EFFECTS OF SALIENCE AND WORKING MEMORY ON L2 PROCESSING OF ENGLISH RELATIVE CLAUSES WITH PAST PARTICIPLES AND PAST PARTICIPIAL REDUCED RELATIVE CLAUSES BY L1 THAI LEARNERS

Mr. Supakit Thiamtawan

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in English as an International Language
Inter-Department of English as an International Language
GRADUATE SCHOOL
Chulalongkorn University
Academic Year 2022

ผลกระทบของความเด่นและความจำขณะปฏิบัติการต่อการประมวลผลในภาษาที่สองของคุณานุประโยคที่ใช้รูปกริยาขยายบ่งกรรมวาจกและคุณานุประโยคลดรูปประเภทใช้รูปกริยาขยายบ่งกรรมวาจกในภาษาอังกฤษโดยผู้เรียนที่มีภาษาไทยเป็นภาษาที่หนึ่ง

นายศุภกิตติ์ เทียมตะวัน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต
สาขาวิชาภาษาอังกฤษเป็นภาษานานาชาติ สหสาขาวิชาภาษาอังกฤษเป็นภาษานานาชาติ
บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2565

Thesis Title	EFFECTS OF SALIENCE AND WORKING MEMORY ON L2 PROCESSING OF ENGLISH RELATIVE CLAUSES WITH PAST PARTICIPLES AND PAST PARTICIPIAL REDUCED RELATIVE CLAUSES BY L1 THAI LEARNERS
By	Mr. Supakit Thiamtawan
Field of Study	English as an International Language
Thesis Advisor	Associate Professor NATTAMA PONGPAIROJ, Ph.D.

Accepted by the GRADUATE SCHOOL, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

..... Dean of the GRADUATE SCHOOL
(Associate Professor YOOTTHANA CHUPPUNNARAT, Ph.D.)

DISSERTATION COMMITTEE

..... Chairman
(Professor Pornsiri Singhapreecha, Ph.D.)
..... Thesis Advisor
(Associate Professor NATTAMA PONGPAIROJ, Ph.D.)
..... Examiner
(Assistant Professor THEERAPORN RATITAMKUL, Ph.D.)
..... Examiner
(Associate Professor WIROTE AROONMANAKUN, Ph.D.)
..... External Examiner
(Associate Professor Supakorn Phoocharoensil, Ph.D.)

ศุภกิตติ์ เทียมตะวัน : ผลกระทบของความเด่นและความจำขณะปฏิบัติการต่อการประมวลผลในภาษาที่สองของคุณานุประโยคที่ใช้รูปกริยาขยายบ่งกรรมวาจกและคุณานุประโยคลดรูปประเภทใช้รูปกริยาขยายบ่งกรรมวาจกในภาษาอังกฤษโดยผู้เรียนที่มีภาษาไทยเป็นภาษาที่หนึ่ง. (EFFECTS OF SALIENCE AND WORKING MEMORY ON L2 PROCESSING OF ENGLISH RELATIVE CLAUSES WITH PAST PARTICIPLES AND PAST PARTICIPIAL REDUCED RELATIVE CLAUSES BY L1 THAI LEARNERS) อ.ที่ปรึกษาหลัก : รศ. ดร.ณัฐมา พงศ์ไพโรจน์

