THE IMPACT OF WORD-BASED AND SITUATION-BASED KNOWLEDGE ON READING SPEED IN ADULTS AND CHILDREN: A SELF-PACED MOVING WINDOW STUDY

by

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This work is dedicated to my beautiful children, Boden, Grayson, Dalton, and Logan. They each bring me joy and fulfillment in ways I never knew possible. Also, to my husband, Terrell, who has stood by me and encouraged me throughout each step of this journey.

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The purpose of this study was to examine the manner in which word-based knowledge and situation-based knowledge affect reading speed in typically developing (TD) 3rd grade children and adults. Research has demonstrated that both word-based and broader situation-based information are critical for optimal text comprehension, but their relative contributions to reading speeds in children and adults is unknown. In the current study, a sample of 36 adults and 36 children from the greater Katy, Texas area silently read sentences using self-paced moving window computer software. Sentences were constructed such that half had main clauses containing agent:action pairs with a relatively high probability of co-occurrence (e.g., . . .*the bird flew from the nest*) and half had relatively improbable agent:action pairs (e.g., . . .*the bird fell from the nest*). In addition, main clauses with improbable relationship were preceded by either a dependent clause containing situation-based information that was expected to make the

improbable agent:action relationship more likely (e.g., *After hurting its wings…*), or a neutral dependent clause containing situation-based information that was not expected to affect the improbable relationship (e.g., *After flapping its wings…*). Three research hypotheses were tested: 1) Adult and child reading times will be faster for probable than for improbable agent:action relationships when preceded by a neutral dependent clause; 2) Adult and child reading times for improbable agent:action relationships will be faster when preceded by a biasing dependent clause than when preceded by a neutral dependent clause, and 3) The situation-based knowledge in the biasing dependent clause will have a relatively greater impact on adults than on children. Results supported the first hypothesis, showing that both adult and child readers were sensitive to the probability of word-based agent:action relationships. By contrast, situation-based information did not significantly affect reading times for improbable agent:action relationships at either age, and there was no significant interaction between age and condition. The current study is the first to use a moving window display to examine the relative effects of these factors on reading speed of adults and children as they process connected text. This study is also the first to carefully control for both syntactic and semantic characteristics, which have mostly been independently manipulated for investigation in prior studies.

TABLE OF CONTENTS

ABSTRACT vii

ACKNOWLEDGMENTS v

LIST OF FIGURES xi

LIST OF TABLES xii

CHAPTER 1 INTRODUCTION AND LITERATURE REVIEW 1

1.1 Purpose of the study 1

1.2 Factors linked to reading comprehension 4

1.2.1 Word-based knowledge 4

1.2.2 Situation-based knowledge 10

1.3 Effects of word- and situation-based knowledge on reading time 13

1.4 Self-paced moving window reading tasks 17

1.5 Significance of the study 18

1.6 Hypotheses 21

CHAPTER 2 METHODS 24

2.1 Participants 24

2.2 Procedures 25

2.3 Materials 30

2.3.1 Stimuli 30

2.3.2 Equipment 34

2.4 Experimental design 34

CHAPTER 3 RESULTS AND DISCUSSION 38

3.1 Descriptive statistics 38

3.2 Main effects and interaction 39

3.3 Post-hoc tests 41

3.4 Additional analyses 44

3.5 General discussion 47

3.6 Conclusion 55

APPENDIX A Adult and child intake forms 57

APPENDIX B Stimulus construction and piloting 59

APPENDIX C Sentence distribution to condition 68

APPENDIX D Test Versions A, B, and C 72

APPENDIX E Calculation of cumulative RT (in ms) for analyses 81

APPENDIX F Adult and child mean RT (in ms) by condition 82

REFERENCES 86

VITA 95

LIST OF FIGURES

Figure 1 ANOVA graph of adult and child RT 41

Figure 2 Mean (*SD*) RT (in ms) by condition and group 44

Figure B1 Comparison of *d*-values for RT 67

LIST OF TABLES

Table 1 Participant characteristics 25

Table 2 Screening test results for individual child participants 26

Table 3 Example of sentence allocation to test version 32

Table 4 Composition of test versions 33

Table 5 Mean (*SD*) RT (in ms) by condition and group 38

Table 6 ANOVA table of adult and child RT 40

Table 7 Post-hoc comparisons of mean RT between conditions 43

Table 8 Word-adjusted clause duration (in ms) for dependent and main clauses 46

Table B1 Example of word-pair piloting 64

Table B2 Example of sentence piloting 65

Table B3 Repeated measures ANOVA of RT 66

Table C1 Sentence distribution to condition 68

Table D1 Test Version A 72

Table D2 Test Version B 75

Table D3 Test Version C 78

Table E1 Calculation of cumulative RT (in ms) for analyses 81

Table F1 Adult mean RT (in ms) by condition 82

Table F2 Child mean RT (in ms) by condition 84

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

"The problem facing a comprehender is analogous to the problem that a detective faces when trying to solve a crime. In both cases there is a set of clues."

-David E. Rumelhart, (1991)

1.1 Purpose of the study

Knowledge about words, and knowledge about the world, are among the clues that a reader can use in attempting to understand a written text. Word-based, or lexical, knowledge and world-based, or situational, knowledge are believed to play distinct, yet complementary roles in successful comprehension of connected text (e.g., Keenan, Potts, Golding, & Jennings, 1990; Matsuki, Chow, Hare, Elman, Scheepers, & McRae, 2011). Word-based effects can be seen in priming studies, where visually or auditorily processing a word can facilitate the processing of subsequent words to which it is linked semantically, phonologically, or orthographically (Betjemann & Keenan, 2008; Bonnotte & Casalis, 2010; Campion & Rossi, 2001; Holderbaum & Fumagalli de Salles, 2011; Joordens & Becker, 1997; Meyer & Schvaneveldt, 1971; Wang, Dong, Ren, & Yang, 2009). Effects of such priming have been found not only when the related words are presented in succession but also when they occur in separate clauses or sentences (e.g., Calvo, Meseguer, & Carreiras, 2001; Vainio, Hyönä, & Pajunen, 2009). Priming effects have been observed for a number of semantic relationships between words, including category

membership and shared function. Of particular interest for the present investigation, we examine roles in predicate-argument structures such as the link between an action verb and its subject or agentive noun. Specifically, reading times for both adults and children are faster for sentences in which the relationship between verbs and subjects are highly predictable (e.g., *The cat meowed*) than for sentences in which these relationships are relatively unexpected (e.g., *The cat sneezed*; see Calvo et al., 2001; Joseph, Liversedge, Blythe, White, Gathercole, & Rayner, 2008; Vainio et al., 2009).

World-based, situational knowledge also facilitates text comprehension as a reader uses knowledge about the situation described in the text to draw inferences that go beyond the information that is stated explicitly (e.g., Calvo et al., 2001; Matsuki et al., 2011; Vu, Kellas, Peterson, & Metcalf, 2003). In Kintsch's construction integration model (1988, 1991), for example, comprehension of most connected texts requires the reader to construct a meaningful representation that goes beyond the individual words. According to Kintsch, skilled comprehenders develop a dynamic situational model of a text by continually integrating information presented in the text with their prior knowledge, a process that depends on the reader's knowledge of the situations described in the text as well as his or her working memory capacity and ability to flexibly and rapidly update the situational model in response to the incoming text.

Both word-based and situation-based knowledge have been shown to significantly influence the speed with which adults read connected texts (e.g., DeLong, Urbach, & Kutas, 2005; Matsuki et al., 2011; Schustack, Ehrlich, & Rayner, 1987; Vainio et al., 2009), but much less is known about their concurrent impact on children's reading. In children, word-based

effects have been reported from tasks involving the reading of single-word primes with either strong or weak semantic associations to their single-word targets, provided that the interval between prime and target is sufficiently long (e.g., Holderbaum & Fumafalli de Salles, 2011; Nievas & Justicia, 2004). Third grade children can integrate some situation-based cues to make inferences during a reading task (Pike, Barnes, & Barron, 2010). However, no study has yet addressed the simultaneous effects of both sources of knowledge on reading speed in children.

Prior investigations into the relative effects of word- and situation-based cues on reading times of connected text have indicated the importance of considering these factors in tandem as any reading task will present both sources of information concomitantly, with effective readers utilizing each factor simultaneously. Currently, it is unclear whether children as compared to adults are affected to a similar degree by each factor as they read connected text. Specifically, adults are able to rapidly integrate situation-based information as they read, thus affecting their early semantic processing at the word level (e.g., Kuperberg, Paczynski, & Ditman, 2011). Yet it remains largely unknown whether, and to what degree, children's incremental processing of words is also influenced by situation-based information.

The purpose of the present study was to quantify the impact of word-based knowledge and situation-based knowledge on reading speed in adults and children. By investigating the contributions of each factor on reading times, we may move closer to understanding how typically developing (TD) children in the third grade use both sources of information in processing written text, and the extent to which their manner of doing so mirrors that of adults. Results from this study may further contribute to a broader understanding of the factors that contribute to reading comprehension deficits. Children with reading comprehension difficulties

appear to struggle with making connections and predictions as they read (e.g., Cain, Oakhill, Barnes, & Bryant, 2001), but it is unknown whether such deficits reflect difficulties in word-based knowledge, shortfalls in situation-based knowledge, or a disability in integrating both sources of information while reading. Examining the impact of these two types of cues in TD children as they read connected texts may offer a starting point for studies of their impact on reading comprehension in readers with disabilities. In what follows is an overview of factors that have been shown to influence reading comprehension.

1.2 Factors linked to reading comprehension

A variety of factors have been linked to reading comprehension, including age, content/domain knowledge, inferencing skills, working memory, vocabulary, and strategy use (e.g., Cain, Oakhill, & Bryant, 2004; Cantrell, Almasi, Carter, Rintamaa, & Madden, 2010; Gregory & Cahill, 2010; McNamara, 2001; Ouellette, 2006). For the present study, the two variables of interest are those reported by Keenan et al. (1990) to serve as a gateway to inference activation: word-based knowledge and situation-based knowledge. Because both sources of information are available to readers concurrently, their effects on comprehension often are confounded, and care must be taken when interpreting results of studies that do not directly address and control for their independent impact. Investigations in which these two factors are individually measured are reviewed below.

1.2.1 Word-based knowledge

Word-based knowledge is a broad construct that encompasses knowledge of the meanings of individual words and knowledge of the semantic and structural relationships between words. Vocabulary knowledge can be conceptualized in terms of breadth, expressed as

the number of entries in the lexicon, and depth, which includes how much knowledge one has of a given word, including the word's pronunciation and spelling, morphological and syntactic properties, and knowledge of how and when to use that word (e.g., Hatami & Tavakoli, 2012; van Kleeck, 2008). Ouellette (2006) investigated the impact of vocabulary knowledge on the reading comprehension skills of 9- and 10-year-old children and reported that vocabulary breadth predicted word decoding skills while vocabulary depth predicted comprehension.

Rupley and Nichols (2005) distinguished between definitional knowledge and contextual knowledge of words. Definitional knowledge of a word involves understanding its conceptual meaning, such as would be found in a dictionary. A reader may have adequate definitional knowledge of the individual words he or she is reading, but fail to comprehend the text as a whole if he or she is unable to make connections between the words that co-occur in the text. Contextual knowledge of a word, by contrast, is specific to the word's meaning as gleaned from clues in the text in which the word is embedded. In this way, contextual knowledge of words may be likened to inferencing in that one must use surrounding information within the passage to gain a fuller understanding of the text. It is therefore not surprising that adults (e.g., Calvo, 2005) and children (e.g., Cain, Oakhill, & Lemmon, 2004; Jenkins, Stein, & Wysocki, 1894; Rupley & Nichols, 2005) who have strong vocabulary skills are more likely to be proficient inference-makers and comprehenders than age-matched readers with poor vocabulary knowledge.

Specific word-based factors such as word frequency, length in letters, imageability, neighborhood density and frequency, and semantic connectivity (i.e., synonyms) have been shown to affect readers' visual word recognition speed and accuracy (e.g., Balota, Cortese,

Sergent-Marshall, Spieler, & Yap, 2004; Grainger & Segui, 1990; Perea & Carreiras, 1998). However, beyond a knowledge of individual entries within one's lexicon, word-based knowledge is further comprised of understanding relationships between words. These relationships have been inferred from objective measures, such as co-occurrence rates for words in texts and corpora (e.g., McNamara, 1992a), as well as from subjective ratings of lexical association strength and semantic relatedness, based on semantic feature overlap or semantic field relationships (e.g., color words), category relationships (e.g., *puppy: dog; tulip: flower*), part to whole relationships (e.g., *finger: hand; class: school*), and source to product relationships (e.g., *bakery: cookies; storm: rain*). Relationships among words based on predicate: argument structures and roles (e.g., agent: action - *chef: cook; dog: bark*) have also been examined and are of particular interest for the current study. Several investigations have manipulated lexical association strength and semantic relatedness independently to determine their relative effects on children's recognition speed in lexical decision tasks (e.g., Nation & Snowling, 1999) and reading speed in word naming tasks (e.g., Bonnotte & Casalis, 2010; Plaut & Booth, 2000). This point will be expanded below.

One method commonly used to investigate how various forms of word-based knowledge affect processing speed is the priming task. Such tasks, first explored by Meyer and Schvaneveldt (1971), can vary from orally reading target words (a naming task) to distinguishing real words from non-words (a lexical decision task). The mode of stimulus presentation can further vary to include visual or auditory input. In a typical priming task, participants are first presented with a single word (the *prime*) followed by a second word (the *target*) to determine whether reaction time for the target is affected by the prime's phonological, morphological,

orthographic, or semantic features (e.g., Campion & Rossi, 2001; Holderbaum & Fumafalli de Salles, 2011; Nevias & Justicia, 2004; Wang et al., 2009). Priming effects appear to reflect both pre- and post-lexical activation (e.g., Ratcliff & McKoon, 1988), with pre-lexical activation of the prime facilitating access to the target and post-lexical priming contributing to the reader's completion of the task involved (e.g., naming, lexical decision, etc.).

Developmental differences have been reported in several direct studies of priming. Typically, priming effects are weaker in younger than in older readers (e.g., Plaut & Booth, 2000) but such differences also could reflect reading ability, as priming effects are generally weaker in poor readers than in age-matched good readers (Bonnotte & Casalis, 2010). Qualitative differences in lexical processing of word-based features by third grade children and adults have also been reported. Specifically, children in the third grade appear to show less inhibition than adults during lexical decision tasks (Plaut & Booth, 2000), and they demonstrate larger priming effects than adults when the time between a stimulus and its target word was over 250 ms (Holderbaum & Fumagalli de Salles, 2011). Stanovich's (1980) interactive compensatory model is one potential account for these age-related differences: because proficient and experienced readers can decode rapidly they are less likely to rely on slower, more strategic processes as they read.

Various theories have been posited to account for word-based priming effects including spreading activation, compound-use, and distributed networks (e.g., Anderson, 1983; Becker, Moscovitch, Behrmann, & Joordens, 1997; Masson, 1995; McNamara, 1992b, 1994; Moss, Hare, Day, & Tyler, 1994; Sharkey & Sharkey, 1992). These models provide an important foundation for the current study as they suggest that when nodes, or words, are tightly connected,

the activation of one node will facilitate the processing of a related node. Because words that are closely related (*bird: fly*) tend to co-occur, when one of them is encountered (*bird*), activation spreads to related words, resulting in faster reading times for probable (*fly*) than improbable (*fall*) words. Similarly, a number of on-line reading studies have examined how readers process information that is semantically congruent or incongruent with previously read text (e.g., Clifton & Staub, 2008; Daneman, Lennertz, & Hannon, 2007; Joseph, et al., 2008). In this literature, lexical predictability, that is, the degree to which the semantic features of one word constrain the identity of a subsequent word, has been shown to influence reading speed, allowing highly predictable target words to be processed more quickly than less predictable words (e.g., Calvo, et al., 2001; Vainio et al. 2009).

A key distinction in spreading activation theories involves automatic versus strategic processes (e.g., Gold et al., 2006; Ratcliff & McKoon, 1988). Processes designated as automatic are thought to produce rapid effects in language processing, whereas strategic processes involve slower and qualitatively different cognitive and linguistic mechanisms. Word- and situation-based knowledge encode distinct sources of information for readers (e.g., Bornkessel & Schlesewsky, 2006), and some investigators (Coulson, King, & Kutas, 1998; Gibson, 1998) have postulated that most word-based features are processed relatively automatically whereas broader sentential information, such as making inferences and predictions from surrounding text and situation-based knowledge, is activated in a slower, more controlled manner. Evidence on this point is unclear, however, as findings from some studies have suggested that some word-based structures are activated in a slow, rule-based way (Paap & Noel, 1991) and others have reported

that readers activate situation-based knowledge immediately for text comprehension (e.g., DeLong et al., 2005).

As mentioned earlier, the degree to which semantic relationships between words affect a reader's speed and accuracy during priming tasks has been of particular interest in several lines of research. For example, Nation and Snowling (1999) conducted a semantic priming study contrasting function versus category relationships as well as the associated strength of word pairs. They found that children identified as good comprehenders exhibited semantic priming for both function (*broom: floor*) and category (*cat: dog*) pairs in the associated and non-associated conditions. Word pairs in the associated category shared semantic information (i.e., they belonged to the same category of animals, food, furniture, etc.), and had a relatively high degree of lexical co-occurrence. Conversely, word pairs in the non-associated category may have shared semantic features, but were not considered to be associated as they were not given in word association norms. Nation and Snowling found that children classified as poor comprehenders demonstrated priming effects commensurate with their TD peers for function pairs, but priming for category pairs was only present when the words were also highly associated. The authors noted that these results were in line with earlier findings from Moss, Ostrin, Tyler, and Marslen-Wilson (1995) showing that functional relationships rather than categorical relationships yielded broader priming effects in children, perhaps because words related by function might have greater associative strength than words related by categorical membership.

