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2016

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UNIVERSITY OF CALIFORNIA,
IRVINE

Technology-Enhanced L2 Reading: The Effects of Hierarchical Phrase Segmentation

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Education

by

Youngmin Park

Dissertation Committee:
Professor Mark Warschauer, Chair
Associate Professor Penelope Collins
Assistant Professor Joshua Fahey Lawrence
Professor Jamal Abedi

2016

DEDICATION

I dedicate this dissertation to my precious daughters Yunjin and Shinyoung, who came all the way to America with me and patiently waited while I completed this long journey and to my dear husband who provided quiet support throughout my educational endeavor

Also I dedicate work to all language teachers and learners whom I hope their educational experiences will be enriched by this research.

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ACKNOWLEDGMENTS

After an intensive period of five years in my Ph.D. study, I finally have an opportunity to write this note of thanks. I would like to express my appreciation to my advisor Professor Mark Warschauer for his continuous support throughout my Ph.D. study and related research. His guidance helped me in completing this research and writing the dissertation as well as a number of book chapters and journal papers. I also appreciate his deep understanding of my situation as a parent who needed to take care of two children on my own during my study. He has been a tremendous mentor for me as a researcher and a parent.

I would also like to thank my dissertation committee members, Professors Jamal Abedi, Penelope Collins, and Joshua Lawrence. They not only let my defense be an enjoyable moment by giving their expertise to better my work, but also allowed me to grow as a research scientist by encouraging my research and giving their brilliant comments and suggestions. I thank them for their contribution and support along the way.

My sincere thanks also goes to Leora Fellus for her emotional and professional support. It was a blessing to have someone like her in the Ph.D. program who was able to listen to us with sympathetic ears.

There are my friends to whom I am grateful as well. Thank you for all the energy, friendship, hospitality, knowledge, and all the fun and food that we made over the last years. Soobin and Jin Kyoung, I truly appreciate that you were always there to hold my hand when times were hard.

Finally, I need to express my gratitude and deep appreciation to my family. My sweet daughters Yunjin and Shinyoung came all the way, more than six thousand miles, with me. They themselves had to go through all the hard times in a new country, but helped me make my way through the hard days with their adorable smiles and love. I also appreciate my husband's patience and quiet support.

This dissertation owes its existence to the help, support, and inspiration of these people.

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SCHOLARLY and PROFESSIONAL ACTIVITIES

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- Park, Y.** & Warschauer, M. (accepted). Syntactic enhancement and second language literacy: An experimental study. *Language Learning & Technology*
- Warschauer, M., Zheng, B., & **Park, Y.** (2013). New ways of connecting reading and writing. *TESOL Quarterly* 14-19, doi: 10.1002/tesq.131.
- Warschauer, M., & **Park, Y.** (2012). Re-envisioning reading in English as a foreign language. *JACET-KANTO Journal*, 8, 5-13.
- Warschauer, M., **Park, Y.**, & Walker, R. (2011). Transforming digital reading with visual-syntactic text formatting. *The JALT CALL Journal*, 7(3), 255-270.
- Park, Y.**, & Yu, J. (2009). Vocabulary teaching and learning through pattern poetry writing. *Journal of Research in Curriculum Instruction*, 13(2), 299-321.

Book Chapters

- Park, Y., & Warschauer, M.** (2016). Reading instruction in a technology age. In B. X. Chen, & R. Helms-Park (Eds.), *Learning to read in a second language: Psycholinguistic and cognitive perspectives* (pp. 283-302), New York: Routledge.
- Park, Y., Dutton, S., & Ruiz-Hau, J.** (2014). Writing pattern poetry on Facebook. In R. E. Ferdig, T. V. Raskinski, & K. E. Pytash (Eds.), *Using technology to enhance writing* (163-170). Bloomington, IN: Solution Tree.
- Park, Y., Warschauer, M., Collins, P., Hwang, J. K., & Vogel, C.** (2013). Building awareness of language structures with visual-syntactic text formatting. In K. E. Pytash, & R. E. Ferdig (Eds.), *Exploring technology for writing and writing instruction* (pp. 21-36). Hershey, PA: IGI Global.
- Park, Y., Zheng, B., Lawrence, J., & Warschauer, M.** (2012). Technology-enhanced reading environments, In M. K. Thomas, H. Reinders, & M. Warschauer (Eds.), *Contemporary computer-assisted language learning* (pp. 418-446). London & New York: Continuum.

International Conference Presentations

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- Park, Y., Warschauer, M., & Oak, M.** (2013, July). *Syntactic scaffolding on literacy development in EFL contexts*. Paper presented at 2013 international conference of the Korea Association of Teachers of English, Seoul, Korea.
- Park, Y., Collins, P., Warschauer, M., & Oak, M.** (2013, July). *The effect of Syntactic scaffolding on adolescent literacy development*. Paper presented at the 20th annual meeting of the Society for the Scientific Study of Reading, Hong Kong, China.
- Park, Y. & Warschauer, M.** (2013, April). *The effect of visual-syntactic text formatting on adolescents' reading competencies*. Poster presented at the biennial meeting of the Society for Research in Child Development, Seattle, WA.
- Park, Y. & Warschauer, M.** (2012, June). *Improving reading with digital scaffolding*. Presented at the 33rd annual conference of the International Society for Technology in Education, San Diego, CA.
- Park, Y.** (2012, April). *Reading aloud to adolescent English learners: A study in a Korean high school*. Presented at the 6th Biennial Conference of the UC Language Consortium, San Diego, CA.
- Park, Y.** (2009, November). *Setting up an extensive reading program at public schools: Making a horse drink water*. Paper presented at the 2nd Annual Extensive Reading Symposium of KOTESOL, Seoul, Korea.

Current Publication Activities

Park, Y. & Oh, R. (in preparation) Does syntactic enhancement reduce foreign language reading anxiety?

Oh, R. & **Park, Y.** (in preparation) L2 reading fluency training through syntactic enhancement

Park, Y., Warschauer, M., Collins, P., & Farkas, G. (in preparation) Technology and adolescent reading: Scaffolding learning of language structure

RESEARCH

July – December 2014 Project Researcher for Mark Warschauer
Supporting Digital Literacy (Funding agency: International Baccalaureate)

- Conducted in-depth literature review on the use of digital literacy in educational contexts as well as emerging pedagogies and technologies that promote digital literacy for students aged 3-19.
- Provided guidelines for including technology as integral to an educational program

September 2013 – June 2014 Project Researcher for Dr. Jamal Abedi, UC Davis
Impact of the WRITE Program on English Learner Achievement and Teacher Instructional Practice (Funding agency: Institute of Education Sciences)

- Cleaned and analyzed student achievement data from quasi-experimental and randomized control trial of the WRITE program

A Comprehensive Research-Based Computer Assessment and Accommodation System for English language learners (Funding agency: Institute of Education Sciences)

- Reviewed 8th grade math items that will be administered in the randomized control trial

September – December 2013 Graduate Student Researcher for Drs. G.P. Li and Mark Warschauer

Developing an English Language Learning App for English Learners as a Foreign Language (In partnership with California Institute for Telecommunications and Information Technology)

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- Tested pronunciation learning software programs for non-native English speakers
- Offered suggestions on what features to focus on when developing mobile apps for teaching English as a foreign language to adults and children

- September 2011 – August 2013 Graduate Student Researcher for Dr. Mark Warschauer
Improving Reading with Digital Scaffolding (Funding agencies: Haynes Foundation, Spencer Foundation)
- Helped with training for teachers who participated in this quasi-experimental study
 - Observed treatment classrooms during the study and interviewed treatment teachers
 - Developed reading tests
 - Analyzed data and presented the results in conferences

TEACHING

Tertiary Education

- March – June 2016 *School of Education - UCI*
Graduate Teaching Assistant for Edu 30: 21st Century Literacies
 Led three discussion sessions for this course, composing of discussion, presentation, collective writing, and completing a digital project. Course familiarizes students with the learning skills and literacies required for academic and career success in the 21st century. Addressed issues include reading, writing, academic language, research skills, media and technology skills, content literacy, critical thinking, communication, and collaboration.
- January – March 2015 *School of Education - UCI*
Graduate Teaching Assistant for Edu 10: Educational Research Design
 Led two discussion sessions for this course. Course familiarizes students with the central concepts of educational research with the goal of helping students become effective consumers of and active participants in educational research. Offers opportunities to gain understanding of a broad range of methods used in the acquisition of knowledge and the testing of competing theories in the social and behavioral sciences. Topics include the development of research questions; participant selection; educational measurement and data collection; and experimental research designs and qualitative and quantitative research methods.
- September – December 2014 *School of Education - UCI*
Instructor for Edu 134: Teaching English Internationally
 March – June 2014 Taught this course for two quarters. Course gives a general overview of English teaching to speakers of other languages and explores second language acquisition theories, instructional approaches, and technology use in diverse learning contexts. Offers opportunities of planning activities, lessons, and a whole unit and teaching an international student so that teacher candidates gain a deeper understanding of how

they can apply what they have learned in this course to a variety of educational settings.

January – March 2014 *School of Education - UCI*
Graduate Teaching Assistant for Edu 350: Adolescent Development

Course explores the physical, cognitive, emotional, and social development of adolescents, with an emphasis on the practical implications of developmental theory and research findings for teachers working with adolescents in middle or high school contexts.

Professional Development for Instructors

April 2012 *American Language Institute, San Diego State University*
Guest Lecturer

Gave a talk to native English Teachers who Teach Adult English Learners in the U.S. Provided an overview of first and second language acquisition theories and research to instructors who taught English to adult learners from all around the world. Offered implications of teaching culturally and linguistically diverse learners into English as a second language teaching practice.

December 2009 *In-service English teacher training, Busan Public Schools, Busan, South Korea*
Workshop leader

Led a two-day training course for non-native English teachers who teach secondary school students in South Korea (50 in-service teachers with 5 to 10 year experience in teaching English in a secondary school). Discussed the use of technology in English classrooms, focusing on how to meet diverse needs of learners using technology. Also led a lab in which teachers had hands-on experience with technological tools and web search.

September – December 2009 *Pusan Electronic Engineering High School, Busan, South Korea*

Workshop leader

Developed an extensive English reading program in this under-resourced and low-performing school and led a workshop for teachers participating in this program.

Secondary Education

March 2007 – August 2010 *Pusan Electronic Technical High School, Busan, Korea*
Native English teacher & intern teacher coordinator, English teacher
 Taught general English to 10th -12th grade students. Designed a literacy program integrating guided reading and systematic phonics instruction for low-performing students. Had intern teachers implement this program in a pull-out model. Coached and supported native English teachers in methods of English language acquisition and learning. Received Distinctive Teacher Award for innovative technology use in teaching and Best Teacher Trainee Award for excellent performance in an in-service English teacher training program.

March 2003 – February 2007 *Dongnae High School, Busan, South Korea*
English teacher
 Taught general English to 10th – 12th grade students. Designed and implemented an advanced English reading program for those who were outstanding but could not afford extracurricular English lessons. Received Distinctive Teacher Award for excellent teaching practice.

September 1998 – February 2003 *Gaesung High School, Busan, South Korea*
English teacher
 Taught general English to 10th – 12th grade students. Designed and implemented an advanced English reading program for those who were outstanding but could not afford extracurricular English lessons. Received Best Teacher Trainee Award for excellent performance in a training program for those who were in charge of a web-based school management system.

AWARDS and SCHOLARSHIPS

	<u>Value</u>	<u>Year</u>
The 11 th Annual Butterworth Product Development Competition	Finalist	2014
(Product: A learning management system for non-native English learners' writing development)	\$64,000	2010-2012
Korean Government Scholarship		
Distinctive Teacher Award		2009
Best Trainee Award in In-service English Teacher Training		2008
		2003
Distinctive Teacher Award		1999
Best Trainee Award in In-service Teacher Training		

Exchange Student Grant at University of British Columbia	Full tuition, stipend, Room & board	1995-1996
Pusan National University Honors Scholarship	Full tuition	1993-1998

SERVICE

Professional Service

- Peer-reviewer of manuscripts at academic journals, 2013-2016
- Member, National Committee of Academic Performance Evaluation, Korea Institute of Curriculum and Evaluation, 2009
- Member, National Committee of College Entrance Examination, Korea Institute of Curriculum and Evaluation, 2009
- Member, National Committee of English Textbook Evaluation, Korea Institute of Curriculum and Evaluation, 2008-2010

University Service

- Running a Professional Development Workshop on Reference Management Programs, School of Education, UC Irvine, 2015
- Student Representative, Admission Committee of School of Education, UC Irvine, 2013-2014

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- American Educational Research Association
- International Society for Technology in Education
- Korean Association of Teachers of English
- Society for the Scientific Studies of Reading

ABSTRACT OF THE DISSERTATION

Technology-Enhanced L2 Reading: The Effects of Hierarchical Phrase Segmentation

By

Youngmin Park

Doctor of Philosophy in Education

University of California, Irvine, 2016

Professor Mark Warschauer, Chair

Sentence processing skills contribute to successful L2 reading, and require understanding and manipulation of the order and interdependence of words within a sentence. Acknowledging that this syntactic awareness is significant but challenging in language development, a small number of researchers have explored whether modified text format increases reading abilities by raising syntactic awareness. This mixed within- and between-subjects study aims to examine whether phrase-segmented format, supported by visual-syntactic text formatting technology, scaffolds rapid and accurate L2 reading. Three groups of college students from the U.S. (NES and ESL) and Korea (EFL) read eight passages (4 block-formatted vs. 4 phrase-segmented) and answered four types of comprehension questions (topic, vocabulary, information, and inference-making). This study also investigates whether the format effect on rapid and accurate reading varies depending on L2 students' working memory capacity.

This study revealed three main findings. First, text format type did not generally affect reading speed in any language group, but the group difference between ESL and NES students narrowed in the phrase-segmented versus the block condition. Second, the

positive impact of the phrase-segmented format on comprehension was found among the L2 groups but not the NES group. Group differences in comprehension were mostly associated with the block condition rather than the phrase-segmented format, except for the persistent difference between EFL and NES groups across format. The third finding was that the phrase-segmented format did not influence the reading speed of L2 students with low working memory; however, it assisted them in making inferences and possibly expanding vocabulary.

Although syntactic cues are only part of a multifaceted L2 reading process, these findings provide support for the phrase-segmented format as a helpful resource to promote L2 reading comprehension without hindering reading speed. This study additionally demonstrated that reading phrase-segmented text may scaffold inference by alleviating working memory overload.

Chapter 1

Introduction

This study seeks to advance knowledge about how technology can enhance second language (L2) reading skills by assisting readers in chunking linguistic information as a cognitive strategy during reading. L2 readers in this study refer to both English as a second language (ESL) and English as a foreign language (EFL) readers. Becoming a proficient L2 reader involves developing automaticity in retrieval of text's linguistic information, such as lexical representations and syntactic patterns (Skehan & Foster, 2002). Skillful use of linguistic cues during reading alleviates cognitive load and contributes to a high level of comprehension seen in abilities such as inference generation (McNamara & Magliano, 2009). When added to lexical and world knowledge, syntactic signals can guide readers toward a rapid, accurate, and sophisticated construction of text in their mind (Givón, 2009).

L2 readers, however, are much less likely to use syntactic cues compared to first language (L1) readers (VanPatten, 2004), although they use vocabulary knowledge to comprehend L2 text in similar ways to L1 readers (Clahsen & Felser, 2006). Due to L2 readers' not-yet automatized linguistic knowledge, reading processing consumes a considerable amount of readers' cognitive capacity, which is inherently limited in storing and processing information and therefore results in inhibited proficient language comprehension (VanPatten, 2004). Chunking as an associative learning mechanism can not only reduce readers' cognitive load but also improve L2 reading in contexts that require substantial information processing capacity (Ellis, 2003).

From the beginning of learning a new language, we learn to chunk sounds, letters, words, phrases, and more (Ellis, 2003). This learning process is recursive rather than

linear; it helps learners build up hierarchical structures in memory that become easy to process and retrieve from a psycholinguistic perspective. Acquiring grammar particularly involves piecemeal processes in which learners need to repeatedly encounter a countless number of syntactic constructions from both oral and written discourses until they can abstract regularities from those streams of linguistic input. Given that the small absolute amount of exposure to L2 input, both oral and written, and especially in a foreign language learning context, is very low, enhancing syntactic knowledge seems exceptionally challenging.

In a digital era, a number of technological solutions have been developed and used to teach L2 metagrammatical knowledge. These tools typically focus on teaching discrete grammatical items. As opposed to these common approaches, which teach an analysis of L2 syntactic structures without reference to the setting in which they occur, this study aims to explore a way of using technology that provides a rich source of syntactic cues during real-time reading in order to assist rapid and accurate L2 reading.

Statement of the Problem

In an attempt to assist readers by making syntactic cues conspicuous to them, several L1 reading studies have manipulated text format (e.g., Cromer, 1970; Jandreau, Muncer, & Bever, 1986; LeVasseur, Macaruso, & Shankweiler, 2006). The methods, criteria, and algorithms used to convert text format have been changed with the advancement of technology. The main concept underpinning these studies, however, remains unchanged. That is, methods of enhancing syntactic awareness have centered on inserting extra space between phrases based on grammatical rules, syntactic constituency, and prosodic cues, in ways similar to how a skilled reader would parse sentences.

In L2 contexts, on the other hand, relatively little attention has been paid to methods for facilitating syntactic awareness (i.e., syntactic enhancement). However, a large body of work has supported the effect of input enhancement (i.e., making target words or forms noticeable) on L2 development (e.g., Lee, 2007; Lee & Huang, 2008; Smith, 1991). It is prudent not only to revisit syntactic enhancement studies in L1 contexts for their implications to L2 contexts, but also to investigate feasible methods and implementation of syntactic enhancement in L2 contexts.

Visual-syntactic text formatting (VSTF), which is automatic natural language parsing and text presentation technology, is a tool that can be used for syntactic enhancement for L2 readers. Studies have suggested that VSTF can scaffold L2 reading by easing eye movement (Walker, Schloss, Fletcher, Vogel, & Walker, 2005), increasing struggling readers' confidence (Park & Warschauer, 2016), drawing readers' attention to syntactic knowledge (Park & Warschauer, 2016) or prosodic cues (Park & Warschauer, 2016; Park, Warschauer, Collins, & Oak, 2013), increasing reading speed (Park & Warschauer, 2016), assisting their understanding of text (Walker & Vogel, 2005), and helping their retention (Walker & Vogel, 2005). Most of these studies hypothesized the potential influence of phrase-segmented format on readers' cognitive capacity, but did not test this influence. In addition, there are contradicting reports regarding reading speed as compared to regular block formatted reading.

As such, this study explores the effectiveness of phrase-segmented format in L2 reading environments and its potential relationship with readers' cognitive capacities. VSTF technology was chosen to convert block-formatted text to phrase-segmented format because of its hierarchical display of phrases in addition to its phrase segmentation based

on specific criteria.

Research Questions

Thus, the purpose of this study is to explore how text format types affect reading speed and comprehension of L2 students. In doing so, the study addresses the following research questions:

1. What is the relationship between text format types and reading speed among EFL, ESL, and NES students?
2. What is the relationship between text format type and reading comprehension among EFL, ESL, and NES students?
3. Are the effects of the phrase-segmented format on L2 reading speed and comprehension moderated by L2 readers' working memory capacity?

The unfamiliarity of this phrase-segmented format may make reading slower when compared to the conventional block format that most people are accustomed to; however, it is hypothesized that reading already-parsed text can compensate for possible speed reduction. I acknowledge that syntactic cues play a significant role in L2 reading processing but are insufficiently employed. This study therefore hypothesizes that the hierarchically segmented phrase format helps L2 readers, especially those with limited immersion experience in L2 environments, to accurately comprehend text. This scaffolding text format is also hypothesized to help alleviate readers' cognitive overload that commonly accompanies L2 reading processes, leading to the better performance of those with low working memory.

The following section presents definitions for key terms and concepts that are used throughout this dissertation.

Definition of Terms

English as a foreign language (EFL): EFL generally refers to the use or learning of English outside English-speaking countries. In other words, English is neither a general medium of instruction nor communication in EFL contexts, such as in South Korea and many other countries in Asia, Europe, the Middle East, and Central or South America.

English as a second language (ESL): ESL commonly refers to the use or learning of English within contexts in which English is an official or primary language for communication, such as in United States of America.

Input enhancement: Input enhancement is manipulating texts in a manner to make the target input more salient in order to positively affect the learning process of L2 students and thereby increase their language awareness. This attempt is what Smith (1991) called *input enhancement*, a technique to draw L2 students' attention to formal language properties by deliberately making them salient.

Native English-speaking (NES): NES students in this study are operationally defined as those who were born into English monolingual families in the United States of America and those who identify English as not only the language they speak the best but also the basis for their sociolinguistic identity. In the latter case, students have learned English at least before puberty and were educated in English. NES is mainly used for the description of the research methods and the results in this study. *L1 students* is interchangeably used with NES students.

Phrase-segmented format: Phrase-segmented format operationally refers to any attempt to vary space between words to indicate syntactic boundaries in order to increase reading abilities.

Reading fluency: Reading fluency is the ability to read rapidly not only with ease and accuracy, but also with appropriate expression and phrasing (Grabe, 2009). Specific skills that are required for this include rapid reading rate as well as rapid word recognition and accurate comprehension.

Reading comprehension: Reading comprehension can be defined as a mental representation that readers construct from textual information (van Den Broek & Kremer, 2000).

Syntactic awareness: Syntactic awareness can be defined as the sensitivity to correct ways in which words are put together, specifically in a sentence (Gary, Gobet, & Pine, 2007). In other words, syntactic awareness is an ability to phrase text into syntactically meaningful multi-word units, which helps readers understand how words, phrases, and clauses fit together in sentences to convey meaning, anticipate what comes next, and thereby avoid confusion. The extraction of syntactic information of words or word groups is essential for the construction of meaning from text (Grabe, 2009).

Visual-syntactic text formatting: As another phrase-spaced format, visual-syntactic text formatting (VSTF) technology makes syntactic structure salient. Unlike phrase-spaced format, VSTF changes lines and indentation instead of varying spaces between words to indicate syntactic boundaries.

Working memory: Working memory is generally defined as a storage system involved in the maintenance and manipulation of goal-relevant information (Baddeley & Hitch, 1974; Engle 2002). Working memory capacity depends on how one holds information in one's mind despite potentially interfering distractions (Jarrold & Towse, 2006). The original working memory model proposed by Baddeley and Hitch (1974) had

three mechanisms: an articulatory loop with a phonological store, a visual-spatial scratch pad, and a central executive for attention regulation. Later models (e.g., Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000) have suggested multiple executive functions of attention regulation, such as inhibition, mental set shifting, self-monitoring, and updating.

Significance of the Study

This study will be a significant endeavor in promoting technological application to syntactic scaffolding in L2 reading contexts. At least three reasons justify the need for more effective technology use that benefits real-time reading comprehension for L2 readers. Syntactic awareness is the necessary supplementary ability to skilled L2 reading. When skillfully capitalized on, syntactic cues can leverage cognitive overload, from which L2 readers commonly suffer. It is relatively challenging for L2 readers to acquire adequate syntactic skills and apply them to real-time reading. This challenge is greater for those with limited immersion experience in L2 environments.

The findings of this study will not only relate to those of similar phrase-segmentation studies that have mostly been done in L1 contexts, but also further contribute new information to the existing bodies of research, such as applied linguistics and psycholinguistics. This investigation will stimulate further empirical studies on the effective use of syntactic enhancement for L2 reading and/or its relations to the limited and dynamic nature of L2 readers' working memory resources.

In addition, this research will provide practical implications to L2 learners, educators, and text developers. L2 learners who have sufficient amounts of vocabulary but limited syntactic knowledge can benefit from reading hierarchically segmented text for more refined comprehension. As technology converts text format in several seconds, the

phrase-segmented format is easily accessible to any teachers who would like to make use of content-related activities rather than tedious metalanguage lessons within their restricted instructional time. Text developers should consider phrase-segmented text as a viable option for L2 reading resources instead of simplified versions of authentic texts.

Limitations

This study had several limiting factors that require consideration when making inferences about the results:

1. This study was limited in terms of participants' individual differences: native languages of L2 students and possible proficiency differences within each group. NES and ESL students were recruited from UCI. EFL students were recruited from two universities in South Korea. The native languages of ESL students were not considered in the data analysis. All of the EFL students spoke Korean as their L1. Although linguistic distance between L1 and L2 is considered a challenge in L2 learning, the analysis did not account for native languages of L2 group. Although there is a possibility that the English proficiency varied within each language group, this study only took into consideration the proficiency difference among the three groups.
2. This study was limited in terms of sample size. Although there was an acceptable number of participants, from which data was drawn to answer research questions 1 and 2, this was not the case for the research question 3. Reasons for this reduced sample size include outlier removal, attrition of EFL students in the working memory test, and invalid working memory scores. Therefore, two L2 group students (EFL and ESL) needed to be combined and regrouped for the hypothesis testing of the research question 3.

