A promising avenue for future research will be to further examine how capacity in language production does and does not change with item-specific experience, and how item-specific and more general constraints might interact.

### 5.2.1.3 Age Invariance in Prime Condition Effects

One important goal of this study was to examine potential developmental differences in lexical-syntactic integration dynamics and the ability to absorb any extra pressures created by lexical buffering. Contrary to expectations, the results did not provide evidence for such differences. Given the fact that there were also no main effects observed for the prime condition with regard to sentence structure, auxiliary use, or dysfluency, the lack of interaction is perhaps not surprising. It may simply reflect the fact that lexical activation pressures do not influence sentence planning and production in the ways that were anticipated. However, given the challenges noted above with respect to measuring auxiliary use, it remains possible that future work may reveal different outcomes related to age or developmental level with respect to the auxiliary.

The prime manipulation did have a negative effect on sentence planning time as revealed in children’s RTs. Accordingly, if we assume that sentence planning is more effortful or less efficient for younger than older speakers, the relative consequences of resolving lexical-syntactic conflicts had the potential to be greater for the younger children. In this study, they were not. It is worth noting that in the current study the two age groups showed a difference in overall RT, but that this difference failed to reach statistical significance. This raises the possibility that the two
groups were not in fact different enough with respect to sentence onset latency for differential effects of the prime to be observed. It is also worth noting that the children in the current study demonstrated considerable variation in their response onset latencies. Among the children who were retained for the RT analysis, the mean overall RTs (collapsed across prime conditions) ranged from 934 ms to 2147 ms ($SD = 317$ ms). This variation suggests that children may differ considerably in the extent or nature of sentence planning before speech onset. In future work with a larger group of participants, it may be profitable to explore how potential differences in the extent of initial sentence planning relate to outcomes in contexts such as that of the current study. Finally, it also worth noting that, in the current study, children sometimes demonstrated initial hesitations following the onset of speech but preceding the actual initiation of the subject-position determiner phrase (i.e., filled pauses such as “um” and any subsequent silent pauses preceding the actual subject phrase). These initial hesitations were counted as part of the dysfluency measure rather than as a part of the child’s speech onset latency. The current study revealed a large and statistically significant age-related difference in the dysfluency measure, which included these sentence-initial pauses. In future work, it may be profitable to examine whether age-related effects on RTs emerge when the full latency up to the initiation of the first true word is considered.

It remains possible that children who are considerably more vulnerable to processing challenges related to speed, such as children with specific language impairment (see Leonard, 1998) might experience relatively greater disruption from a similar context of lexical-syntactic conflict. Indeed, part of the motivation for this work was to lay a foundation for future work aimed at examining the production difficulties of children with SLI. With this motivation in
mind, one goal was to observe whether or not lexical activation and lexical-syntactic conflict
could negatively affect sentence processing outcomes at all. The current results suggest that they
can, although they failed to reveal several of the hypothesized effects. Future work will need to
determine whether or not exceptionally vulnerable speakers pattern similarly or differently to
typically-developing children.

5.2.1.4 Caveats and Methodological Limitations

Potential caveats and alternative interpretations of the results have been discussed where
appropriate in the preceding sections. However, it is important to acknowledge several
outstanding issues that are relevant to the interpretation of this investigation’s results.

5.2.1.4.1 Confidence Intervals and Measurement Challenges

The analyses of RT revealed statistically significant effects of the prime manipulation,
providing support for the conclusion that conflicts between lexical activation and syntactic
planning do produce negative processing consequences. Lexical activation can act as a
processing hazard. However, the results revealed very large 95% confidence intervals for the
prime condition difference (subtracting the control prime scores from the patient prime scores),
with the lower bound near zero and an upper bound that would be consistent with substantial
differences. These values highlight the need for caution in drawing conclusions about the likely
reliability and true magnitude of difficulty created by lexical-syntactic conflicts. The current
study has a novel focus within the developmental language literature. To my knowledge, it is the
first to examine and document effects of lexical-syntactic conflicts in young children’s speech,
and the results indicate that this is a promising avenue for future investigation. However, the
confidence interval results indicate a clear need for replication in order to evaluate the range and reliability of these effects. Insights from the current study offer an opportunity to identify and address methodological and measurement challenges in the future, and in turn draw firmer conclusions about the nature of these effects. These challenges are addressed below.