Nation and Snowling's finding that priming of functional relationships is demonstrated across children with a range of comprehension skills is further supported by the syntagmatic-

paradigmatic shift that has been observed to occur in children's word association responses. A syntagmatic response to a word (e.g., *dog*) consists of a word with which it frequently co-occurs in a sequence (e.g., *bark*). By contrast, paradigmatic associations are based on category membership (*dog: cat*), and can include synonyms and antonyms. This syntagmatic-to-paradigmatic shift reportedly occurs between the ages of six and seven (Cronin, 2002; Ervin, 1961), the approximate age of school entry. Numerous word-association studies have indicated that prior to this age, children are more likely to provide syntagmatic responses to word association tasks than children older than six to seven years, whose responses are more likely to reflect paradigmatic relationships (e.g., Corsale & Ornstein, 1980; Nelson, 1977; Sheng, McGregor, & Marian, 2006). As these relationships appear to be familiar to children, the predicate-argument structure of agent:action relationships was specifically chosen for use in the current study.

1.2.2 Situation-based knowledge

Situation-based knowledge is a broad construct that has been referred to in terms such as event knowledge (Matsuki et al., 2011), event schemas (Rumelhart, 1975), and contextual knowledge (Woolley, 2010). Each of these terms represents the idea that readers combine information in text with their own experiences to make predictions, draw conclusions, and form opinions about what is read. In the construction integration model proposed by Kintsch (1988), readers construct mental models to extend their understanding beyond individual words in a text, and a reader's situation-based knowledge can greatly affect his or her ability to generate a mental model that can guide the inferences necessary for optimal comprehension. For example, a reader who has no experience with shoes that fasten with laces rather than with Velcro may not

understand a text describing a girl who steps on her shoelace and cuts her knee, because the reader is unable to infer that the girl tripped. According to Kintsch, a reader may begin to build a mental model for a text before reading it, based on the title or illustrations that accompany it. As the text is read, this mental model must be modified in light of each new piece of information encountered in the text. The model will then be expanded, adjusted, or completely revised as the reader incorporates what is read with his or her prior knowledge and beliefs about the situation described in the text, as well as with his or her experiences with similar circumstances (Zwaan & Rapp, 2006). In this view, full understanding of a text requires word-based knowledge and situation-based knowledge, as well as working memory skills adequate to integrate information as it is encountered in processing the text. Although it has been argued that readers do not always construct or use mental models when reading, these cases appear to be limited to specific types of surface reading, such as proofreading (e.g., Singer & Halldorson, 1996).

Many studies have shown that the ability to integrate situation-based knowledge plays an important role in successful text comprehension (e.g., Hannon & Daneman, 2001; Kendeou & van den Broek, 2007; Lipson, 1982; Milosky, 1990; Potts & Peterson, 1985). This strong relationship has led some researchers to target prior knowledge in an effort to facilitate reading comprehension (e.g., Carr & Thompson, 1996; Hansen & Pearson, 1983). However, it is extremely difficult, if not impossible, to measure and control for differences in readers' prior knowledge and experiences, and because these vary from person to person it is possible that no two readers of a text will derive identical interpretations (Zwaan & Rapp, 2006). Accordingly, care must be taken to minimize the potential impact of individual differences in prior knowledge when investigating reading comprehension.

Research has shown that adult readers rapidly access situation-based knowledge and mental scripts when reading connected texts (i.e., Matsuki et al., 2011; Vu et al., 2003), which facilitates reading speed and comprehension. Additional research demonstrates facilitated reading speeds when adult readers are able to generate predictions about a text by making connections to their own knowledge (e.g., Calvo et al., 2001; Cozijn, Noordman, & Vonk, 2011). For example, Kuperberg et al. (2011) conducted an ERP investigation in which the strength of a situational model was manipulated to determine the effect on university students' abilities to draw inferences during reading. Subjects were presented with scenarios consisting of three sentences. These sentences were presented in one of three conditions: highly related (in which a target word in the final sentence was highly causally related in meaning to words in the preceding sentences), intermediately related (in which a target word in the final sentence was only causally related to the first sentence, requiring the reader to make a more complex inference from the second to the third sentence), and causally unrelated (in which the first two sentences make the third sentence unlikely to occur). Examples of these three conditions are: Highly related - *Jill had very fair skin. She forgot to put sunscreen on. She had sunburn on Monday.* Intermediately related - *Jill had very fair skin. She usually remembered to wear sunscreen. She had sunburn on Monday.* Causally unrelated - *Jill's skin always tanned well. She always put on sunscreen. She had sunburn on Monday.*

Mean N400 amplitude values (325-475 ms after the onset of a critical word) were significantly larger when the critical word was causally unrelated to the preceding context than when it was highly causally related ($p<0.01$ for midline, medial, lateral, and peripheral columns). This suggested that when related information was available in the first two sentences, readers

were able to construct a mental framework from which they could make an inference to the critical word in the third sentence. However, mean amplitude values indicated that critical words were more difficult to process in the causally unrelated condition because there was not enough information to make an inference connecting the first two sentences to the critical word. From these findings the authors concluded that adults use information from situation-based cues, in addition to word-based knowledge, to make inferential connections as they read.

1.3 Effects of word- and situation-based knowledge on reading time

Typical readers' understanding of words, as well as the knowledge and experiences with situations and events, appear to generate expectations about what they will encounter next in a text. Both word-based and situation-based knowledge can be gained through direct personal experience and through indirect experiences such as hearing or reading about the word or situation (e.g., Milosky, 1990). Although both of these sources of information are available to readers at any level of text, only a handful of studies have attempted to address the relative influence of each on reading times of connected text, and of these studies, none have involved children. A line of eye tracking research of particular interest to the current study investigated the effects of word- and situation-based knowledge on reading speed of semantically predictable and non-predictable target words in connected text (Calvo et al., 1996, 2001, & 2005). Of most relevance to the current investigation, the 2001 study presented *introductory* and *continuation* sentence pairs that manipulated word- and situation-based information to investigate their effects on adults' reading times of target words in continuation sentences. The introductory sentence contained one of two types of information: that which prepared the reader to make an inference about the target word (the *inducing* sentence) or that which was neutral toward the target word

(the *non-inducing* sentence). The second sentence (the *continuation* sentence) contained an inferential target word that was either predictable or non-predictable based on semantic features that related to words in the introductory sentence. Reading times (measured in ms) of predictable target words were contrasted against those of non-predictable target words.

It was found that when an inducing sentence primed an inference, second-pass reading times of the target words were facilitated when the target words were predictable as compared to non-predictable (d=0.42, p<0.05), with more regressions within the sentence when readers encountered non-predictable target words (d=0.46, p<0.05). Additionally, reading times of continuation sentences were faster when the target words were expected, but only for words after the target word, not on the target word itself. The authors concluded that "predictive inferences are higher level processes which involve representation of a situational model (prediction of events) rather than lexical or semantic association (prediction of words)" (p. 160). The authors' findings support the minimalist hypothesis (McKoon & Ratcliff, 1992, 1995) and constructionist theory (Graesser, Singer, & Trabasso, 1994), which assume that predictive inferences are not constructed immediately, but that they require post-lexical processing after one has finished reading a given text.

Matsuki et al. (2011) likewise investigated the contribution of situation-based knowledge, described in their study as event knowledge, on reading times of sentences by university students while controlling for lexical effects in a moving window design, where words are presented one at a time. Pairs of sentences with instrument-verb-patient triplets were rated as typical (e.g. *hose-wash-car*) or atypical (e.g. *hose-wash-hair*). The first of three experiments in their study demonstrated that target patient nouns in the typical condition (i.e., *car*) were read faster than

atypical target patient nouns (i.e., *hair*) when readers encountered these words in a self-paced moving window paradigm. A lexical decision task was then used to demonstrate that the outcomes in their first experiment were not directly attributable to the semantic associations between the instrument and patient word pairs. Analyses revealed that first fixation duration and gaze duration to the patient noun were affected by its typicality, suggesting that adult readers access event knowledge immediately in processing connected texts.

Outcomes from the Matsuki et al. (2011) study contrast with earlier findings showing delayed effects of event knowledge when readers encounter likely and unlikely instrument-verb-patient arrangements (Rayner, Warren, Juhasz, & Liversedge, 2004; Warren & McConnell, 2007). These discrepancies, however, might reflect methodological differences among these studies. Specifically, moving-window tasks allow only one word to be read at a time; readers cannot go back to re-read words. Such regressions appear to occur naturally in reading (see Karatekin, 2007; Liversedge & Findlay, 2000; Rayner, 1998; and Starr & Rayner, 2001 for reviews), but they cannot be examined in most moving-window tasks. Conversely, although eye tracking can reveal areas of a text where readers pause, regress, and skip forward, these movements are not necessarily indicative of a reader's difficulty in processing specific words. In short, although moving window tasks do not allow for natural reading movements, they enable precise measurement of first-pass reading times for specific words and/or portions of sentences, making them well suited for identifying points of slowed processing during on-line reading.

In addition to these methodological differences, variations in stimuli construction might also have contributed to discrepant findings in previous studies. For example, in the Matsuki et al. (2011) study, the sentences for the typical instrument-verb-patient triplet of *joystick-control-*

game were: *John used a joystick to control the brand-new game that he bought yesterday. He had to stop using the regular controller because of the blisters on both his thumbs*. For the atypical triplet of *joystick-control-television*, the sentences were: *John used a joystick to control the brand-new television that he bought yesterday. He is a heavy gamer, and likes to control everything with his joystick.* This lack of lexical and syntactic consistency might have contributed to differences in reading speed across conditions.

Similarly, Calvo et al. (2001) did not fully control for syntactic characteristics within the inducing and non-inducing sentences that preceded predictable versus non-predictable words. For example, for one comparison the inducing sentence was: *Three days before the examination the pupil went to the library, looked for a separate table and opened his notebook*. and the non-inducing sentence was: *The pupil, who was a little tired after finishing his examination, forgot his notebook and left it on a table in the library*. Again, variations in reading times between conditions might simply have been due to syntactic differences between the inducing and non-inducing sentences.

When addressing effects of situation-based information on reading times of target words, it is similarly important to account for specific word-based associations between target words of interest and information preceding them in the situation-based context. This factor was not well controlled in the study by Kuperberg et al. (2011) that was described previously, as some words in the target sentence did have strong semantic ties to words in earlier sentences. For example, one highly causally related sentence set was: *Jill had very fair skin. She forgot to put sunscreen on. She had a bad sunburn on Monday.* While the target word *sunburn* was considered highly causally related to the described situation, it was also semantically associated to *sunscreen*. The

authors were clear that they accounted for semantic similarity among the three conditions, that is, there was no significant difference in semantic similarity values among the conditions; however, it appears that they did not thoroughly address the possible effect of semantic associations between words within a sentence set. It is therefore difficult to determine whether reading time of the target word *sunburn* was facilitated due to expectations generated by the situation-based information or by its additional semantic association to the word *sunscreen*.

1.4 Self-paced moving window reading tasks

Much research has focused on reading speed as a measure of reading comprehension, using measures including rapid automatic naming (or rapid serial naming) tasks, moving window reading tasks, and more recent on-line measures such as eye-tracking. Reading speed is generally accepted as an accurate representation of reading skill as it is strongly related to reading achievement in school-age children (e.g., Cutting & Scarborough, 2006; Kirby, Parrila, & Pfeiffer, 2003; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997).

Self-paced moving window reading tasks have been used to measure certain on-line processes that are not adequately captured by traditional pencil and paper methods. This technique, developed by McConkie and Rayner (1975), has been used to investigate myriad aspects of perceptual span in word- and sentence-level processing in adults (see Rayner, 1998 for review), and, to a lesser degree, in children (e.g., Booth, MacWhinney, & Harasaki, 2000; Rayner 1986). Traditional self-paced moving window tasks are controlled by the reader via key-press or through a gaze-contingent method, such as with the use of an eye tracker. In a keyboard-based moving window task, sentences are presented on the computer screen as a series of dashes or Xs, where each dash or X represents a letter in a word. The reader presses a

computer key to reveal one word at a time, with the previous word transforming back to dashes or Xs once the key is pressed to move forward to the next word. In this way, researchers are able to examine how the initial presentation of lexical information at the beginning of a sentence affects the processing of forthcoming text based on a reader's anticipation of encountering that information. The use of a self-paced moving window method was important for the current study because it provides a way to examine how readers process and integrate word- and situation-based knowledge when they know they will not be allowed to re-read a text. Preventing re-readings enables precise measurement of word-by-word reading times, making it possible to quantify how readers adjust and accommodate their mental models after encountering word-based and situation-based information.

1.5 Significance of the study

Research has indicated that on-line reading comprehension is heavily influenced by both word-based lexical features and situation-based information from the broader sentential context and knowledge about events in the world (i.e., DeLong et al., 2005; Smith & Levy, 2013). Studies involving adults demonstrate both an expert use of their lexical knowledge (e.g., Campion & Rossi, 2001; Holderbaum & Fumagalli de Salles, 2011; Nevias & Justicia, 2004) as well as rapid access to their event knowledge or mental scripts about a given situation (i.e., Matsuki et al., 2011; Vu et al., 2003) to facilitate reading comprehension and speed. Likewise, evidence from priming studies suggests that children's reading speed and comprehension may be influenced by word-based as well as situation-based knowledge (e.g., Pike et al., 2010; Wang et al., 2009; Wehner, Ahlfors, & Mody, 2007). However, no evidence is available concerning the degree to which word- and situation-based knowledge independently affect reading speed for

connected text, and whether these effects differ as a function of age. Developmental differences are of particular interest for children in third grade, the approximate period in which a shift from *learning to read* to *reading to learn* has been argued to occur (Harlaar, Dale, & Plomin, 2007). In many states, including Texas, third grade is a pivotal stage for reading comprehension, being the first time at which children attending public school are subject to state testing of skills such as reading comprehension, text-integration, and inferencing (Texas Education Agency, TEA, 2009, 2011). Results of such testing may have substantive impacts, not only on academic monitoring of students but also on state funding and teacher compensation.

The specific groups of adults and third grade children were chosen as earlier studies have demonstrated qualitative differences in processing speed during word-based priming tasks (e.g., Holderbaum & Fumagalli de Salles, 2011; Plaut & Booth, 2000). It also has been reported that third grade children are capable of using situation-based information to generate some inferences as they read (e.g., Pike et al, 2010). Third grade appears to be a critical age for identifying the relative impact of word- and situation-based information on reading comprehension, as children who exhibit poor reading comprehension at the end of third grade are likely to continue to struggle academically as they age (Juel, 1988). Standardized examinations provide educators with useful information regarding whether a child has needs in the areas of vocabulary and/or reading comprehension, but it would be helpful to pinpoint whether difficulties involve deficits in word-based knowledge, situation-based knowledge, or both.

The current study was designed to separate the effects of word- and situation-based information on reading times for short texts carefully controlled for linguistic variables such as semantic and syntactic characteristics. Further, the study intended to address whether any

interaction was present as a function of age, specifically with respect to the integration of situation-based knowledge. To examine the impact of word-based knowledge, participants read sentences in which the relationship between an agentive subject and an action verb in the main clause was relatively probable (e.g., *the bird flew from the nest*) or relatively improbable (e.g., *the bird fell from the nest*). To examine the impact of situation-based knowledge, main clauses with improbable relationships were preceded by either a "biasing" dependent clause intended to increase the probability of the improbable agent: action relationship (e.g., *After hurting its wings, the bird fell from the nest*) or by a "neutral" dependent clause that was not expected to affect its probability (e.g., *After flapping its wings, the bird fell from the nest*). When the preceding dependent clause is neutral, word-based activation should result in faster reading times for probable than improbable main clauses. When the dependent clause biases toward the improbable relationship, however, the activation of situation-based knowledge should alter the reader's mental model to make the improbable relationship more likely, resulting in relatively faster reading times for improbable main clauses in the biasing than in the neutral condition. The presence of an interaction would signify the degree to which adult and child readers were differently affected by their use of word- and situation-based knowledge.

Materials were presented through a moving-window technique to more precisely capture word-by-word processing. This was accomplished by expanding on portions of the frameworks presented in the ERP study by Kuperberg et al. (2011), the moving window study by Matsuki et al. (2011), and the eye tracking studies by Calvo et al. (1996, 2001). We manipulated the strength of word-based relationships that may affect reading speed separately from situation-based context, something that was only partially accounted for by Kuperberg et al. We

controlled the similarity of lexical structure of sentences between conditions, a consideration not fully implemented in the Matsuki et al. (2011) or Calvo et al. (1996, 2001) experiments. We also extended the framework of Calvo et al. (2001) by specifically examining the effects of biasing situation-based information on reading times of improbable agent:action relationships. Finally, we compared the relative effects of word-based and situation-based knowledge on reading speed in adults and children in an effort to better understand how children use word- and situation-based knowledge in reading connected texts, and to determine whether they do so in a manner similar to adults.