3. Because participants were recruited from different schools and different countries, testing environments were not identical across research sites.
4. This study did not include a large amount of time in which participants could become used to the phrase-segmented format. Participants read training passages in the phrase-segmented condition only until they felt comfortable taking a reading test in this condition.

In what follows, Chapter 2 concerns the theoretical framework on which this study is based, various theoretical perspectives relevant to the research questions, and empirical studies with a similar focus to that of the current study. Chapter 3 describes the details of the research design, the measures used to test hypotheses, and the testing procedures. Chapter 4 presents the analysis methods used and the results in relation to the research questions and hypotheses. Chapter 5 discusses the findings by integrating them with the literature reviewed in Chapter 2. Chapter 6 concludes by summarizing this study and elaborating on potential implications for future research and practice.

Chapter 2

Conceptual Framework

This chapter presents a synthesis of the literature that helped guide this study. I found clues to understanding the role of syntactic awareness in accurate and rapid reading. As such, I will first review a theory of comprehension, which helps us understand how syntactic awareness assists reading comprehension. The second section will address how working memory affects reading comprehension processes. This review will be followed by an exploration of the relationship between syntactic awareness and oral language skills, which will naturally lead to an investigation of the role of reading speed in the process of comprehension and its relation with syntactic awareness. The next section will concern L2 reading processes and syntactic awareness within the framework established in the preceding sections. The final section will discuss the use of technology with the aim of facilitating L2 syntactic awareness during reading.

Reading Comprehension and Syntactic Awareness

The reader's mental representation comprises various aspects, such as explicit information from the text, information associated to the text, and the inferences that readers make (McNamara & Magliano, 2009). The process of building a coherent mental representation entails an understanding of words, sentences, and their relations, for which lower-level processes (i.e., decoding, syntactic parsing) stand as prerequisites. Influential models of comprehension suppose that decoding and syntactic parsing contribute to comprehension (e.g., Construction-Integration, Structure-Building, Resonance, Causal Network, and Constructionist); yet, the impact of these lower-level processes has not been thoroughly explored in the models (McNamara & Magliano, 2009). Among the few models

that have taken into account lower-level processes, the Structure-Building model proposed by Gernsbacher (1997) largely involves dimensions of syntactic processing and its contribution to comprehension. The following section reviews fundamental assumptions of the Structure-Building model.

Structure-building model. Gernsbacher (1990, 1997) has focused on cognitive abilities involved in comprehension processes. The three primary cognitive processes in her model are *laying a foundation*, *mapping information onto the foundation*, and *shifting to build new substructures*. There are two mechanisms involved that control these primary processes: suppression and enhancement.

Readers first engage in laying a foundation, which usually occurs at the beginning of stories, sections, or paragraphs. This initial process demands more resources than the next comprehension processes, but plays a fundamental role as a structure on which subsequent information is mapped. Once the foundation is laid, readers map incoming information, which relates to previously processed information, from a new clause or sentence onto the existing structure or substructure. Mapping occurs when the incoming information is related to or overlaps with the existing information. Various types of cues signal overlap and likely lead readers to mapping: syntactic forms, conceptual repetition, causal coherence, and other cues for continuity. When incoming information is less coherent, readers lay another foundation or a new substructure. This is called shifting. Readers thus have mental representations that comprise multiple branching substructures.

Building structures and substructures as well as maintaining them is controlled by suppression and enhancement. Incoming information that coheres with the previous information can be enhanced and added for further structure building. In contrast, if new

information is not deemed to be necessary for constructing the current structure, readers may suppress this incoherent information or shift to a new structure.

Differences in comprehension skills depend on differences in the efficiency of these primary processes and mechanisms. In particular, skilled and less skilled readers are distinguished by how they deal with irrelevant information. While skilled readers can inhibit irrelevant information and create fewer substructures, suppression is lacking for less skilled readers so that they may have multiple substructures during reading (Gernsbacher, 1990).

The use of syntactic cues for building cohesive structures. One of the differences between skilled and less skilled readers is whether they are able to construct a hierarchical representation of text. As described earlier with Gernsbacher's (1997) model, less skilled readers tend to shift and create too many substructures that are hard to assemble into a whole structure, leading to these readers' slow processing and inaccurate comprehension. In other words, less skilled readers focus their attention on local levels and build a linear structure rather than a hierarchical structure. Such individual differences in comprehension skills have to do with how to utilize syntactic information as it signals coherence relations in text and guides the mapping process. Those who have inefficient enhancement and suppression mechanisms may have difficulty utilizing linguistic cues. For example, Gernsbacher and her colleagues found the facilitative effect of a syntactic form of preceding sentences (e.g., parallel form) on the comprehension of following sentences (1997). In this case, syntactic information served as a cue for mapping, facilitating the enhancement mechanism. Syntactic sources of information also help suppression mechanisms modulate the activation of potential meanings that a word or phrase might

have. When reading homonyms such as *bear* or *work*, readers may often activate multiple meanings of these ambiguous words. An ability to use the syntactic context (*She glanced at the bear* versus *He could not bear to see her grief*) helps readers suppress inappropriate meanings.

In the same vein as Gernsbacher's model, Givón (1995, 2009) and Kintsch and Mangalath (2011) have detailed syntactic cues as basic and continuous resources for the construction of structures and meaning. In particular, Givón provided support for syntactic cues being used for the enhancement mechanism in Gernsbacher's model. According to Givón, overt grammatical signals, including syntactic constructions, instruct readers in establishing a coherent mental representation of a text through anaphoric (backward) processing and cataphoric (anticipatory) grounding. Processing anaphoric elements refers to the connection of incoming new chunks of text to some existing mental representation. Grounding cataphoric elements involves the opening of forthcoming associations in not yet completed structure. Linguistic elements that provide coherence across text include referents, temporality, aspectuality, modality/mood, location, and action/script. Both vocabulary and syntactic knowledge can guide readers through the processing of these elements. Givón argued that, while vocabulary knowledge is fundamental for fine-grained text comprehension, syntactic cues can expedite the processing of text coherence elements and thereby comprehension.

Kintsch and his colleague (1995, 2011) also stressed the important role of syntax in forming a coherent mental representation of text as it guides parsing processes. He stated that parsed chunks are easy to analyze and retain in the working memory buffer (cognitive perspective will be discussed in more detail in the following section), assisting readers

make connections between the previous information (either of text or of world) and the current input. In this process, a large amount of readers' knowledge can be activated or inhibited, but does not necessarily remain activated. Some portions of the information become deactivated unless they relevantly fit into the current context. In other words, syntax-cued comprehension processing enables readers to make causal inferences by selecting coherent and relevant ideas from multiple information. This understanding of Kintsch reminds us of the suppression mechanism in Gernsbacher's model.

Going back to the disparity between skill and less-skilled readers, some studies other than those dealing with comprehension theories have also attended to the use of syntactic cues (e.g., reading strategy and eye movement studies). One of the strategies that skilled readers commonly employ when reading challenging texts is to grasp words in clausal or phrasal units (LeVasseur et al., 2006). This is a process that helps them understand how words, phrases, and clauses fit together in sentences to convey meaning, anticipate what comes next, and thus avoid confusion. In contrast, poor readers read one word at a time (Cromer, 1970) and rarely parse words into phrases or clauses (Fuchs, Fuchs, Hosp, & Jenkins, 2001). This tendency is consistent with what has been observed in eye movement studies where poor readers tend to have a higher number of fixations, longer fixation durations, and more regressions (Hutzler, Kronbichler, Jacobs, & Wimmer, 2006; Rayner, Chace, Slattery, & Ashby, 2009). This value of understanding phrase and clausal structure of sentences helps explain why students' syntactic awareness is significantly related to both fluency and comprehension (Gaux & Gombert, 1999; Ravid & Mashraki, 2007; Mokhtari & Thompson, 2006).

Working memory and reading comprehension. Reading comprehension is subject to various inherent constraints on human cognitive capacity, for example, working memory, which is the capacity to store and manipulate information online (Carretti, Borella, Cornoldi, & De Beni, 2009). A number of complex span tasks have been developed to measure this ability to simultaneously process and store information (Unsworth, Heitz, Schrock, & Engle, 2005). Task types vary depending on items to be processed and remembered (e.g., verbal, numerical, or spatial). Studies have found that the processes of processing and storage in complex span tasks are highly related to higher-order cognition (e.g., Unsworth, Redick, Heitz, Broadway, & Engle, 2009). Other studies have shown that an individual's working memory capacity reflects a domain-general factor such that various complex span tasks, not just verbal tasks, account for variance in verbal ability tests (e.g., Kane et al., 2004; Li, Christ, & Cowan, 2014). In fact, it is well documented that skilled readers tend to have higher working memory capacity than do less skilled readers (Cain, Oakhill, & Bryant, 2004; Sesma, Mahone, Levein, Eason, & Cutting, 2009; Swanson & O'Connor, 2009). The following paragraphs further detail the relationship between working memory and syntactic awareness in the process of reading comprehension, mainly drawing on Gernsbacher's (1997) comprehension model.

Working memory in structure building. Taking into account the aforementioned individual differences of using syntactic cues, it is fruitful to speculate how varying working memory capacities affect the enhancement and suppression mechanisms within Gernsbacher's (1997) model. One key question is whether the high working memory capacity entails maintaining more information to be used for enhancement or less information as a result of suppression. Considering that chunking (i.e., grouping of several

single units into a meaningful compound element) is a common learning strategy to increase the efficiency of working memory (Cowan, 2012), it seems reasonable to conjecture that high capacity readers store large amounts of inputs effectively by chunking them. This is empirically evidenced by a number of studies suggesting that individuals with greater working memory capacity tend to hold more information relevant to a current task (Swanson & O'Connor, 2009; van Leeuwen, van den Berg, Hoekstra, & Boomsma, 2007). The pieces of information retained in one's consciousness can help one with anaphora or cataphora resolution. For example, when reading a pronoun, a reader with high working memory capacity tends to recall the noun to which the pronoun refers. This is how the new information that is related to the current structure becomes enhanced in the mental structure according to Gernsbacher's model.

The existing literature, however, yields support for suppression as well as enhancement. Another line of research has shown that high capacity readers inhibit irrelevant information such that they store less information than low capacity readers (Kane, Conway, Hmabrick, & Engle, 2007; St Clair-Thompson & Gathercole, 2006). This implies that readers with high working memory are more likely to suppress the new irrelevant information and to shift to a new substructure. In either case, enhancement or suppression, the result can be the efficient construction of structures in readers' mental representation, accordingly leading to resourceful memory storage for readers.

Given the limited working memory involving a combination of storage and processing, another question concerns whether this efficient mental structure building affects higher level processing such as inference generation. An inference can be defined as information that is implicit in the text but that can be made by connecting two or more

pieces of information (Elbro & Buch-Iversen, 2013). Inference can be as simple as solving anaphora resolutions or as complex as drawing on world knowledge.

Research supports that high capacity readers can generate more inferences while reading than low capacity readers (Estevez & Calvo, 2000; Cain et al., 2004). I conjecture that this association between cognitive capacity and high level comprehension ability should be reviewed within the frame of enhancement and suppression mechanisms. For instance, high capacity readers simultaneously retain multiple cohesive information blocks in working memory, serving as resources that allow them to construct more inferential relationships of a given story, such as identifying (in)consistencies in a text (e.g., Carretti, Cornoldi, De Beni, & Romano, 2005). The suppression mechanism may be helpful in this higher order cognitive process as well. High capacity readers have less irrelevant information in memory than low capacity readers, information which would otherwise compete for working memory resources and disrupt inference making processes (McNamara & O'Reilly, 2009).

Syntactic cues as a facilitator for inference generation. Although an inference-making ability in large part depends on varying degrees of one's knowledge structure (Elbro & Buch-Iversen, 2013), syntactic cues in text can also play a role in this higher level of information processing. According to Givón (2009), surface information of text, including syntactic cues, does not survive beyond one's working memory; however, this information assists readers in placing chunks, with which the information is associated, in a coherent structure—a hierarchical and sequenced representation of text. This associatively structured network of text can make information be more readily available for later retrieval. Givón added that a current context cues the retrieval of stored information.

Although he did not directly address the role of syntactic information of current text in the old information retrieval, one may take this and his previous explanation as an implication that syntactic sources in the given context can make it easy to access and recollect the stored information for making inferences.

Kintsch (1995) agreed with Givón that syntax plays a role of mental process instruction in comprehension processes. He argued that due to limited working memory capacity, all of the information cannot always remain activated; instead, readers experience recurring processes of analyzing, storing, and connecting pieces of chunks from text. Syntactic cues usher readers through this processing, telling them specifically where to search for what in a specific text (e.g., subject-verb-object construction, cues for topicality, etc.). It is in this way that although sophisticated levels of comprehension cannot be completed without full knowledge (e.g., vocabulary, prior knowledge, etc.) about a given text, syntactic cues can expedite the readers' processing toward high levels of comprehension, such as inferences (Kintsch, 1995).

Word knowledge and syntactic awareness. One clue to understanding the role of syntactic awareness in reading may also lie in its association with vocabulary development. Word knowledge is the principal source that learners refer to when they try to make sense of L2 input (VanPatten, 2004). Research on the relationship between vocabulary and reading comprehension shows that readers need to be familiar with 95 percent or more of the words in a text if they are to be able to comprehend the text and to infer the meanings of new words (Horst, 2009). In fact, a number of theorists have placed word knowledge at the center of their reading models, such as the Reading Systems Framework (Perfetti & Stafura, 2014). Perfetti and Stafura maintained that readers' word knowledge plays a

fundamental role in local comprehension processes that necessitate the integration of word level and text level comprehension systems. They added that adequate syntactic processing can make this system integration robust and thereby lead to skilled reading. The next paragraphs provide examples showing how syntactic awareness is closely associated with developing vocabulary knowledge.

First of all, syntactic knowledge assists building multiple meanings that connect to a single form (e.g., *bear* as ‘animal’ or ‘to carry’). Commonly in L2 learning contexts, words are taught and tested as isolated units—to map a form to a meaning. Therefore, most learning time is spent on the definitions of words as basic vocabulary knowledge. This is because L2 learners need extra exposure to the form-meaning mapping as compared to L1 learners, who frequently encounter utterances that have a readily identifiable meaning. Moreover, L2 learners should understand that vocabulary frequently has multiple meanings instead of focusing on the one-to-one relationship between form and meaning. While the one-to-one relationship can be achieved even without referring to other resources available in context, multiple meanings of a word that are sometimes unrelated to each other are nuanced by, and should be inferred from, the context in which the word appears even if the word is already familiar to the reader (Scott & Nagy, 2009). Developing such extended mapping (the process of progressive refinement of word knowledge, Nagy & Scott, 2000) requires syntactic awareness. For example, interpreting *bear* meaning “animal” and *bear* meaning “to carry” necessitates not only more than one form-meaning association but also an ability to analyze the structure of a sentence where the word appears.

Identifying the grammatical function of a word largely depends on morphological awareness (i.e., an ability to recognize morphological structure and employ word formation rules). Effective morphological awareness requires syntactic awareness (Nagy & Scott, 2000). As an example of morphemes, *works* can be divided into two morphemes, *work* and *s*. Derivational suffixes, such as *-s* in *works*, which give crucial help in grasping meanings of new words, reflect on a syntactic role of the suffixed word in a sentence. Therefore, developing morphological awareness is closely related to syntactic awareness. Children usually acquire basic morphological insight around the fourth grade and continue to develop morphological awareness beyond that grade level (Berninger, Abbott, Nagy, & Carlisle, 2010).

Empirical studies have supported the positive influence of syntactic awareness on vocabulary skills. Training to read for context has resulted in increased abilities to learn words (Kuhn et al., 2006), not by increasing short-term phonological memory, but by increasing metalinguistic and metacognitive awareness (e.g., syntactic awareness). In another training study (Snellings, Van Gelderen, & De Glopper, 2002), lexical access speed improved for students who received computerized training that required them to make decisions about target words (e.g., whether an item was used appropriately in a sentence)

Oral Language Skills and Syntactic Awareness. A significant association between oral competence and reading has been well documented in studies that examined and developed Hoover and Gough's Simple View of Reading (1990). In the literature surrounding this reading model, there is a consensus that reading comprehension requires two independent components: automatic word decoding and effective linguistic comprehension skills (Catts, Adlof, & Weismer, 2006; Hoover & Gough, 1990; Joshi &

Aaron, 2000; Scarborough, 2001; Vellutino, Tunmer, Jaccard, & Chen, 2007). Decoding refers to the process of translating a printed word into a sound. Linguistic comprehension includes parsing, bridging, or discourse building. The linguistic comprehension skills in the simple view of reading model was measured by listening comprehension. In fact, listening comprehension skill is highly related to written language comprehension (Berninger & Abbott, 2010).

The relationship between decoding and linguistic comprehension in the reading process is graphically depicted by Scarborough (2001), where decoding skills and linguistic comprehension represent two major strands that are woven together to form a rope of skilled reading. As a strong rope is built with relatively equally balanced individual strands, it seems ideal to develop both decoding skills and linguistic comprehension in a proportionate manner to prevent rope kinks.

What is interesting is that the two major strands of reading are thought to develop and operate to some extent separately in reading acquisition and the reading process (Hoover & Gough, 1990). It is evidenced by some empirical studies that poor decoders have deficits in phonological processing but not in linguistic competence while poor comprehenders have the opposite pattern (Catts et al., 2006; Nation, Cocksey, Taylor, & Bishop, 2010). In a longitudinal study to test relationships between reading achievement, intelligence, language competencies, and phonological processing from kindergarten through eighth grade, poor decoders demonstrated equal or better reading comprehension scores as compared to typical readers, despite their poor word reading abilities (Catts et al., 2006). These poor decoders may compensate for their decoding deficits with advanced language processing skills, such as parsing, bridging, and discourse building. In the same

study, however, poor comprehenders who had similar reading comprehension scores with poor decoders in second grade started to show diverging scores in fourth grade. In other words, their ability to decode individual phonemes and words is a necessary skill for effective reading but not a sufficient skill for effective comprehension (Cain, Oakhill, Barnes, & Bryant, 2001; Catts, Fey, Zhang, & Tomblin, 1999; Nation & Snowling, 2000), especially as readers move up in grade level and encounter texts of greater variety and complexity.

These disparate difficulties experienced by poor decoders and poor comprehenders allow us to consider the importance of syntactic awareness in reading. One of the strategies that skilled readers commonly employ when reading challenging texts is to grasp words in clausal or phrasal units (LeVasseur et al., 2006). This is a process that helps them understand how words, phrases, and clauses fit together in sentences to convey meaning, anticipate what comes next, and thus avoid confusion. In contrast, poor readers read one word at a time (Cromer, 1970) and rarely parse words into phrases or clauses (Fuchs et al., 2001). This tendency is consistent with what has been observed in eye movement studies where poor readers tend to have a higher number of fixations, longer fixation durations, and more regressions (Hutzler et al., 2006; Rayner et al., 2009). This value of understanding phrase and clausal structure of sentences helps explain why students' syntactic awareness is significantly related to both fluency and comprehension (Gaux & Gombert, 1999; Ravid & Mashraki, 2007; Mokhtari & Thompson, 2006). This discussion naturally leads us to the next section—reading fluency and syntactic awareness.

Reading Fluency and Syntactic Awareness. The role of using syntactic cues in reading can be understood in its relationship to rapid reading as well as accurate reading. Although the reading rate that this study examined is not always interchangeable with

reading fluency, this section considers fluency as a broader umbrella term and reading rate is its key factor. According to the National Reading Panel (2000), reading fluency is a set of skills that allows readers to rapidly decode text while maintaining a high level of comprehension. This may include readers' ability to make logical connections within and between sentences to make sense of a text as a whole and to review their prior knowledge in order to construct new knowledge based on reading (Fuchs et al., 2001). Therefore, automatic syntactic processing (Grabe, 2009) and recognition of phrasing (Kuhn & Stahl, 2003) are among the skill components needed for reading fluency. Given the complex and dynamic series of tasks related to reading, faster speeds of syntactic processing may indicate that fewer cognitive resources are needed to make meaningful connections among sentences (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). This in turn makes more cognitive resources available for other comprehension-related activities, such as making inferences or retrieving background knowledge.

Further elaboration on the correlation between reading fluency and comprehension is needed. In fact, fluency development is often neglected by teachers and learners who feel that they should always be learning something new, as Nation stated (2009). Yet, considering successful reading necessitates accurate and rapid reading (Kame'enui & Simmons, 2001), fluency, which involves making the best use of what is already known (Nation, 2009), requires proper attention. The studies reviewed below provide empirical evidence indicating that reading fluency is an important factor in comprehension and that syntactic awareness is closely engaged in the relationship between fluency and comprehension

In particular, Klauda and Guthrie (2008) found that various levels of fluency and

reading comprehension had a strong positive bidirectional relationship. Their study of 278 fifth graders examined fluency at three levels—word, sentence, and passage—and the relationship of each level to reading comprehension. Word-level fluency means the correct and effortless recognition of individual words, and sentence-level fluency concerns the readers' capacity to parse text into meaningful phrases. Fluency at the passage level refers to the processing of passage-level features, such as the macrostructure of the text. At the beginning of the school year, a series of tests were administered, including a comprehension test, background knowledge test, and inference-making test as well as three different levels of fluency tests. Twelve weeks later, all participants again completed the comprehension test and the sentence-level fluency test at the same level as the original test point. Reading fluency at the beginning of the study predicted growth in comprehension 12 weeks later. Likewise, comprehension at the beginning of the study predicted growth in fluency 12 weeks later.

In addition to rapid recognition of words, phrases, and sentences, reading fluency involves reading with appropriate prosodic components, that is, the rhythmical features of speech that include stress, pitch, and duration (Kuhn et al., 2006; National Reading Panel, 2000). Prosodic features play an especially significant role in oral communication (Speer & Ito, 2009), but they are also useful in the reading process (Miller & Schwanenflugel, 2006). Prosody again is highly associated with syntactic awareness, as prosodic features suggest syntactic information that cannot be easily conveyed in a linear manner. When phrase boundaries are not explicitly marked in written texts, prosodic cues can aid readers in constructing meaning by segmenting or chunking text into syntactically appropriate and meaningful phrases. A number of studies have found that skilled readers capitalize on

prosodic knowledge during both oral reading and silent reading (Ashby, 2006; Benjamin & Schwanenflugel, 2010; Miller & Schwanenflugel, 2006).

The role of prosodic knowledge in reading comprehension provides convincing evidence regarding how significant syntactic awareness is linked to effective reading. A correlation study conducted by Whalley and Hansen (2006) examined the relationship between word- and phrase-level prosodic sensitivity and reading ability. A total of 84 fourth graders were tested on reading ability, phonological awareness, word-level prosodic sensitivity, phrase-level prosodic sensitivity, and rhythmic sensitivity. For the phrase-level prosody test, students were asked to match a spoken phrase with a phrase that substituted the words with nonsense syllables but retained the prosodic features of the spoken phrase. After controlling for phonological awareness and general rhythmic sensitivity, students' prosodic word and phrase sensitivity predicted unique variances in word-reading accuracy and reading comprehension. Phrase-level prosodic sensitivity predicted unique variation in reading comprehension after additionally controlling for word reading accuracy. Whalley and Hansen interpreted their findings as evidence that prosodic sensitivity helped students recognize syntactic structure, thereby facilitating text comprehension.

L2 Reading Comprehension as Structure Building and Syntactic Awareness

Simply speaking, L2 readers process information more slowly, use fewer metacognitive strategies, and monitor comprehension more slowly (Goldenberg, 2011). It is challenging to move beyond this stage and achieve competence in L2 reading. Employing the framework set forth in the previous sections, the following paragraphs discuss factors underlying this challenge and suggest what it takes to become proficient L2 readers.

L2 oral language skills. A significant association between oral competence and reading has been already discussed in the previous section within the frame of the simple view of reading (see Hoover & Gough, 1990). L2 sentence comprehension is also strongly correlated with L2 oral competence (Lefrancois & Armand, 2003). When learning a mother language, children can extract and remember linguistic knowledge (e.g., sound sequences and syntactic structure) that is learned from oral communication when they encounter new vocabulary and syntax while reading. However, this is less likely to happen for L2 learners, because they can be, and often are, taught reading before reaching a certain level of oral English proficiency (Goldenberg, 2011). The learning seems even harder in contexts where there is little exposure to oral communication, such as EFL contexts. With insufficient spoken language data available for processing, EFL readers have far fewer chances than L1 speakers or ESL readers to transfer linguistic knowledge that is learned from oral communication to written texts. This implies that it is very challenging for EFL readers to develop knowledge related to language forms on their own.