With respect to the RT analysis, a notable challenge was the number of trials that were lost due to voice key errors and off-topic talking between the prime and target. All analyses involving the RT (prime condition effects, age group effects, and correlation analyses) were limited to a subgroup of the participants and responses, which may place limits on the extent to which the results can be expected to generalize to other, larger samples or populations. However, although RT-based studies of children’s sentence planning are extremely limited (but see Anderson & Conture, 2004; McDaniel et al., 2010), a comparison to available data suggests that the RT values generated in the current study are at least broadly representative of sentence planning within the age range in question. In particular, in a study of syntactic priming, Anderson and Conture (2004) reported average unprimed sentence onset RTs of approximately 1500 ms for simple active transitive sentences produced by typically-developing 3- to 5-year-old children. This value is remarkably similar to the mean onset time observed for the younger children in the current study. Together, these studies suggest that RT-based investigations of young children’s sentence planning are feasible, if challenging. As a larger base of evidence regarding children’s sentence planning is created, this will allow for greater certainty in the outcomes of individual studies.

In addition to the RT analysis, the auxiliary analysis also presented a measurement challenge, as previously discussed in section 5.2.1.2.2. In future work, methodological changes
may allow for both greater RT data retention and more precise measurement of auxiliary outcomes. With regard to the RT analysis, these changes may include minimizing speech requirements other than the production of the target response sentence (by, for example, providing an auditory prime rather than having the child name the prime), and/or examining the acoustic record to manually recover RTs affected by voice key artifacts. With regard to the auxiliary analysis, these changes may include adding additional training trials and/or having children repeat the experimenter’s demonstration sentences, repeating the sentential prompt (i.e., *What is happening?”*) between the prime and target, manipulating lexical activation in a way that does not require children to alternate between single word and sentential responses, and/or embedding the trials within a more realistic communicative context. Finally, future investigations of lexical-syntactic integration and conflicts in children’s speech may benefit from larger sample sizes. The sample size in the current study ($n = 24$ at each age) was determined based on the goal of having sufficient power to detect effects within each age group at least as large as those observed in syntactic priming with young children (Shimpi et al., 2007). However, the effects of lexical activation on syntactic planning and sentence production outcomes may be more distal or less consistent than syntactic priming effects, and thus may require relatively larger sample sizes.

### 5.2.1.4.2 The Role of Experience: Block Effects

The results of Study 1 and Study 2 indicate that “experience” may affect production in different ways, depending on the context. In Study 1, experience led to increases in the likelihood that children would produce a passive response. These increases were suggested to reflect increases in activation levels for the passive as a function of repeated attempts. In Study 2,
repeated experience appeared to provide some benefit to processing the familiar and preferred active transitive form (although as noted above, this experience did not benefit all aspects of production). In Study 2, repetition priming of items across experimental blocks may have attenuated the ability of lexical-syntactic conflicts to disrupt sentence production outcomes. Prime condition effects on the rate of patient-first mentions and RT (analyzed over items) both revealed more reliable effects in Block 1 than Block 2. These interactions suggest that some aspect of repeated experience with the animations – viewing them, accessing the relevant lexical items, and/or producing the active transitive frame – influenced processing dynamics. In Block 2, some of the children’s responses may also have been influenced in uncontrolled ways by explicit memories or expectations of the animations. In future work, the construction of a larger stimulus set would permit a sufficient number of trials while avoiding the need to repeat items, and thus could potentially produce larger or more reliable effects.