1.6 Hypotheses

The current study was designed to quantify the impact of word- and situation-based knowledge on adult and third grade children's reading times (RT) of connected text in the form of sentences consisting of a dependent clause followed by a main clause. To examine the effect of word-based knowledge on RT, the agent:action relationship in each main clause was designated as *probable* or *improbable.* To examine the impact of situation-based knowledge on RT, preceding dependent clauses were either *biasing* (i.e., expected to make the improbable relationship more likely), or *neutral* (i.e., expected to have no impact on the improbable relationship).

Reading times, in ms, were collected for each word in the sentences as readers encountered them. Analyses were conducted using cumulative RTs for a specific *word set* within the main clauses. Reading times for these word sets began when the reader pressed the spacebar to reveal the verb and ended when the reader read the final word in the sentence and pressed the spacebar to move on to the next screen. Reading times were compared across the

three conditions of interest: (a) Neutral Probable, where probable agent:ation relationships are preceded by a neutral clause; (b) Neutral Improbable, where improbable agent:action relationships are preceded by a neutral clause; and (c) Biasing Improbable, where improbable agent:action relationships are preceded by a biasing clause. A Biasing Probable condition was excluded as the semantic nature of these sentences was deemed odd, and any comparison of RT to this condition would not enhance the central focus of the study.

The decision to use a summed RT measure for analyses was motivated by three sources. First, conflicting findings have been noted throughout prior studies on the immediate or delayed effects of situation-based knowledge when adults read connected text, with some noting immediate effects (e.g., Matsuki et al., 2011), while others report effects occurring through the end of a sentence (e.g., Rayner et al., 2004; Warren & McConnell, 2007). Second, because previous research has suggested that adult readers use word- and situation-based information to generate predictions and inferences as they read, it was thought that RTs of target verbs may not be facilitated on the verb, but rather *after* the verb has been processed, as has been reported in prior investigations (i.e., Calvo et al., 2001; Daneman et al., 2007). Finally, results from a pilot investigation for the current study found that once adult readers processed a target verb, the cumulative RT of all words following the target verbs were significantly affected.

The specific aims and hypotheses were designed to contribute to the current knowledge base regarding how the integration of word- and situation-based knowledge affect adult and child reading speed. Specifically, this study intended to measure the degree to which child readers use these sources of knowledge in a manner that is similar to adults as they read connected text. There were three specific aims regarding RT in main clauses:

Aim 1: To quantify the impact of word-based knowledge on RT of main clauses presented in the neutral condition.

Hypothesis: Main clauses with probable agent:action relationships will be read faster than main clauses with improbable relationships when they are preceded by the neutral dependent clause.

Aim 2: To quantify the impact of situation-based information on RT of main clauses containing improbable agent:action relationships.

Hypothesis: Main clauses with improbable relationships will be read faster in the biasing condition than in the neutral condition.

Aim 3: To quantify the impact of situation-based knowledge on RT of main clauses with improbable agent:action relationships as a function of age.

Hypothesis: The impact of biasing situation-based knowledge will be relatively greater in adults than in children when processing improbable relationships.

CHAPTER 2

METHODS

2.1 Participants

This study included 36 adults and 36 third grade children (Table 1). Adults and children were recruited in the greater Katy, Texas area through fliers, emails, face-to-face conversations, and through preexisting connections. Inclusionary criteria were determined by self-reported measures, with adults self-reporting, and parents reporting on behalf of their children. To be considered for inclusion, all participants were to meet age requirements, be monolingual English speakers with typical language development, and have normal or corrected to normal vision. Adult participants, and parents of child participants, completed an intake form prior to testing that gathered information regarding ethnicity, race, other languages spoken, and highest level of education completed (Appendix A). Participants were excluded if they were bilingual or had a history of dyslexia, epilepsy, autism, hearing impairment, language impairment, or any neurological disorder. Children's language, reading, and working memory skills were also screened using standardized measures to validate parent report of typical functioning in these areas. Prior to testing, adult participants, child participants, and children's parents signed informed consent forms, all of which were approved by The University of Texas at Dallas Institutional Review Board.

Table 1

Participant Characteristics

Characteristic	Adult (n=36)	Children (n=36)
Age	41 years (*SD*=15)	8.8 years (*SD*=0.5)
% female	86%	50%
% Caucasian	94%	94%
% College Graduate	94%	---

2.2 Procedures

Location. All participants were tested individually. Locations varied and were dependent on the schedule and travel restrictions of the participant. All adult participants were tested either in a quiet office at their place of employment, in a quiet room at their place of residence, or in a reserved room within the Katy Branch public library. Children were tested in a quiet room within the library, or in a quiet room at their place of residence. The duration of testing sessions was approximately 20 minutes for adults, and approximately 50 minutes for children (approximately 20 minutes for testing and 30 minutes for screening).

Screening. Screening procedures for children were conducted individually by a trained examiner immediately following the testing procedure in order to reduce the potential for fatigue or boredom during the testing. During screening, all child participants completed portions of three brief standardized assessments measuring receptive language skills, reading proficiency, and working memory. Children were to be excluded if they scored beyond 1.5 *SD* below the mean of the standardized measures; however, all children scored within or above the average

range of functioning. Mean scores and standard deviations for these measures are reported in Table 2.

Table 2

Screening Test Results for Individual Child Participants

ID	Age	Receptive Vocabulary[a]	Digit Span[b]	Reading Fluency[c]
C-1	9	107	13	38
C-2	8.5	101	13	38
C-3	8.11	135	7	42
C-4	8.11	118	8	39
C-5	8.6	133	12	44
C-6	9.2	127	10	38
C-7	9.3	125	7	42
C-8	9.2	117	11	42
C-9	8.11	133	9	40
C-10	9.4	126	12	34
C-11	8.8	132	10	41
C-12	9.4	116	10	39
C-13	8.11	121	9	27
C-14	8.7	114	11	37
C-15	8.3	101	9	41
C-16	9.5	127	11	36
C-17	8.11	122	14	28
C-18	8.8	129	14	41
C-19	8.7	116	13	31
C-20	8.9	121	7	39
C-21	9.1	115	10	39
C-22	8.8	119	9	40
C-23	9.0	120	13	41
C-24	9.2	131	12	39
C-25	8.11	117	6	42
C-26	9	101	9	39
C-27	8.9	127	12	39

(continued)

Table 2 (continued)

Screening Test Results for Individual Child Participants

ID	Age	Receptive Vocabulary[a]	Digit Span[b]	Reading Fluency[c]
C-28	9	116	12	37
C-29	8.11	145	9	36
C-30	9.3	118	15	39
C-31	9.1	123	13	43
C-32	8.7	107	8	36
C-32	8.7	107	8	36
C-33	8.11	119	11	34
C-34	8.8	129	13	39
C-35	8.7	130	8	42
C-36	9.3	120	9	42
Sample Mean	8.84	121.06	10.02	38.44
Sample *SD*	0.496	9.937	3.198	3.850
Sample Range	8.7, 9.5	101, 145	6, 15	27, 44

[a] Standard score (*M*=100, *SD*=15), Receptive One-Word Picture Vocabulary Test 4 (Bronwell, 2010). [b] Standard score (*M*=10, *SD*=3), Digit Span subtest, Wechsler Intelligence Scale for Children 4 (Wechsler, 2003). [c] Total raw score (of 45 possible points), from Stories 3-5, Gray Oral Reading Test 4 (Wiederholt & Bryant, 2001)

Instructions and training. Once consent was obtained, all adult and child participants were instructed and trained on how to complete the online reading task. Participants were positioned in front of the examiner's laptop computer which presented them with written instructions for the task. Adults were allowed to read the instructions on their own, however, the examiner read the instructions aloud for all child participants to ensure uniformity with directives. The instructions were as follows:

Welcome. In this experiment, you'll be reading some sentences on the computer screen. You will first see a row of dashes like this:

These dashes are covering letters of words in the sentence. When you press the space bar, dashes will transform into letters so that the first word will appear. With every press of the space bar, a new word will appear and the last word will become dashes again. You should try to read as naturally as possible, making sure that you understand what you read.

When you finish reading the last word in the sentence, press the space bar again. The dashes will go away and you will see a Yes/No question about the sentence you just read. To answer the question, press the "F" key for YES or the "J" key for NO. You will be reminded which key is yes and which is no. Try to answer as quickly and accurately as possible.

If you are unsure of the answer (or if you think that both answers are right), try to pick the better answer.

Participants were then instructed to press a key to progress to the next screen containing a review of the instructions.

Just to review, this is how the experiment goes:

1. Some dashes will appear on the screen and you must press the space bar to see each new word of the sentence.

2. Read at a natural rate, making sure you understand what you read.

3. You'll see a Yes/No question about the sentence and should answer by pressing the "F" key for YES or the "J" key for NO. You will be told if your answer was incorrect. You should take this as an indication to read more slowly and carefully.

4. After the question is answered, the computer will automatically go on to the next sentence.

When the experiment is over, a screen will appear telling you to stop. At that point, you should let the experimenter know you are finished.

If you have any questions about the procedure, ask the experimenter now. We will begin with some training sentences.

Once the instructions were completed, participants were prompted to read six training sentences to become familiar with a moving window technique. An example of a sentence from the task follows:

---------- [reader-controlled key press]

The---------- [key press]

----bird---------- [key press]

---------fell---------- [key press]

----------from---------- [key press]

----------the------ [key press]

----------nest. [key press moved reader to screen with comprehension question]

Upon completion of the training, participants were prompted about whether they had any additional questions and whether they felt comfortable with the procedures. They were informed that once testing began they would not be able to take a break until the completion of the task.

Once it was clear to the examiner that a participant was familiar with manipulating the task independently, the testing began.

Testing. The testing phase was conducted prior to child screening, and typically did not exceed 20-25 minutes in length. Participants pressed the spacebar to reveal each word as they silently read each sentence. After the sentence ended, it was replaced on the screen by a Yes/No comprehension questions that was directly related to the sentence. Progression through the sentences was self-paced, determined by the reader's key press, and there was no maximum time limit for testing.

2.3 Materials

2.3.1 Stimuli

A set of 96 target sentences were created and validated for the study over a series of pilot investigations detailed in Appendix B. Briefly, adult ratings were gathered and used for two main purposes: 1) to select agent:action pairs that were considered relatively probable or improbable, and 2) to determine whether biasing clauses increased the likelihood of adults selecting improbable agent:action pairs. In the first round of piloting, adults rated word pairs as not related, neutral, or very related. Findings from this task led to the development of 40 pairs of probable and improbable agent:action relationships.

The second pilot investigation involved a sentence completion task where adults were presented with either a neutral or biasing dependent clause, followed by two main clauses: one with a probable agent:action relationship and one with an improbable agent:action relationship. Adults were asked to select the main clause that fit best with the dependent clause. All main clauses were constructed so that the probable and improbable verbs could be interchanged while

maintaining the structure of the clause as much as possible (e.g., the bird *flew* from the nest; the bird *fell* from the nest). All main clauses followed the sequence of Article+ Noun+ Verb+ {Prepositional Phrase/ Noun Phrase/ Adverbial Phrase}, ranging in length from 5-8 words (M=6.06, SD=0.79). Outcomes from this round of piloting led to the pairing of dependent and main clauses, resulting in the final 32 target sentences used for the current investigation.

Word- and situation-based information in these sentences were manipulated to fit the three conditions of interest: Neutral Probable, Neutral Improbable, and Biasing Improbable. Appendix C demonstrates how these sentences were constructed. Each target sentence only appeared in one condition per test version. Thus, there were three equal blocks of 32 sentences per test version (A, B, and C), for a total of 96 sentences. Six additional sentences were used in training, and ten filler sentences also appeared across all test versions. Training and filler sentences were carefully designed so as not to duplicate any noun or verb from a target sentence.

An equal number of participants, 12 from each age group, were randomly assigned to one of three test versions. Within each test version, the sentence condition order (Neutral Probable, Neutral Improbable, and Biasing Improbable) was pseudo-randomized such that no sentence condition occurred more than two times in succession. The ten filler sentences were distributed so that at least two, but not more than four target sentences were presented between the fillers. Target sentence order was identical across all three test versions in an effort to minimize potential confounding due to order effects. That is, each test version began with the same target sentence presented in one of the three conditions. In this way, no subject received the same target sentence in more than one condition. Table 3 provides an example of sentence allocation.

Table 3

Example of Sentence Allocation to Test Version

Test Version A		Test Version B		Test Version C	
After flapping its wings, the bird flew from the nest	NP	After hurting its wings, the bird fell from the nest	BI	After flapping its wings, the bird fell from the nest	NI
When the boy grabbed some bread, the duck wiggled in the stream	NI	When the boy grabbed some bread, the duck quacked in the stream	NP	When the boy grabbed its tail, the duck wiggled in the stream	BI
After looking at the stranger, the baby cried for his mama	NP	After looking at his hands, the baby clapped for his mama	BI	After looking at the stranger, the baby clapped for his mama	NI
After kicking the soccer ball, the boy scored a goal	F	After kicking the soccer ball, the boy scored a goal	F	After kicking the soccer ball, the boy scored a goal	F

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler.

The final consideration for constructing the three test versions was the distribution of sentences from each condition across test version. With 32 sentences in each condition to be allocated into three test versions, it was not possible to equally distribute the sentences among the three versions. Therefore, there were an unequal number of sentence conditions within each test version, but an equal number of total sentences across each test version. As an example, the 32 sentences in the Neutral Probable condition were randomly assigned to test versions A, B, C, A, B, C, A, B, C, etc., designating 11 Neutral Probable sentences to test Version A, 11 Neutral Probable sentences to Version B, and 10 Neutral Probable sentences to Version C. Sentences in the Neutral Improbable and Biasing Improbable conditions were assigned to each test version in

a similar manner. Table 4 demonstrates how the tests were constructed. The final test versions contained 42 sentences consisting of 32 target sentences and 10 filler sentences.

All sentences, including fillers, were followed by a Yes/No comprehension question. These questions were constructed so as to directly relate to explicitly stated information in the most recently read sentence. Questions tapped surface knowledge of what was read, as they were not intended to stress the participants' mental resources. These questions were designed only to maintain attention and to assure that readers were focused on the task. The order of Yes/No answers was pseudo-randomized so that no Yes or No answer appeared more than four times in a row. For each of the 42 answers, 21 were Yes's and 21 were No's. Although not controlled, 66% of questions pertained to information in dependent clauses, and 34% of questions pertained to information in main clauses. All three test versions with target sentences, filler sentences, and Yes/No comprehension questions and answers are shown in Appendix D.

Table 4

Composition of Test Versions

Version	Neutral Probable	Neutral Improbable	Biasing Improbable
A	11	11	10
B	11	10	11
C	10	11	11

2.3.2 Equipment

All instructions, training, and testing stimuli were presented on a Hewlett Packard Pavilion dv6 laptop computer, with a screen size of 15.5 inches. The software utilized for the study was Linger (http://tedlab.mit.edu/~dr/Linger/, Rohde, 2001), a program available online that uses a self-paced moving window technique to measure reading speeds for sequences of words presented in succession. All stimuli were presented on the computer in black text against a white screen, in size 12 Microsoft Times New Roman font.

Reaction time measure. Reading times, in ms, were collected within the program for each word within the target sentences. This time stamp began at the moment the reader pressed the space bar to reveal a word, to the moment the space bar was pressed again to move on to the next word. Output from Linger was filed on the computer by randomly coded participant number, and consisted of two columns of data: individual words and each word's time stamp in ms. These data were exported from Linger through Microsoft WordPad, and placed into an Excel file for ease of use in further analyses. The RT measure used for statistical analyses consisted of the summed RT for the sequence of words within the main clause that began with the keypress that revealed the verb, and ended with the keypress after the last word in the sentence (see Appendix E for example). These RTs were averaged for each participant for sentences in each condition (Appendix F).

2.4 Experimental design

The current study employed a self-paced moving window technique to examine the impact of word- and situation-based knowledge on RT of connected text in adults and children. The study used a partially repeated 2 x 3 ANOVA, consisting of a between-factor of age (*adults*

and *third graders*) and a within-factor of the three conditions of interest: *Neutral Probable*, *Neutral Improbable*, and *Biasing Improbable*. The three specific aims tested were: 1) to examine the impact of word-based knowledge on reading times, 2) to examine the impact of situation-based knowledge on reading times, and 3) to determine whether an interaction was present between age and situation-based knowledge.

Main Effects. The variables analyzed were age and condition. A main effect of age was expected to be present. Specifically, it was predicted that adults would yield faster RT than children in all conditions due to greater experience and automaticity. The second anticipated main effect was that of condition, with word- and situation-based knowledge expected to have an effect on RT of connected text in both children and adults. The strength with which words are connected within one's mental lexicon may be influenced by multiple exposures to the same sequence of agent: action words (*cat: meow*), allowing the activation of one word to facilitate the activation of another due to their high probability of co-occurrence (e.g., Ratcliff & McKoon, 1988). For this reason, relatively high frequency co-occurring agent: action associates were chosen for the current study using words with an early age of acquisition and high familiarity. Further, dependent clauses with neutral or biasing situation-based information were constructed, also using words with an early age of acquisition and high familiarity, as adults and children were expected to use this information to generate mental models as they read (e.g., Kintsch, 1988).

Interaction of condition and age. Of most interest was the anticipated interaction between condition and age. This effect was critical for determining whether adults and third grade children were affected to a similar degree by situation-based knowledge as they read. We

expected that, as compared to children, adults would be able to identify relative situation-based information in a preceding clause, hold that information in working memory, integrate it with their prior knowledge, and make rapid predictions about word-based relationships, resulting in relatively faster reading times of improbable relationships in the biasing condition. While we still anticipated a simple main effect of situation-based knowledge for children, we postulated that they were to be less affected than adults by biasing information in a preceding clause. Accordingly, children's RT of improbable relationships were not expected to be facilitated to the same degree as adults' RT in the biasing condition.