Working memory overload. Like in reading in general, both storage and processing abilities contribute to L2 reading processing. This is evidenced by research findings that L2 reading scores were explained by test-takers' working memory span but not by their simple storage-only memory (Juffs & Harrington, 2011). Yet, L2 readers are possibly faced with an extra load on working memory during L2 processing, as L2 language process exerts a greater demand on the processing and storing capacity of working memory than L1 processing (VanPatten, 2004). The reason for this particular challenge involved in L2 reading can be found in information processing theories.

According to information processing models that explain how information is stored

and processed in the human mind, learners can attend to and process only a limited amount of information at a time, due to limited working memory (Baddeley, 2003). Sometimes learners do not need to pay much attention or make much effort to process information, whereas other times, they are consciously aware of other processes that require a substantial number of resources. Depending on the amount of attention and effort that a process requires, the process can be controlled or automatic. Controlled processes make considerable demands on cognitive capacity and require more resources, while automatic processes are unintentional and relatively effortless with little need for processing energy. From this information processing view of language, L2 researchers asserted that L2 acquisition requires more controlled processes that exert a greater demand on the processing capacity of working memory, because L2 learners may have little proceduralized linguistic knowledge (Loewen, 2005).

Linguistic distance between L1 and L2. Another factor that may discourage L2 readers from using syntactic cues is the linguistic distance between L1 and L2. van Hell and Tokowicz (2010) assert that the more dissimilar L2 syntactic structure is from L1, the less likely L2 readers are to catch syntactic cues. They further note that L2 readers' inefficiency in processing syntactic information would prevent them from automatic structure building out of text. Bernhardt (2000, 2011) acknowledges a disproportionate contribution of L1 literacy to L2 reading development and proposes a compensatory model of L2 reading. She argues that readers' L1 knowledge, which accounts for 20 percent of L2 reading processing, can compensate for deficiencies in L2. In this process of compensation, the contribution of L1 literacy to L2 reading development varies depending on the similarity between the L1 and L2. She stresses that we need to distinguish reading languages that share cognate

words and syntactic similarity from reading languages that do not. This is also why L2 reading for those with high linguistic dissimilarity with a target language entails significantly more parsing errors than those without (Frenck-Mestre, 2005).

In fact, a number of studies have examined linguistic distances between native languages and a target language and how the distance between the two influences the efficiency of learning L2. Chiswick and Miller (1995) have studied the relationship between English acquisition of immigrants and their income-level with focus on the linguistic distances between English and their native languages. In this and their subsequent studies (e.g, Chiswick, Lee, & Miller, 2005), immigrants whose native languages were more distant from English in terms of language family had less likelihood of gaining high proficiency in English compared to those whose native languages were more linguistically similar to English. A similar result was found in another study, where the linguistic distance between German and other languages was measured and its effects on the proficiency of learning German were examined (Isphording & Otten, 2013). Greater linguistic distance decreases the probability of being proficient in the host country's language, which is more apparent in the case of older learners' language acquisition.

Enhancing syntactic awareness for structure building. Through the repeated exposure to and experience of language, linguistic knowledge becomes proceduralized (Lyster & Sato, 2013). Among other critical components of linguistic knowledge, increasing syntactic awareness is a prospective contributor toward proceduralizing linguistic knowledge based on the preceding discussion. However, it seems exceptionally challenging for L2 readers to achieve the proceduralization of syntactic skills as compared to other language skills until they develop strong knowledge of the syntax to the extent that they

can perform syntactic parsing nearly as effortlessly as L1 readers do (Bernhardt, 2000).

In fact, L2 readers are significantly less likely to utilize syntactic cues than other linguistic information while reading. VanPatten (2004) theorizes that once meaning is taken into account as default for information processing, L2 learners' attention can then be directed to *less important* structures in the input. Due to the limited attentional resources of L2 learners, they selectively process input for meaning before form, lexical items before grammatical form, and meaningful grammatical forms before non-meaningful grammatical forms. This processing pattern has been reported in a number of empirical studies. For example, L2 readers relied more on non-syntactic information than syntactic information (Felser, Roberts, Gross & Marinis, 2003; Lee & VanPatten, 1995; Papadopoulou & Clahsen, 2003). Adult L2 readers were able to use lexical semantic cues in the same way as L1 readers but this was not the case in terms of syntactic information (Clahsen & Felser, 2006; van Hell & Tokowicz, 2010). L2 readers were also less efficient in integrating prosodic cues in reading tasks than L1 readers (Akker & Cutler, 2003). Therefore, it is not surprising that L2 readers, especially those with low proficiency, tend to have weak syntactic processing skills.

Despite aforementioned adverse factors, syntactic awareness needs to be meticulously developed for effective L2 structure building processes. In this sense, VanPatten (2004) early on suggested that L2 reading instruction should be designed in a manner that discourages readers from solely relying on meaning-based cues and from ignoring syntactic cues. Teaching how to chunk isolated pieces of words into meaningful phrases can be a useful instructional strategy, as a way to reduce working memory load and to facilitate the reading mechanisms. In fact, studies on the cognitive process have

demonstrated that meaningful unit-based chunking of information has beneficial effects on learning, either by reducing repeated attention-switching between old and new information (Barrouillet & Camos, 2007) or by reducing the cognitive load that learners need to identify salient boundaries between information units (Schwan, Garsoffky, & Hesse, 2000; Wouters, Paas, & van Merriënboer, 2008). However, chunking as a reading strategy is insufficient in providing learners with abilities to capture hierarchical syntactic structure. From an instructional perspective, it is time consuming and uneconomical to teach how to parse sentences while students are reading. The following section turns its attention to the use of technology to address such issues.

Technology-Enhanced Reading

Technology is adaptive and facilitates repetitive practice, thereby allowing for learning in and outside of classrooms. This is especially helpful in EFL settings, where students learn mainly through interaction of non-native English teachers and textbooks. Regardless of individual learning or instructional context, there are a number of technological applications that help improve reading English. For instance, those who want to improve their basic grammatical knowledge of English can easily access many cell phone applications, including those that work on grammar, punctuation, and test-specific grammar skills. On the other hand, there are also many software programs for those who want to enhance or teach comprehension skills. This software that provides comprehension strategies helps individuals learn discipline-specific knowledge (Computer Assisted Strategy Teaching and Learning; Sung, Chang, & Huang, 2008). Animated instructional agents in an e-reading program facilitate development of metacognitive awareness and learning comprehension strategies (e.g., Rose & Dalton, 2002). When

students have limited background knowledge relevant to the reading materials, teachers can use online multimedia resources (e.g., PBS or National Geographic).

Input Enhancement. There are a relatively small number of technology applications, though these involved only minimal use of technology, which emerged within the framework of focusing on syntactic awareness while enabling reading for meaning. Such technology-enhanced reading modes were designed based on the assumption that natural exposure alone is insufficient to enable struggling readers to acquire the knowledge of English grammatical forms. These kinds of input modification aim to change the way input (i.e., grammatical features) is perceived by EFL readers by transforming input that may be otherwise unnoticed. For example, the frequently used input modification mode is visual input enhancement, which emphasizes a target grammatical form in a given text, as shown in Figure 2.1. For visual input enhancement, prosodic cues in oral communication are substituted with orthographic conventions in reading, which include italicizing, underlining, boldfacing, and capitalizing. This text modification mode may help EFL learners saturated by input flooding, leading them to notice a target form while maintaining a communicative focus. However, the limitation of this method is to isolate one grammatical form (e.g., passive form) at a given time. This text presentation type does not seem to help increase overall syntactic awareness, an ability to phrase text into syntactically meaningful multi-word units.

The opinions of this junto **were** completely **controlled** by Nicholas Vedder, ... It is true he **was** rarely **heard** to speak, but smoked his pipe incessantly. His adherents, however (for every great man has his adherents), perfectly understood him, and knew how to gather his opinions. When any thing that **was read** or **related** displeased him, he **was observed** to smoke his pipe vehemently; and to send forth short, frequent and angry puffs; but when **pleased**, he would inhale the smoke slowly and tranquilly, and emit it in light and placid clouds; and sometimes, taking the pipe from his mouth, and letting the fragrant vapor curl about his nose, would gravely nod his head in token of perfect approbation.

Figure 2.1. Visual input enhancement. Some verb phrases in an excerpt from Rip Van Winkle (written by Washington Irving) are boldfaced to highlight passive verb construction.

Syntactic Enhancement. Another way of input modification is text reformatting, making it possible to increase the quantity and quality of targeted input. There has been an attempt to draw readers' attention to overall syntactic structure. Traditional block text format, which all readers are familiar with, is dense, packing a considerable amount of text content into a limited space. Avoiding the linear sequence in block text, text-reformatting studies have used varying degrees of technology to divide texts into smaller units (hereafter syntactic enhancement). However, only a few studies has investigated the effect of syntactic enhancement on reading skills in either L1 or L2 contexts. Though different studies used different terms to indicate syntactic enhancement, including meaningful phrases condition (Cromer, 1970), phrase spacing (Jandreau & Bever, 1992; Jandreau et al., 1986), phrase cued text (LeVasseur et al., 2008), and visual text formatting (Walker, U.S. Patent No. 6,279,017, 2001), the concept that underlies these studies is segmenting phrases (chunks or clusters) based on meaning. By using *phrase-segmented* as a common term to represent syntactic enhancement conditions, the following paragraphs review how each

study implemented its conditions and how the phrase-segmented format affected reading performance.

As early as in 1970 Cromer found that additional space between major phrase boundaries in printed text supported those who poorly parse sentences to read as well as normal readers. In his study, a total of 64 college students read five stories and answered 20 comprehension questions under four conditions—regular sentences, single words, phrase-segmented, and fragmented word groupings. The single words condition had each word typed separately on a roll of paper. In the phrase-segmented condition, words were presented in groups, which were determined by a criterion of syntactic structures, punctuation, and semantics. In order to establish this condition, two researchers made the phrasings independently and then deliberated to come to an agreement on phrasings in each sentence. In contrast, the fragmented groupings condition presented words in relatively meaningless groups with the same length. None of the groupings in this condition was the same as phrases used in the phrase-segmented condition. Cromer found that poor readers performed as well in the phrase-segmented condition as good readers did in either the regular or the phrase-segmented conditions. These two groups had the comparable intelligence and vocabulary knowledge, but the average reading level of the poor readers were three years behind the good readers. The scores of the poor readers in the phrase-segmented condition were even higher than those of the good readers in the single words or fragmented conditions. Cromer employed this as the evidence that the phrase-segmented format facilitated the readers who did not otherwise use syntactic cues (i.e., reading word by word or fragments) due to their low syntactic awareness.

Drawing on Cromer's (1970) research, Jandreau and his colleagues (1986)

developed an algorithm that determined varying degrees of space between words depending on syntactic structure and investigated the effect of converted texts using this algorithm. Unlike Cromer's study in which spaces indicating phrase boundaries were assigned by hand, Jandreau and his colleagues used an algorithm for automatically converting texts. This algorithm first identified whether each word was a function word or a content word. Then the words were checked for which pattern they were categorized into (e.g., modal verbs and determiners). Once a pattern was determined, the algorithm inserted a break into phrase boundaries. The size of the breaks varied. As a result, different sizes of spaces between words indicated a hierarchical syntactic structure within each sentence (e.g., <<<<Mary> <was sitting>> <<on> <the seashore>>> <<one hot day> <in June.>>). College students ($n = 44$) read passages both in normally spaced or phrase-segmented condition. The findings indicated that reading speed (i.e., the total number of words read) was 16% faster in the phrase-segmented than the normal condition. Jandreau et al. conducted a similar experiment with more finely segmented texts, in which college students ($n = 36$) read 20% faster in the phrase-segmented than in the normal condition.

A few years later, Jandreau and Bever (1992) explored the effect of syntactically cued text on a comprehension task. They used an algorithm for recognizing word class and patterns, then isolating minimal length phrases, and finally indicating phrase breaks. Extra spaces were added at the end of each within-sentence phrase group. This phrase-segmented condition was compared to both normal-spaced and even-spaced conditions. In the latter text condition, extra space was simply added between each word. A total of 134 L1 college students participated, among whom there were 65 average and 69 high proficiency students based on their verbal SAT scores. The participants read ninth- and

tenth-grade level science texts in normal-spaced and even- and phrase-segmented format. While no effect of text format was found on reading speed for both proficiency groups, the phrase-segmented format was effective for comprehension, for average proficiency students.

LeVasseur et al. (2008) examined the effect of phrase-segmented text on L1 reading fluency and comprehension in their repeated reading training study supported by a computer-based reading training program. English L1 students (ages 7 to 9 years) participated in three conditions of training: word list, standard text, and phrase-segmented text. In particular, phrase-segmented text had salient phrase boundaries that were indicated by extra spaces between them. Clausal structures were also preserved at line breaks. For example, noun phrases, verb groups, and predicative adjective phrases, which were identified as a syntactic chunk, were spaced and preserved. These boundaries were adjusted to associate complementizers, prepositions, and connective devices. The findings of this study suggest that all three training conditions positively affected reading comprehension. Repeated reading training regardless of text format positively affected reading fluency as compared to reading training with word lists. Phrase-segmented text reading especially resulted in greater gains in fluent reading with natural prosody than the other two reading conditions.

Walker (2001) developed another phrase-segmented format which is relatively more sophisticated than those in the previous studies: visual-syntactic text formatting (VSTF). In addition to the idea of making clausal boundaries salient as syntactic enhancement, Walker attempted to visualize the hierarchical syntactic structure by displaying no more than a couple of phrases per line as well as including varying degrees of

indentations. Figure 2.2 shows an example of a linear text (at the top) and how some of its clauses are nested within larger ones (in the middle). In order to present this complex structure in VSTF (on the bottom), computer calculations are performed for each sentence in the text (Walker, 2001). The procedure ordering algorithm which is simplified from that in Walker (2001) is as follows:

1. Tokenize each sentence into words and punctuation
2. Identify characteristics of each word: possible parts of speech, numbers of syllables, educational levels, and pronunciation time
3. Investigate further the features of a word (e.g., reader- or text-specific lexicon) and disambiguate multiple parts of speech
4. Apply folding point rules using punctuation and parts of speech
5. Create text segments based on folding points and minimum/maximum line lengths (minimum and maximum line lengths were determined based on the range readers wish to see on a separate line, resulting in a range of 10 to 35 characters per line)

Given that syntactic processing is the transformation of a linear structure of words into a hierarchical structure (Hurford, 2011), VSTF's additional feature of visualized hierarchical syntactic structure makes it appropriate for the purpose of this study. Since this syntactic processing takes up readers' working memory load during the left-to-right processing of a sentence (King & Just, 1991), already-transformed text in VSTF is hypothesized to facilitate L2 reading. The next section discusses in some detail whether and how VSTF affected reading performance of L1 and L2 students.

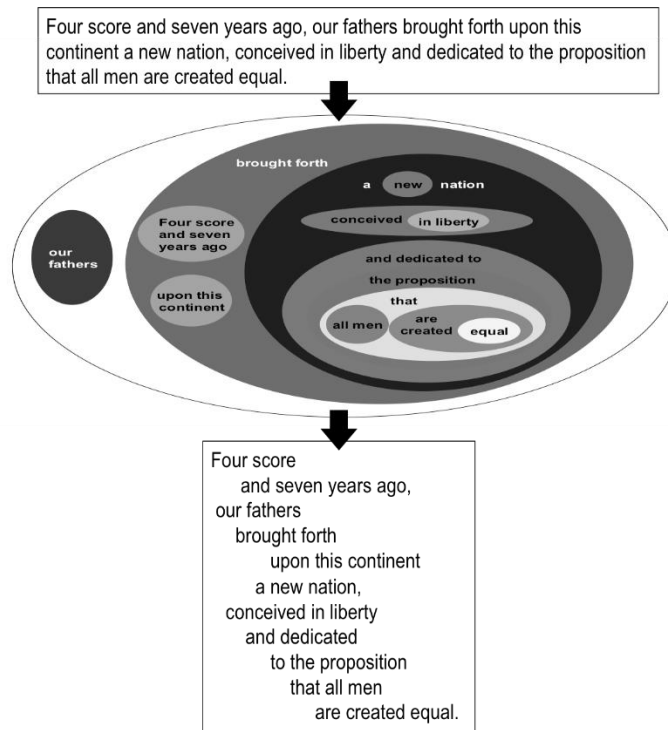


Figure 2.2. Text converted into visual-syntactic text formatting (VSTF).

VSTF: Findings and limitations from previous studies. Some studies conducted by VSTF developers and others explored the effectiveness of segmented phrases across multiple rows out of one sentence, though few studies were published in refereed journals. Unlike the aforementioned syntactic enhancement studies, most of VSTF studies included not only L1 students but also L2 students as participants.

Walker and his colleagues tested the hypothesis that phrase-segmented format would help overcome the physical limit of human eye spans, leading to efficient reading (Walker et al., 2005). In this within-subjects study, 48 college students wore eye-tracking equipment to measure the amount of total eye fixation time per word while reading three passages in block format and three in phrase-segmented format supported by VSTF on computer screens. Walker et al. found that readers had shorter fixation durations and fewer regressive eye movements per word in the phrase-segmented condition, resulting in

a 20 percent faster reading rate. Participants answered comprehension questions with 40 percent greater accuracy for the phrase-segmented passages than those in the block format. Thus, this study concluded that the phrase-segmented format led to gains in both reading speed and comprehension for college students.

Another hypothesis that Walker and his colleague attempted to test was that the phrase-segmented format would free up cognitive resources (i.e., working memory) which could then be employed in making sense of texts (Walker & Vogel, 2005). They found that the participating high school students (both L1 and L2) improved their reading retention in social studies and history. For example, tenth grade students ($n = 40$) who read their history texts in the phrase-segmented format showed greater improvement in a number of exams throughout the school year as compared to their control peers ($n = 44$) who read block-formatted texts. It is important to note that the text format effect became larger with a longer intervention as the effect size was larger in exams run in the second semester (.55) than in those in the first semester (.38). This implies that students may need time to familiarize themselves to the new text format. L2 students ($n = 12$) especially needed more reading sessions than their L1 peers until they grew accustomed to the format and outperformed their L2 control peers ($n = 17$). These L2 students in the phrase-segmented condition had closed one-half to almost the full gap between themselves and L1 students in the control group by the end of the year. Although these results show that the phrase-segmented reading may contribute to the retention of content knowledge, this study did not provide direct evidence for whether the phrase-segmented reading supported limited working memory capacity.

Vogel (2011) reported his successful use of phrase-segmented text in a standardized test preparation program at a high school in Colorado, in which two-thirds of participants were L2 students. In the 4-week test preparation sessions, the participating students, who were at an unsatisfactory or partially proficient level, read sample test passages in VSTF for 20 minutes on a daily basis. As a result, 81% of the students met the state standard for acceptable growth and 62% met the school goal of reading at a proficient level by the end of the school year. This result should, however, be carefully interpreted given that this study was not in a refereed publication.

A more extended study conducted by Park et al. (2013) investigated which components of language (e.g., vocabulary, comprehension, literary analysis, written conventions, and writing strategies) were most affected by phrase-segmented reading. In this two-group pre- and post-test experimental study in California, 347 sixth grade students read a digital textbook generated by VSTF technology in their English language arts (ELA) class for one school year, while a control group ($n = 222$) read a traditional paper textbook (block format) with the same content. The ELA subtest results from the California Standards Tests (CST) for two consecutive years, one before and one after the treatment, served as the pre- and post-tests. The treatment group outperformed the control group in the subtest of vocabulary, written conventions, and writing strategies. The authors speculated from these findings that phrase-segmented text reading could draw students' attention to syntactic structures that might have otherwise been ignored. Performance on the written conventions is closely and directly related to syntactic knowledge, as this subtest requires knowledge of sentence structure, grammar, punctuation, capitalization, and spelling. In addition, performance on the writing strategies

subtest represents knowledge of vocabulary analysis and language structures rather than writing abilities, as this subtest does not require the ability to write an essay, but rather the ability to choose the best option when revising a flawed text.

A couple of small classroom studies reported in Park et al. (2013) examined the use of phrase-segmented text reading in South Korea, which is an EFL context. One study used phrase-segmented text in twelfth grade English classrooms and assessed reading performance of treatment ($n = 71$) and control ($n = 96$) group students using pre- and post-tests. On the post reading comprehension test conducted three months after the treatment started, the treatment students outperformed their control peers by .45 standard deviations. The teacher who conducted this study observed that her students preferred reading in the phrase-segmented format to block format because they felt the former less overwhelming and faster than the latter.

Another study presented in Park et al. (2013) used VSTF technology to reformat listening test scripts, as well as reading materials, in eighth grade English classrooms. Due to the great linguistic difference between L1 and L2 in an EFL context such as South Korea, listening instructions are often accompanied by reading scripts. This practice aimed at students' better understanding of vocabulary, expressions, prosodic features, structures, and content found in listening materials, and ultimately better listening comprehension. The treatment group ($n = 36$), who studied reading and listening materials over three months, outperformed the control group ($n = 18$) on the researcher-developed reading post-test by .70 standard deviations after controlling for pretest scores. The treatment group also gained higher scores than the control group on the listening post-test, but the effect size was not statistically significant. The teacher reported that the treatment

condition was especially useful to demonstrate the role of prosodic cues in communication. Despite their promising findings, these two studies are vulnerable to experimental bias; that is, the classroom teachers who conducted the experiment might have unconsciously behaved differently to members of control and experimental groups.

Yu and Miller (2010) recently provided an interesting study that compared three different text formats: block, phrase-segmented (VSTF), and sentence-segmented format (see Figure 2.3). The last format was invented by the authors and named after the game Jenga. According to the inventors, the shape of interlocking sentences in this text format resembles the way in which blocks of Jenga are stacked after some blocks are moved out. A click on a given paragraph of a web page converts the paragraph into this sentence-segmented format with unaligned sentences that each connect to a previous one with a space. Another click can return this sentence-segmented format to the original format at readers' discretion. In this within-subjects study, 30 adult L2 readers with high proficiency in English (proved by their TOEFL or SAT test scores) read in three text formats and were assessed in terms of speed and comprehension. The participants also answered survey questions on their perceptions on the formats. It was found that the participants read fastest in block format and comprehended better in sentence-segmented format than in the other two. Survey results indicated that the participants felt that reading was easier in either phrase- or sentence-segmented formats than in block format, whereas they reported that text format did not affect how well they comprehended text. Yu and Miller concluded that segmented formats might be more comfortable to eyes and brain as compared to dense block format, but also that frequent segmentation in VSTF might hinder the participants' reading performance. The interpretation of these findings needs to take into

account proficiency levels or ages of participants. High proficiency adult L2 readers in this study might have sufficient syntactic skills and not been responsive to phrase-segmented format.

In a long ramble of the kind on a fine autumnal day, Rip had unconsciously scrambled to one of the highest parts of the Kaatskill mountains.

He was after his favorite sport of squirrel shooting, and the still solitudes had echoed and re-echoed with the reports of his gun.

Panting and fatigued, he threw himself, late in the afternoon, on a green knoll, covered with mountain herbage, that crowned the brow of a precipice.

From an opening between the trees he could overlook all the lower country for many a mile of rich woodland.

He saw at a distance the lordly Hudson, far, far below him, moving on its silent but majestic course, with the reflection of a purple cloud, or the sail of a lagging bark, here and there sleeping on its glassy bosom, and at last losing itself in the blue highlands.

Figure 2.3. Sentence-segmented formatting. An excerpt from Rip Van Winkle (written by Washington Irving) is reformatted such that sentences are spaced and each sentence is followed by the next one connected to the next one with space in between.

CHAPTER 3

METHODS

This study seeks to explore how text format types affect reading speed and comprehension of college students. In doing so, this study employed a within- and between-subjects design to compare effects of different text format types on both individual and language group levels. In what follows, the participants, reading materials, measurements, apparatus, data collection procedure, and data analysis are explained.