5.2.1.4.3 The Role of Awareness or Strategic Processing

One important issue to consider is the question of whether or not awareness of the prime-target relationships could account for the effects that were and were not observed on sentence processing. The current investigation was intended to examine the influence of “background” variations in lexical activation dynamics on sentence production outcomes. The methods were designed to operate outside of the speaker’s awareness, rather than being designed to invoke strategic decisions about whether or not to talk about the primed element. Prior studies of lexical activation effects on adult’ sentence production have documented that these effects did not depend on conscious or strategic processing. Bock (1986a), for example, reported that although many adult participants were aware of the semantic relationships between the primes and targets,
there was no difference in outcome between the aware and unaware participants. Similarly, Gleitman et al. (2007) reported that participants were unaware of the presence of the visual cue that had directed their visual attention to either the agent or the patient in the scene. In the current study, the experimenter asked a series of questions at the end of the session that were designed to explore the participants’ degree of awareness of the presence of relationships between the primes and the animation stimuli. As noted in section 4.2.3.1.1, none of the children in the younger group gave any indication in their responses of noticing these relationships. Their comments during the course of the task also gave no indication that they were consciously focused on or aware of the relationships that were present. Some of the responses of the older children to the post-experiment questions were more challenging to decipher. No children spontaneously reported on a strategy related to the prime pictures or reported on any of the relationships when given relatively open-ended questions (i.e., “How did you know what to say?”; “Did you use any tricks or strategies?”). When pressed further (“You know how it went picture-movie? Did the picture that came before the movie help you decide what to say?”), several children made some attempt at explanation. It was often unclear from children’s spontaneous explanations whether they were attempting to express a relevant strategy that they had consciously followed, or were simply attempting to comply with an evident request for some kind of explanation (e.g., “It was sometimes the same thing”). As noted in section 4.2.3.1.1, only four children were able to recall any of the actual relationships. For all dependent variables, the range for these four children was well within the limits of the difference scores observed for the remaining participants. The fact that so few of the older children were able to identify any of the relationships, coupled with the
fact that there were no differences in prime effects between the younger group and older group, supports the assumption that the overall pattern of outcomes did not reflect explicit processes.

5.2.1.5 Secondary Implication: A Role for Working Memory in Language Production

Although the current study did not reveal a relationship between lexical-syntactic conflicts, lexical buffering, and WM costs, the overall pattern of results nonetheless pointed to potential WM involvement in language production. Children’s overall level of fluency was correlated with their performance on a WM measure. WM and dysfluency both differed by age; however, the correlation between WM and dysfluency remained after controlling for age.

As noted above, given that sentence production involves concurrent processing and maintenance of information, it seems to be an ideal candidate to be subject to or to be accounted for in terms of WM constraints. Despite this fact, however, researchers working within the adult literature have noted on several occasions that the body of research examining the relationship of WM to language production outcomes is surprisingly small (Acheson & MacDonald, 2009; Ferreira & Slevc, 2007; Slevc, 2011). This situation is mirrored in the developmental literature. Although the concept of capacity limits has been well developed in the developmental literature, little research has directly examined the particular relationship of WM mechanisms to language production ability. In a relevant investigation, Blake, Austin, Cannon, and Lisus (1994) examined the relationship of children’s forward word span to their mean length of utterance in morphemes (MLUm) in spontaneous speech. The authors reported that word span was significantly correlated with children’s MLUm. In one experiment, word span together with chronological age predicted MLUm, and in a second experiment, word span was a better predictor than either chronological or mental age. These results applied to children younger than
3;6, whereas for an older group of children (3;6 to 4;11) there was no apparent relationship between word span and MLU. In another relevant investigation, Adams and Gathercole (1995) compared the mean length of utterance in morphemes (MLUm) in spontaneous speech between two groups of 3-year-old children who differed in their phonological memory ability, measured via non-word repetition scores and forward digit span. The children in the high memory group produced longer sentences in their speech samples.

Based on the results of their correlation and regression analyses, Blake et al. (1994) noted two relevant conclusions: First, they argued that complexity in language production is related to memory span. It should be noted that the dependent measure reported by Blake et al. was MLU rather than complexity. Caution should therefore be used in interpreting the results in term of complexity rather than length per se. However, in the study reported by Blake et al., MLU was also strongly correlated with a separate measure of syntactic complexity, suggesting that the MLU measure did also reflect variations in complexity.47 Second, Blake et al. also argued that increased automaticity of production in older children may render memory constraints irrelevant. Blake et al.’s study (and, similarly, Adams & Gathercole, 1995) used forward word span as its memory measure rather than a WM task requiring coordinated storage and processing; however, the results certainly invite further consideration of the role of WM in production. The results of the current study support the contention that memory span and language production outcomes are related. Given that the current study focused on simple transitive sentences, it cannot speak to the role of WM in sentence length/complexity, but does indicate that its role likely also extends to fluency of production. The results of the current study do not support the contention that WM