Dependent variable. The dependent measure of interest involved the cumulative RT of words within main clauses containing probable and improbable agent:action relationships.

Independent Variables. The effects of three independent variables on RT were addressed. The first variable of interest was word-based knowledge, contrasting the RTs of probable and improbable main clauses when they were preceded by neutral dependent clauses. The second variable addressed situation-based knowledge, measuring RTs of improbable relationships when they were preceded by dependent clauses designed either to be neutral to, or biased toward, the improbable verb. The final variable was age, contrasting the RTs of improbable relationships in the biasing condition between TD third grade children and adults.

Statistical approach. The final sample size of 36 participants per group was determined based on a pilot study of 10 adults that is described in Appendix B. Effect sizes (*d*-values for repeated measures designs; see Cohen, 1988; Rosenthal, 1991; Lakens, 2013) for comparisons of the three conditions ranged from 0.63 to 2.19; a minimum effect size of 0.50 was selected in designing the present study. With experiment-wise alpha set at 0.05, statistical power at 0.80,

and an effect size of 0.5, a minimum sample size of 36 subjects per age group was required (Aberson, 2010; Cohen, 1988).

Outliers and missing data. With 36 subjects per age group each providing 32 RT data points, a total of 1,152 data points was available per age group. Prior to analyses, data were analyzed individually by participant to determine if outliers were present. For a data point to be considered an outlier, its RT must have fallen outside 3 *SD* of that participant's mean RT. There were no outlying data points in either adult or child data.

There were no missing data points in the adult data, but there were four missing data points in the child data, in which children pressed keys that bypassed the target sentence and went directly to the comprehension question. As a result, two children lacked RT data for one sentence, and one child lacked RT data for two sentences. Data that were collected from these children were kept as the missing data only accounted for 0.3% of the total data. Thus, all available child data were included for analyses.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Descriptive statistics

The central aim of this study was to determine the degree to which adult and TD third grade children's RTs of connected text were affected by word-based and situation-based knowledge. To accomplish this, participants read neutral and biasing situation-based information in dependent adverbial clauses that were followed by main clauses containing probable and improbable word-based relationships. Reading times of each word set in main clauses were collected, in ms, as participants encountered agent:action relationships presented in three conditions: Neutral Probable, Neutral Improbable, and Biasing Improbable. Thirty-six adult participants and 36 child participants were randomly assigned to one of three test versions (A, B, and C) so that each test version was given to 12 participants from each age group.

Table 5

Mean (SD) RT (in ms) by Condition and Group

Condition	Neutral Probable	Neutral Improbable	Biasing Improbable
Group			
Adults	2676 (*750*)	2812 (*750*)	2865 (*843*)
Children	3157 (*942*)	3265 (*954*)	3308 (*1013*)

Table 5 presents means and *SD* of adult and child RT in each condition. In both adults and children, the fastest mean RT was in the Neutral Probable condition, followed by the Neutral Improbable condition and finally the Biasing Improbable condition.

3.2 Main effects and interaction

The primary analysis of interest involved a repeated measures ANOVA to address the effects of age and condition on RT, and to determine whether any interaction between these independent variables was present. Findings from the ANOVA showed a significant main effect of age, $F(1,35)=5.36$, $p=0.027$, demonstrating that adult readers processed connected texts more rapidly than children. A significant main effect of condition was also present, $F(2,70)=11.41$, $p<0.001$, suggesting that readers processed sentences differently depending on the constraints of word- and situation-based knowledge. Table 6 presents these ANOVA results, and Figure 1 contains a graph displaying the estimated marginal means.

A main interest of the current study involved whether there was an interaction of age and condition on RT. Specifically, it was hypothesized that adults would be more sensitive to biasing situation-based information than children. We expected that adult RT of main clauses containing improbable relationships would be facilitated in the biasing condition as compared to the neutral condition to a greater degree than child RT in those conditions; however, as the ANOVA output in Table 6 shows, there was a nonsignificant interaction between age and condition, $F(2,70)=0.138$, $p=0.87$.

Table 6

ANOVA Table of Adult and Child RT

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
age	Sphericity Assumed	11391218.72	1	11391218.7	5.358	.027	.133
	Greenhouse-Geisser	11391218.72	1.000	11391218.7	5.358	.027	.133
	Huynh-Feldt	11391218.72	1.000	11391218.7	5.358	.027	.133
	Lower-bound	11391218.72	1.000	11391218.7	5.358	.027	.133
Error(age)	Sphericity Assumed	74406914.06	35	2125911.83			
	Greenhouse-Geisser	74406914.06	35.000	2125911.83			
	Huynh-Feldt	74406914.06	35.000	2125911.83			
	Lower-bound	74406914.06	35.000	2125911.83			
condition	Sphericity Assumed	1103463.617	2	551731.809	11.141	.000	.241
	Greenhouse-Geisser	1103463.617	1.921	574494.452	11.141	.000	.241
	Huynh-Feldt	1103463.617	2.000	551731.809	11.141	.000	.241
	Lower-bound	1103463.617	1.000	1103463.61	11.141	.002	.241
Error (condition)	Sphericity Assumed	3466717.389	70	49524.534			
	Greenhouse-Geisser	3466717.389	67.226	51567.754			
	Huynh-Feldt	3466717.389	70.000	49524.534			
	Lower-bound	3466717.389	35.000	99049.068			
age * condition	Sphericity Assumed	13255.898	2	6627.949	.138	.871	.004
	Greenhouse-Geisser	13255.898	1.749	7577.630	.138	.844	.004
	Huynh-Feldt	13255.898	1.834	7228.483	.138	.854	.004
	Lower-bound	13255.898	1.000	13255.898	.138	.712	.004
Error (age* condition)	Sphericity Assumed	3350557.235	70	47865.103			
	Greenhouse-Geisser	3350557.235	61.227	54723.425			
	Huynh-Feldt	3350557.235	64.184	52201.982			
	Lower-bound	3350557.235	35.000	95730.207			

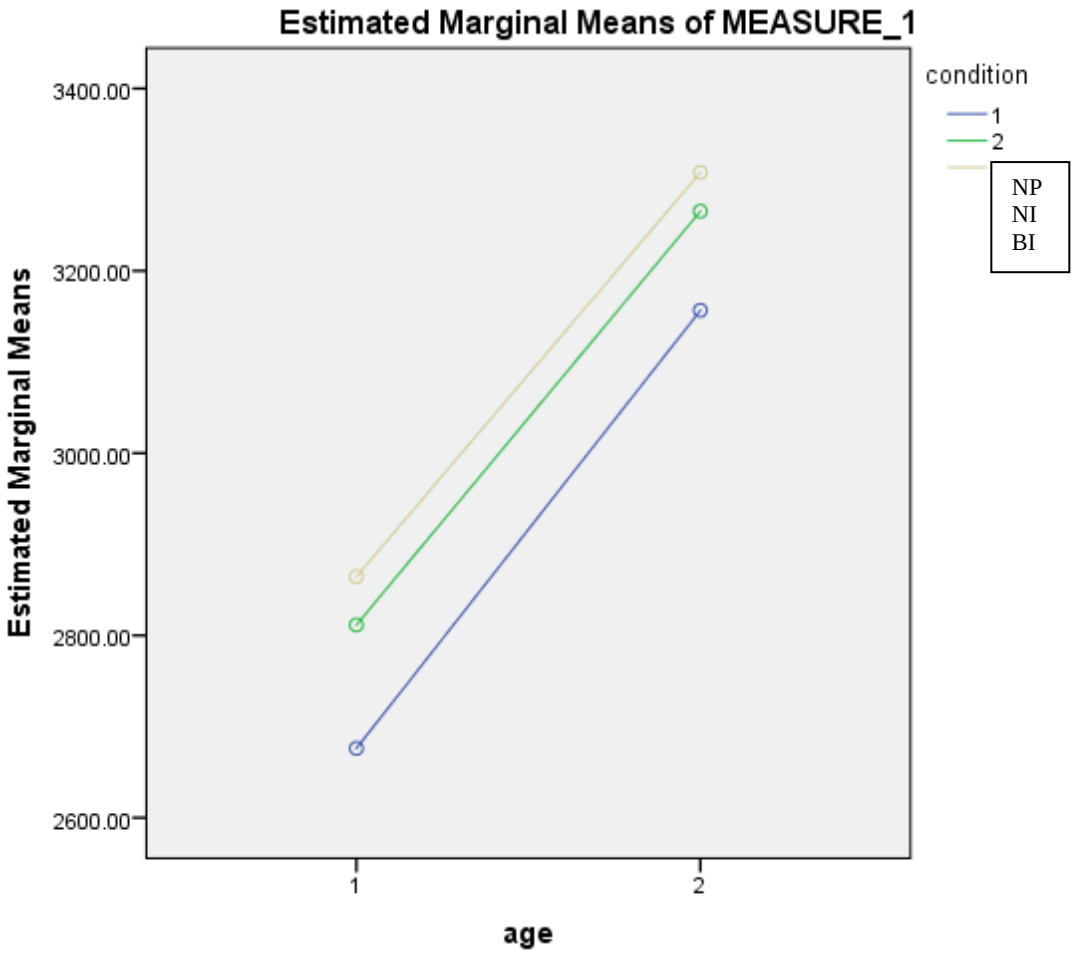

Figure 1. ANOVA Graph of Adult and Child RT

3.3 Post-hoc tests

Because the ANOVA yielded a significant effect of condition, two post hoc dependent t-tests were conducted on RTs for each age group to determine whether word- or situation-based information drove the main effect of condition. The first t-test accounted for word-based knowledge, comparing RTs between the Neutral Probable: Neutral Improbable conditions. The

second t-test determined the effect of situation-based knowledge by addressing RTs between the Neutral Improbable: Biasing Improbable conditions.

A Bonferroni correction was used to determine the alpha level of 0.025 for each of the four post-hoc comparisons: Neutral Probable: Neutral Improbable, and Neutral Improbable: Biasing Improbable, in the adult group and in the child group. With a *p* value at 0.025, an effect size of 0.5, and a sample size of 36 per group, statistical power was calculated at 0.99 using GPower software (http://www.softpedia.com/get/Science-CAD/G-Power.shtml; see Buchner, Erdfelder, Faul, & Lang, 2007).

Table 7 summarizes the results of the post-hoc tests. In adults, a dependent t-test revealed a statistically significant difference in the Neutral Probable: Neutral Improbable comparison (t=3.94, p=0.0004; d=0.66), showing that in the presence of a neutral dependent clause, word-based knowledge, specifically the probability of the agent:action relationship in the main clause, affected adult RTs. By contrast, there was no significant difference between adult RTs in the Neutral Improbable and Biasing Improbable conditions (t=0.91, p=0.37; d=0.15), revealing no effect of situation-based knowledge. Adult readers processed main clauses with improbable relationships similarly irrespective of whether they had encountered a neutral or biasing dependent clause, suggesting that adult RTs in the current study were not affected by situation-based knowledge.

Mirroring the findings in the adult data, dependent t-tests using child RT data revealed a statistically significant difference in the Neutral Probable: Neutral Improbable comparison (t=2.02, p=0.025, d=0.34), but not in the Neutral Improbable: Biasing Improbable comparison (t=0.86, p=0.19; d=0.14). These findings reveal that TD third grade readers, like adults, are

sensitive to word-based knowledge as they read connected texts. However, also like adults, they were not affected by situation-based knowledge predicated on information in a preceding dependent clause. Figure 2 displays these data, which also demonstrate that adult RTs are facilitated to a greater degree than child RTs across all conditions.

As these t-tests demonstrated, readers from both age groups used word-based knowledge during the task, but neither group appeared to incorporate situation-based knowledge. It is interesting to compare the effect sizes (ES) observed in the two groups. As mentioned previously, d-values were calculated using Cohen's (1988) formula for repeated measures designs, $d=t/n\text{^}2$, where *t* represents the dependent *t*-value and *n* is the sample size (Cohen, 1988; Rosenthal, 1991; Lakens, 2013). It is generally considered that a d-value of 0.2 represents a small effect, 0.5 a medium effect, and 0.8 a large, although it is recognized that these cutoffs are arbitrary and should be interpreted carefully (Cohen, 1988).

Table 7

Post-hoc Comparisons of Mean RT between Conditions

Comparison	NP	NI	t[a]	p	d[b]	95% CI
Adults	2676 (*750*)	2812 (*750*)	3.94	0.0004	0.66	[0.29, 1.01]
Children	3157 (*942*)	3265 (*954*)	2.02	0.025	0.34	[-0.002, 0.67]
Comparison	NI	BI	t[a]	p	d[b]	95% CI
Adults	2812 (*750*)	2865 (*843*)	0.91	0.37	0.15	[-0.18, 0.48]
Children	3265 (*954*)	3308 (*1013*)	0.86	0.19	0.14	[-0.19, 0.47]

Note. NP=Neutral Probable; NI=Neutral Improbable; BI=Biasing Improbable; CI=Confidence interval
[a]Dependent t-test. [b]Cohen's d-value.

	Neutral Probable (NP)	Neutral Improbable (NI)	Biasing Improbable (BI)
Adult	2676 (*750*)	2812 (*750*)	2865 (*843*)
Child	3157 (*942*)	3265 (*954*)	3308 (*1013*)

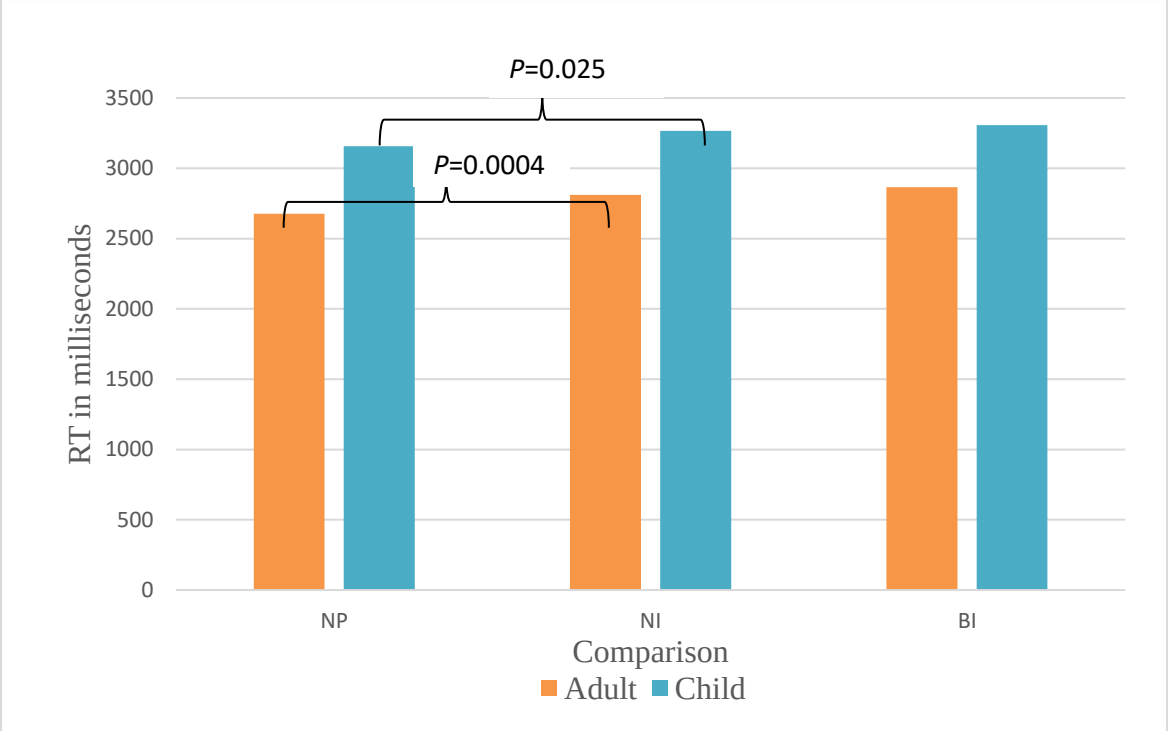

Figure 2. Mean (SD) RT (in ms) by Condition and Group. *Note*. p-values only reported for statistically significant pairwise comparisons within groups

Based on the Neutral Probable: Neutral Improbable comparison, word-based knowledge had a larger effect on adults (d=0.66) than on children (d=0.34). However, effect sizes for the Neutral Improbable: Biasing Improbable comparison were almost identical (d=0.15 and d=0.14, respectively), suggesting that the impact of situation-based knowledge was minimal at either age.

3.4 Additional analyses

The unexpected lack of a situation-based knowledge effect in either group motivated additional analyses of potential confounds. As mentioned previously, some work suggests that readers are not always affected by situation-based knowledge while reading, particularly in "surface-level" tasks such as proofreading (Singer & Halldorson, 1996). Comprehension questions were included in the present study in order to facilitate processing of sentence content, and as noted above, the information needed to answer correctly sometimes occurred in dependent clauses and sometimes in main clauses. However, because sentences in the present study had highly similar syntactic structures and began with dependent clauses that may or may not have appeared relevant to the main clause, it was possible that readers might have focused more on main clauses as a source of pertinent information for answering the comprehension questions. This could have led participants to engage in a more surface-level reading of dependent clauses in which situation-based knowledge was not activated. To address this possibility, we asked whether there was a systematic difference in the speed with which dependent and main clauses were read. Specifically, evidence that readers spent relatively less time reading dependent than main clauses might suggest that they were "skimming" through dependent clauses in a manner akin to proofreading, reducing the integration of situation-based knowledge.