Participants

To address the research questions stated above, the sample of this study included not only L2 English speaker data but also L1 English speaker data as a baseline for interpreting L2 English speakers' performance. Sampling of L2 participants aimed to ensure that they were representative of English learners who were challenged by limited exposure to English in daily life and difficult linguistic aspects of the English language. As such, Korean speakers of English were chosen because they learn English as a foreign language (EFL) and the Korean language is linguistically very distant from the English language (e.g., orthography, vocabulary, and syntactic structure). I first contacted several professors at potential research sites in Korea to gain their permission for the recruitment of students in their schools. Korean students in two universities, who had less than one year of experience of staying in English speaking countries, agreed to voluntarily participate in this study. At the end of the experiment, they were offered a one-year subscription to the software program that was used in this study. Another group of L2 participants—learners of English as a second language (ESL)—and a group of L1 participants were recruited from the University of California, Irvine (UCI). These students

voluntarily participated in this study for extra-credit points in Psychology classes.

Participants were between the age of 18 and 35. The data collection procedure, including participant recruitment at all sites, was approved by UCI Institutional Review Board. The following paragraphs further describe the three groups of participants.

EFL students. Thirty-six college students (12 males and 24 females) from three majors (18 secondary school teaching, 10 elementary school teaching, and 8 engineering) and two different universities in Korea participated in this study. In this EFL context, English was a school subject, not a medium of instruction or communication. Within the government-mandated curriculum that the participants were taught, they received English instruction from second to twelfth grade, ranging from two hours to five hours per week. English classes, especially in secondary schools, generally comprised non-native teachers giving textbook dependent instruction. To make sure whether all the EFL participants shared similar learning profiles, I modified and used the Language History Questionnaire (LHQ, Li, Sepanski & Zhao, 2006) (see Appendix A). Their responses confirmed that they had similar learning experiences in terms of instruction time at school and little use of English outside the classroom. Most of the participants had never been to English speaking countries (91.7

%), and even those who had experience abroad spent less than one year in English speaking countries (8.3%). Data from 32 out of 36 students were used for analyses after removing outliers (the specific outliers removed are discussed in Chapter 4).

ESL students. Forty-one UCI participants (8 males and 33 females) who identified themselves as L2 English speakers were categorized as ESL students. These students majored in Psychology (58.5%), Biology (17.1%), Criminology (12.2%) and Public health

(12.2%). According to these students' responses to LHQ, the majority of them were native speakers of Chinese (39%), followed by Spanish (14.6%) and other languages (Farsi, Vietnamese, Korean, Dutch, and Konkani). The number of years they lived in the U.S. ranged from 1 to 10 years. The first time an ESL participant attended a school where English was the medium of instruction was UCI in most cases (36.6%), while other participants started schools with English instruction during their K-12 education (26.8% in high school, 19.5% in elementary school and up, and 17.1% in middle school and up) in the U.S. Important differences from EFL contexts included more opportunities of communication in English and availability of authentic language input. Data from 33 out of 41 students were used for analyses after removing outliers (the specific outliers removed from the analyses are discussed in Chapter 4).

NES students. Thirty-three UCI participants (14 males and 19 females) identified themselves as NES speakers. Five of these participants were monolingual, while the rest were bilingual, considered English as the main medium of daily communication, and their English proficiency was higher than other languages they spoke. These students majored in Psychology (60.6%), Criminology (18.2%), Public health (12.1%), and Biology (9.1%). Data from 30 out of 33 students were used for analyses after removing outliers (the specific outliers removed are discussed in Chapter 4).

Design

This study employed a two-way mixed design. This research design included a within-subjects factor of *text format types* (block-formatted or phrase-segmented), a between-subjects factor of groups (*Language*—EFL, ESL, and NES—for research questions 1 and 2; *Working Memory*—High, Low—for research question 3), and covariates of baseline

English proficiency scores.

The within-subjects factor of this study was the text format type; to test this, each participant read two sets of reading passages, one in a regular block format and the other in a phrase-segmented format. A primary advantage of a within-subjects design over a between-subjects design (i.e., each participant would be assigned to either the Block or Segmented condition) is that the former is better able to detect an effect, if any (Gravetter & Forzano, 2012). In a within-subject design, each participant serves as his or her own control counterpart, instead of being compared to other participants in a control condition. Putting the same person into two text format conditions has two advantages: having an increased number of participants and increasing the power of detecting a true effect (Salkind, 2010). First, I had twice as many participants as I would have otherwise had in a between-subject design, in which half of the participants would be assigned to a treatment condition and half to a control condition. Having an increased number of participants reduces the probability of not finding an effect when a true effect exists. Second, the varying pre-existing linguistic knowledge of participants, which is the source of error variance in a between-subject design, was controlled for across the two reading conditions. Individual differences, therefore, did not cause confounding in the causal pathway between the two reading conditions and reading performance. This within-subject design has greater statistical power than a between-subject factor to detect the effect of text formats on reading performance (Salkind, 2010).

However, a within-subjects design is vulnerable to potential threats to its internal validity. For example, a testing effect may occur: participants may gain higher scores on later passages than on earlier passages because they are more experienced with the test.

Conversely, participants may perform worse after repeated testing due to fatigue. Another concern is that the score differences actually may be due to the readability of passages rather than the text format types. To rule out a testing effect, all passages had the same chance of being read in block format by half the participants and in phrase-segmented format by the other half. Each passage in Set A was paired with a passage in Set B that had a similar topic (e.g., humanities or science) and readability levels (e.g., easy, difficult). Half of the participants were given Set A in phrase-segmented format and Set B in block format. The other half read Set A in block format and Set B in phrase-segmented format. This method helped reduce the possibility that any score changes might be caused by naturally occurring comprehending processes instead of the text format types. In addition, the order of presenting passages was randomized to counterbalance any potential testing effects caused by the presentation order.

Two between-subjects factors were used: language and working memory. As explained in the Participant section, there were three language groups: EFL, ESL, and NES. This participant categorization was entered as a between-subjects factor into the analysis for research questions 1 and 2. To answer the research question 3, the combined L2 participants (EFL and ESL) were divided into two groups depending on their working memory capacity. In order to divide participating students into low- and high-working memory capacity levels, a complex span task, which is explained in the following section, was used.

The effects of text types on participants' performance were evaluated in terms of two main outcomes: reading speed and comprehension. Reading speed in block and segmented condition served as repeated measures for the research question 1 and the part

of the question 3. Comprehension scores in block and segmented condition were treated as repeated measures for the research question 2 and the part of the question 3.

In attempting to control for the effect of participants' English proficiency level thought to influence reading speed and comprehension, baseline English proficiency as measured by vocabulary and word recognition tests was included as covariates.

Apparatus and Measures

This section details the apparatus used for testing and the measures to assess participants' working memory, baseline reading proficiency (vocabulary and word recognition), and experimental reading measures (speed and comprehension).

Apparatus. In this study three software tools were used to build and/or execute tests for this study: E-Prime (Schneider, Eschman, & Zuccolotto, 2002), Psychopy (Peirce, 2007), and VSTF (Walker, 2001). Tasks in the working memory measure were programmed and administered using E-Prime experimental software. For all other tasks, including vocabulary, word recognition, and reading, Psychopy was used. This is an open-source software package that is written in Python programming language and creates psychological experiments with the presentation of stimuli and collection of data. It is reported that Psychopy has sub-millisecond precision with a latency of 4-25 ms depending on platforms and keyboards. VSTF technology converted standard block passages into phrase-segment formatted passages.

With regard to devices used for testing, separate computers were used for the working memory task and all other tasks. A Lenovo 12 inch laptop was used to administer the working memory test for all participants. To present stimuli and record responses of other tasks, a Dell Vostro computer and a 20 inch widescreen LCD monitor were used in the

U.S. research site and Samsung desktop and 21.5 inch widescreen LCD monitor were used in the Korean research site.

The sections below not only illustrate how stimuli were presented in each task, but also detail each of the measures used in this study with a rationale as to why the measure was chosen.

Working memory measure. One of the two groupings (between-subjects factors) was defined based on a participant's current functioning on a working memory measure. *Symmetry span task* with spatial locations as a to-be-remembered item, developed by Shah and Miyake (1996), was chosen in this study for two reasons. This task does not require English skills to ensure that participants' performance in this task would not be significantly confounded by their language ability. This is especially important for L2 English speakers whose English proficiency might be otherwise reflected in their scores on other tasks (e.g., verbal) rather than working memory capacity that needed to be measured. Nonetheless, as reviewed earlier, an individual's working memory capacity is domain-general so that the symmetry span tasks account for variance in verbal ability tests (Kane et al., 2004). Another reason is related to the fact that to-be-remembered items in the symmetry span task were the shapes and spatial locations as the visual features of text format that this study examined: phrase-segmented format vs. block format.

For each trial in the computerized symmetry span task, participants were asked to judge whether a given pattern was symmetry (i.e., processing task) and to simultaneously recall sequences of red squares within a matrix (i.e., storage task). Figure 3.1 shows the example of a sequence of tasks. For the processing task participants were presented with an 8×8 matrix with some squares in black and others in white. They were required to

decide whether the black pattern was symmetrical along its vertical axis. For the storage task participants saw a 4×4 matrix with one of the cells filled in red, presented for 650 ms. They were asked to recall correct sequences of red squares within a matrix by clicking on the cells of an empty matrix. After three practice conditions—storage task only, processing task only, and interleaved tasks, participants were processed to the actual trials. Individualized time limits were calculated during the processing task only session (the participant's mean plus 2.5 *SD*) and used as the maximum processing time during the processing and storage task sessions. The score was the number of correct items recalled in the correct position and processing time. The test-retest reliability was reported to be high somewhere else (.77 in Unsworth et al., 2005; .80 in Unsworth et al., 2009).

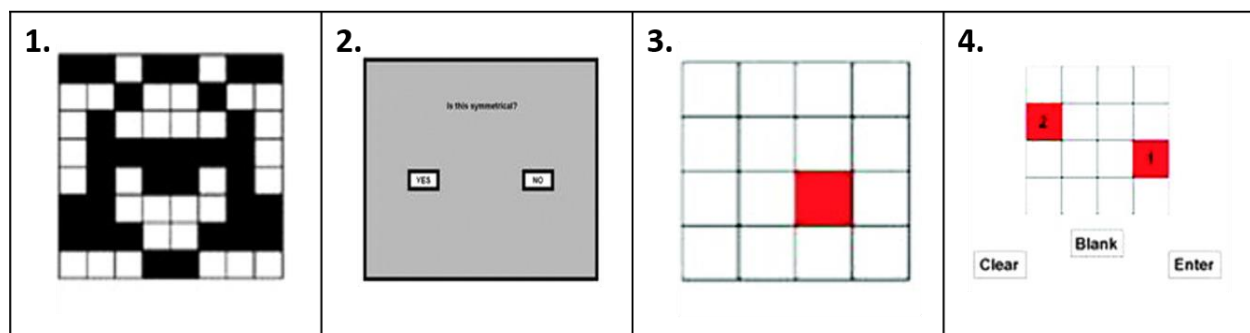


Figure 3.1 Example of a sequence of tasks in the working memory measure. Picture 1 shows a symmetry task. Test takers should respond by clicking either Yes or No depending on their decision about symmetry, as shown in Picture 2. Picture 3 is an example of a storage task, in which test takers should memorize the location of the red cell. There can be multiple red cells, one by one at a time. Test takers then have to recall the correct sequence of red cells, as shown in Picture 4.

All of the participants in ESL and NES groups took this working memory test, but 8 out of 36 EFL students opted to not take this test. Chapter 4 details the specific decisions made to select the sample for further analysis.

Baseline reading proficiency measure. A reading proficiency measure, which was developed to assess reading proficiency of both native and non-native students (Abedi, Courtney, & Leon, 2003), was used to provide an indicator of each participant's current English reading proficiency level in this study. This proficiency test consisted of two subtests: vocabulary and word recognition tests.

Vocabulary. One part of the proficiency measure was a vocabulary test. This test included 10 items that asked participants to fill in a blank with a word that made sense in a given sentence. Each item had four multiple-choice answers to select from, which were from the same part of speech. Each correct answer was awarded one point. Raw scores were converted into percentage scores to allow easy comparisons. The vocabulary test was an internally consistent instrument, as evidenced by the Cronbach's alpha (.69).

Psychopy (Peirce, 2007) was used to program and run this test. As shown in Figure 3.2, one question represented each stimulus; that is, one stimulus (one question) was presented at a time. All stimuli were horizontally and vertically centered and presented in black against a white background. Ten questions appeared in a random order for each participant. The maximum time for this task was set for 5 minutes, as it was set in the previous paper and pencil test (Abedi et al., 2003), but the time for answering one question was not limited. Pressing any key allowed participants to move from one screen to the next; they pressed a number key corresponding to a correct answer. Going back to a previous question was not allowed. This programmed test recorded answers selected by a participant and whether they were correct. The test results were provided in a spreadsheet. In scoring, one point was awarded for each correct answer.

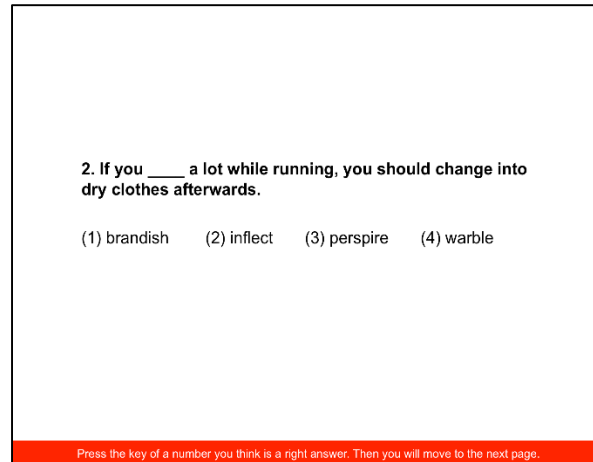


Figure 3.2 Screenshot of the proficiency test (vocabulary). This test was programmed using Psychopy.

Word recognition. The other part of the proficiency measure was a recognition test, which consisted of 75 words and non-words. Participants were asked to identify English words from non-words. Each correct answer was awarded one point. Raw scores were converted into percentage scores to allow easy comparisons. This test was an internally consistent instrument, as evidenced by the Cronbach's alpha (.84).

Psychopy (Peirce, 2007) was also used to program this test with one word representing each stimulus (See Figure 3.3). All stimuli were horizontally and vertically centered and presented in black against a white background. Words were presented in a random order. The maximum time for this task was not to exceed 3 minutes, as in the previous paper and pencil test (Abedi et al., 2003), but the time for responding to a single stimulus was not limited. Keystrokes (1 or 0) allowed participants to move to the next stimulus. Participants pressed a number key "1" if they thought a word they saw was a real word and "0" if a non-word. As in the vocabulary section, participants' answers and whether they were correct were recorded and provided in a spreadsheet.

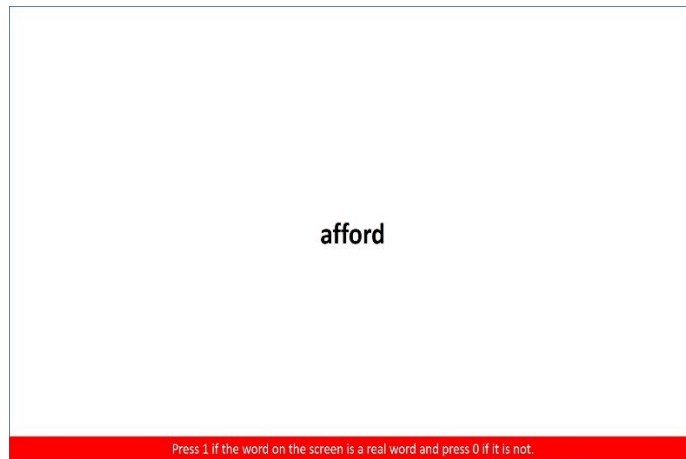


Figure 3.3. Screenshot of the proficiency test (word recognition). This test was programmed using Psychopy.

Experimental reading measure. This and following paragraphs describes how I selected reading passages and comprehension questions, prepared these test materials for automated testing, and measured reading speed.

Reading passage selection. Reading passages for reading speed and comprehension assessments were obtained from the reading comprehension section of a test-preparation book for the Test of English as a Foreign Language (TOEFL, Rogers, 2001). The TOEFL test was chosen because it measures an ability of non-native English speakers to use and understand English at the university level. Performing tasks in this test requires academic English skills that range between intermediate and advanced levels. As such, the test was appropriate for the target participants in this study.

Twelve passages were initially chosen. Types of passages were matched between two text format conditions in terms of topic and difficulty levels. There were six passages on humanities (e.g., geography, art, and psychology) and six on science (e.g., biology and earth science). To control for lexical and syntactic difficulty, reading difficulty levels were calculated by using more than two readability formulas—Flesch-Kincaid readability test,

Funning for index, and McLaughlin's SMOG formula. Readability scores of six passages at a moderate difficulty level ranged 7.3 to 9.9, while those of six difficult passages were between 10.1 and 13.6. As a result, selected passages fell in one of the following categories: three humanities-moderate, three humanities-difficult, three science-moderate, and three science-difficult. The number of words per passage ranged from 179 to 370 ($M = 252$, $SD = 62$).

A pilot study was administered to ensure similar difficulty levels of the reading passages and the comprehension questions in each category of the experimental reading measure. Twenty-five college students, including both L1 and L2 English speakers, read and answered comprehension questions for 12 selected passages. Based on the mean scores, one of three passages in each category was ruled out if its score was far from the other two. As a result, a total of eight passages were used in the actual experiment.

Reading comprehension questions. Guided by research on comprehension tasks (Raphael & Au, 2005), comprehension questions included topic (e.g., The main subject of the passage is ____), vocabulary (e.g., The phrase "throw off" is closest in meaning to ____), basic recall (e.g., The musicians who made the earliest jazz recordings were originally from ____), and inference-making (e.g., It can be inferred from the passage that the Sun ____). Each passage had one of each question type and two basic recall questions. All of these questions were multiple-choice questions with four potential answers. Each correct answer was awarded one point. Raw scores were converted into percentage scores to allow easy comparisons.

The comprehension test was an internally consistent and valid instrument. Reliability was assessed by the Cronbach's alpha (.76). The construct validity of

comprehension questions was evaluated from a confirmatory factor analysis with one factor and the standardized root mean squared residual (SRMR) index. The SRMR measures an average discrepancy between the observed and model implied correlations with a cut-off value of less than .08 as suggested by Hu and Bentler (1999). The SRMR values for each question type were in the acceptable range (.05, .05, .07, and .06 for topic, vocabulary, information, and inference-making, respectively). This result indicates that all of the items within each question type were linked to a unique underlying factor, implying good construct validity.

Automated test preparation. Once passages and comprehension questions were selected, VSTF technology was used to convert block-formatted reading passages into phrase-segmented passages. Each passage (both block and phrase-segmented) was arranged in three columns to fit on one page. Passages were each saved as a separate image file with words in black Arial MS 18 pt font size against an alternating white and grey background. Each comprehension question was also prepared as a separate image file. Words were black Arial MS 24pt font size against a white background. Figure 3.4 shows how passages in block and phrase-segmented conditions as well as a question were displayed on the screen.

The sun today is a yellow dwarf star. It is fueled by thermonuclear reactions near its center that convert hydrogen to helium. The Sun has existed in its present state for about 4 billion, 600 million years and is thousands of times larger than the Earth.

By studying other stars, astronomers can predict what the rest of the Sun's life will be like. About 5 billion years from now, the core of the Sun will shrink and become hotter. The surface temperature will fall. The higher temperature of the center will increase the rate of thermonuclear reactions. The outer regions of the Sun will expand approximately 35 million miles, about the distance to Mercury, which is the closest planet to the Sun. The Sun will then be a red giant star. Temperatures on the Earth will become too hot for life to exist.

Once the Sun has used up its thermonuclear energy as a red giant, it will begin to shrink. After it shrinks to the size of the Earth, it will become a white dwarf star. The Sun may **throw off** huge amounts of gases in violent eruptions called nova explosions as it changes from a red giant to a white dwarf.

After billions of years as a white dwarf, the Sun will have used up all its fuel and will have lost its heat. Such a star is called a black dwarf. After the sun has become a black dwarf, the Earth will be dark and cold. If any atmosphere remains there, it will have frozen onto the Earth's surface.

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Such a star is called a black dwarf.

After the sun has become a black dwarf, the Earth will be dark and cold.

If any atmosphere remains there, it will have frozen onto the Earth's surface.

3-2. It can be inferred from the passage that the Sun

- (1) is approximately halfway through its life as a yellow dwarf.
- (2) has been in existence for 10 billion years.
- (3) is rapidly changing in size and brightness.
- (4) will continue as a yellow dwarf for another 10 billion years.

Figure 3.4. Screenshot of passages and a question. Participants read a passage either in the block-formatted condition (left) or phrase-segmented condition (right). VSTF technology was used to convert block-formatted passages into phrase-segmented format. When ready, they move to a next screen with a question (bottom). Participants are not allowed to go back to the passage when answering questions.

One important determinant of this study is text accessibility. In this study, text was not displayed when students were trying to answer each question for the following reasons. If a reading passage is available during question answering, some readers may reread portions of the given passage. In this case, comprehension test results may be influenced by skills that are not intended to be assessed in this study (e.g., information search skills). Allowing information search skills may give an advantage for L1 students but

not for L2 students, leading to unfair between-group comparison among L1 and L2 students. More importantly, a comprehension test with accessible text may not be able to detect what this study intends to assess, such as relations between format and working memory. Ozuru, Best, Bell, Witherspoon, and McNamara (2007) asserted that when students need to answer comprehension questions without an access to a text, demands on memory capacity may become higher. Readers may not need to fully use their cognitive capacity and simply go back to the passage for the portion with information relevant to a given question. This effect of text availability on comprehension performance was evidenced by empirical studies, such as Schaffner and Schiefele's (2013) study. In their study, Schaffner and Schiefele also demonstrated that readers were more likely to use their decoding skills, make inferences, and capitalize on previous knowledge when solving comprehension questions without text access than with text available. Therefore, passages were inaccessible when the participants were solving comprehension questions in this study.

Psychopy (Peirce, 2007) was also used to program and run this reading test. Either a passage or a comprehension question represented each stimulus. Each passage fit one page such that there was no need for the participants to scroll or advance to a next page. There was no time limit for this reading task. Participants were able to stay on screen with a passage until they were ready to answer comprehension questions. Once ready, participants pressed any key to advance to the next screen. Again, they were allowed to stay on screen with a question until they selected an answer. Then they pressed a number key, 1 to 4, corresponding to the answer they thought correct to a multiple-choice question. One point was awarded for each correct answer.

Reading speed. The programmed test recorded response time to each stimulus (i.e., how long it took a participant to respond after a stimulus was presented on a screen) in milliseconds. Using this reaction time data, silent reading speed was calculated in words per minute (WPM) based on the formula: $WPM = (\text{the number of words in a passage} / \text{reading time in seconds}) \times 60$. The total time spent on each passage was automatically recorded by Psychopy at the millisecond level and available in a spreadsheet for analysis at the end of the trial. Reading time was defined as time between a keystroke triggering an onset of a given passage and a following keystroke for the next stimulus. The internal reliability coefficient was obtained by the Cronbach's alpha (.95).

Procedure

Participants were asked to individually complete the LHQ (Li et al., 2006) prior to coming in to the laboratory in which all testing was held. Submitting this online questionnaire was considered implied consent to participate in this study.

The testing session included working memory, reading proficiency, and experimental reading tests, lasting approximately 75 minutes. Participants were allowed to take breaks between successive tests if they wished. The working memory test was first administered. Participants then took the baseline proficiency test. The experimental reading test session consisted of a practice session and an actual test. The practice session, which had eight sample passages in phrase-segmented format with comprehension questions, was aimed at ensuring that participants became familiar with the phrase-segmented format as well as the testing environment. When ready for the actual test, participants were allowed to skip the rest of the sample passages. The actual test had eight passages: four of them in phrase-segmented format and the rest in block format. Both the

format type of each passage and the order of text presentation were randomized. Immediately following each passage, participants answered five multiple-choice questions. The order of question presentation was also randomized. Participants were not allowed to go back to passages while answering questions.

Chapter 4

Data Analysis and Findings

This chapter presents the analysis and interpretation of the data collected from EFL, ESL, and NES groups. The following section explains the statistical methods used to analyze collected data in this study. Then the second section reports the results in response to the three research questions.

Data Analysis

A variety of analyses were conducted on collected data. These included calculating means and standard deviations and conducting t-tests, Pearson's correlation tests, and within and between analyses of variance and covariance. The General Linear Model (GLM) procedure was applied for analyses of variance and covariance to determine the effects of text format on reading performance with reference to language learning status. A repeated measures analysis of variance was run on reading comprehension and speed, respectively. A within-subjects factor was text format types (block vs. phrase-segmented); between-subjects factor was language learning status (EFL vs. ESL vs. NES). Dependent variables were WPM values for each passage and scores for each question type. A univariate analysis of variance (ANOVA) was conducted for each variable. To control for the effect of other language-related skills that might influence the dependent variables, a repeated measures analysis including covariates was carried out on the dependent variables covarying word recognition and vocabulary scores. As an estimate of variance attributed to effects in independent variables, partial eta squared (η^2) was used in the analysis models with .01, .06, and .14 were considered as small, medium, and large effects, respectively

(Hatcher, 2013). The analysis tool was Statistical Package for the Social Sciences (SPSS), Version 21.