47 Because of the strong correlation between MLU and syntactic complexity, the analyses with respect to memory were reported for MLU only.
constraints no longer apply for older children. However, the current results cannot rule out the possibility that the relationships between WM constraints and particular aspects of language use (e.g., MLU vs. fluency) might vary with age or development. It is possible that at a certain point in development, sentence length is no longer sensitive to WM constraints, even if other aspects of production are. To my knowledge, further investigations aimed at examining specific relationships between WM and sentence production in children’s early language use have yet to be pursued. These results of the current study invite further research into the nature of this relationship within a wider range of sentence structures and looking at a wider range of variables. Promising directions include addressing which aspects of sentence production implicate WM capacity, and how WM capacity for sentence production changes as a function of age and language-specific experience.

5.2.2 Summary and Conclusions

In sum, the results of this investigation point to a strong influence of syntactic constraints on children’s sentence structure choices, even when lexical activation dynamics likely favour a different course of planning. The processing-based measures support the conclusion that lexical activation dynamics may influence sentence outcomes in other ways. These conflicts produce negative consequences for sentence planning speed. In this way, lexical-syntactic conflicts can act as a form of processing hazard during sentence planning. The current results suggest that lexical-syntactic conflicts do not produce reliable negative effects on auxiliary use or fluency after the onset of production. However, the results also suggest that exploring the effects on auxiliary use remains a promising avenue for future investigation. Within the age range that was investigated in the current study, lexical-syntactic conflicts do not appear to have greater
negative effects for younger children, who are less experienced and more capacity-limited than older speakers.

This investigation addressed a novel question that to date has received little attention in the developmental literature, and the results help to address a noted need for a broader base of knowledge regarding the organization and dynamics of children’s sentence production processing (McKee et al., 2006). The results underscore the view that sentence production is fundamentally a process of activation and coordination, and invite further investigation of whether or how these processes might change with development. The current results further highlight that different aspects of sentence production ability vary with age, consistent with prior expectations, and may be correlated with working memory ability.

The current results do not provide evidence to support the expectation that lexical-syntactic conflicts produce lexical buffering costs to WM capacity. They point to the possibility that the negative consequences of lexical activation dynamics may be absorbed relatively early in the planning process as reflected in speech onset times, and suggest that different challenges might affect fluency and/or auxiliary use after production onset. Directions for future research include further investigation of the effects of lexical-syntactic conflicts on other sentence structure types as well as the productions of particularly vulnerable language users, and a closer examination of the role of WM in language production as well as how capacity changes with age and/or specific language experience.
References


frequency, sentence position, and duration. *Journal of Child Language*, 26(3), 531-543. doi: 10.1017/s030500099900392x


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Available from EBSCOhost psyh database.


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## Appendices

### Appendix A  Animation Stimulus Items and AoA Values in Months for Agents and Patients

<table>
<thead>
<tr>
<th>Item</th>
<th>Agent</th>
<th>Patient</th>
<th>AoA MCDI (Dale &amp; Fenson, 1996)</th>
<th>AoA Morrison et al. (1997)</th>
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<td>--</td>
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<tr>
<td>Kick</td>
<td>Kangaroo</td>
<td>Piano</td>
<td>--</td>
<td>--</td>
</tr>
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|      |       |         |       |         |       |         |
| **M** | 25.3  | 24.9    | 34.3  | 35.1    |
| **SD** | 3.62  | 5.17    | 13.06 | 13.19   |

### 3-Option Scenes

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<td>&gt; 30**</td>
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<td>Break</td>
<td>Crab</td>
<td>Shell</td>
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<td>--</td>
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|      |       |         |       |         |       |         |
| **M** | 25.3  | 25.0    | 39.3  | 34.5    |
| **SD** | 2.81  | 4.4     | 17.3  | 17.6    |

### M across Alternation Types

|      |       |         |       |         |
| **M** | 25.3  | 24.9    | 36.6  | 34.7    |
| **SD** | 3.15  | 4.65    | 14.91 | 15.3    |
Notes:
*Matched based on MCDI. ** The MacArthur-Bates CDI indicates that 70% of children produce the word “nail” at 30 months, the highest age for which data are provided. For the purposes of calculating the mean AoA value, the value for “nail” was set to 30 months.
### Appendix B  Frequency Values and Word Length in Syllables for Agents and Patients