A direct comparison of RTs for dependent and main clauses was not possible because of their different lengths: dependent clauses ranged in length from 3-7 words (M=5.0, SD=1.11), and the range for main clauses was 5-8 words (M=6.06, SD=0.79). In an effort to control for this difference, the cumulative duration of the interval between the first and final words in each clause was divided by the number of words in that clause prior to comparing mean durations of

this interval within each age group and condition. For example, given the sentence *After flapping its wings, the bird flew from the nest,* the cumulative duration of *After flapping its wings* was divided by the number of words in that clause (four), and compared to the cumulative duration of *the bird flew from the nest* (divided by six), yielding a word-adjusted clause duration for each sentence.

As shown in Table 8, adults read dependent clauses significantly faster than main clauses in all three sentence conditions. By contrast, no significant differences were found in children, who neither sped up nor slowed down their reading speed as they encountered the two clauses.

Table 8

Word-adjusted clause duration (in ms) for dependent and main clauses

Adult Condition	DC	MC	t[a]	p	d[b]	95% CI
Neutral Probable	570 (*77*)	637 (*66*)	4.27	0.0001	1.23	[0.34, 1.07]
Neutral Improbable	603 (*66*)	659 (*63*)	6.78	0.0001	1.96	[0.71, 1.54]
Biasing Improbable	613 (*76*)	668 (*72*)	3.95	0.0004	1.14	[0.29, 1.02]
% Total questions correct	97 (*6*)	93 (*12*)				
Child Condition	DC	MC	t[a]	p	d[b]	95% CI
Neutral Probable	796 (*123*)	774 (*73*)	1.17	0.25	0.34	[-0.14, 0.52]
Neutral Improbable	784 (*111*)	806 (*99*)	0.96	0.35	0.28	[-0.17, 0.49]
Biasing Improbable	796 (*100*)	804 (*79*)	0.35	0.6	0.15	[-0.27, 0.38]
% Total questions correct	87 (*17*)	91 (*12*)				

Note. DC=Dependent clause; MC=Main clause; CI=Confidence interval
[a]Dependent t-test. [b]Cohen's d-value.

Table 8 also suggests that comprehension questions were answered with high accuracy by adults and children regardless of whether the questions tapped into information from dependent or main clauses. Accordingly, the lack of a situation-based knowledge effect does not appear to reflect a failure to process information in the dependent clauses.

3.5 General discussion

The current study is the first to manipulate word-based relationships in conjunction with biasing situation-based context in connected text to examine their relative effects on adult and children's RT during a moving window task. Previous studies investigating the effects of word-based knowledge on reaction time have done so primarily in priming tasks using word pairs, not broader text-based tasks (e.g., Holderbaum & Fumafalli de Salles, 2011; Nievas & Justicia, 2004). Investigations analyzing the effects of situation-based knowledge on RT have centered mainly on adults, and have not fully controlled for semantic associations and syntactic consistency (e.g., Calvo et al., 2001; Cozijn et al., 2011; Matsuki et al., 2011; Vu et al., 2003). The current investigation extends the frameworks from this prior research in four aspects: 1) by allowing word- and situation-based information to be independently controlled to quantify the relative effects of each on RT, 2) by employing separate groups of adults and children to account for an effect of age, 3) by embedding word-based relationships and situation-based context in connected text to examine how these factors affect RT beyond the single word level, and 4) by using a moving window task to capture participant-controlled word reading times for well-defined intervals of text.

Effect of word-based knowledge. In the current study, RTs were faster for main clauses containing probable versus improbable agent:action relationships in adults and children, with

larger effects in adults than in children. This finding suggests that both groups were sensitive to word-based relationships rooted in the specific predicate-argument structure of agent:action relationships. These results not only affirm previous findings from studies investigating the role of word-based knowledge on adults' RT for connected text (e.g., Calvo et al., 2001; Vainio et al., 2009), but extend them to younger readers by demonstrating that typically developing third graders are also sensitive to the effects of word-based knowledge during a reading task.

Prior research has noted a robust tendency of school-age children to provide syntagmatic responses (i.e., dog: bark) during single-word association tasks (Corsale & Ornstein, 1980; Nation & Snowling, 1999; Nelson, 1977; Sheng et al., 2006). In addition, priming studies have shown children to be sensitive to word-based knowledge in lexical priming tasks involving the reading of single words (e.g., Bonnette & Casalis, 2010; Plaut & Booth, 2000). However, the current study is the first to demonstrate that the effects of word-based knowledge in the form of agent: action relationships can be detected in reading of connected texts by typically developing children as early as third grade. The word-based effects observed in the present study are consistent with predictions from the spreading activation and compound-use theories concerning the processing of individual words (e.g., Anderson, 1983; Becker et al., 1997; Masson, 1995; McNamara, 1992b, 1994; Moss et al., 1994; Sharkey & Sharkey, 1992), and also words embedded in connected text (e.g., Clifton & Staub, 2008; Daneman et al., 2007; Joseph, et al., 2008).

Effect of situation-based knowledge. For this sample of adult and child participants, there was no significant effect of situation-based knowledge on RTs. Although additional analyses yielded evidence that adults read dependent clauses significantly faster than main clauses, their

high accuracy in answering comprehension questions related to dependent clauses did not suggest that they were "skimming" or failing to activate a mental model that incorporated situation-based knowledge. While child readers did not demonstrate significant differences in their RT of dependent and main clauses, they also answered comprehension questions with high accuracy, alluding to an ability to recognize, integrate, and retain pertinent situation-based information within the dependent clauses. However, as discussed further below, the correct answering of comprehension questions does not directly indicate that situation-based knowledge was activated for these readers. Because of the manner in which situation-based information was constrained and limited in the current study to short dependent clauses, the current findings of no effect may suggest that the activation of situation-based knowledge might not be required unless lexical aspects are more complex, or necessitate connections to be made with information in prior text or to a reader's prior knowledge.

The idea that adults and children may not activate, or even need, situation-based knowledge to comprehend simple texts challenges current thinking of when and how situation-based knowledge is used. Specifically, with the exception of findings directly related to proofreading (e.g., Singer & Halldorson, 1996), evidence supporting the construction of mental frameworks and integration of situation-based knowledge during any reading is prolific (e.g., Calvo et al., 2001; Cozijn et al., 2011; Hannon & Daneman, 2001; Kendeou & van den Broek, 2007; Lipson, 1982; Milosky, 1990; Potts & Peterson, 1985). As the current findings offer a new and different perspective on when situation-based knowledge is activated, questions arise as to the point at which a reader can no longer rely on simple syntactic structure for comprehension and must begin to generate a mental model based on integration of situation-based knowledge.

Study limitations. The study had several limitations that may have contributed to the lack of an effect of situation-based knowledge. First, the biasing information in the dependent clauses may not have been "biasing enough" to sufficiently constrain the readers' mental framework to expect an improbable verb in the main clause. Although piloting was completed to generate sentences with perceivable differences between neutral and biasing situation-based information, the piloting used a forced-choice task in which adults read a biasing clause (e.g., *After hurting its wings*…) and had to choose a probable or improbable verb (*fly* or *fell*) that was most likely to follow the biasing information. In this way, it may be possible that the biasing clauses only appeared biasing when both verb choices were present. Consequently, once the finalized sentences were implemented in the reading task, the sentences with biasing dependent clauses may have narrowed, but not fully constrained, a reader's mental model to arrive at the desired improbable target verb. For example, upon encountering *After hurting its wings*, a number of mental models may have been constructed to the point that readers may have expected that the bird *died, hid, slept, was eaten*, etc. Models of parallel ambiguity resolution suggest that readers may concurrently activate multiple possibilities of what may come next in the sentence for it to make sense (McClelland, St. John, & Taraben, 1989; Vosse & Kempen, 2000). However, even with such competition among mental models, there is evidence to suggest that RT would not be significantly affected as multiple options are entertained, then ultimately confirmed or dismissed, by a reader (Clifton & Staub, 2008). This is supported by research surrounding competition models (e.g., Frazier 1995), arguing that mental models are updated on-line with the processing of each incoming word. In this way, no significant differences in RT would be detected between

the Neutral Improbable and Biasing Improbable conditions, resulting in no distinguishable effect of situation-based knowledge in the current study.

A second possibility for the lack of an effect is that the comprehension questions were directly related to surface-level information in the preceding sentences, requiring no inferences or connections to be made between the text and prior knowledge in order to answer correctly. Questions were designed in this way only to maintain attention and to limit the strain on mental resources such as working memory. As such, the majority of questions contained words that had been presented in the text. Consequently, many questions may have been answered correctly simply due to word recognition, without requiring the integration of situation-based knowledge for a correct answer to be made. There is evidence to suggest that readers may engage in shallow processing when they are able to maintain global comprehension of the text (Barton & Sanford, 1993). That is, when words appear to semantically fit with prior text, a factor that was controlled in the present study, readers may engage in shallow processing, where not every word is individually processed and fully integrated. As shallow processing does not necessarily impede comprehension (Barton & Sanford, 1993), it would not be surprising that participants in the current study were able to correctly answer most comprehension questions if they were indeed engaging in such a process.

A third limitation involves the effect size that had been used to determine the requisite sample size given the desired alpha level and statistical power. In the pilot study of 10 adults, situation-based knowledge had a significant effect on RT (t=2.55, p=0.03), with a large effect size (d=0.81). The full study was powered conservatively, on the assumption that the effect size could be as small as d=0.5. However, the resulting sample size was not sufficient to detect effect

sizes as small as those observed in adults and children (d=0.14 and d=0.15, respectively) in the full study with adequate statistical power. In the pilot study, the 95% CI surrounding the point estimate for d (0.81) was wide (0.07, 1.51), and it seems likely that the magnitude of the effect of situation-based knowledge is closer to the lower than to the upper bound. At present, the effect sizes observed in the full study represent the best available estimates of effect size that should be used in designing future investigations of situation-based knowledge. Thus, for a study to detect an effect of this factor on RT given an effect size of d=0.14, alpha level of 0.05, and power of 0.95, a sample of 67 adults and 67 children would be required. This sample size is indicative of a need to continue investigating situation-based knowledge, as its effects on RT can be difficult to detect and quantify without a large enough sample.

A final methodological issue concerns the self-paced moving-window task, which differs in obvious respects from more typical reading tasks. Although the current design was thought to precisely capture effects of word- and situation-based knowledge on RT at the moment when words are first encountered, a more natural reading task allowing for regressions may have been needed in order to elicit a subtler effect of situation-based knowledge. Two previous eye tracking studies (Calvo et al., 2001; Daneman et al., 2007) suggest that anomalies or unexpected words in connected text may not be fully processed on initial reading, and may require additional regressions to those words for clarification and comprehension. As previously discussed, Calvo et al. (2001) analyzed RTs for target words that were designed to be predictable or non-predictable based on preceding lexical constraints. Their findings showed that first-pass RTs of target words were not significantly affected by situation-based information, but second-pass RTs of predictable target words were significantly facilitated. Additionally, there were significantly

more regressions within sentences containing non-predictable target words, suggesting readers needed multiple encounters with a text when it contained unexpected words. Daneman et al. (2007) examined the effect of encountering anomalies in noun phrases (i.e., *tranquillizing stimulants*) on readers' eye movements and their abilities to detect such incongruent relationships. Their analyses revealed that the detection of such anomalous relationships was delayed, and that eye movements were only significantly affected by these anomalies in re-fixation analyses, not on first-pass reading. A moving window design was chosen for the current study as it was thought that effects of situation-based knowledge may be detected in first-pass reading if the option for regressions was removed. That is, it was expected that when readers encountered an improbable verb, the lack of an ability to re-read prior text would cause readers to pause on target words for clarification and integration, resulting in longer RTs of unexpected words in the neutral condition as compared to the biasing condition. However, the current findings point to the contrary, suggesting that the use of a technique not allowing for regressions may have resulted in unforeseen masking of any situation-based knowledge effect.

Future directions. Although the current study is the first to provide reliable data showing that adults and typical readers in the third grade are sensitive to the effects of word-based knowledge during a reading task, the manner in which situation-based information was designed may have ultimately concealed its effects on RT. These limitations, specifically in regard to the prospect of insufficiently biasing dependent clauses and surface-level comprehension questions, offer a framework on which a future investigation may improve. To better pilot clauses that contain biasing or neutral situation-based information, participants may be given a task in which they provide the biasing word that they feel would fit best in a dependent clause rather than

choosing a target word from a binary option. For example, participants may be asked to fill in the blank with a word that best fits into the dependent clause of *After _____ its wings*, when they are given the main clause of *the bird fell from the nest*. In this way, we may find that answers such as *injuring* or *breaking*, may better constrain a reader's mental model to expect the improbable verb of *fell*.

Additionally, rather than using surface-level comprehension questions that may be answered correctly as a result of mere word recognition, a future study may construct questions so as to necessitate a connection to prior knowledge in order to increase the likelihood of selecting the correct answer. Specifically, the reader would be required to integrate their own knowledge about the world with the information given in the text to ensure activation of situation-based knowledge occurs. In the above example, a corresponding question may be *Is it likely that the bird was happy?* A reader who is able to hold in working memory that the bird was hurt and therefore fell, and integrate prior knowledge that being hurt and falling are not events that generally make one happy, would be expected to conclude that the bird was not happy. As the word *happy* is not found in the preceding sentence, readers may not be able to answer the question correctly due to shallow processing or word recognition.

Lastly, although a moving window design is advantageous for capturing word-by-word processing speed, the use of this design limits events that naturally occur in more typical reading, such as the ability to re-read elements as needed (Karatekin, 2007; Liversedge & Findlay, 2000; Rayner, 1998; Starr & Rayner, 2001). The current study confirms previous findings suggesting that effects of situation-based knowledge are not detected on first pass reading; however, prior studies have not controlled situation-based information to the same degree as in the present

investigation, and the present investigation did not allow for regressions as in prior studies. Had regressions been permitted in the current study, this effect would be expected to occur when comparing differences in RTs between the Neutral Improbable and the Biasing Improbable conditions. Specifically, it is thought that second-pass reading analyses would demonstrate more regressions and longer RTs on words in the Neutral Improbable condition, with fewer regressions and facilitated RTs on words in the Biasing Improbable condition. With the apparent lack of an effect of situation-based knowledge in the current design, a subsequent study using eye tracking may examine whether the lack of an effect was due to the constraints under which situation-based information was constructed, or to the inability to re-read text.

3.6 Conclusion

The roles of word- and situation-based knowledge in overall text comprehension have been frequently studied, and it is generally accepted that both are integral during reading to attain full understanding. The present study attempted to design lexical elements in such a way that the relative effects, and any interaction, of word- and situation-based knowledge would be detected in adult and children's RT of sentences. The robust effect of word-based knowledge not only confirms prior research noting effects of this factor on adult RT of connected text, but extends previous findings by demonstrating that typical third grade readers are also sensitive to these effects at the sentence level. The lack of an effect of situation-based knowledge suggests that mental models may not always be generated in specific cases of lexical constraints. This finding does not support the current belief that mental models are constructed during most reading tasks. Additionally, the lack of an interaction suggests that adults and children were affected to a similar degree by word- and situation-based information in the current moving window design.

Results of the current investigation demonstrate that there is a continued need to examine how and when situation-based knowledge is activated, as many aspects related to its effects on adult and child RT remain largely unknown. This may be partly due to the various ways in which it has been defined (Matsuki et al. 2011; Rumelhart, 1975; Woolley, 2010), and not fully controlled in reading time studies (Calvo et al., 2001; Matsuki et al., 2011). Whether the lack of an effect of situation-based knowledge in the present study was due to the manner in which lexical components were constructed, or due to the nature of a moving window design, the findings invite future research to inspect the lexical conditions and limits at which situation-based knowledge is activated for text comprehension.

Appendix A. Adult and child intake forms

Adult Participant Intake Form

Date of Birth:_____ **Gender**: Male Female

Ethnicity (circle one):

Hispanic or Latino Not Hispanic or Latino Unknown

Race (circle one):

American Indian/Alaska Native Asian Native Hawaiian or Pacific Islander

Black or African American Caucasian (White) More than one race

Other Unknown

Do you speak any other language aside from English? Yes No

Is there another language aside from English spoken at home? Yes No

What is your highest level of education?

No high school Some high school High school

Some college College Graduate

Do you wear glasses? Yes No

Do you have a hearing impairment? Yes No

Do you have a history of any of the following?

Dyslexia Yes No

Epilepsy Yes No

Autism Yes No

Other Yes No

If other, please describe:

_____

(continued)

Appendix A. Adult and child intake forms (continued)

Child Participant Intake Form

Date of Birth:_____ **Gender**: Male Female

Ethnicity (circle one):

Hispanic or Latino Not Hispanic or Latino Unknown

Race (circle one):

American Indian/Alaska Native Asian Native Hawaiian or Pacific Islander

Black or African American Caucasian (White) More than one race

Other Unknown

Does your child speak any other language aside from English? Yes No

Is there another language aside from English spoken at home? Yes No

Does your child wear glasses? Yes No

Does your child have a hearing impairment? Yes No

Does your child have a history of any of the following?