Both reading comprehension and speed data were screened for violations of assumptions of the General Linear Model (GLM), such as outliers, normality, collinearity, and homogeneity of variance-covariance. This preliminary assumption checking was separately performed for each language group. In order to identify participants who did not actually participate in the study as indicated by the fact that they read a passage at abnormally fast speed, reading speed data was initially examined for outliers. There were seven univariate outliers in this data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box. These cases were excluded not only from reading speed data but also from reading comprehension data because reading comprehension data of these participants might not be reliable. Four multivariate outliers were identified by those observations that exhibited a large Mahalanobis distance score and were also removed from the analysis (Hills, 2005). In total, 15 cases from the original 110 participant sample were eliminated from further analyses. As a result, cases of 32 EFL, 33 ESL, and 30 NES students remained in the analyses. Subsequent screening for outliers confirmed that there was no univariate or multivariate outlier in the reading comprehension data.

Another assumption, normality, was assessed by skewness and kurtosis z-scores, wherein a z-score of $<|3.29|$ ($p < .001$, two-tailed test) was considered as providing sufficient evidence for normality to use the parametric test (Tabachnick & Fidell, 2007). Dependent variables were normally distributed within each group of independent variables. Presence of collinearity was assessed by Pearson's correlation r , wherein no

bivariate correlation among dependent variables should be above $r = .90$. There was a moderate correlation between each pair of dependent variables (less than .90) for each group. Finally, homogeneity of variance-covariances matrices was tested through the examination of Box's test of equality of covariance matrices. The result of this test was insignificant in reading comprehension ($p = .24$) but significant in reading speed ($p < .000$). The reading speed data did not meet the assumption that the population covariance matrices are equal across groups; therefore, this data was interpreted using Pillai's Trace test statistics, which is robust to the violation of this assumption, instead of Wilks' Lambda, as suggested by Tabachnick and Fidell (2007).

For the hypothesis testing for research question 3, the approach to grouping by participants' working memory needs to be clarified. As briefly stated in Chapters 1 and 3, not all of the EFL students took the working memory test while all of the participants in the ESL and NES groups did. Based on the validity check, 3 ESL and 2 NES students were excluded from the remaining cases. NES students were excluded from this analysis due to the discrepancy in test scores between comprehension and working memory: they performed significantly worse than their L2 peers on the working memory test whereas they did significantly better on the comprehension test. Mean scores on the working memory tasks were 44.09 (EFL), 40.80 (ESL) and 40.60 (NES), which were significantly different. In addition, the preliminary analysis showed that no text format effect was detected on reading speed and comprehension of NES students. This finding is not reported here. For the hypothesis testing, EFL and ESL groups were combined and regrouped into high and low capacity groups based on their scores on the working memory measure. L2 students' scores ranged from 20 to 53 with a median (41.41) split grouping factor. As a

result, 28 L2 students (12 EFL and 16 ESL) were assigned to the low working memory capacity group and the remaining 30 (16 EFL and 14 ESL) to the high capacity group. Mean working memory score of high working memory group ($M = 47.14$, $SD = 3.27$) is different from that of low working memory group ($M = 35.98$, $SD = 4.83$) at a significance level of 0.05. However, working memory scores of EFL ($M = 43.05$, $SD = 6.56$) and ESL students ($M = 40.53$, $SD = 7.17$) who remained in this analysis were not significantly different from each other.

Findings

Before conducting hypothesis testing, descriptive statistics and correlations were checked (see Table 4.1). A Pearson's product-moment correlation was run to assess the relationship among dependent variables (reading speed and comprehension) and the baseline proficiency (vocabulary and word recognition). This analysis was repeatedly conducted for the whole group of participants and for each language group. There was a moderate positive correlation between reading speed and comprehension in the whole group, with coefficients ranging from .11 to .21. The baseline proficiency scores for the whole group are positively correlated with both reading speed and comprehension, with moderate to large coefficients ranging from .32 to .56.

The patterns of correlations among reading speed, comprehension, and basic proficiency are inconsistent across the three language groups. With regard to the EFL group, there is a moderate negative correlation between reading speed and comprehension, with coefficients ranging from -0.33 to -0.10. It seems that the faster the EFL students read a passage, the lower comprehension scores they had, but this relationship is not significant. The baseline proficiency scores of EFL students do not

appear to correlate with reading speed, as evidenced by insignificant small correlation coefficients; however, these scores correlate with reading comprehension with moderate to large coefficients from .31 to .59.

In the ESL group, correlation coefficients are all positive among reading speed, comprehension, and baseline proficiency scores, but significant only between speed and word recognition scores. The correlation coefficients are small between reading speed and comprehension. The covariates have small to moderate correlations with reading speed and comprehension.

The patterns of correlation among dependent variables and covariates for the NES group is similar to those for the EFL group. There are negative correlations between reading speed and comprehension for the NES students. The covariates have insignificant small correlations, either positive or negative, with reading speed, but positive small to moderate correlations with reading comprehension.

It is interesting to observe negative correlations between reading speed and comprehension for EFL and NES students but a positive relationship between them for ESL students. The observed negative correlations between reading speed and comprehension contradict the previous findings on reading fluency and comprehension (e.g., Klauda & Guthrie, 2008). Perhaps the reasons for the negative relationship are not the same for the two groups, EFL and NES. First of all, the testing environment might have affected the EFL group. The participants were allowed to stay with a given passage until they felt ready to answer questions but were not allowed to go back to the passage while answering questions. This testing condition might have made them anxious about the retention of the information that might be necessary to answer questions. Therefore, EFL students might

have stayed with a text for an extended duration, resulting in the slower reading speed that is associated with higher comprehension scores. On the other hand, the fact that a ceiling was imposed on the reading comprehension measure but not on the speed measure may explain the negative correlation between reading speed and comprehension in the NES group. Given that the NES students had the same reading passages and questions as L2 group students, the reading measures might not be sensitive enough to reflect the variance of the NES students' comprehension abilities.

The next three sections lay out the results of the hypothesis testing. Section two is devoted to reading speed of three language groups. It provides the test results of the hypotheses pertaining to patterns and any possible changes in reading speed that are associated with text format type. Section three concerns reading comprehension of the three language groups and provides the test results of the hypotheses relating to the effects of text format type on comprehension. This section also identifies varied effects across comprehension question types. Section four is about the L2 readers' working memory function. Data from L2 students, not NES students, was used to test the hypothesis pertaining to working memory. L2 students were divided into two groups: high and low working memory capacity groups. This section shows the results of the effects of text format type on both reading speed and comprehension among two WM groups.

Each section begins with the research questions (RQ) formulated based on the theoretical framework and previous studies reviewed in Chapter 2.

Table 4.1.

Descriptive Statistics and Correlations of Dependent Variables and Covariates

		Pearson's Correlation					
	<i>M</i> <i>(SD)</i>	1	2	3	4	5	6
Total (<i>n</i> = 95)							
1. Speed (VSTF, total)	135.45 (52.10)	1.00					
2. Speed (BLOCK, total)	142.33 (64.31)	0.85**	1.00				
3. Comprehension (VSTF, total)	70.37 (15.30)	0.10	0.11	1.00			
4. Comprehension (BLOCK, total)	65.74 (17.26)	0.15	0.21*	0.71**	1.00		
5. Vocabulary (Covariate)	82.32 (13.64)	0.32**	0.35**	0.47**	0.48**	1.00	
6. Word recognition (Covariate)	83.55 (7.16)	0.34**	0.41**	0.44**	0.44**	0.56**	1.00
EFL (<i>n</i> = 32)							
1. Speed (VSTF, total)	100.40 (29.27)	1.00					
2. Speed (BLOCK, total)	101.20 (28.08)	0.81**	1.00				
3. Comprehension (VSTF, total)	63.91 (18.04)	-0.25	-0.33	1.00			
4. Comprehension (BLOCK, total)	54.69 (16.65)	-0.10	-0.13	0.74**	1.00		
5. Vocabulary (Covariate)	72.50 (16.06)	-0.12	0.06	0.40*	0.38*	1.00	
6. Word recognition (Covariate)	80.33 (6.86)	-0.05	-0.03	0.40*	0.31	0.59**	1.00
ESL (<i>n</i> = 33)							
1. Speed (VSTF, total)	132.90 (43.35)	1.00					
2. Speed (BLOCK, total)	132.83 (49.41)	0.79**	1.00				
3. Comprehension (VSTF, total)	72.42 (11.53)	0.14	0.21	1.00			
4. Comprehension (BLOCK, total)	68.48 (15.03)	0.05	0.15	0.50**	1.00		
5. Vocabulary (Covariate)	84.24 (9.02)	0.26	0.29	0.23	0.12	1.00	
6. Word recognition (Covariate)	82.18 (6.76)	0.26	0.43*	0.27	0.33	0.19	1.00
NES (<i>n</i> = 30)							
1. Speed (VSTF, total)	175.64 (52.68)	1.00					
2. Speed (BLOCK, total)	196.66 (69.61)	0.76**	1.00				
3. Comprehension (VSTF, total)	75.00 (13.83)	-0.17	-0.15	1.00			
4. Comprehension (BLOCK, total)	74.50 (14.04)	-0.46	-0.28	0.79**	1.00		
5. Vocabulary (Covariate)	90.67 (7.40)	-0.06	-0.12	0.51**	0.34	1.00	
6. Word recognition (Covariate)	88.49 (5.15)	0.00	0.07	0.53**	0.29	0.53**	1.00

Note. ** Significant at the 0.01 level (2-tailed); * significant at the 0.05 level (2-tailed)

RQ1. What is the relationship between text format types and *reading speed* among EFL, ESL, and NES students?

Analysis without covariates. A repeated measures analysis without covariates sought out WPM changes as a function of text format types and differences among groups for text format effects. Appendix B provides the descriptive statistics of participants' reading speed of each passage in terms of WPM and covariates including sample means, standard deviations, and correlation coefficients. There were four sets of passages that each included one block-formatted and one phrase-segmented passage: sets on a topic of humanities at a moderate reading level, humanities at a difficult level, science at a moderate level, and science at a difficult level. These sets of passages are from here on referred to as Hum-Mod, Hum-Diff, Sci-Mod, and Sci-Diff.

The main effect of text format showed a trend of a statistically significant difference on combined dependent variables ($F(4, 89) = 2.12, p = .08$; Pillai's Trace = .09; partial $\eta^2 = .09$). That is, the mean WPM of block reading was slightly different from that of reading in phrase-segmented format if we ignore the language difference of participants. The partial η^2 value implied that the magnitude of the difference due to text format types was medium, as 9 % of multivariate variance of the dependent variables was associated with the text format. However, this format effect did not vary across groups, as implied by no significant interaction between the format and group ($F(8, 180) = 1.65, p = .11$; Pillai's Trace = .14; partial $\eta^2 = .07$). A significant group difference was found ($F(8, 180) = 6.02, p < .0005$; Pillai's Trace = .42; partial $\eta^2 = .21$). This result indicated that the mean WPM was significantly different among groups with large magnitude of effect (21% of variance) if we ignore all other variables.

Follow-up univariate ANOVAs further showed that no significant within-group difference was found in all but the Sci-Mod set ($F(1, 92) = 6.41, p = .01$, partial $\eta^2 = .07$). The significant difference in this set was not observed in all three groups, as implied by the fact that the format * group interaction was significant. Only the NES group showed the speed difference. Significant between-group differences were found in all sets of passages.

Additional GLM procedure analyses with Bonferroni post hoc testing were run for each group to further examine the specific nature of the within-group effects. Table 4.2 summarizes these results in terms of mean differences for each question type within groups. EFL and ESL students read faster in block format than in phrase-segmented format in all but one case (Sci-Mod and Sci-Diff, respectively), but no statistical significance was found. NES students read all passages faster in block format than in phrase-segmented format. The significant difference was found only in Sci-Mod ($F(1, 31) = 4.86, p = .03$, partial $\eta^2 = .14$).

Table 4.2.

Pairwise Comparisons of Mean Speed^a Difference (VSTF – Block) within Group

Measure	Mean Speed Difference (Standard Error)		
	EFL	ESL	NES
Humanities-Moderate	-2.94 (8.06)	-2.42 (7.94)	-11.69 (8.32)
Science-Moderate	-2.52 (6.83)	-0.98 (6.73)	-13.62 (7.06)
Humanities-Difficult	2.61 (11.12)	-0.99 (10.95)	-48.61 (11.48) *
Science-Difficult	-0.33 (9.17)	4.65 (9.03)	-10.17 (9.47)

Note. Bonferroni adjustment for multiple comparisons was employed; ^a word per minute
+ $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

Post hoc comparisons with the Bonferroni adjustment revealed the specific nature of the between-group effects, as shown in Table 4.3. As compared to ESL students, EFL students read more slowly the block formatted Hum-Diff passage. A marginal difference

between these two groups was found in sets Hum-Mod and Sci-Mod. As compared to NES students, EFL students read more slowly in all sets. Mean differences between ESL and NES students were significant in all block passages. In the phrase-segmented reading condition, the three groups still differed significantly in almost all passages. Reading speed between EFL and ESL students was significant in phrase-segmented passages of Hum-Mod, Hum-Diff, and Sci-Mod; marginal significance was found in the phrase-segment passage of Sci-Diff. EFL students read more slowly than NES students in all phrase-segmented passages. A significant difference between ESL and NES students was found in three phrase-segmented passages, Hum-Mod, Hum-Diff, and Sci-Diff.

Table 4.3.

Pairwise Comparisons of Mean Speed ^a Difference among Language Group

Measure	Mean Speed Difference (Standard Error)					
	BLOCK			VSTF		
	EFL vs. ESL	EFL vs. NES	ESL vs. NES	EFL vs. ESL	EFL vs. NES	ESL vs. NES
Humanities-Moderate	-30.87+ (14.02)	-86.07*** (14.36)	-55.84** (14.25)	-31.39* (12.18)	-77.96*** (12.48)	-46.57** (12.38)
Science-Moderate	-32.84* (12.71)	-94.27*** (13.02)	-61.43*** (12.93)	-34.38* (12.63)	-83.16*** (12.93)	-48.78** (12.84)
Humanities-Difficult	-37.91+ (16.78)	-112.03*** (17.18)	-74.12*** (17.06)	-34.31* (12.27)	-60.81*** (12.57)	-26.50 (12.48)
Science-Difficult	-24.94 (13.33)	-88.85*** (13.65)	-63.92*** (13.55)	-29.91+ (12.94)	-79.01*** (13.26)	-49.10** (13.16)

Note. Bonferroni adjustment for multiple comparisons was employed; ^a word per minute

+ $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

Analysis with covariates. It was expected that reading ability might depend on the participants' other language-related skills. As such, two covariates—word recognition and vocabulary knowledge—were included in a MANCOVA model that examined the effect of text format on reading speed. After adjustment for covariates, within-group effects

disappeared but between-group differences were still observed. Detailed results are presented in the following.

There was no statistically significant main effect of the within-subjects factor ($F(4, 87) = .60, p = .66$; Pillai's Trace = .03; partial $\eta^2 = .03$) nor a significant interaction ($F(8, 176) = .94, p < .49$; Pillai's Trace = .08; partial $\eta^2 = .04$). This result implied that the text format did not affect reading speed for all participants regardless of language learning status when covariates were controlled for in the analysis. The main effect of language group was listed separately from the repeated measure effects ($F(8, 176) = 3.88, p < .0005$; Pillai's Trace = .3; partial $\eta^2 = .15$). That is, reading speed was still significantly different among the three groups with covariates controlled. Figure 4.1 gives us a general view about how fast each group of students read in two text format conditions. Scores in this figure are average WMPs.

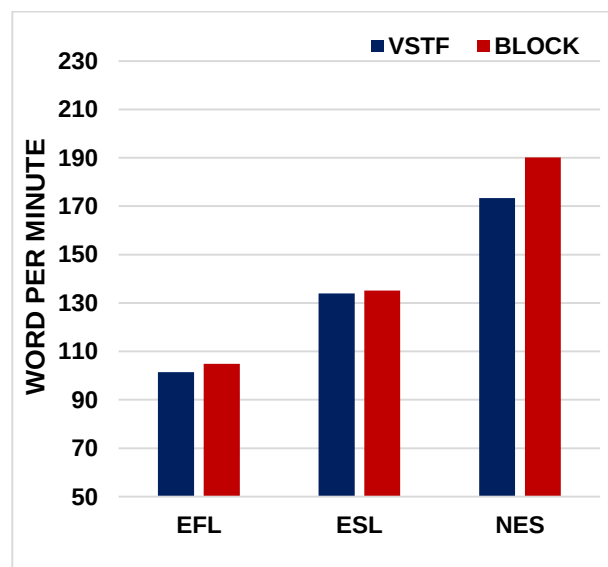


Figure 4.1. Adjusted means of total reading speed (WPM) by language group.

Follow-up ANOVAs showed that within-group difference was not detected in any passage set, but the format * group interaction was found in Hum-Diff ($F(1, 90) =$

3.08, $p = .05$, partial $\eta^2 = .06$). The between-group differences after adjustment for covariates were found in sets Hum-Mod ($F(2, 90) = 12.58$, $p < .0005$, partial $\eta^2 = .22$), Hum-Diff ($F(2, 90) = 15.99$, $p < .0005$, partial $\eta^2 = .01$), Sci-Mod ($F(2, 90) = 13.94$, $p < .0005$, partial $\eta^2 = .24$), and Sci-Diff ($F(2, 90) = 14.52$, $p < .0005$, partial $\eta^2 = .24$). Pairwise multiple comparison tests with the Bonferroni adjustment were performed to specify group differences.

Figure 4.2 illustrates these results in terms of the adjusted means and standard errors. Only NES students had significant speed change across text format, which was in Hum-Diff ($M = 41.93$, $SE = 12.92$, $p = .00$). With regard to between-group differences, the EFL group read all passages slower than the other two groups, regardless of text format type, with varying degrees of significance. The EFL-ESL group difference was significant in only one block passage (Sci-Mod, $M = 34.09$, $SE = 13.80$, $P = .05$) but in more than one phrase-segmented passages (Hum-Diff, $M = 38.58$, $SE = 13.443$, $p = .02$; Hum-Mod, $M = 31.296$, $SE = 13.356$, $p = .06$; Sci-Mod, $M = 32.849$, $SE = 13.873$, $p = .06$). This result stemmed from EFL students' relatively slow speed in the phrase-segmented condition. NES students read all passages faster than EFL students at a significant level in both reading conditions: Hum-Mod (in block, $M = 74.44$, $SE = 17.52$, $p = .00$; in VSTF, $M = 73.08$, $SE = 15.32$, $p = .00$), Sci-Mod (in block, $M = 87.68$, $SE = 15.82$, $p = .00$; in VSTF, $M = 77.30$, $SE = 15.91$, $p = .00$), Hum-Diff (in block, $M = 101.50$, $SE = 21.05$, $p = .00$; in VSTF, $M = 63.35$, $SE = 15.42$, $p = .00$), and Sci-Diff ($M = 77.45$, $SE = 16.52$, $p = .00$; $M = 73.59$, $SE = 16.34$, $p = .00$). The ESL-NES comparison was statistically significant in all block passages (Hum-Mod, $M = 47.27$, $SE = 15.42$, $p = .01$; Sci-Mod, $M = 53.60$, $SE = 13.92$, $p = .00$; Hum-Diff, $M = 65.84$, $SE = 18.53$, $p = .00$; Sci-Diff, $M = 53.74$, $SE = 14.54$, $p = .00$). In the phrase-segmented condition, this comparison

was significant in three passages (Hum-Mod, $M = 41.79$, $SE = 13.48$, $p = .01$; Sci-Mod, $M = 44.45$, $SE = 14.00$, $p = .01$; Sci-Diff, $M = 46.43$, $SE = 14.38$, $p = .01$). This seeming reduction in the ESL-NES group difference is due to the slower reading speed of NES in the phrase-segmented condition.

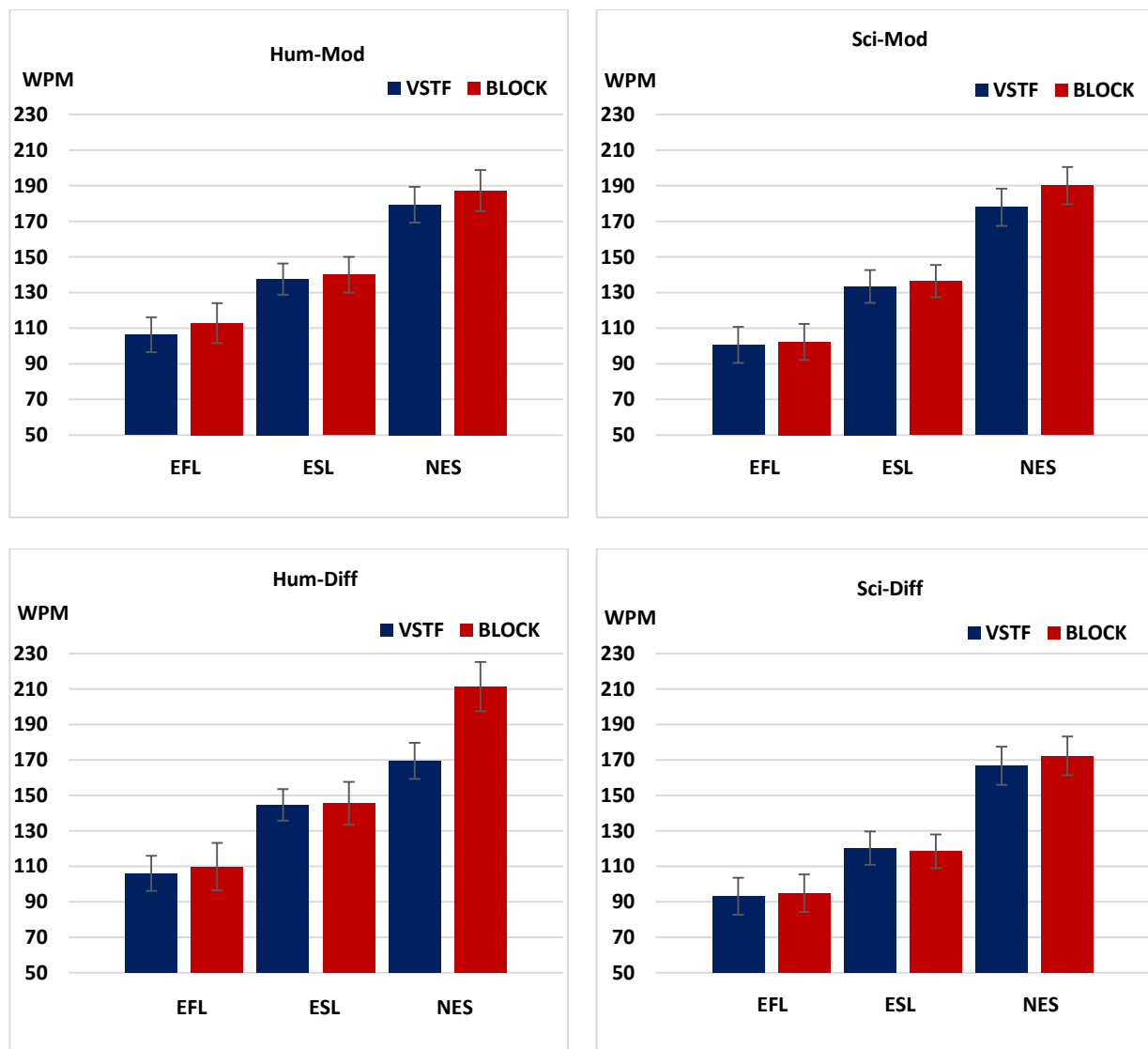


Figure 4.2. Adjusted means of reading speed (WPM) by language group. ^a Significant between-group differences in both BLOCK and VSTF are in EFL-NES and ESL-NES comparisons. EFL-ESL difference is marginally significant only in BLOCK. ^b All group comparisons are significant in both format conditions, except for a marginally significant difference in the EFL-ESL comparison in VSTF. ^c NES students showed significant different reading speed when reading Hum-Diff passages with high speed in the block formatted

condition. EFL-ESL difference is significant in VSTF while ESL-NES difference is in BLOCK. The EFL-NES comparison is significant both in BLOCK and VSTF. ^d EFL-NES and ESL-NES comparisons are significant both in BLOCK and VSTF. All other comparisons are insignificant.