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\[
\begin{align*}
M & = 260.4 & 292.7 & 1.5 & 1.6 \\
SD & = 317.3 & 271.2 & 0.7 & 0.7
\end{align*}
\]

3-Option Scene Items

<table>
<thead>
<tr>
<th>Item</th>
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<th>Patient</th>
<th>Frequency (Zeno et al., 1995)</th>
<th>Word Length (Syllables)</th>
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\[
\begin{align*}
M & = 355.8 & 293.3 & 1.8 & 1.7 \\
SD & = 532.5 & 311.0 & 1.0 & 0.8
\end{align*}
\]

\textit{M across Scene Types}

\[
\begin{align*}
M & = 308.1 & 293.0 & 1.65 & 1.65 \\
SD & = 429.4 & 284.0 & 0.88 & 0.75
\end{align*}
\]
## Appendix C Patient-Related and Control Primes

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<th>Control (Unrelated) Prime</th>
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Notes:
### Appendix D  Evidence for Verbal Association Between Patient Targets and Patient-Related Primes

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<th>Verbal Associate Children?</th>
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<td>Turn</td>
<td>Butterfly</td>
<td>Caterpillar</td>
<td>Categorical, Thematic</td>
<td>1 Backwards, Weak</td>
<td>4 Backwards</td>
</tr>
<tr>
<td>Stretch</td>
<td>Frog</td>
<td>Pond</td>
<td>Thematic</td>
<td>--</td>
<td>4 Backwards</td>
</tr>
<tr>
<td>Shake</td>
<td>Scarecrow</td>
<td>Corn</td>
<td>Thematic</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bounce</td>
<td>Ball</td>
<td>Bat</td>
<td>Categorical, Thematic</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>Roll</td>
<td>Apple</td>
<td>Pie</td>
<td>Thematic</td>
<td>--</td>
<td>3 Backwards, 4</td>
</tr>
<tr>
<td>Bend</td>
<td>Nail</td>
<td>Hammer</td>
<td>Thematic</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>Close</td>
<td>Window</td>
<td>House</td>
<td>Thematic</td>
<td>1 (weak)</td>
<td>4</td>
</tr>
<tr>
<td>Cook</td>
<td>Hamburger</td>
<td>French fries</td>
<td>Categorical, Thematic</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Break</td>
<td>Shell</td>
<td>Snail</td>
<td>Thematic</td>
<td>--</td>
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Notes:
# Appendix E  List of Working Memory Task Stimuli

<table>
<thead>
<tr>
<th>Item</th>
<th>AoA</th>
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</thead>
<tbody>
<tr>
<td><strong>Small items (“Fits in the box”)</strong></td>
<td></td>
</tr>
<tr>
<td>Mouse</td>
<td>27</td>
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<tr>
<td>Bee</td>
<td>26</td>
</tr>
<tr>
<td>Ant</td>
<td>30</td>
</tr>
<tr>
<td>Leaf</td>
<td>25</td>
</tr>
<tr>
<td>Grape</td>
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<td>Egg</td>
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<td>Watch</td>
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<td>Sock</td>
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<td>Tooth</td>
<td>25</td>
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<td>Cup</td>
<td>22</td>
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<tr>
<td>Soap</td>
<td>27</td>
</tr>
<tr>
<td>Fork</td>
<td>25</td>
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<td>Key</td>
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<table>
<thead>
<tr>
<th>Item</th>
<th>AoA</th>
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<tbody>
<tr>
<td><strong>Large items (“Doesn’t fit in the box”)</strong></td>
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<tr>
<td>Cow</td>
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<td>Dog</td>
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<td>Pig</td>
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<tr>
<td>Tree</td>
<td>23</td>
</tr>
<tr>
<td>Pie</td>
<td>--</td>
</tr>
<tr>
<td>Cake</td>
<td>25</td>
</tr>
<tr>
<td>Coat</td>
<td>27</td>
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<tr>
<td>Boot</td>
<td>27</td>
</tr>
<tr>
<td>Leg</td>
<td>26</td>
</tr>
<tr>
<td>Fridge</td>
<td>29</td>
</tr>
<tr>
<td>Sink</td>
<td>29</td>
</tr>
<tr>
<td>Bed</td>
<td>23</td>
</tr>
<tr>
<td>Broom</td>
<td>27</td>
</tr>
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</table>