Dyslexia Yes No

Epilepsy Yes No

Autism Yes No

Language impairment Yes No

Other Yes No

If other, please describe:

_____

Appendix B. Stimulus construction and piloting

Construction of stimuli

Several rounds of piloting were conducted to produce the final 96 sentences used in the experiment. It was crucial for these sentences to contain well controlled *probable* and *improbable* agent: action relationships in main clauses. It was also important to validate the differences between dependent clauses that were *neutral* or *biasing* toward the improbable verb. First, each of 57 agent words was paired with two actions expected to have relatively high or relatively low probability of co-occurrence based on the University of South Florida's Free Association Norms (Nelson, McEvoy, & Schreiber, 1998). These word pairs were further controlled to account for semantic relatedness, word length, and age of acquisition. This was accomplished by ensuring each word was between 3-11 letters in length, and met a minimum age of acquisition of six years, as reported by Bird, Franklin, and Howard (2001), Stadthagen-Gonzalez and Davis (2006), Cortese and Khanna (2008), and Schock, Cortese, Khanna, and Toppi (2012).

Next, in an effort to control for semantic relatedness, 120 students at the University of Texas at Dallas rated each agent-action pair on a three-point scale from 0 (not related) to 1 (somewhat related) to 2 (very related) after they had been given the examples of *sky smiled* as being not related, and *airplane flew* as very related. Two versions of the rating survey were created so that each agent was paired with only one action in a given version. Participants were randomly assigned to one version (Table B1). Of the 57 agents, only 20 were judged to be very related to one action and not related to the other by at least 70% of raters. In this way, 20 agents were paired with both a probable and improbable action, for a total of 40 agent:action word pairs.

Because the majority of improbable actions were judged to be unrelated to agents when pairs were presented in isolation, these 40 agent: action pairs were presented in sentence contexts for further piloting.

In the second round of piloting, the 40 agent: action pairs were placed in monoclausal sentences constructed so that for each agent, the two actions could be interchanged while maintaining the syntactic structure of the sentence as much as possible (e.g., the *bird flew* from the nest; the *bird fell* from the nest). All sentences consisted of the sequence Article+Noun+Verb+Prepositional Phrase or Noun Phrase and ranged in length from 5-8 words (M=6.06, SD=0.79). Seven pairs were excluded subsequently due to difficulty in generating plausible sentences that met the criteria above. However, because it was anticipated that the remaining 13 sentence pairs would not be sufficient to ensure adequate statistical power for the study, an additional 27 sentence pairs were created using the next highest rated agent: action pairs from the original pilot study. This resulted in a total of 40 sentence pairs (80 sentences total). Some probable and improbable verb tenses were altered from the first pilot as to ensure the sentences flowed appropriately. In an effort to keep the syntactic structure the same regardless of which action was paired with the agent, these 40 sentence pairs were constructed to follow the same structure to be used in formal testing: Adverbial clause (either *neutral* or *biasing* toward the improbable relationship)+Article+Noun/+Verb/+Prepositional phrase or Noun phrase. With the addition of the adverbial clause, sentences averaged 11.75 words in length (SD=1.35), and varied from 10-15 words.

Once the 40 sentence pairs were constructed, a convenience sample of 16 adults were presented with a sentence completion task. Within the task, an adverbial clause was followed by

a choice of two main clauses, one containing a probable agent:action relationship and one containing an improbable agent:action relationship (e.g., After flapping its wings, □ the bird flew from the nest □ the bird fell from the nest). Two test versions were created so that both main clauses were presented after only one adverbial clause condition (neutral or biasing) per test version, with the neutral/biasing condition order randomized by version. Therefore, if the above example had been presented in Version 1, the correlate in Version 2 would be: After hurting its wings, □ the bird flew from the nest □ the bird fell from the nest. Subjects were instructed to read each dependent clause and to select which of the two main clauses they felt best completed the sentence (Table B2). In this way, we were able to determine whether there was agreement on word-based relationships, while controlling for situation-based context.

Of the 40 sentence pairs piloted, 32 had main clauses that were judged to have probable word-based relationships in the neutral condition and improbable word-based relationships in the biasing condition by 68% of raters. These 32 main clauses were used as the starting point for constructing three versions of each sentences for the present investigation: a neutral dependent clause followed by a main clause with a probable agent:action relationship (Neutral Probable), a neutral dependent clause followed by a main clause with an improbable agent:action relationship (Neutral Improbable), and a biasing dependent clause followed by a main clause with an improbable agent:action relationship (Biasing Improbable). Each sentence only appeared in one condition within a given test version. Thus, a total of 96 sentences were used for the final testing, with three equal blocks of 32 sentences per test version (A, B, and C).

Pilot study

The primary aim of the pilot study was to estimate effect sizes in order to calculate statistical power and sample size for the main investigation. Participants in the pilot study were 10 adults (five men and five women) ranging in age from 39 to 63 years. During the task, participants were asked to read single sentences on the examiner's laptop computer and answer a comprehension question after each sentence. They were informed that the questions related directly to information presented in the preceding text. Reading times were collected, in ms, for each word in the main clause of the target sentences. A repeated-measure ANOVA was conducted using individual subjects' cumulative RTs of words starting with the main clause verb and ending with the last word of the sentence. This RT measure was used specifically to account for post lexical processing which has been shown to occur on words following the target word of interest (Calvo, et al., 2001; Vainio et al. 2009).

A repeated measures ANOVA showed significant differences in RT among conditions ($F(2,18)=12.43$, $p<0.05$). See Table B3. Dependent t-tests revealed statistically significant differences in the Neutral Improbable: Neutral Probable comparison ($t=6.95$, $p<0.0001$, $d=2.19$), and the Neutral Improbable: Biasing Improbable comparison ($t=2.55$, $p=0.03$, $d=0.81$). There was no significant difference for RT in the Biasing Improbable: Neutral Probable comparison ($t=1.99$, $p=0.08$, $d=0.63$); however statistical power was likely low given this small sample size.

Figure B1 plots d-values across the conditions, calculated using Cohen's (1988) formula of $d=t/n\text{^}2$, where t represents the t-value and n is the sample size (Cohen, 1988; Rosenthal, 1991; Lakens, 2013). Effect sizes for the Neutral Improbable: Neutral Probable and Neutral Improbable: Biasing Improbable comparisons were large, and the effect size for the Biasing

Improbable: Neutral Probable comparison was medium. Accordingly, sample size for the main investigation was calculated using a minimum effect size of d=0.5.

Table B1

Example of word-pair piloting

Instructions: Read the pairs of words below. For each pair, rate how closely you think Word 1 and Word 2 are related by circling the number to the right of the word pair that best reflects your judgment. For example, the words *sky* and *smiled* are not related, while the words *airplane* and *flew* are very related.

Word 1	**Word 2**	**Not Related**	**Slightly Related**	**Very Related**
rain	poured	0	1	2
prisoner	escaped	0	1	2
police	called	0	1	2
spider	crawled	0	1	2
Santa	kissed	0	1	2
maid	cleaned	0	1	2
hose	sprayed	0	1	2
monkey	swung	0	1	2
dog	barked	0	1	2
frog	choked	0	1	2
glue	leaked	0	1	2
actor	tripped	0	1	2
chicken	clucked	0	1	2
bee	smelled	0	1	2
drawer	closed	0	1	2
goalie	kicked	0	1	2

Table B2

Example of sentence piloting

Instructions: Read each introductory clause and choose the phrase that best completes the sentence. For example, if the introductory clause is "After taking off," and the completion phrase choices are "the airplane flew in the sky" and "the airplane danced in the sky," the best completion phrase is the first choice. In some cases, both phrases may be appropriate, but please choose the phrase that you think fits best.

When he woke up,
- ☐ the fish swam with all the other fish
- ☐ the fish hid with all the other fish

Staying up to watch her favorite TV show,
- ☐ the teacher graded late into the night
- ☐ the teacher laughed late into the night

When a lion roared nearby,
- ☐ the snake hissed at the sound
- ☐ the snake woke at the sound

After waking from his nap,
- ☐ the baby cried for his mama
- ☐ the baby clapped for his mama

When she arrived at the theatre,
- ☐ the ballerina danced on the stage
- ☐ the ballerina sat on the stage

When he found the milk,
- ☐ the cat meowed three times
- ☐ the cat sneezed three times

When the sun was too bright,
- ☐ the lion roared at the sight
- ☐ the lion blinked at the sight

When it ran through the dust,
- ☐ the horse raced on the track
- ☐ the horse coughed on the track

Table B3

Repeated measures ANOVA of RT

	SS	df	MS	F
Between	615878.414	2	307939.207	12.429
Within	8657090.101	27	320632.967	
Error	445977.132	18	24776.507	
Subjects	8211112.969	9	912345.885	
Total	9272968.514	29		

F-Statistic	Critical Value	Result	Conclusion
12.429	3.5546	Reject the null hypothesis.	The compared groups differ significantly, $F(2,18) = 12.429$, $p < 0.05$.

Condition	NI:NP	NI:BI	BI:NP
Rosenthal's d-value	2.19	0.81	0.63

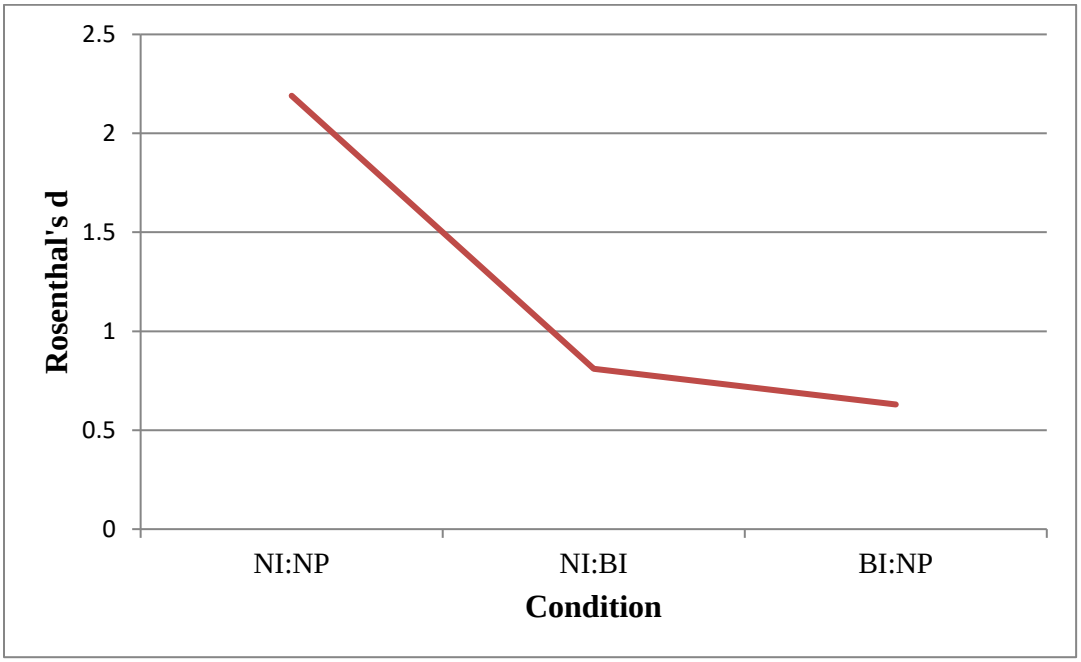

Figure B1. Comparison of *d*-values for RT. *Note*. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable

Appendix C. Sentence distribution to condition

Table C1

Sentence distribution to condition

Dependent Clause	*Neutral* / *Biasing*		*Main Clause*	*Probable* / *Improbable*	
After	flapping	its wings	the bird	flew	from the nest
	hurting			fell	
When the boy grabbed	some bread		the duck	quacked	in the stream
	its tail			wiggled	
After looking at	the stranger		the baby	cried	for his mama
	his hands			clapped	
As they waited for the	ambulance		the police	helped	behind the bank
	signal			whispered	
As	night	began to fall	the fire	burned	very slowly
	the rain			disappeared	
When the	drummer	arrived	the band	played	in front of the cameras
	reporter			talked	
When the girl	came inside		the clock	ticked	on the counter
	dropped her bag			flipped	
When they saw the	final score		the team	won	the trophies
	table of prizes			counted	
Using	his flashlight		the thief	stole from	the jewelry store
Forgetting				returned to	
After getting	water	on her brush	the artist	painted	the canvas
	perfume			sniffed	

(continued)

Appendix C. Sentence distribution to condition (continued)

Table C1

Sentence distribution to condition

Dependent Clause	*Neutral* / *Biasing*		*Main Clause*	*Probable* / *Improbable*	
When the sun hit	the gazelle		the lion	roared	at the sight
	its face			blinked	
When she spilled the open	bottle		the glue	stuck	on the paper
	glitter			sparkled	
With	careful	hands	the maid	cleaned	the dishes
	wet			dropped	
When the fly landed in	the water		the frog	croaked	in the pond
	its mouth			choked	
When it	found the milk		the cat	meowed	three times
	breathed the dust			sneezed	
When	the car drove	into the storm	the wheels	spun	in the water
		into the river		floated	
When it saw a	tadpole		the fish	swam	behind the rocks
	shark			hid	
Being very quiet			the spy	watched	in his hideout
Because he was hungry				ate	
After hitting the	gas pedal		the car	drove	faster than he expected
	water			sank	

(continued)

Appendix C. Sentence distribution to condition (continued)

Table C1

Sentence distribution to condition

Dependent Clause	*Neutral* / *Biasing*	*Main Clause*	*Probable* / *Improbable*	
When he	got his new pans	the chef	cooked	in the kitchen
	stepped on his apron		tripped	
When the girl fell	asleep	her phone	rang	over and over
	down		bounced	
When her	costume was ready	the ballerina	danced	on the stage
	shoe came untied		sat	
When	morning came	the kangaroo	jumped	under a tree
	nighttime		slept	
After getting a	uniform	the soldier	marched	with his friends
	medal		cheered	
Because	it was spring	the farmer	planted	in the field
	he was thirsty		drank	
When the	little boy grabbed it	the hose	sprayed	in the grass
	lawn mower hit it		tore	
When the	sun came up	the rooster	crowed	on top of the barn
	dog chased it		climbed	
When he got to the	gym	the boxer	punched	the bag
	store		carried	

(continued)

Appendix C. Sentence distribution to condition (continued)

Table C1

Sentence distribution to condition

Dependent Clause	*Neutral* / *Biasing*		*Main Clause*	*Probable* / *Improbable*	
After	checking his watch	the prisoner	escaped	in the dark	After
When their director was	ready		the choir	sang	in front of the crowd
Because the	yard was small		the carpenter	built a	flower box
	weather was dry			watered the	
Trying to make a good	grade		the student	read	the long paper
	airplane			folded	

Appendix D. Test Versions A, B, and C

Table D1

Test Version A

#	Sentence	Condition	Y/N question	Answer
	While sitting at his desk, the scientist looked through the microscope	Training	Did the scientist sit at a desk	YES
	After looking at the patient, the doctor ordered some medicine	Training	Did the nurse look at the patient	NO
	When the water began to boil, the mother added the spaghetti	Training	Was the water boiling	YES
	Once the starting gun went off, the horse raced around the track	Training	Did the horse race around the pasture	NO
	After catching the ball, the football player scored a touchdown	Training	Did the football player catch the ball	YES
	When the service was over, the priest prayed for his church	Training	Did the priest pray before the service	NO
1	After flapping its wings, the bird flew from the nest	NP	Did the bird fly from a cage	NO
2	When the boy grabbed some bread, the duck wiggled in the stream	NI	Did the boy grab some bread	YES
3	After looking at the stranger, the baby cried for his mama	NP	Did the baby see a dog	NO
4	After kicking the soccer ball, the boy scored a goal	F	Did the boy play baseball	NO
5	As they waited for the signal, the police whispered behind the bank	BI	Were the police behind the bank	YES
6	As night began to fall, the fire disappeared very slowly	NI	Was it night time	YES
7	When the drummer arrived, the band played in front of the cameras	NP	Did the band play in their garage	NO
8	After working all day, the spider crawled up the web	F	Was the spider in the web	YES
9	When the girl came inside, the clock flipped on the counter	NI	Did the clock flip on the desk	NO
10	When they saw the table of prizes, the team counted the trophies	BI	Were the trophies on the table	YES
11	As the man worked on the computer, the doorbell rang loudly	F	Was the man working on his car	NO

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D1

Test Version A

#	Sentence	Condition	Y/N question	Answer
12	Forgetting his flashlight, the thief returned to the jewelry store	BI	Did the thief forget his knife	NO
13	After getting water on her brush, the artist painted the canvas	NP	Did the artist get oil on her brush	NO
14	When the sun hit the gazelle, the lion blinked at the sight	NI	Did the sun hit the gazelle	YES
15	When she spilled the open bottle, the glue sparkled on the paper	NI	Was the bottle closed	NO
16	When the pilot pushed the button, lights flashed in the airplane	F	Did the pilot turn on the lights	YES
17	With wet hands, the maid dropped the dishes	BI	Did the mother drop the dishes	NO
18	When the fly landed in the water, the frog choked in the pond	NI	Did the fly land in the water	YES
19	When it found the milk, the cat meowed three times	NP	Did the cat find a fish	NO
20	When the car drove into the river, the wheels floated in the water	BI	Was the car in the river	YES
21	Trying to finish her work, the teacher graded late into the night	F	Was the teacher working late	YES
22	When it saw a tadpole, the fish hid behind the rocks	NI	Did the fish see a tadpole	YES
23	Because he was hungry, the spy ate in his hideout	BI	Was the spy tired	NO
24	After hitting the gas pedal, the car drove faster than he expected	NP	Did the man drive a car	YES
25	Before the grandfather went to bed, he took off his glasses	F	Did he take off his glasses to drive	NO
26	When he got his new pans, the chef cooked in the kitchen	NP	Did the chef use old pans	NO
27	When the girl fell down, her phone bounced over and over	BI	Did the phone bounce	YES