RQ2. What is the relationship between text format types and *reading comprehension* among EFL, ESL, and NES students?

Analysis without covariates. A repeated measures analysis sought out score changes as a function of text format types and differences among groups for text format effects. Appendix C provides the descriptive statistics of participants' reading comprehension on each question type and covariates including sample means, standard deviations, and correlation coefficients.

The main within-subjects effect was significantly different on combined dependent variables, ($F(8, 178) = 4.30, p = .00$; Wilks' Lambda = .84; partial $\eta^2 = .16$). That is, mean comprehension scores of block reading were significantly different from those of phrase-segmented reading if we ignore the language difference of participants. The partial η^2 value implied that the magnitude of the difference due to text format types was large, as 16.2 % of multivariate variance of the dependent variables was associated with the text format. However, this format effect did not vary across groups, as implied by no significant interaction between the format and group ($F(8, 178) = 1.55, p = .14$; Wilks' Lambda = .87; partial $\eta^2 = .07$). A significant between-subjects difference was also found ($F(8, 178) = 4.75, p < .0005$; Wilks' Lambda = .68; partial $\eta^2 = .18$). This result indicates that mean comprehension scores were significantly different among groups if we ignore all other variables. The magnitude of the between-group difference was also large (18% of variance).

Follow-up univariate ANOVAs further showed how text format types affected each type of comprehension questions and whether groups varyingly performed on each dependent variable. With regard to simple main effects for format, i.e., the differences in reading scores due to format types, there was a significant difference in topic ($F(1, 92) = 4.06, p = .05$, partial $\eta^2 = .04$) and information questions ($F(1, 92) = 7.40, p = .01$, partial $\eta^2 = .07$). Significant between-group differences were found in vocabulary ($F(2, 92) = 10.07, p = .00$, partial $\eta^2 = .18$), information ($F(2, 92) = 7.93, p = .00$, partial $\eta^2 = .15$), and inference-making questions ($F(2, 92) = 11.79, p = .00$, partial $\eta^2 = .20$).

Additional GLM procedure analyses were run for each group to further examine the specific nature of the within-subjects effects. Table 4.4 summarizes these results in terms of mean differences for each question type within groups. Phrase-segmented reading was effective for EFL students in topic ($F(1, 31) = 4.86, p = .03$, partial $\eta^2 = .14$) and information questions ($F(1, 31) = 9.62, p = .004$, partial $\eta^2 = .24$); a trend of a positive effect of phrase-segmented format was found in vocabulary questions ($F(1, 31) = 3.43, p = .07$, partial $\eta^2 = .10$). For ESL students, no significant effect was found in all but information questions ($F(1, 32) = 3.13, p = .04$, partial $\eta^2 = .09$). Text format did not affect reading comprehension scores for NES students.

Table 4.4.

Pairwise Comparisons of Mean Reading Comprehension Score Difference (Phrase-segmented – Block-formatted) within Group

Measure	Mean Difference (Standard Error)		
	EFL	ESL	NES
Topic	10.16 (4.51)*	1.52 (4.44)	4.17 (4.66)
Vocabulary	10.16 (5.81)+	1.52 (5.72)	-5.84 (6.00)
Information	11.33 (3.72)**	7.58 (3.67) *	-1.25 (3.85)
Inference making	6.25 (5.08)	1.52 (5.01)	6.67 (5.25)

Note. Bonferroni adjustment for multiple comparisons was employed.

+ $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

To find out where the differences in reading comprehension between groups lie, GLM procedures with Bonferroni multiple comparisons were separately conducted at each format type. Table 4.5 shows the specific nature of the between-group effects in terms of mean difference. In the block condition, between-group differences lied in vocabulary ($F(2, 92) = 11.33, p < .0005$, partial $\eta^2 = .20$), information ($F(2, 92) = 10.71, p < .0005$, partial $\eta^2 = .19$), and inference-making questions ($F(2, 92) = 6.88, p = .002$, partial $\eta^2 = .13$). In particular, mean differences between EFL and ESL students are significant in vocabulary, information, and inference-making questions. A significant difference between EFL and NES students was in vocabulary, information, and inference-making questions. A significant difference between ESL students and NES students, however, was not found.

In the phrase-segmented condition, between-group differences were in vocabulary ($F(2, 92) = 3.07, p = .05$, partial $\eta^2 = .06$) and inference-making questions ($F(2, 92) = 7.05, p = .001$, partial $\eta^2 = .13$). In particular, a significant group difference between EFL and ESL students and between EFL and NES students remained in vocabulary and inference-making questions, respectively. A group difference between ESL and NES students was not still significant in all question types. It is interesting that although there was no statistical

significance, EFL students scored higher than other groups in topic questions and ESL students scored higher than NES students in vocabulary questions.

Table 4.5.

Pairwise Comparisons of Mean Reading Comprehension Score among Language Group

Measure	Mean Difference (Standard Error)					
	BLOCK			VSTF		
	EFL vs. ESL	EFL vs. NES	ESL vs. NES	EFL vs. ESL	EFL vs. NES	ESL vs. NES
Topic	-3.74 (4.70)	-1.77 (4.82)	1.97 (4.78)	4.90 (4.52)	4.22 (4.63)	-0.68 (4.59)
Vocabulary	-25.19*** (6.28)	-27.08*** (6.43)	-1.89 (6.38)	-16.55* (6.79)	-11.09 (6.96)	5.46 (6.91)
Information	-12.17* (5.08)	-24.06*** (5.20)	-11.89 (5.16)	-8.42 (5.13)	-11.48 (5.26)	-3.07 (5.22)
Inference making	-14.16* (5.56)	-20.52*** (5.69)	-6.36 (5.65)	-9.42 (5.45)	-20.94** (5.58)	-11.52 (5.54)

Note. + $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

Analysis with covariates. A GLM procedure with covariates was run to factor out the influence of word recognition and vocabulary knowledge and examine if this would change the results. After adjustment for covariates, there was still a statistically significant main effect of the within-subjects factor ($F(4, 87) = 2.60, p = .04$; Wilks' Lambda = .89; partial $\eta^2 = .11$). In addition to the main effect, the interaction between format and language on reading was also significant ($F(8, 174) = 2.07, p = .04$; Wilks' Lambda = .83; partial $\eta^2 = .09$). This result implied that the text format effect on comprehension scores more or less varied across EFL, ESL, and NES students when covariates were controlled for in the analysis. The main effect of language group was listed separately from the repeated measure effects ($F(8, 174) = 2.19; p = .03$, Wilks' Lambda = .83; partial $\eta^2 = .09$). That is, reading scores were still significantly different among the three groups with covariates controlled.

Figure 4.3 gives us an idea about overall performance of each group on the comprehension test in two text format conditions. Scores were averaged across question types in each condition.

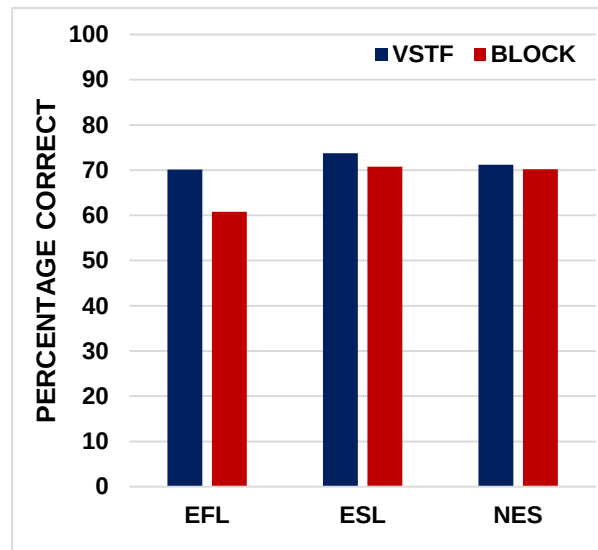


Figure 4.3. Adjusted means of overall reading comprehension scores by language group.

Follow-up ANOVA results showed that significant within-group difference was found only in information questions ($F(1, 90) = 5.95$; $p = .01$, partial $\eta^2 = .06$). The text format effect on information questions needs to be interpreted within the context of its interaction with language group because the interaction was significant in this question type ($F(1, 90) = 6.47$; $p = .00$, partial $\eta^2 = .13$). The two-way interactions in all other question types were not significant.

A between-group difference was statistically significant or marginally significant in two question types: vocabulary ($F(2, 90) = 5.22$; $p = .01$, partial $\eta^2 = .10$) and inference-making questions ($F(2, 90) = 2.64$; $p = .07$, partial $\eta^2 = .06$).

A post hoc test with a Bonferroni adjustment was performed for pairwise multiple comparisons. With regard to within-group differences, EFL and ESL students performed

better in all types of questions in phrase-segmented format than in the block reading condition, some of which were statistically significant. EFL students gained higher scores in the phrase-segmented condition than in the block on information ($M = 15.84, SE = 4.05, p = .00$). A mean score difference for ESL students was only significant on information questions ($M = 8.01, SE = 3.64, p = .03$). A significant difference was found only in information questions for both groups. NES students scored higher in topic and inference-making questions in the phrase-segmented condition than in the block; the opposite was true in vocabulary and information questions. These differences, though, were not significant in any question type. Figure 4.4 shows the average comprehension scores for each language group in terms of adjusted means and standard errors.

Pairwise multiple comparison tests also identified the difference among groups. Topic questions had no significant between-group difference in either text format type. In all other question types, mean score differences were apparent in the block condition for most pairs of groups whereas these between-group differences varied across pairs in the phrase-segmented condition. Mean differences in the block condition between EFL and ESL students were significant in one question type: vocabulary ($M = 21.30, SE = 6.75, p = .01$). This pair comparison was not significant in the phrase-segmented condition. With regard to the comparison between EFL and NES students, significant mean differences in the block condition existed in information ($M = 16.23, SE = 6.26, p = .03$) and possibly in vocabulary ($M = 17.87, SE = 7.74, p = .07$).

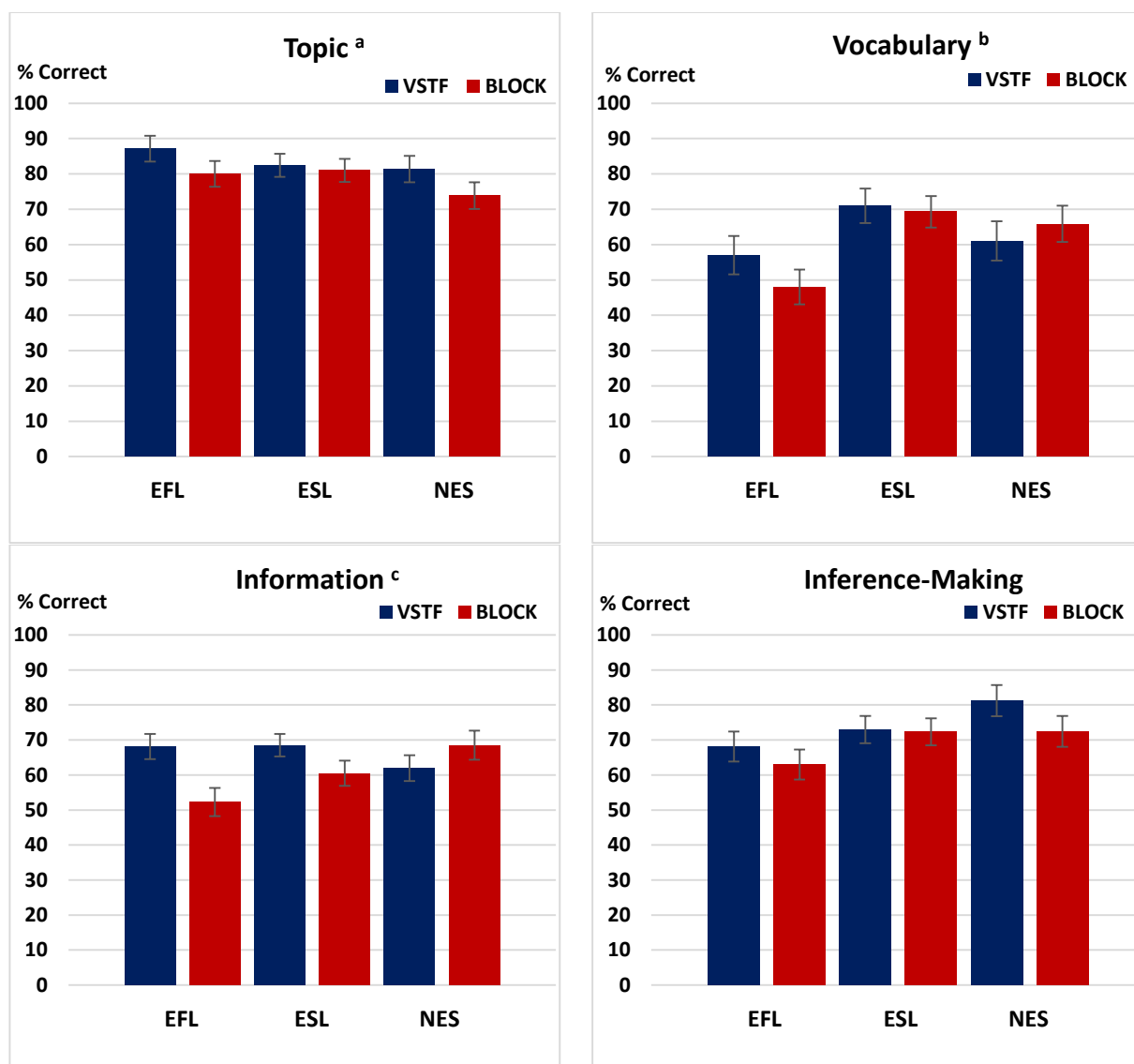


Figure 4.4. Adjusted means of reading comprehension scores by language group. ^a Overall within-group difference is significant ($M = 5.35$, $p = .04$) but each individual group does not show statistical significance. ^b Significant group-difference (EFL-ESL) and marginal significant group-difference (EFL-NES) are in BLOCK. ^c Significant within-group differences were in both EFL and ESL, but not in NES. Significant between-group difference (EFL-NES) is in BLOCK.

In the phrase-segmented condition, NES students still outperformed EFL students at a significance level (information: $M = 11.33$, $p = .05$; inference-making: $M = 20.94$, $p = .00$). Vocabulary questions had no significant difference between these groups ($M = 10.96$, $p = .35$). A significant mean difference between ESL and NES students only existed in the

block condition in one question type (information: $M = 12.18$, $p = .05$); however, there was no significant group difference in the phrase-segmented condition.

RQ3. Are the effects of the phrase-segmented format on L2 reading speed and comprehension moderated by L2 readers' working memory capacity?

Reading speed and comprehension data from 58 L2 students were analyzed to answer research question 3. Unlike analyses for research questions 1 and 2, the between-subjects factor in this analysis is participants' working memory capacity level. As described in the Data Analysis section, high ($n = 30$) and low ($n = 28$) working memory groups were compared in terms of their reading performance. These two groups are hereafter referred to as high and low WM groups.

Analysis of reading speed with covariates. Reading speed was again analyzed using a two-way mixed GLM with format as within-subjects factor and working memory group as between-subjects factor. This model included the same covariates—vocabulary and word recognition scores. This analysis sought out reading speed changes as a function of text format types for each level of the group. Appendix D provides the descriptive statistics of WM groups' reading speed in terms of WPM and covariates including sample means, standard deviations, and correlation coefficients.

The analysis result showed that the main within-subjects effect was not significantly different on combined dependent variables ($F(4, 51) = .65$; $p = .63$, Pillai's Trace = .05; partial $\eta^2 = .02$) nor was the interaction ($F(4, 51) = .17$; $p = .95$, Pillai's Trace = .01; partial $\eta^2 = .02$). These results implied that text format types did not affect reading speed for either group. Figure 4.5 clearly shows that there was no overall difference within and between groups.

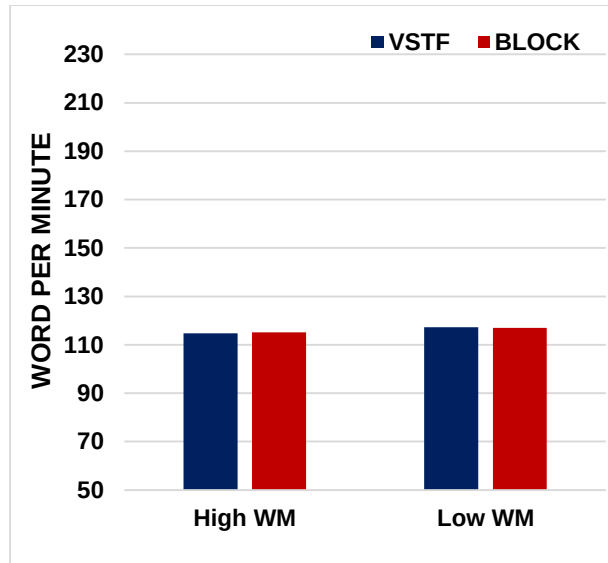


Figure 4.5. Adjusted means of overall reading speed (WPM) by working memory group among L2 students.

With regard to between-subjects factors, no significant difference was found across groups ($F(4, 51) = 0.65$; $p = .16$, Pillai's Trace = .12; partial $\eta^2 = .12$). These data did not provide evidence of the association between reading speed and working memory capacity (See Figure 4.6. for adjusted means and standard errors by group).

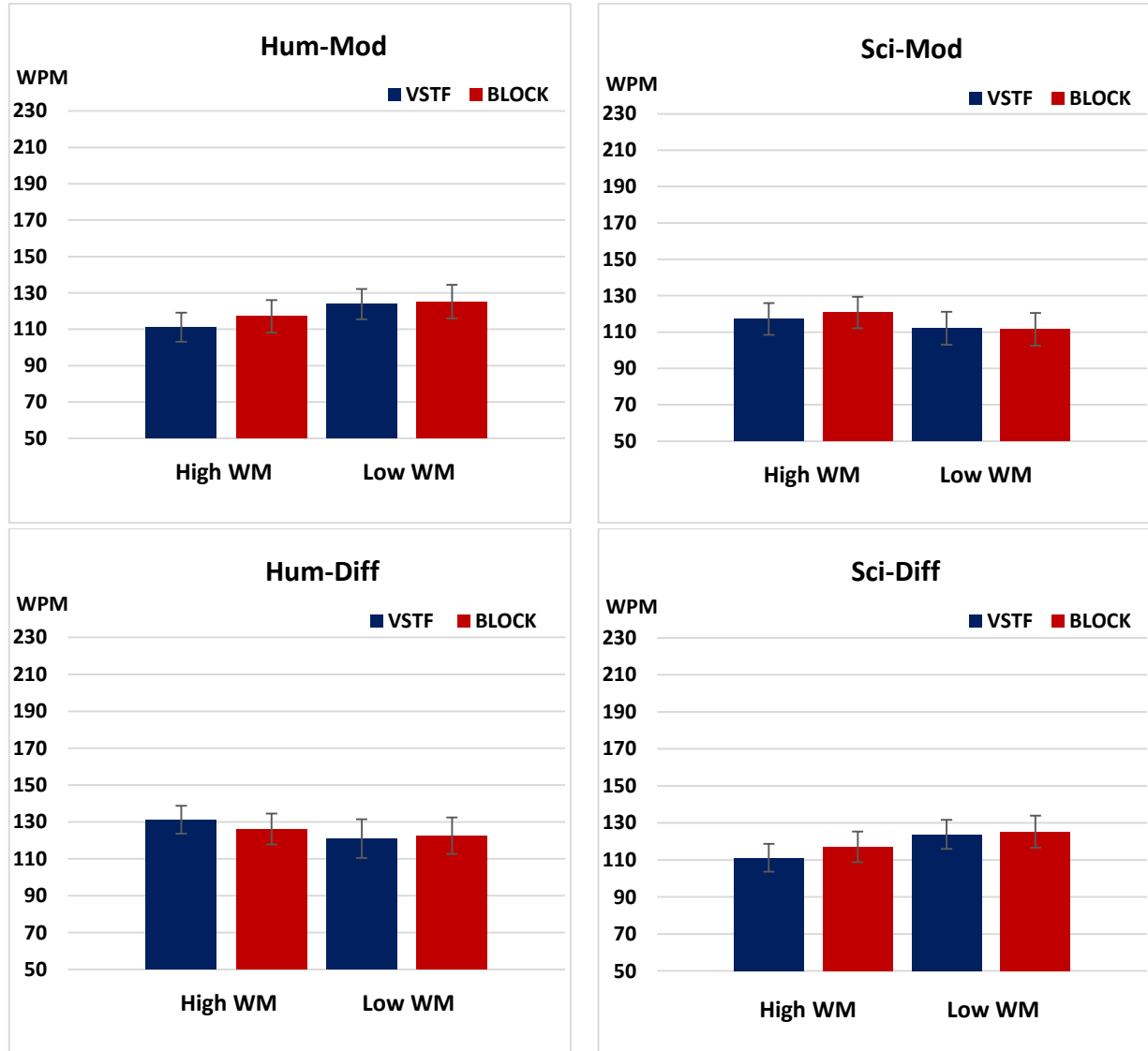


Figure 4.6. Adjusted means of reading speed (WPM) by working memory group among L2 students.

Analysis of reading comprehension with covariates. A two-way mixed GLM was also conducted to understand the effects of text format types (block, phrase-segmented) and working memory capacity (high, low) on reading comprehension. This analysis included the same within- and between-subjects factors and covariates as in the analysis above of reading speed. Appendix E provides the descriptive statistics of WM groups'

reading comprehension scores and covariates including sample means, standard deviations, and correlation coefficients.

The main effect of format was statistically significant ($F(4, 51) = 3.60; p = .01$, Wilks' Lambda = .78; partial $\eta^2 = .22$). The two-way interaction was also significant ($F(4, 51) = 2.66; p = .04$, Wilks' Lambda = .83; partial $\eta^2 = .17$). The group difference, however, was not significant ($F(4, 51) = 0.79; p = .54$, Wilks' Lambda = .94; partial $\eta^2 = .06$). Figure 4.7 displays overall within- and between-group differences on comprehension tests.

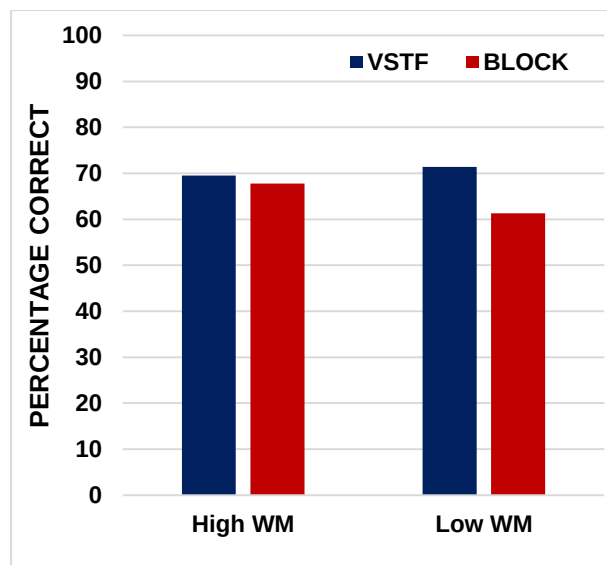


Figure 4.7. Adjusted means of overall reading comprehension scores by working memory group among L2 students.

Follow-up ANOVAs identified which dependent variables had significant differences. In particular, the effect of format types on topic and information questions was significant to a similar extent for both working memory groups. This is evidenced by a significant main effect (topic: $F(1, 54) = 3.32, p = .07$, partial $\eta^2 = .05$) and a non-significant interaction. Text format types affected vocabulary and inference-making questions differently for high and low working memory groups. This is suggested by a significant or marginally significant

interaction on these question types (vocabulary: $F(1, 54) = 3.29, p = .07$, partial $\eta^2 = .06$; inference-making: $F(1, 54) = 3.24, p = .04$, partial $\eta^2 = .07$).

In order to further investigate the differences, all pairwise comparisons with Bonferroni corrections were performed for statistical significant simple main effects. Figure 4.8 illustrates these differences in terms of adjusted means and standard errors. No significant group difference was detected across format types. Only a marginal significance in the block condition was found in vocabulary ($M = 12.41, SE = 7.15, p = .08$). With regard to the within-group differences, students from both working memory groups scored higher in phrase-segmented format than in the other condition on topic and information questions. A significant difference, however, was only found in the latter question type (High: $M = 9.31, SE = 4.13, p = .03$; Low: $M = 9.22, SE = 4.29, p = .04$). Only marginal significance existed in topic questions for low WM group ($M = 7.98, SE = 4.75, p = .09$). The two groups showed different patterns on vocabulary and inference-making questions: the high WM group scored higher in block condition than the other while the low WM group produced the opposite pattern of results. The within-group difference in the high WM group was not significant. The low WM group had a marginal significance in vocabulary questions ($M = 12.24, SE = 6.3, p = .06$) and a statistical significance in inference-making questions ($M = 12.76, SE = 5.9, p = .04$).