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D1

Test Version A

#	Sentence	Condition	Y/N question	Answer
28	After singing happy birthday, the girl blew out her candles	F	Was it the girl's birthday	YES
29	When her costume was ready, the ballerina danced on the stage	NP	Did the ballerina dance in her room	NO
30	When morning came, the kangaroo slept under a tree	NI	Did the kangaroo sleep in the morning	YES
31	After getting a medal, the soldier cheered with his friends	BI	Did the soldier get a ribbon	NO
32	As the father pulled the drawer open, the handle broke off	F	Did the father open a drawer	YES
33	Because it was spring, the farmer drank in the field	NI	Was it spring time	YES
34	When the little boy grabbed it, the hose tore in the grass	NI	Did the girl grab the hose	NO
35	When the teacher wrote too hard on the board, the chalk snapped in half	F	Did a doctor write on the board	NO
36	When the dog chased it, the rooster climbed on top of the barn	BI	Was the rooster chased by the dog	YES
37	When he got to the gym, the boxer punched the bag	NP	Did the boxer go to the bank	NO
38	After stubbing his toe, the prisoner hopped in the dark	BI	Did the prisoner hurt his toe	YES
39	When their director was ready, the choir stood in front of the crowd	NI	Did the director lead a band	NO
40	After sitting out on the counter, the ice cream melted in the bowl	F	Was the ice cream on the counter	YES
41	Because the yard was small, the carpenter built a flower box	NP	Was the yard small	YES
42	Trying to make a good airplane, the student folded the long paper	BI	Did the student make a paper plane	YES

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D2

Test Version B

#	Sentence	Condition	Y/N question	Answer
	While sitting at his desk, the scientist looked through the microscope	Training	Did the scientist sit at a desk	YES
	After looking at the patient, the doctor ordered some medicine	Training	Did the nurse look at the patient	NO
	When the water began to boil, the mother added the spaghetti	Training	Was the water boiling	YES
	Once the starting gun went off, the horse raced around the track	Training	Did the horse race around the pasture	NO
	After catching the ball, the football player scored a touchdown	Training	Did the football player catch the ball	YES
	When the service was over, the priest prayed for his church	Training	Did the priest pray before the service	NO
1	After hurting its wings, the bird fell from the nest	BI	Did the bird fall from the cage	NO
2	When the boy grabbed some bread, the duck quacked in the stream	NP	Did the boy grab some bread	YES
3	After looking at his hands, the baby clapped for his mama	BI	Did the baby look at his hands	YES
4	After kicking the soccer ball, the boy scored a goal	F	Did the boy play baseball	NO
5	As they waited for the ambulance, the police whispered behind the bank	NI	Were the police behind the bank	YES
6	As night began to fall, the fire burned very slowly	NP	Was it night time	YES
7	When the reporter arrived, the band talked in front of the cameras	BI	Did the band talk with the reporter	YES
8	After working all day, the spider crawled up the web	F	Was the spider in the cabinet	NO
9	When the girl came inside, the clocked ticked on the counter	NP	Was the clock on the counter	YES
10	When they saw the final score, the team counted the trophies	NI	Did the team count ribbons	NO
11	As the man worked on the computer, the doorbell rang loudly	F	Did the man work on his car	NO

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D2

Test Version B

#	Sentence	Condition	Y/N question	Answer
12	Using his flashlight, the thief returned to the jewelry store	NI	Did the thief use a flashlight	YES
13	After getting perfume on her brush, the artist sniffed the canvas	BI	Did the artist get oil on her brush	NO
14	When the sun hit the gazelle, the lion roared at the sight	NP	Did the sun hit the gazelle	YES
15	When she spilled the open bottle, the glue stuck on the paper	NP	Was the bottle closed	NO
16	When the pilot pushed the button, lights flashed in the airplane	F	Did the pilot turn on the lights	YES
17	With careful hands, the maid dropped the dishes	NI	Did the mother drop the dishes	NO
18	When the fly landed in the water, the frog croaked in the pond	NP	Did a fly land in the water	YES
19	When it breathed the dust, the cat sneezed three times	BI	Did the cat meow three times	NO
20	When he drove into the storm, the wheels floated in the water	NI	Did the wheels sink in the water	NO
21	Trying to finish her work, the teacher graded late into the night	F	Was the teacher working late	YES
22	When it saw a tadpole, the fish swam behind the rocks	NP	Did the fish see a tadpole	YES
23	Being very quiet, the spy ate in his hideout	NI	Was the spy tired	NO
24	After hitting the water, the car sank faster than he expected	BI	Did the car float in the water	NO
25	Before the grandfather went to bed, he took off his glasses	F	Did he take off his glasses to drive	NO
26	When he stepped on his apron, the chef tripped in the kitchen	BI	Did the chef trip on his apron	YES
27	When the girl fell asleep, her phone bounced over and over	NI	Did the phone bounce	YES

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D2

Test Version B

#	Sentence	Condition	Y/N question	Answer
28	After singing happy birthday, the girl blew out her candles	F	Was it the girl's birthday	YES
29	When her shoe came untied, the ballerina sat on the stage	BI	Did the ballerina dance on stage	NO
30	When morning came, the kangaroo jumped under a tree	NP	Did the kangaroo sleep in the morning	NO
31	After getting a uniform, the soldier cheered with his friends	NI	Did the soldier get a medal	NO
32	As the father pulled the drawer open, the handle broke off	F	Did the father open a drawer	YES
33	Because it was spring, the farmer planted in the field	NP	Was it winter time	NO
34	When the little boy grabbed it, the hose sprayed in the grass	NP	Did a girl grab the hose	NO
35	When the teacher wrote too hard on the board, the chalk snapped in half	F	Did a doctor write on the board	NO
36	When the sun came up, the rooster climbed on top of the barn	NI	Was a goose on top of a barn	NO
37	When he got to the store, the boxer carried the bag	BI	Did the boxer go to a store	YES
38	After checking his watch, the prisoner hopped in the dark	NI	Did the prisoner sleep in the dark	NO
39	When their director was ready, the choir sang in front of the crowd	NP	Did the director lead a choir	YES
40	After sitting out on the counter, the ice cream melted in the bowl	F	Was the ice cream on the counter	YES
41	Because the weather was dry, the carpenter watered the flower box	BI	Was the weather cold	NO
42	Trying to make a good grade, the student folded the long paper	NI	Did the student want a good grade	YES

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D3

Test Version C

#	Sentence	Condition	Y/N question	Answer
	While sitting at his desk, the scientist looked through the microscope	Training	Did the scientist sit at a desk	YES
	After looking at the patient, the doctor ordered some medicine	Training	Did the nurse look at the patient	NO
	When the water began to boil, the mother added the spaghetti	Training	Was the water boiling	YES
	Once the starting gun went off, the horse raced around the track	Training	Did the horse race around the pasture	NO
	After catching the ball, the football player scored a touchdown	Training	Did the football player catch the ball	YES
	When the service was over, the priest prayed for his church	Training	Did the priest pray before the service	NO
1	After flapping its wings, the bird fell from the nest	NI	Did the bird fall from the cage	NO
2	When the boy grabbed its tail, the duck wiggled in the stream	BI	Did the boy grab a duck's tail	YES
3	After looking at the stranger, the baby clapped for his mama	NI	Did the baby look at a dog	NO
4	After kicking the soccer ball, the boy scored a goal	F	Did the boy play baseball	NO
5	As they waited for the ambulance, the police helped behind the bank	NP	Were the police behind the bank	YES
6	As the rain began to fall, the fire disappeared very slowly	BI	Did the fire go out quickly	NO
7	When the drummer arrived, the band talked in front of the cameras	NI	Did the band wait for the drummer	YES
8	After working all day, the spider crawled up the web	F	Was the spider in a web	YES
9	When the girl dropped her bag, the clock flipped on the counter	BI	Did the girl drop her brush	NO
10	When they saw the final score, the team won the trophies	NP	Did the team win trophies	YES
11	As the man worked on the computer, the doorbell rang loudly	F	Was the man working on a car	NO

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D3

Test Version C

#	Sentence	Condition	Y/N question	Answer
12	Using his flashlight, the thief stole from the jewelry store	NP	Did the thief use a knife	NO
13	After getting water on her brush, the artist sniffed the canvas	NI	Did the artist get oil on her brush	NO
14	When the sun hit its face, the lion blinked at the sight	BI	Did the sun hit the lion	YES
15	When she spilled the open glitter, the glue sparkled on the paper	BI	Was the glitter closed	NO
16	When the pilot pushed the button, lights flashed in the airplane	F	Did the pilot turn on the lights	YES
17	With careful hands, the maid cleaned the dishes	NP	Was the maid careful	YES
18	When the fly landed in its mouth, the frog choked in the pond	BI	Did the fly land in the water	NO
19	When it found the milk, the cat sneezed three times	NI	Did the cat find milk	YES
20	When he drove into the storm, the wheels spun in the water	NP	Did the car drive into a storm	YES
21	Trying to finish her work, the teacher graded late into the night	F	Was the teacher working late	YES
22	When it saw a shark, the fish hid behind the rocks	BI	Did the fish see a tadpole	NO
23	Being very quiet, the spy watched in his hideout	NP	Was the spy tired	NO
24	After hitting the gas pedal, the car sank faster than he expected	NI	Did the driver hit the gas	YES
25	Before the grandfather went to bed, he took off his glasses	F	Did he take off his glasses to read	NO
26	When he got his new pans, the chef tripped in the kitchen	NI	Was the chef using old pans	NO
27	When the girl fell asleep, her phone rang over and over	NP	Did the girl's alarm ring	NO

(continued)

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix D. Test Versions A, B, and C (continued)

Table D3

Test Version C

#	Sentence	Condition	Y/N question	Answer
28	After singing happy birthday, the girl blew out her candles	F	Did the girl have a birthday party	YES
29	When her costume was ready, the ballerina sat on the stage	NI	Did the ballerina dance on the stage	NO
30	When nighttime came, the kangaroo slept under a tree	BI	Did the kangaroo sleep at night	YES
31	After getting a uniform, the soldier marched with his friends	NP	Did the solder get a uniform	YES
32	As the father pulled the drawer open, the handle broke off	F	Did the father open a drawer	YES
33	Because he was thirsty, the farmer drank in the field	BI	Was the farmer hot	NO
34	When the lawn mower hit it, the hose tore in the grass	BI	Did a car hit the hose	NO
35	When the teacher wrote too hard on the board, the chalk snapped in half	F	Did a doctor write on the board	NO
36	When the sun came up, the rooster crowed on top of the barn	NP	Was a rooster on the barn	YES
37	When he got to the gym, the boxer carried the bag	NI	Did the boxer go to the store	NO
38	After checking his watch, the prisoner escaped in the dark	NP	Did the prisoner sleep in the dark	NO
39	When their director was late, the choir stood in front of the crowd	BI	Did the choir wait for the director	YES
40	After sitting out on the counter, the ice cream melted in the bowl	F	Was the ice cream on the counter	YES
41	Because the yard was small, the carpenter watered the flower box	NI	Was the yard small	YES
42	Trying to make a good grade, the student read the long paper	NP	Did the student want a good grade	YES

Note. NP = Neutral Probable; NI = Neutral Improbable; BI = Biasing Improbable; F = Filler

Appendix E. Calculation of Cumulative RT (in ms) for Analyses

Table E1

Calculation of cumulative RT (in ms) for analyses

Word	Word duration	RT for analyses
After	723	
flapping	874	
its	1059	
wings,	810	
the	821	
bird	699	
flew	736	
from	686	
the	651	
nest.	1489	3562
When	939	
the	758	
boy	944	
grabbed	865	
some	866	
bread,	891	
the	930	
duck	862	
wiggled	971	
in	920	
the	1019	
stream.	1260	4170

Appendix F. Adult and child mean RT (in ms) by condition

Table F1

Adult mean RT (in ms) by condition

Adult Participant ID	Test Version	Condition Neutral Probable	Neutral Improbable	Biasing Improbable
A-1	A	3396.1	3548.091	3272.818
A-2	A	2170.9	2341.273	2310.182
A-3	A	3397.9	3628.455	3436.455
A-4	A	1728.6	1846.909	1769
A-5	A	2032	2325.273	2271.818
A-6	A	2021.5	2587.364	2536.455
A-7	A	2193.9	2280.364	2091.182
A-8	A	2144.7	2538.818	2678.545
A-9	A	2102.4	2461.636	2589.818
A-10	A	2042.6	2048.636	2090.727
A-11	A	2819.5	3149.545	2877.364
A-12	A	2183.5	2593.727	2272.727
A-13	B	4447	4414.636	4413.1
A-14	B	2698.455	2940.545	3138.9
A-15	B	3796.636	3966	3991.8
A-16	B	2167.455	2029	2831.7
A-17	B	2373.727	2468.545	2483.5
A-18	B	1767.091	1824.455	1864
A-19	B	2261.909	2504.727	2224.6
A-20	B	2400.727	2202.091	2311
A-21	B	2929.545	2927.909	3119.9
A-22	B	2682.364	3038.182	2600.9
A-23	B	3627.455	3869.545	5174.3
A-24	B	2884.909	3118.636	2972
A-25	C	2983.364	2657.6	3113.636
A-26	C	1976.545	2427.1	2211.364
A-27	C	1990.909	1980.1	2128.364
A-28	C	3464.091	3607.9	4164
A-29	C	3888.727	3639	3490.727
A-30	C	4677.091	5028.2	4787.818
A-31	C	2905.818	3079.1	3247.636
A-32	C	2345.273	2442.6	2458.909

(continued)

Table F1

Adult mean RT (in ms) by condition (continued)

Adult Participant ID	Test Version	Condition		
		Neutral Probable	Neutral Improbable	Biasing Improbable
A-33	C	2340.727	2349.3	2295.455
A-34	C	3194.545	3016.6	3749.455
A-35	C	1943.455	2020	1790.909
A-36	C	2358.18	2310.6	2359.36
M		2676.1	2811.457	2864.456
SD		750.2998	749.7597	842.49

Appendix F. Adult and child mean RT (in ms) by condition (continued)

Table F2

Child mean RT (in ms) by condition

Child Participant ID	Test Version	Condition		
		Neutral Probable	Neutral Improbable	Biasing Improbable
C-1	A	3121.2	3375.182	2931.545
C-2	A	3697.6	3976.909	3831.273
C-3	A	3677.2	4800	4785.636
C-4	A	2909	3592.182	3396.455
C-5	A	2715.6	3136.364	2881.818
C-6	A	3549.6	3854.909	3716.909
C-7	A	2456.3	2345.818	2360.909
C-8	A	3521.4	3768.8	3524.727
C-9	A	2578	2689.091	2472.182
C-10	A	3900.6	3806	4077.455
C-11	A	1767	1840.455	1729.273
C-12	A	4776.4	4295.273	4299.364
C-13	B	3401.818	3368.545	3968.6
C-14	B	3237.636	2986.182	3375.2
C-15	B	2728.636	2500.636	2811.4
C-16	B	5509.909	5513.3	6436
C-17	B	4905.727	5056.727	4942.1
C-18	B	1804.182	1699.818	1794.4
C-19	B	5889.545	5493.182	5615.9
C-20	B	3393.727	3384.091	3614.7
C-21	B	2292	2475.909	2983.7
C-22	B	2023.636	1358.182	1908.5
C-23	B	2326.182	2593.545	2510.7
C-24	B	3045.545	3169.727	2873.7
C-25	C	2771.818	2699.2	2447.455
C-26	C	3574.636	3635.5	3444.818
C-27	C	2191	2703.6	2423.364
C-28	C	3140.909	3539.8	3425.909
C-29	C	2943.455	3241.4	3313
C-30	C	3131.455	3138.2	3121.545
C-31	C	3337.636	3500.9	3655.636
C-32	C	2569.636	2539.7	2592.091

Table F2

Child mean RT (in ms) by condition (continued)

Child Participant ID	Test Version	Condition Neutral Probable	Neutral Improbable	Biasing Improbable
C-33	C	3109.545	3204.3	3289.909
C-34	C	2708.273	3065.8	3418.5
C-35	C	2125.182	2272.2	2318.091
C-36	C	2808.909	2932.4	2788.455
M		3156.692	3265.384	3307.812
SD		941.7789	953.6675	1012.682

REFERENCES

Aberson, C.L. (2010). *Applied power analysis for the behavioral sciences.* New York: Routledge.

Anderson, J.R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Balota, D.A., Cortese, M,J., Servent-Marshall, S.D., Spieler, D.H., & Yap, M.J. (2004). Visual word recognition of single-syllable words. *Journal of Experimental Psychology: General, 133*(2), 283-316.

Barton, S.B. & Sanford, A.J. (1993). A case study of anomaly detection: Shallow semantic processing and cohesion establishment. *Memory & Cognition, 21*, 447-487.

Becker, S., Moscovitch, M., Behrmann, M., & Joordens, S. (1997). Long term semantic priming: A computational account and empirical evidence. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1059-1082.

Betjemann, R.S. & Keenan, J.M. (2008). Phonological and semantic priming in children with reading disability. *Child Development, 79*(4), 1086-1102.

Bird, H., Franklin, S., & Howard, D. (2001). Age of acquisition and imageability ratings for a large set of words, including verbs and function words. *Behavior Research Methods, Instruments, & Computers, 33*(1), 73-79.

Bonnotte, I. & Casalis, S. (2010). Semantic priming in French children with varying comprehension skills. *European Journal of Developmental Psychology, 7*(3), 309-328.

Booth, J.R., MacWhinney, B., & Harasaki, Y. (2000). Developmental differences in visual and auditory processing of complex sentences. *Child Development, 71*(4), 981-1003.

Bornkessel, I. & Schlesewsky, M. (2006). The extended argument dependency model: A neurocognitive approach to sentence comprehension across languages. *Psychological Review, 113*,787-821.

Buchner, Erdfelder, Faul, & Lang. (2007). *G-Power*. Retrieved from http://www.softpedia.com/get/Science-CAD/G-Power.shtml

Cain, K., Oakhill, J.V., Barnes, M.A., & Bryant, P.E. (2001). Comprehension skill, inference-making ability, and their relation to knowledge. *Memory & Cognition, 29*(6), 850-859.

Cain, K., Oakhill, J.V., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*(1), 31-42.

Cain, K., Oakhill, J., & Lemmon, K. (2004). Individual differences in the inference of word meanings from context: The influence of reading comprehension, vocabulary knowledge, and memory capacity. *Journal of Educational Psychology, 96*(4), 671-681.

Calvo, M.G. (2005). Relative contribution of vocabulary knowledge and working memory span to elaborative inferences in reading. *Learning and Individual Differences, 15,* 53-65.

Calvo, M.G. & Castillo, M.D. (1996). Predictive inferences occur on-line, but with delay: Convergence of naming and reading times. *Discourse Processes, 22,* 57-78.

Calvo, M.G., Meseguer, E., & Carreiras, M. (2001). Inferences about predictable events: Eye movements during reading. *Psychological Research, 65,* 158-169.

Campion, N. & Rossi, J. (2001). Associative and causal constraints in the process of generating predictive inferences. *Discourse Processes, 31*(3), 263-291.

Cantrell, S.C., Almasi, J.F., Carter, J.C., Rintamaa, M., & Madden, A. (2010). The impact of a strategy-based intervention on the comprehension and strategy use of struggling adolescent readers. *Journal of Educational Psychology, 102*(2), 257-280.

Carr, S.C. & Thompson, B. (1996). The effects of prior knowledge and schema activation strategies on inferential reading comprehension of children with and without learning disabilities. *Learning Disability Quarterly, 19,* 48-61.

Clifton, C. & Staub, A. (2008). Parallelism and competition in syntactic ambiguity resolution. *Language and Linguistics Compass, 2,* 234-250.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (rev. ed.). Hillsdale, NJ, England: Lawrence Eribaum Associates, Inc.

Corsale, K. & Ornstein, P.A. (1980). Developmental changes in children's use of semantic information in recall. *Journal of Experimental Child Psychology, 30,* 231-245.

Cortese, M.J. & Khanna, M.M. (2008). Age of acquisition ratings for 3,000 monosyllabic words. *Behavior Research Methods, 40*(3), 791-794.

Coulson, S., King, J.W., & Kutas, M. (1998). Expect the unexpected: Event-related brain response to morphosyntactic violations. *Language and Cognitive Processes, 13*(1), 21-58.

Cozijn, R., Noordman, L.G.M., & Vonk, W. (2011). Propositional integration and world-knowledge inference: Processes in understanding *because* sentences. *Discourse Processes, 48,* 475-500.

Cronin, V.S. (2002). The syntagmatic-paradigmatic shift and reading development. *Journal of Child Language, 29,* 189-204.

Cutting, L.E. & Scarborough, H.S. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific Studies of Reading, 10*(3), 277-299.

Daneman, M., Lennertz, T., & Hannon, B. (2007). Shallow semantic processing of text: Evidence from eye movements. *Language and Cognitive Processes, 22*(1), 83-105.

DeLong, K.A., Urbach, T.P., & Kutas, M. (2005). Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. *Nature Neuroscience, 8*(8), 1117-1121.

Ervin, S.M. (1961). Changes with age in the verbal determinants of word association. *American Journal of Psychology, 74,* 361-372.

Frazier, L. (1995). Constraint satisfaction as a theory of sentence processing. *Journal of Psycholinguistic Research, 24,* 437–68.

Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition, 68,* 1-76.

Gold, B.T., Balota, D.A., Jones, S.J., Powell, D.K., Smith, C.D., & Andersen, A.H. (2006). Dissociation of automatic and strategic lexical-semantics: Functional magnetic resonance imaging evidence for differing roles of multiple frontotemporal regions. *The Journal of Neuroscience, 26*(24), 6523-6532.

Graesser, A.C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 101,* 371-395.

Grainger, J. & Segui, J. (1990). Neighborhood frequency effects in visual word recognition: A comparison of lexical decision and masked identification latencies. *Perception & Psychophysics, 47,* 191-198.

Gregory, A.E. & Cahill, M.A. (2010). Kindergartners can do it, too! Comprehension strategies for early readers. *The Reading Teacher, 63*(6), 515-520.

Hannon, B. & Daneman, M. (2001). A new tool for measuring and understanding individual differences in the component processes of reading comprehension. *Journal of Educational Psychology, 93*(1), 103-128.

Hansen, J. & Pearson, P.D. (1983). An instructional study: Improving the inferential comprehension of good and poor fourth grade readers. *Journal of Educational Psychology, 75*, 821-829.

Harlaar, N., Dale, P.S., & Plomin, R. (2007). From learning to read to reading to learn: Substantial and stable genetic influence. *Child Development, 78*(1), 116-131.

Hatami, S. & Tavakoli, M. (2012). The role of depth versus breadth of vocabulary knowledge in success and ease in L2 lexical inferencing. *TESL Canada Journal, 30*(1), 1-21.

Holderbaum, C.S. & Fumagalli de Salles, J.F. (2011). Semantic priming effects in a lexical decision task: Comparing third graders and college students in two different stimulus onset asynchronies. *The Spanish Journal of Psychology, 14*(2), 589-599.

Jenkins, J.R., Stein, M.L., & Wysocki, K. (1984). Learning vocabulary through reading. *American Educational Research Journal, 21*(4), 767-787.

Joordens, S. & Becker, S. (1997). The long and short of semantic priming effects in lexical decision. *Journal of Experimental Psychology, 23*(5), 1083-1105.

Joseph, H.S.S.L., Liversedge, S.P., Blythe, H.I., White, S.J., Gathercole, S.E., & Rayner, K. (2008). Children's and adults' processing of anomaly and implausibility during reading: Evidence from eye movements. *The Quarterly Journal of Experimental Psychology, 61*(5), 708-723.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80*(4), 437-447.

Karatekin, C. (2007). Eye tracking studies of normative and atypical development. *Developmental Review, 27,* 283-348.

Keenan, J.M., Potts, G.R., Golding, J.M., & Jennings, T.M. (1990). Which elaborative inferences are drawn during reading? A question of methodologies. In D.A. Balota, G.B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension Processes in Reading* (pp. 377-402). Hillsdale, NJ: Lawrence Erlbaum.

Kendeou, P. & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition, 35*(7), 1567-1577.

Kintsch, W. (1988). The role of knowledge in discourse processing: A construction-integration model. *Psychological Review, 95*, 163-182.

Kintsch, W. (1991). How readers construct situation models for stories: The role of syntactic cues and causal inferences. In A.F. Healy, S.M. Kosslyn, & R.M. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes* (Vol. 2, pp. 261–278). Hillsdale, NJ: Lawrence Erlbaum.

Kirby, J.R., Parrila, R.K., & Pfeiffer, S.L. (2003). Naming speed and phonological awareness as predictors of reading development. *Journal of Educational Psychology, 95*(3), 453-464.

Kuperberg, G.R., Paczynski, M., & Ditman, T. (2011). Establishing causal coherence across sentences: An ERP study. *Journal of Cognitive Neuroscience, 23*(5), 1230-1246.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in Psychology,* 4:863, doi: 10.3389/fpsyg.2013.00863.

Lipson, M.Y. (1982). Learning new information from text: The role of prior knowledge and reading ability. *Journal of Reading Behavior, 14*(3), 243-261.

Liversedge, S.P. & Findlay, J.M. (2000). Saccadic eye movements and cognition. *Trends in Cognitive Sciences, 4,* 6-14.

Masson, M.E. (1995). A distributed memory model of semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(1), 3-23.

Matsuki, K., Chow, T., Hare, M., Elman, J.L., Scheepers, C., & McRae, K. (2011). Event-based plausibility immediately influences on-line language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(4), 913-934.

McClelland, J. L., St. John, M., & Taraban, R. (1989). Sentence comprehension: A parallel distributed processing approach. *Language and Cognitive Processes, 4*(3-4) 287–336.

McConkie, G.W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. *Perception & Psychophysics, 17,* 578-586.

McKoon, G. & Ratcliff, R. (1992). Inference during reading. *Psychological Review, 99*, 440-446.

McKoon, G. & Ratcliff, R. (1995). The minimal hypothesis: Directions for research. In C.A. Weaver, S. Mannes, & C.R. Fletcher (Eds.), *Discourse Comprehension* (pp. 97-116). Hillsdale, NJ: Erlbaum.

McNamara, D.S. (2001). Reading both high-coherence and low-coherence texts: Effects of text sequence and prior knowledge. *Canadian Journal of Experimental Psychology, 55*(1), 51-62.

McNamara, T. P. (1992a). Priming and constraints it places on theories of memory and retrieval. *Psychological Review, 99,* 650–662.

McNamara, T.P. (1992b). Theories of priming: I. Associative distance and lag. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1173-1190.

McNamara, T.P. (1994). Theories of priming: II. Types of primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 507-520.

Meyer, D.E. & Schvaneveldt, R.W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90,* 227-235.

Milosky, L.M. (990). The role of word knowledge in language comprehension and language intervention. *Topics in Language Disorders, 10*(3), 1-13.

Moss, H.E., Hare, M.L., Day, P., & Tyler, L.K. (1994). A distributed memory model of the associative boost in semantic priming. *Connection Science, 6,* 413-427.

Moss, H.E., Ostrin, R.K., Tyler, L.K., & Marslen-Wilson, W.D. (1995). Accessing different types of lexical semantic information: Evidence from priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(4), 863-883.

Nation, K.. & Snowling, M.J. (1999). Individual differences in contextual facilitation: Evidence from dyslexia and poor reading comprehension. *Child Development, 69,* 996-101.

Nelson, D.L., McEvoy, C.L., & Schreiber, T.A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.

Nelson, K. (1977). The syntagmatic-paradigmatic shift revisited: A review of research and theory. *Psychological Bulletin,84,* 93-116.

Nievas, F. & Justicia, F. (2004). A cross-sectional study about meaning access processes for homographs. *Cognitive Development, 19,* 95-109.

Ouellette, G.P. (2006). What's meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psuchology, 98*(3), 554-566.

Paap, K.R. & Noel, R.W. (1991). Dual route models of print to sound: Still a good horse race. *Psychological Research, 53,* 13-24.

Perea, M. & Carreiras, M. (1998). Effects of syllable frequency and syllable neighborhood frequency in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 24*(1), 134-144.

Pike, M.M., Barnes, M.A., & Barron, R.W. (2010). The role of illustrations in children's inferential comprehension. *Journal of Experimental Child Psychology, 105,* 243-255.

Plaut, D.C. & Booth, J.R. (2000). Individual and developmental differences in semantic priming: Empirical and computational support for a single-mechanism account of lexical learning. *Psychological Review, 107*(4), 786-823.

Potts, G.R., & Peterson, S.B. (1985). Incorporation versus compartmentalization in memory for discourse. *Journal of Memory and Language, 24,* 107-118.

Ratcliff, R. & McKoon, G. (1988). A retrieval theory of priming in memory. *Psychological Review, 95*(3), 385-408.

Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology, 41*(2), 211-236.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124,* 372–422.

Rayner, K., Warren, T., Juhasz, B.J., & Liversedge, S.P. (2004). The effect of plausibility on eye movements in reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 1290-1301.

Rohde, D. (2001). *Linger.* Retrieved from http://tedlab.mit.edu/~dr/Linger/

Rosenthal R. (1991). Meta-analytic procedures for social research. Newbury Park, CA: SAGE Publications, Incorporated.

Rumelhart, D. (1975). Notes on a schema for stories. In D.G. Bobrow & A. Collins (Eds.), *Representation and Understanding: Studies in Cognitive Science,* (pp. 211-236). New York, NY: Academic Press, Inc.

Rupley, W.H. & Nichols, W.D. (2005). Vocabulary instruction for the struggling reader. *Reading & Writing Quarterly, 21,* 239-260.

Schock, J., Cortese, M.J., Khanna, M.M., & Toppi, S. (2012). Age of acquisition estimates for 3,000 disyllabic words. *Behavior Research Methods, 44*(4), 971-977.

Schustack, M., Ehrlich, S.F., & Rayner, K. (1987). Local and global sources of contextual facilitation in reading. *Journal of Memory and Language, 26,* 322–340.

Sharkey, A.J., & Sharkey, N.E. (1992). Weak contextual constraints in text and word priming. *Journal of Memory and Language, 31,* 543-572.

Sheng, L., McGregor, K.K., & Marian, V. (2006). Lexical-semantic organization in bilingual children: Evidence from a repeated word association task. *Journal of Speech, Language, and Hearing Research, 49,* 572-587.

Singer, M., & Halldorson, M. (1996). Constructing and validating motive bridging inferences. *Cognitive Psychology, 30,* 1-38.

Smith, N.J. & Levy, R. (2013). The effect of word predictability on reading time is logarithmic. *Cognition, 128,* 302-319.

Stadthagen-Gonzalez, H. & Davis, C.J. (2006). The Bristol norms for age of acquisition, imageability, and familiarity. *Behavior Research Methods, 38*(4), 598-605.

Stanovich, K.E. (1980). Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly, 16,* 32-71.

Starr, M.S. & Rayner, K. (2001). Eye movements during reading: Some current controversies. *Trends in Cognitive Sciences, 5,* 156-163.

Texas Education Agency. (2009). *Texas assessment of knowledge and skills, reading test, grade 3.* Retrieved from http://www.tea.state.tx.us/student.assessment/taks/released-tests/archive/

Texas Education Agency. (2011). *State of Texas assessments of academic readiness, reading test, grade 3.* Retrieved from http://www.tea.state.tx.us/student.assessment/staar/testquestions/

Torgesen, J.K., Wagner, R.K., Rashotte, C.A., Burgess, S., & Hecht, S. (1997). Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second- to fifth-grade children. *Scientific Studies of Reading, 1*(2), 161-185.

Vainio, S., Hyönä, J., & Pajunen, A. (2009). Lexical predictability exerts robust effects of fixation duration, but not on initial landing position during reading. *Experimental Psychology, 56*(1), 66-74.

van Kleeck, A. (2008). Providing preschool foundations for later reading comprehension: The importance of and ideas for targeting inferencing in storybook-sharing interventions. *Psychology in the Schools, 45*(7), 627-643.

Vosse, T. & Kempen, G. (2000). Syntactic structure assembly in human parsing: A computational model based on competitive inhibition and lexicalist grammar. C*ognition, 75,* 105–43.

Vu, H., Kellas, G., Peterson, E., & Metcalf, K. (2003). Situation-evoking stimuli, domain of reference, and the incremental interpretation of lexical ambiguity. *Memory & Cognition, 31*(8), 1302-1315.

Wang, S., Dong, X., Ren, Y., & Yang, Y. (2009). The development of semantic priming effect in childhood: an event-related potential study. *Cognitive Neuroscience and Neuropsychology, 20,* 574-578.

Warren, T. & McConnell, K. (2007). Investigating effects of selectional restrictions violations and plausibility violation severity on eye-movements in reading. *Psychonomic Bulletin & Review, 14,* 770-775.

Wehner, D.T., Ahlfors, S.P., & Mody, M. (2007). The influence of semantic processing on phonological decisions in children and adults: A magnetoencephalography (MEG) Study. *Journal of Speech, Language, and Hearing Research, 50,* 716-731.

Wiederholt, J.L. & Bryant, B.R. (2001). *Gray Oral Reading Test-4 (GORT-4).* Austin, TX: Pro-Ed.

Woolley, G. (2010). Developing reading comprehension: Combining visual and verbal cognitive processes. *Australian Journal of Language and Literacy, 33*(2), 108-125.

Zwaan, R.A. & Rapp, D.N. (2006). Discourse comprehension. In M. Traxler & M.A. Gernsbacher (Eds.), *Handbook of Psycholinguistics, 2nd Ed.* (pp. 725-764). San Diego, CA: Elsevier.

VITA

Blair Catherine Miller was born in Waco, Texas. She received her Bachelor of Arts degree in Communication Sciences and Disorders at Baylor University in Waco, Texas in August 2004. That fall she entered The University of Texas at Dallas to pursue her Masters of Science in Communication Disorders. After obtaining her degree, Blair worked as an ASHA certified Speech-Language Pathologist for Richardson Independent School District for three years. While there, Blair gained invaluable experience working with children with mild to severe articulation and language disorders, as well as children with multiple disorders. She also served as chair of the Special Education department within her school. Blair then returned to The University of Texas at Dallas in August 2009 to obtain her PhD in Communication Sciences and Disorders. During this time, she remained active within her community, involving herself with Literacy Instruction for Texas (LIFT), a nonprofit organization focusing on giving adults and their families the lifelong gift of literacy. Blair served as chair of the Programs Committee for LIFT from 2012-2013. Blair is married to Terrell Miller, and they have four wonderful children, Boden, Grayson, Dalton, and Logan.