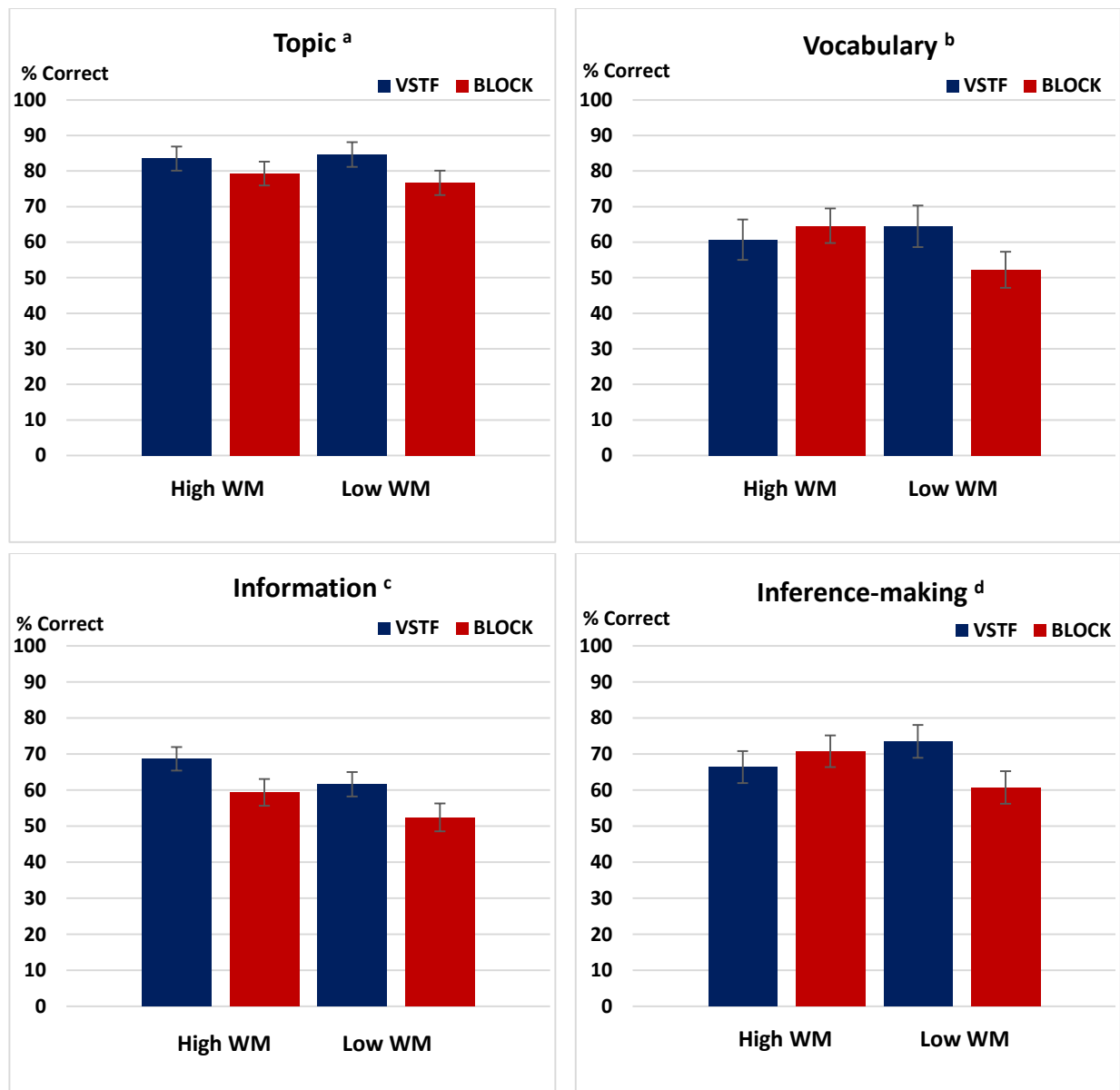


Figure 4.8. Adjusted means of reading comprehension scores by working memory group among L2 students. ^a Marginal within-group difference is in Low WM. ^b Low WM's score in BLOCK is lower than in VSTF. This score is lower than that of high WM in BLOCK. These within- and between-group differences are both marginally significant. ^c Significant within-group difference is in both High and Low WM. ^d Significant within-group differences in Low WM.

Chapter 5

Discussion

Chapter 5 discusses the findings of the study and examines the effects of phrase-segmented format on rapid and accurate L2 reading. Each section begins with the hypotheses articulated, which are underlined and marked with H1. This discussion integrates the results with the literature reviewed in Chapter 2.

Phrase-Segmented Format and Reading Speed

H1: Phrase-segmented format positively influences L2 students' reading speed, but not that of native English students.

The results showed that text format types did not generally affect reading speed for all three groups of students. Although the participants all read block-formatted text slightly faster than phrase-segmented text, no statistical difference was found except for one out of four passage sets, and only for NES students. Regarding group differences, as expected, students with more exposure to an English-speaking environment read faster than those with less exposure, regardless of format type. In other words, ESL and NES students read faster than EFL students and the reading speed of NES students was higher than that of ESL students. Where the group differences lie can be obtained by taking a closer look at the speed difference in each set of passages. The speed difference between EFL and ESL students seems bigger in the phrase-segmented format than in the block format. This is evidenced by the EFL-ESL comparisons which are significant or marginally significant in three phrase-segmented passages and in one block-formatted passage. EFL students' relatively slow reading speed in the phrase-segmented format might have caused this larger group difference in that format over the block format. This result, however, does not

mean that the phrase-segmented format slowed down EFL students' reading nor that it increased ESL students' reading speed. In contrast, the gap between ESL and NES students seems wider in block format than in phrase-segmented format. This reduced group difference did not stem from ESL students' better performance in the phrase-segmented condition but from NES students' slower speed in the phrase-segmented condition.

These findings are inconsistent with those of previous studies on phrase-segmented format reading (Jandreau et al., 1986; LeVasseur et al., 2008; Walker et al., 2005). What differentiates these studies from the current study is that they were all conducted by format developers, which can make them vulnerable to confirmation bias. This bias can lead researchers to an incorrect interpretation of results due to the tendency to look for information that conforms to their hypotheses. Another factor to consider is a sufficient amount of training before a post-test (LeVasseur et al., 2008). Studies that did not find positive effects of reformatted format on reading speed did not include training periods other than a one-time training session preceding a reading test (Jandreau & Bever, 1992; Yu & Miller, 2013). More importantly, the phrase-segmentation in this study is different from that in other studies in a manner that phrases are hierarchically displayed with varied indentation levels. Considering its unfamiliarity, it is understandable for participants to read faster in block format than in phrase-segmented format to which they are far less accustomed. The data collected in this study did not provide enough evidence on which factor, the magnitude of format unfamiliarity or the effect of hierarchical segmentation, affected reading speed to a greater degree. Therefore, it is inconclusive that the findings for the research question 1 reject my hypotheses.

Despite null findings in relation to speed, it is feasible to further investigate whether syntactic enhancement can improve reading fluency for three reasons. First, rapid recognition of phrases contributes to reading speed (National Reading Panel, 2000) and phrase-segmented format is expected to help readers easily identify phrase boundaries. Second, null findings in this and other studies can be interpreted as that the non-standard text format does not harm reading speed, presumably because reading already-parsed text may compensate for possible speed decrease. Third, some VSTF studies with no reading speed measure but with a user report suggested a potential of phrase-segmented format as a speed accelerator (Park et al., 2013; Park & Warschauer, 2016). The EFL teacher in Park et al. (2013) observed that using phrase-segmented format in reading-listening combined lessons enabled her to easily teach prosodic cues to her low proficiency students. ESL students in another study (Park & Warschauer, 2016) reported that they felt their reading fluency improving while using VSTF for an academic year. Thus the hypothesis formulated in this study remains viable and is worthy of continued research.

Phrase-Segmented Format and Reading Comprehension

H1: Phrase-segmented format has a significant impact on reading comprehension of the L2 group students (ESL and EFL) but not of NES students.

The results for research question 2 on reading comprehension support my hypothesis that the phrase-segmented format has a significant impact on the reading comprehension of L2 students and less of an impact on NES students. Although the participants performed significantly better in the phrase-segmented condition than the block condition on topic questions, there was no significant score change detected in each individual group. Both L2 group students scored higher on information questions when

reading phrase-segmented passages than block passages. However, no difference emerging from text format types was found among NES students.

Perceived group differences were found in the block condition but not in the phrase-segmented condition. When reading block passages, EFL students performed poorer than ESL students on vocabulary questions and their scores were significantly lower than NES students on information questions. On the other hand, the group difference between ESL and NES students was not large enough to detect across text format.

The absence of group difference especially on topic questions, in no matter which format, shows that L1 and L2 students had comparable abilities to understand the main idea of the text. Even EFL students scored higher than NES students, although there was no statistical significance. The questions with which L2 students, especially EFL students, struggled the most in the standard condition are vocabulary and information questions. These questions require linguistic knowledge to understand words in context and the abilities to accurately recall specific information. Based on the literature reviewed in Chapter 2, these skills, abilities, and knowledge are to some extent connected to syntactic awareness. A reasonable amount of syntactic knowledge can facilitate making sense of words in context (e.g., Perfetti & Stafura, 2014), constructing mental representations from which to retrieve information (e.g., Givón, 2009). Given the limited facility in using syntactic cues during L2 processing, it is not unexpected at all that L2 students gained considerably lower scores than L1 students.

Furthermore, it was important to find that phrase-segmented format significantly affected L2 students in some of these questions, while it did not for L1 students. These findings add new evidence to a number of studies that found phrase-segmented reading is

helpful for less skilled readers (Jandreau & Bever, 1992) or L2 readers (Park et al., 2013; Park et al., 2013; Vogel, 2011; Walker et al., 2005). As Cromer (1970) argued, the phrase-segmented format seemed to scaffold reading comprehension of readers with low syntactic awareness by helping them make syntactic sense of sentences. One may consider that the starkly different way of displaying text in VSTF can hinder reading processing, as stated in Yu and Miller (2013). However, considering that syntactic processing is the transformation of a linear structure of words and phrases into a hierarchical structure (Hurford, 2011), VSTF's already-transformed text in a hierarchically organized form turned out to be helpful for L2 readers. Drawing on Gernsbacher's (1997) model, it can be postulated that phrase-segmented format discourages L2 readers from shifting and creating too many substructures, which can cause slow processing and inaccurate comprehension.

The NES student group in the current study was not responsive to phrase-segmented format text presumably because they already had an adequate amount of syntactic knowledge. Similar findings were already reported in Cromer's (1970) and Jandreau and Bever's (1992) studies in which the phrase-segmented format did not influence comprehension scores of high proficiency readers.

The heterogeneous effect of text format on L1 and L2 groups lends indirect evidence that L2 readers are far less likely to use syntactic cues while reading than L1 readers, as theorized by VanPatten (2004) and empirically investigated in other studies (Akker & Cutler, 2003; Clahsen & Felser, 2006; van Hell & Tokowicz, 2010). Given the likelihood that syntactic cues facilitate the enhancement and suppression mechanisms involved in comprehension processes based on Gernsbacher's (1995) structure building model, the phrase-segmented format evidently eases L2 reading processing. Moreover, phrase-

segmented format reading is recommended for learners who face particular challenges in light of their L2 learning environments. These challenges include little immersion experience and a distinct linguistic distance between L1 and L2. The EFL group in the current study had both of these difficulties.

Phrase-segmented format and working memory in L2 reading

H1: The effects of phrase-segmented format on reading speed and comprehension are greater for L2 students with low working memory capacity than for those with high capacity.

The third research question was concerned with how L2 readers respond to the phrase-segmented text format depending on their working memory capacities. The two parts of this question aimed at delving into the format effects on reading speed and comprehension in relation to participants' working memory span. ESL and EFL groups were combined and regrouped into high or low capacity groups based on their scores on the working memory measure.

It was found that the two groups were basically equivalent in terms of reading speed and comprehension. In both groups alike, the phrase-segmented format did not affect reading speed but did facilitate reading comprehension. The two WM groups, however, responded differently to the text format types in comprehension tests. In particular, both groups performed better on topic and information questions when reading phrase-segmented passages than block passages. A statistically significant difference was found only in information questions. Additionally, the low WM group showed marginally significant difference in topic questions. Diverging patterns across groups were observed in inference-making and vocabulary questions. When reading phrase-segmented text, the low

WM group gained significantly higher scores in inference making questions and slightly higher scores in vocabulary questions. The opposite patterns were observed among the high capacity group but with no statistical significance.

The finding of no group difference across text format appears to contradict the observations from previous studies in which skilled readers tend to have higher working memory capacity than less skilled readers (e.g., Swanson & O'Connor, 2009). Perhaps this was because the L2 groups in this study did not represent a wide range of English proficiency, as stated earlier in Chapters 1 and 2. This speculation may also explain the absence of significant group difference in the phrase-segmented condition.

In spite of this absence, it is important to take into account a small but critical difference that was found in inference-making and vocabulary questions. This result clearly suggests that the phrase-segmented format reading contributed to a high level of text comprehension that L2 readers, especially those with inefficient working memory function, find challenging. Therefore, the absence of group difference in each individual question type should not be interpreted as a direct indication that phrase-segmented format does not influence reading comprehension. In addition, this diverging outcome can provide a partial answer to the research question 2, explaining why L2 students in general were not responsive to the phrase-segmented format when required to generate inferences. The heterogeneous effects of text format across the two WM groups might have yielded L2 students' unchanged scores in vocabulary and inference-making questions.

The outcome of the low capacity group in the phrase-segmented condition supports the previous studies on the correlation between working memory capacities and inference-generation abilities (e.g., Estevez & Calvo, 2000; Cain et al., 2004). This association between

working memory and high level comprehension skill can be elucidated in relation to the enhancement and suppression mechanisms within Gernsbacher's (1995) structure building model. Individuals with greater working memory capacity tend to store and process information effectively by holding more of the relevant information (e.g., Swanson & O'Connor, 2009) and less of the irrelevant information (e.g., McNamara & O'Reilly, 2009). Resourceful working memory skills through effective enhancement and suppression mechanisms subsequently enable readers to generate inferences during reading.

In this inference making process, the hierarchically segmented text format can help L2 readers with low working memory capacity for the following reasons. According to Givón (2009) and Kintsch (1995), syntactic information serves as guidance in the structure building process of comprehension. Syntactic processing, in which readers process linear arranged sentences from left to right and transform them to a hierarchical structure (Hurford, 2011), may result in working memory overload (Frank, Bod, Christiansen, 2012; King & Just, 1991). This problem becomes worse for L2 readers because L2 reading processing entails controlled information processing that inherently involves great demand on working memory capacity (VanPatten, 2004). For L2 readers to develop from this controlled processing to automatic processing is excessively demanding (e.g., VanPatten, 2004). In this bootstrapping process, it makes little sense to improve syntactic knowledge through reading without an adequate amount of syntactic knowledge in the first place. Reading already-parsed text in a hierarchical manner consequently helps comprehension of L2 readers who do not have high working memory capacity and extensive amounts of syntactic knowledge.

My claim about the relationship between text format and working memory function is particularly validated by the testing environment of this study. That is, reading passages were not available when the participants were answering the questions, as suggested by Schaffner and Schiefele (2013). If the passages had been made available to the readers, as they were in other studies (e.g., Oakhill, 1984), one would have casted doubt on readers' performance on inference questions in the phrase-segmented format condition. As McNamara & O'Reilly (2009) emphasized, readers' memory resources might be relieved to a certain degree when passages, in which answers to inference questions can be found, are made available. Therefore, in the testing condition without passages available when readers were answering questions, such as the current study, generating inferences requires a considerable amounts of capacity and knowledge that enable readers to relate different parts of text and even prior knowledge. Phrase-segmented format is thought to facilitate this perplex process.

Chapter 6

Summary and Conclusion

Summary

This dissertation set out to explore syntactic enhancement in L2 reading contexts and its potential relationship with readers' limited cognitive capacities. The use of syntactic enhancement as scaffolding of L2 reading is drawn from the idea of input enhancement that has been commonly used in L2 research and instruction. Input enhancement manipulates texts in a way to make target L2 input salient, which otherwise learners are likely to neglect, in order to make learning of this particular input take place. A number of L1 research, but a very few L2 studies, have examined the idea of manipulating text to make phrase boundaries noticeable. Drawing on the theoretical literature on the use of syntactic cues for efficient working memory function as well as enhanced comprehension, this study investigated how phrase-segmented format facilitates rapid and accurate L2 reading. As a tool to convert standard block text to phrase-segmented text, VSTF technology, which reformats text into hierarchically organized segmentation based on linguistic rules and human perceptual tendency, was used. Phrase-segmented text, supported by VSTF, was hypothesized to positively affect L2 reading speed and comprehension, granted that syntactic processing is transformation of linear structure into hierarchical arrangement, which can accompany working memory overload for L2 readers. The effects were expected to be larger for those with low working memory capacity.

The following section reexamines the results in light of the original thesis and the claims made in Chapters 1, which is followed by the significance and weaknesses of this

study. This chapter concludes with an exploration of directions for future research and recommendations for practice.

Hypotheses Revisited

This section reviews the research questions and associated hypotheses that were generated in Chapter 1 and synthesize the empirical findings to verify that each has been addressed in this study.

RQ1. What is the relationship between text format types and *reading speed* among EFL, ESL, and NES students?

H1. Phrase-segmented format positively influences L2 students' reading speed, but not that of NES students.

Summary. Generally speaking, the text format type did not affect reading speed with minimal within-group variation and unchanging between-group differences across text format. However, it is too early to arrive at the conclusion that the findings reject my hypothesis that phrase-segmented format has a positive impact on L2 reading speed. The data analysis revealed that the participants all read block-formatted text slightly faster than phrase-segmented text, but no statistical difference was found in most cases. The results concerning group differences showed that the more exposure to an English-speaking environment students had, the faster they read regardless of format types. Although the gap between ESL and NES students waned for one time when they read phrase-segmented texts, this reduced group difference resulted from NES students' exceptionally fast speed in the block formatted passage and their relatively slow reading in the paired phrase-segmented passage. Drawing on findings from previous studies on phrase-segmented format reading, I speculate that it may be an insufficient amount of

exposure to unfamiliar text format, rather than the phrase-segmented text format itself, that slows down reading speed.

RQ2. What is the relationship between text format types and *reading comprehension* among EFL, ESL, and NES students?

H1. Phrase-segmented format has a significant impact on reading comprehension of the L2 students but not of NES students.

Summary. The predominant results from the reading comprehension data analyses are the conspicuous effects of text format in information questions only for L2 students. Participants as a whole group scored higher in topic questions, but each language group did not show a particular within-group difference in this question type. NES students did not show significant difference in any question type. In addition, their scores were higher in the block condition than in the phrase-segmented condition in vocabulary and information questions, even though there was no significant score change. This result especially contrast that related to L2 students. These exclusive effects of text format on L2 reading and NES students' lower score in the phrase-segmented condition leads to the reduction in group differences in the phrase-segmented condition, as compared to the block format condition especially between EFL and NSE students. The group difference between EFL students who had little exposure to L2 communication and ESL students with immersion experience was found only in the block condition. Taken together, the reading comprehension data generally corroborated my hypothesis of the potential scaffolding of phrase-segmented format reading on L2 comprehension.

RQ3. Are the effects of the phrase-segmented format on L2 reading speed and comprehension moderated by L2 readers' working memory capacity?

H1. The effect of phrase-segmented format on reading speed and comprehension is greater for L2 students with low working memory capacity than for those with high capacity.

Summary. The data analyses indicated that the effects of text format type varied with readers' working memory capacity in reading comprehension but not in reading speed. No association between text format type and reading speed was detected in the result from the entire group analysis. Likewise, no association between text format type and reading speed was found in this analysis. With regard to reading comprehension, both groups benefited from phrase-segmented format in topic and information questions, though all within-group comparisons were not statistically significant. While significant difference for the high WM group was only in information questions, the low WM group's score difference in information and topic questions were significant or marginally significant. On the other hand, the two WM groups responded differently to the text format types in vocabulary and inference-making questions. The phrase-segmented format benefited the low WM group significantly when making inferences and making questions and possibly when solving vocabulary questions. In contrast, the high WM group was not responsive to the phrase-segmented condition when answering these two question types. The result of the phrase-segmented format favoring the low WM group over the high WM group is especially noteworthy because it lends further evidence confirming not only that syntactic cues facilitate a high level of text comprehension, but also that syntactic scaffolding supports those with inefficient working memory processing. On the other hand, this diverging pattern of text format effect was not found in the other two question types: both WM groups performed better on topic and information questions when reading

phrase-segmented passages than block passages. These findings suggest that the association between text format type and L2 reading comprehension was moderated in part by readers' working memory capacity.

Recommendations for future research

Since this study is at the front of implementing syntactic enhancement in L2 contexts, there are many areas for further research. Some of the ideas have been presented earlier. The findings from this study will need to be further validated with better design, such as with more participants who range from low to high proficiency in L2. Due to the slow recruitment processes in two countries, this study only involved an acceptable number of participants. This small sample size possibly affected research question 3 that focused on L2 groups so that two different L2 groups needed to be combined and regrouped to answer this question. A study with a larger sample size will not only have less sampling process error but also ensure the desired precision. For the purpose of providing information for future sampling, power analysis was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). On the basis of a desired power >0.80 with alpha and beta errors set at 0.05 and 0.20, respectively, the sample size of 158 was acceptable for repeated measures with within-between interaction.

With regard to generalizability, Korean learners of English may not represent the EFL population. Even though they share characteristics of learning environments with other students in many EFL contexts, it is highly possible that students' native languages and educational systems, which may be different from those in the Korean context, have an impact on study results. It is therefore necessary to conduct a study with EFL students from different contexts to draw broader conclusion on the effects of syntactic enhancement on

L2 reading. Likewise, native languages of ESL students may have direct or indirect association with L2 learning. Linguistic properties of native languages may attribute to L2 readers' response to syntactic enhancement as well as their L2 learning. Therefore, I suggest that future studies take native languages of L2 participants into consideration.

Considering that there were negative correlations between reading speed and comprehension for the EFL and NES groups, I suggest that a future study with various population groups provide different stimuli (reading passages) for each group. Given that the possible ceiling effect for the NES group on the reading comprehension in the current study with no ceiling imposed on the reading speed measure, it may be reasonable to provide different levels of reading passages that are appropriate for the varied proficiency levels of participating groups. This may solve the issue of the disparity that the three language groups had in terms of the relationship between speed and comprehension.

An important suggestion germane to participants' proficiency levels is to separate participants in terms of their syntactic knowledge and vocabulary knowledge, as did Cromer (1970). It is assumed that those with vocabulary knowledge comparable to skilled readers but with insufficient syntactic knowledge would benefit from hierarchical syntactic enhancement. The current study separated participants based on their working memory capacity and demonstrated that L2 readers with low working memory capacity benefited more from syntactic enhancement. A study with experiment and control groups based on various linguistic knowledge levels would answer the question: whether struggling readers with different profiles of reading skills varyingly respond to hierarchical syntactic enhancement.

Perhaps the most intriguing area would be an evaluation of syntactic enhancement and reading fluency. Despite the absence of any effects of text format on reading speed, it is rather early to come to a conclusion that syntactic enhancement does not affect L2 reading fluency. Understanding that it will take at least a certain amount of time for users to become accustomed to the hierarchical segmentation format, I suggest for a fluency study with pre- and post-tests and a decent amount of training in between. The fluency-related findings from other studies with the same phrase-segmented text format as the current study validate this suggestion. Both sixth-grade ESL students from the U.S. and twelfth-grade EFL students from Korea reported that they felt that their reading speed was increasing during the one-year (Park & Warschauer, 2016) and three-month studies (Park et al., 2013), respectively.

This study was situated within the Structure Building Model with the enhancement and suppression mechanisms underlying comprehension processes. Even though this framework helps to explain how the phrase-segmented text format facilitates L2 reading, the measures used in the current study were not designed to examine whether the phrase-segmented format aids readers in either or both of the mechanisms. In order to delve into this particular issue, case studies with qualitative methods, such as think-aloud, interviews, and observations, will be valuable. These case studies will allow further assessment of how readers behave and think differently when reading standard block-formatted text and phrase-segmented text.

Similarly, I used the Structure Building Model with two separate but closely related mechanisms to elucidate how syntactic enhancement supports L2 readers with low working memory capacity in generating inferences. It seems that syntactic enhancement

positively interferes with the association between limited working memory functioning and inference-making. However, the working memory task used in the current study did not separate storage and processing components. The data in the current study does not successfully demonstrated whether syntactic enhancement is associated with economic storage (enhancement and/or suppression) and how it affects rapid and intricate processing. I suggest that the research design for future studies include tasks involving inhibitory control as well as working memory in order to better understand whether syntactic enhancement influences L2 readers' working memory as a mediator variable, which in turn affects sophisticated L2 reading activities,

Participants in each group were recruited from the same university (in the U.S.) or from two different but similar universities in terms of academic performance (in South Korea). Although this study involved three language groups that had varied English proficiency, this diversity in proficiency levels stemmed from their different language contexts rather than individual differences. It would be useful to conduct a study with a large number of L2 readers from a wider range of proficiency levels. Participants can be categorized based on their vocabulary and syntactic knowledge levels. This study design will be appropriate to test whether readers with high vocabulary and low syntactic knowledge benefit more from syntactic enhancement than other types of readers.

Theoretical and Practical Implications

One aspects of the results from this study is of interest for reading comprehension theories. This study has reported that a greater improvement in reading comprehension for L2 readers than for L1 readers as a function of phrase-segmented formatting. In other words, the reason for L2 readers' ineffective comprehension is to some degree related to

their abilities to process syntactic information. Thus, this finding can be taken as additional confirmation for the claim of information processing theory that L2 readers' default strategy is processing non-syntactic information (VanPatten, 2004); furthermore, it justifies the use of syntactic enhancement. The point that phrase-segmented format eases the L2 reading processing also supports the argument of Givón (2009) and Kintsch (1995) that syntactic cues facilitate the enhancement and suppression mechanisms involved in comprehension processes based on Gernsbacher's (1995) structure building model.

Another finding of interest is that the heterogeneous effect of phrase-segmented format among two working memory groups was found only in inference-making questions. This result contributes to speculation that working memory capacity is associated with high level comprehension skills, such as inference-generation abilities. This specific association has been reported in a number of studies (Estevez & Calvo, 2000; Just & Carpenter, 1992; Yuill & Oakhill, 1991). Furthermore, the format effect on inference generation found in this study lends a support to accounts of Givón (2009) and Kintsch (1995) on the role of syntactic information as a guide in coherent text construction that consumes much of working memory resources.

It is imperative to extend these theoretical insights to practice. First, learners who independently use the phrase-segmented format would have enriched opportunities to stimulate their L2 reading skills. As informed by information processing theories, we understand that L2 learners have difficulties extracting syntactic cues from text and applying them to structure building processes. Without having support by teachers, resources, or technological applications, L2 readers who have not acquired enough facility in syntactic awareness are likely to have few chances to improve their syntactic knowledge

through independent reading. Granted that grammar acquisition is a piecemeal learning process, in which chunks used frequently can be more likely remembered later (Ellis, 2003), the consistent use of the phrase-segmented format would increase the learning opportunities.

Second, this study sheds light on the little used syntactic enhancement in L2 reading instruction. L2 grammar is commonly taught in an intensive course and tested as discrete points. Frequently used instructional approaches to teach L2 syntactic knowledge include drill-and-practice exercises, input enhancement, and input modification. These approaches are either critiqued as being ecologically invalid or providing unauthentic materials. An advantage of the hierarchically segmented text format over other instructional methods is to help readers recognize the complex relationship within and across various nested linguistic ecosystems during reading. Therefore teachers would be able to focus on other reading activities, such as vocabulary, strategies, and comprehension, while students remain exposed to a limited number of syntactic cues. The fact that VSTF technology converts text format in several seconds is an attractive attribute for teachers who can now spend negligible time to prepare phrase-segmented texts.

A final recommendation points to the need for consideration of the phrase-segmented format as an option for L2 reading materials. One of the most controversial issues in L2 reading is whether to provide simplified English texts or authentic texts to learners. Simplified texts are more engaging to L2 readers, while authentic texts are better at preparing L2 learners for academic language. Authentic texts, however, entail challenges for L2 readers due to their complicated syntactic structures and vocabulary. The findings of this study provides support for using authentic text in the phrase-segmented format for L2

readers. As this format can aid the enhancement and suppression mechanisms within the Structure Building framework and lighten the burden of working memory, complex L2 text that is transformed into the hierarchical segmented format may be accessible to L2 readers.

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Appendix A

Language History Questionnaire (LHQ, Li, Sepanski & Zhao, 2006)

Contact Information:

Name: _____

Email: _____

Telephone: _____

Today's Date: _____

Please answer the following questions to the best of your knowledge.

▪ **PART A**

1. Age (in years):

2. Sex (circle one): Male/Female

3. Education (degree obtained or school level attended):

4. (a) Country of origin:

(b) Country of Residence:

5. If 4(a) and 4(b) are the same, how long have you lived in a foreign country where your second language is spoken?

If 4(a) and 4(b) are different, how long have you been in the country of your current residence?

6. What is your native language? (If you grew up with more than one language, please specify)

7. Do you speak a second language?

___ YES my second language is _____.

___ NO (**If you answered NO, you need not to continue this form**)

8. If you answered YES to question 6(b), please specify the age at which you started to learn your second language in the following situations (write age next to any situation that applies).

- At home _____
- In school _____
- After arriving in the second language speaking country _____

9. How did you learn your second language up to this point? (Check all that apply)

- Mainly through formal classroom instruction _____

- Mainly through interacting with people ____
- A mixture of both ____
- Other (specify) ____

10. List all foreign languages you know in order of most proficient to least proficient. Rate your ability on the following aspects in each language. Please rate according to the following scale (write down the number in the table):

Very poor	Poor	Fair	Functional	Good	Very good	Native-like
1	2	3	4	5	6	7

Language	Reading proficiency	Writing proficiency	Speaking proficiency	Listening proficiency

11. Provide the age at which you were first exposed to each foreign language in terms of speaking, reading, and writing and the number of years you have spent on learning each language.

Language	Age first exposed to the language			Number of years learning
	Speaking	Reading	Writing	

12. Do you have a foreign accent in the languages you speak? If so, please rate the strength of your accent on a scale from 1 (not much of an accent) to 7 (very strong accent).

Very poor	Poor	Fair	Functional	Good	Very good	Native-like
1	2	3	4	5	6	7

Language	Accent (circle one)		Strength
	Y	N	
	Y	N	
	Y	N	
	Y	N	

▪ **PART B**

13. What language do you usually speak to your mother at home? (If not applicable for any reason, write N/A)

14. What language do you usually speak to your father at home? (If not applicable for any reason, write N/A)

15. What languages can your parents speak fluently? (If not applicable for any reason, write N/A)

- Mother: _____
- Father: _____

16. What language or languages do your parents usually speak to each other at home? (If not applicable for any reason, write N/A)

17. Write down the name of the language in which you received instruction in school, for each schooling level:

- Primary/Elementary School _____
- Secondary/Middle School _____
- High School _____
- College/University _____

18. Estimate, in terms of percentages, how often you use your native language and other languages per day (in all daily activities combined):

- Native language _____%
- English _____%
- Other languages _____% (specify: _____) (Total should equal 100%)

19. Estimate, in terms of hours per day, how often you watch TV (movie) or listen to radio in your native language and other languages per day.

- Native language _____ (hrs)
- English _____ (hrs)
- Other languages _____ (specify the languages and hrs)

20. Estimate, in terms of hours per day, how often you read newspapers, magazines, and other general reading materials in your native language and other languages per day.

- Native language _____ (hrs)
- English _____ (hrs)
- Other languages _____ (specify the languages and hrs)

21. Estimate, in terms of hours per day, how often you use your native language and other languages per day for work or study related activities (e.g., going to classes, writing papers, talking to colleagues, classmates, or peers).

- Native language _____ (hrs)
- English _____ (hrs)

- Other languages _____ (specify the languages and hrs)

22. In which languages do you usually:

- Add, multiply, and do simple arithmetic? _____
- Dream? _____
- Express anger or affection? _____

23. When you are speaking, do you ever mix words or sentences from the two or more languages you know? (If no, skip to question 25).

24. List the languages that you mix and rate the frequency of mixing in normal conversation with the following people, on a scale from 1 (mixing is very rare) to 5 (mixing is very frequent). Write down the number in the box.

Very rare	Rare	Fair	Frequent	Very frequent
1	2	3	4	5

Relationship	Language mixed
Spouse/family members	
Friends	
Co-workers	

25. In which language (among your best two languages) do you feel you usually do better? Write the name of the language under each condition.

	At home	At work
Reading		
Writing		
Speaking		
Understanding		

26. Among the languages you know, which language is the one that you would prefer to use in these situations?

- At home _____
- At work _____
- At a party _____
- In general _____

27. If you have lived or travelled in other countries for more than three months, please indicate the name(s) of the country or countries, your length of stay, and the language(s) you learned or tried to learn.

- 1.
- 2.
- 3.

28. If you have taken a standardized test of proficiency for languages other than your native language (e.g., TOEFL or Test of English as a Foreign Language), please indicate the scores you received for each.

Language	Scores	Name of the Test

29. If there is anything else that you feel is interesting or important about your language background or language use, please comment below.

Appendix B

Descriptive Statistics of Reading Speed^a and Covariates (Word Recognition and Vocabulary) by Language Group

	M	SD	S	K	Pearson's Correlation									
					1	2	3	4	5	6	7	8	9	10
EFL (<i>n</i> = 32)														
1. VSTF 1	104.68	45.59	0.70	-0.49	1.00									
2. BLOCK 1	107.62	45.27	0.40	-0.34	0.77**	1.00								
3. VSTF 2	98.19	32.31	0.50	-0.48	0.69**	0.73**	1.00							
4. BLOCK 2	98.82	30.83	0.75	-0.33	0.46**	0.65**	0.48**	1.00						
5. VSTF 3	108.32	40.46	0.96	0.20	0.30	0.37*	0.40*	0.51**	1.00					
6. BLOCK 3	105.71	31.19	-0.21	-0.78	0.54**	0.56**	0.67**	0.58**	0.45*	1.00				
7. VSTF 4	90.42	30.65	0.63	-0.03	0.42*	0.56**	0.45**	0.62**	0.71**	0.42*	1.00			
8. BLOCK 4	90.75	23.80	-0.15	-0.98	0.43*	0.44*	0.60**	0.43*	0.40*	0.79**	0.20	1.00		
9. Word recognition ^b	80.33	6.85	0.20	-0.68	0.07	0.05	0.15	-0.10	-0.24	-0.03	-0.14	-0.04	1.00	
10. Vocabulary ^b	72.50	16.10	-0.64	-0.30	-0.04	0.03	0.06	-0.07	-0.29	0.16	-0.08	0.11	0.59**	1.00
ESL (<i>n</i> = 33)														
	M	SD	S	K	1	2	3	4	5	6	7	8	9	10
1. VSTF 1	136.07	42.93	0.27	-0.34	1.00									
2. BLOCK 1	138.49	49.92	0.50	-0.76	0.51**	1.00								
3. VSTF 2	132.57	54.46	0.57	-0.40	0.75**	0.71**	1.00							
4. BLOCK 2	133.54	51.33	0.09	-0.89	0.63**	0.72**	0.65**	1.00						
5. VSTF 3	140.48	52.95	0.68	-0.28	0.66**	0.45**	0.67**	0.54**	1.00					
6. BLOCK 3	143.62	62.69	0.83	0.00	0.66**	0.71**	0.70**	0.73**	0.57**	1.00				
7. VSTF 4	120.33	45.89	0.67	-0.01	0.55**	0.46**	0.58**	0.64**	0.66**	0.60**	1.00			
8. BLOCK 4	115.68	56.97	0.87	-0.09	0.62**	0.59**	0.64**	0.78**	0.62**	0.85**	0.70**	1.00		
9. Word recognition ^b	82.19	6.76	-0.44	0.26	0.27	0.34	0.12	0.43*	0.27	0.35*	0.22	0.42*	1.00	
10. Vocabulary ^b	84.20	9.00	-0.17	-0.74	0.26	0.38*	0.21	0.23	0.21	0.23	0.21	0.19	0.19	1.00

Native (n = 30)	M	SD	S	K	Pearson's Correlation									
					1	2	3	4	5	6	7	8	9	10
1. VSTF 1	182.64	58.22	0.45	-0.07	1.00									
2. BLOCK 1	194.33	71.99	0.72	0.15	0.64**	1.00								
3. VSTF 2	181.35	61.88	0.29	-0.93	0.67**	0.79**	1.00							
4. BLOCK 2	190.24	53.96	0.43	-0.38	0.60**	0.81**	0.84**	1.00						
5. VSTF 3	169.13	47.15	0.21	0.03	0.59**	0.62**	0.66**	0.58**	1.00					
6. BLOCK 3	217.74	95.55	0.43	-0.95	0.57**	0.79**	0.87**	0.85**	0.43*	1.00				
7. VSTF 4	169.44	72.83	0.33	-0.20	0.74**	0.70**	0.73**	0.68**	0.71**	0.61**	1.00			
8. BLOCK 4	179.60	70.49	0.46	-0.43	0.39*	0.66**	0.68**	0.79**	0.27	0.87**	0.48**			
9. Word recognition ^b	88.49	5.15	-0.87	-0.16	-0.03	0.07	0.00	0.09	0.01	0.02	0.02	0.11	1.00	
10. Vocabulary ^b	90.70	7.40	-0.11	-1.09	-0.09	-0.07	-0.15	-0.13	-0.13	-0.14	0.10	-0.08	0.53**	1.00

Note. M= mean; SD=standard deviation; S=skewness; K=kurtosis; ^a word per minute; ^b covariates
+ p< .1, * p < .05, ** p < .01, ***p< .001

Appendix C

Descriptive Statistics of Comprehension Scores and Covariates (Word Recognition and Vocabulary) by Language Group

	M	SD	S	K	Pearson's Correlation									
					1	2	3	4	5	6	7	8	9	10
EFL ($n = 32$)														
1. Topic (VSTF)	86.72	17.94	-1.00	-0.28	1.00									
2. Topic (block)	76.56	21.00	-0.47	-0.52	0.11	1.00								
3. Vocabulary (VSTF)	53.91	31.82	0.09	-1.28	0.06	0.26	1.00							
4. Vocabulary (block)	43.75	24.59	-0.33	-0.82	0.13	0.06	0.42*	1.00						
5. Information (VSTF)	59.77	22.16	-0.28	-0.76	0.01	0.38*	0.40*	0.26	1.00					
6. Information (block)	48.44	21.94	0.28	-0.69	0.10	0.29	0.46**	0.50**	0.56**	1.00				
7. Inference (VSTF)	64.06	26.13	-0.09	-1.12	0.02	0.29	0.44*	0.39*	0.36*	0.32	1.00			
8. Inference (block)	57.81	24.13	0.23	-0.82	0.25	-0.03	0.43*	0.49**	0.34	0.39*	0.11	1.00		
9. Word recognition ^a	80.33	6.85	0.20	-0.68	0.06	0.24	0.13	0.08	0.51**	0.13	0.16	0.44*	1.00	
10. Vocabulary ^a	72.50	16.10	-0.64	-0.30	0.11	0.25	0.08	0.33	0.54**	0.25	0.28	0.26	0.59**	1.00
ESL ($n = 33$)														
	M	SD	S	K	1	2	3	4	5	6	7	8	9	10
1. Topic (VSTF)	81.82	17.98	-0.47	-0.89	1.00									
2. Topic (block)	80.30	17.41	-0.31	-0.83	0.01	1.00								
3. Vocabulary (VSTF)	70.45	24.57	-0.24	-1.01	0.07	0.29	1.00							
4. Vocabulary (block)	68.94	28.66	-0.68	-0.44	0.31	0.34	-0.01	1.00						
5. Information (VSTF)	68.18	19.03	-0.62	0.81	0.40*	0.26	-0.15	0.42*	1.00					
6. Information (block)	60.61	17.71	-0.35	-0.59	0.10	0.35*	0.00	0.57**	0.11	1.00				
7. Inference (VSTF)	73.48	21.60	-0.50	-0.25	-0.12	0.07	-0.12	0.24	0.24	0.15	1.00			
8. Inference (block)	71.97	24.81	-0.56	-0.61	0.18	0.13	-0.06	0.30	0.62**	0.10	0.25	1.00		
9. Word recognition ^a	82.19	6.76	-0.44	0.26	0.10	0.44*	-0.03	0.37*	0.35*	0.16	0.06	0.03	1.00	
10. Vocabulary ^a	84.20	9.00	-0.17	-0.74	0.01	0.00	-0.09	-0.02	0.31	0.05	0.15	0.30	0.19	1.00

Native (n = 30)	M	SD	S	K	Pearson's Correlation									
					1	2	3	4	5	6	7	8	9	10
1. Topic (VSTF)	82.50	18.74	-0.57	-0.96	1.00									
2. Topic (block)	78.33	18.36	-0.21	-1.02	0.05	1.00								
3. Vocabulary (VSTF)	65.00	25.09	0.04	-1.05	0.12	0.17	1.00							
4. Vocabulary (block)	70.83	21.86	-0.32	-0.47	0.18	-0.13	0.28	1.00						
5. Information (VSTF)	71.25	20.80	-0.45	-0.57	0.16	0.35	0.46*	0.42*	1.00					
6. Information (block)	72.50	21.63	-0.70	-0.55	0.21	0.65**	0.45*	0.21	0.69**	1.00				
7. Inference (VSTF)	85.00	16.87	-0.69	-0.52	-0.04	0.24	0.30	-0.06	0.17	0.31	1.00			
8. Inference (block)	78.33	17.03	-0.17	-0.72	0.12	-0.04	0.43*	0.21	0.61**	0.35	0.11	1.00		
9. Word recognition ^a	88.49	5.15	-0.87	-0.16	0.16	0.08	0.49**	0.06	0.44*	0.26	0.18	0.37*	1.00	
10. Vocabulary ^a	90.70	7.40	-0.11	-1.09	0.27	0.24	0.50**	0.18	0.38*	0.31	0.08	0.12	0.53**	1.00

Note. M= mean; SD=standard deviation; S=skewness; K=kurtosis; ^a covariates
+ p<.1, * p<.05, ** p<.01, ***p<.001

Appendix D

Descriptive Statistics of Reading Speed^a and Covariates (Word Recognition and Vocabulary) by Working Memory Group

Pearson's Correlation														
High WM (<i>n</i> = 30)	M	SD	S	K	1	2	3	4	5	6	7	8	9	10
1. VSTF 1	108.31	50.82	0.73	-0.51	1.00									
2. BLOCK 1	113.92	51.64	0.76	0.16	0.78**	1.00								
3. VSTF 2	113.58	51.62	0.96	0.72	0.81**	0.72**	1.00							
4. BLOCK 2	118.95	50.71	0.78	-0.49	0.66**	0.73**	0.68**	1.00						
5. VSTF 3	129.77	64.94	1.12	0.95	0.60**	0.50**	0.74**	0.62**	1.00					
6. BLOCK 3	122.86	62.40	1.55	2.01	0.67**	0.56**	0.77**	0.74**	0.64**	1.00				
7. VSTF 4	107.29	44.00	0.99	0.74	0.65**	0.52**	0.66**	0.71**	0.68**	0.68**	1.00			
8. BLOCK 4	104.91	50.55	1.54	1.58	0.62**	0.61**	0.73**	0.76**	0.66**	0.95**	0.69**	1.00		
9. Word recognition ^b	81.03	7.41	-0.12	-0.79	0.26	0.41*	0.34	0.24	0.07	0.30	0.17	0.37*	1.00	
10. Vocabulary ^b	77.00	13.00	-1.05	1.25	0.24	0.40*	0.33	0.33	0.08	0.35	0.17	0.38*	0.67**	1.00

Pearson's Correlation														
Low WM (<i>n</i> = 28)	M	SD	S	K	1	2	3	4	5	6	7	8	9	10
1. VSTF 1	126.90	39.41	0.44	0.20	1.00									
2. BLOCK 1	128.68	50.21	0.47	-0.43	0.54**	1.00								
3. VSTF 2	115.91	47.31	1.22	0.88	0.66**	0.76**	1.00							
4. BLOCK 2	113.50	45.82	0.53	-0.52	0.62**	0.73**	0.66**	1.00						
5. VSTF 3	122.54	39.97	1.24	2.37	0.52**	0.48*	0.49**	0.58**	1.00					
6. BLOCK 3	126.05	45.20	0.76	0.51	0.52**	0.84**	0.66**	0.72**	0.46*	1.00				
7. VSTF 4	103.46	39.58	0.73	0.96	0.54**	0.63**	0.66**	0.67**	0.84**	0.60**	1.00			
8. BLOCK 4	99.57	42.90	1.45	3.53	0.43*	0.47*	0.56**	0.66**	0.52**	0.68**	0.59**	1.00		
9. Word recognition ^b	80.81	6.69	0.13	0.09	0.23	0.08	0.01	0.29	0.32	0.21	0.15	0.22	1.00	
10. Vocabulary ^b	82.50	1.61	-0.52	-0.71	0.55**	0.31	0.40*	0.20	0.36	0.38*	0.45*	0.20	0.27	1.00

Note. M= mean; SD=standard deviation; S=skewness; K=kurtosis; ^a word per minute; ^b covariates
+ p< .1, * p < .05, ** p < .01, ***p< .001

Appendix E

Descriptive Statistics of Comprehension Scores and Covariates (Word Recognition and Vocabulary) by Working Memory Group

	M	SD	S	K	Pearson's Correlation									
					1	2	3	4	5	6	7	8	9	10
High WM (<i>n</i> = 30)														
1. Topic (VSTF)	84.17	17.96	-0.69	-0.70	1.00									
2. Topic (block)	79.17	18.67	-0.82	1.09	0.67**	1.00								
3. Vocabulary (VSTF)	60.83	26.82	0.10	-1.20	0.14	0.15	1.00							
4. Vocabulary (block)	63.33	28.42	-0.77	-0.07	0.43*	0.40*	0.01	1.00						
5. Information (VSTF)	67.50	18.45	-0.34	-0.28	-0.16	-0.10	0.06	0.42*	1.00					
6. Information (block)	58.33	21.10	-0.63	-0.12	0.26	0.43*	0.30	0.42*	0.26	1.00				
7. Inference (VSTF)	69.17	23.38	-0.31	-0.66	0.61**	0.60**	0.18	0.48*	-0.27	0.34	1.00			
8. Inference (block)	65.83	23.20	0.00	-0.81	0.37*	0.53**	0.25	0.51**	0.24	0.67**	0.64**	1.00		
9. Word recognition ^a	81.03	7.41	-0.12	-0.79	0.26	0.25	0.39*	0.21	0.01	0.48**	0.27	0.41*	1.00	
10. Vocabulary ^a	77.00	13.00	-1.05	1.25	0.14	0.16	0.11	0.34	0.06	0.52**	0.29	0.34	0.22	1.00
Low WM (<i>n</i> = 28)														
1. Topic (VSTF)	83.93	18.28	-0.69	-0.75	1.00									
2. Topic (block)	76.79	19.16	-0.13	-1.23	0.15	1.00								
3. Vocabulary (VSTF)	64.29	32.93	-0.48	-0.97	0.13	0.14	1.00							
4. Vocabulary (block)	53.57	26.97	0.27	-0.52	0.22	0.17	0.41*	1.00						
5. Information (VSTF)	62.95	22.94	-0.41	-0.66	0.27	0.24	0.51**	0.35	1.00					
6. Information (block)	53.57	20.09	0.19	-0.76	-0.15	0.28	0.53**	0.45*	0.20	1.00				
7. Inference (VSTF)	62.50	26.79	0.00	-1.20	0.05	0.05	0.55**	0.32	0.65**	0.13	1.00			
8. Inference (block)	74.11	24.04	-0.73	-0.20	-0.09	0.21	0.31	0.26	0.36	0.40*	0.12	1.00		
9. Word recognition ^a	80.81	6.69	-0.12	-0.79	0.01	0.29	0.30	0.35	0.36	0.02	0.25	0.09	1.00	
10. Vocabulary ^a	82.50	1.61	-1.05	1.25	-0.36	0.02	0.14	0.20	0.35	0.00	0.50**	0.14	0.28	1.00

Note. M= mean; SD=standard deviation; S=skewness; K=kurtosis; ^a covariates + *p* < .1, * *p* < .05, ** *p* < .01, ****p* < .001