งานวิจัยนี้ศึกษาผลกระทบของความจำขณะปฏิบัติการ (working memory) โครงสร้าง (structure) และความเด่น (salience) ต่อการประมวลผลรูปกริยาขยายอดีตไม่ปกติ (irregular past participial forms) ในคุณานุประโยค (relative clauses) และคุณานุประโยคลดรูปประเภทใช้รูปกริยาขยาย (participial reduced relative clauses) ในภาษาอังกฤษของผู้เรียนที่มีภาษาไทยเป็นภาษาที่หนึ่ง จากงานวิจัยของ Bayley (1994) ความเด่นในงานวิจัยนี้เกี่ยวข้องกับการเปลี่ยนแปลงทางระบบเสียงจากรูปกริยาแสดงกาลอดีต (past tense form) ของกริยารูปไม่ปกติ (irregular verbs) ในภาษาอังกฤษสู่รูปกริยาขยายอดีต (past participial form) งานวิจัยนี้ศึกษารูปกริยาขยายอดีตสองประเภทที่มีระดับความเด่นแตกต่างกัน ได้แก่ กลุ่มการเปลี่ยนแปลงสระภายในและการเพิ่มหน่วยคำ [ən] ที่เป็นแกนพยางค์ (an internal vowel change plus an addition of the syllabic [ən] morpheme) และกลุ่มการเปลี่ยนแปลงสระภายในและการเติมหน่วยคำเติม *n* (an internal vowel change plus an affixation of *n*) ผู้เข้าร่วมงานวิจัยนี้เป็นนักศึกษาระดับปริญญาตรีชาวไทยที่มีสมิทธิภาพทางภาษาอังกฤษระดับสูงจำนวน 70 คน เครื่องมือวิจัยประกอบด้วยแบบทดสอบวัดช่วงการอ่าน (reading span task) และแบบทดสอบกำหนดความเร็วในการอ่านด้วยตนเอง (self-paced reading task) แบบทดสอบวัดช่วงการอ่านใช้เพื่อแบ่งกลุ่มผู้เข้าร่วมงานวิจัยเป็นสองกลุ่มตามระดับความจำขณะปฏิบัติการ ได้แก่ กลุ่มระดับความจำขณะปฏิบัติการสูงกว่าและกลุ่มระดับความจำขณะปฏิบัติการต่ำกว่า แบบทดสอบกำหนดความเร็วในการอ่านด้วยตนเองใช้ศึกษาการประมวลผลรูปกริยาขยายอดีตทั้งสองประเภทของผู้เข้าร่วมงานวิจัย งานวิจัยนี้ตั้งสมมติฐานว่ากลุ่มผู้เข้าร่วมงานวิจัยสองกลุ่มที่มีระดับความจำขณะปฏิบัติการแตกต่างกันจะแสดงการประมวลผลแบบทันที (online processing) และการประมวลผลแบบเตรียมการ (offline processing) ที่มีลักษณะแตกต่างกัน นอกจากนี้คาดว่าผู้เรียนที่มีระดับความจำขณะปฏิบัติการสูงกว่าจะใช้เวลาอ่านคุณานุประโยคใกล้เคียงกับผู้เรียนที่มีระดับความจำขณะปฏิบัติการต่ำกว่า และใช้เวลาอ่านคุณานุประโยคลดรูปประเภทใช้รูปกริยาขยายมากกว่าผู้เข้าร่วมงานวิจัยที่มีทรัพยากรปริชานน้อยกว่า ผลวิจัยสนับสนุนสมมติฐานแรกบางส่วน แต่ไม่สนับสนุนสมมติฐานที่สอง กล่าวคือ ความแตกต่างระหว่างระดับความสามารถทางปริชาน (cognitive capacity) ของกลุ่มผู้เข้าร่วมวิจัยทั้งสองกลุ่มมีแนวโน้มส่งผลกระทบต่อการประมวลผลแบบทันที แต่ไม่ส่งผลต่อการประมวลผลแบบเตรียมการ ผลวิจัยนี้แสดงให้เห็นว่า ผลกระทบของความจำขณะปฏิบัติการขึ้นอยู่กับประเภทของแบบทดสอบ ซึ่งสอดคล้องกับผลการวิจัยของ Hopp (2015) และ Zhou et al. (2017) นอกจากนี้ผู้เข้าร่วมงานวิจัยที่มีระดับความจำขณะปฏิบัติการสูงกว่ามีแนวโน้มที่จะอ่านทั้งสองโครงสร้างเร็วกว่าผู้เข้าร่วมงานวิจัยที่มีระดับความจำขณะปฏิบัติการต่ำกว่า ผลวิจัยบ่งชี้ว่าความสามารถทางปริชานระดับสูงสามารถเพิ่มความเร็วของผู้เรียนภาษาที่สองในการรวมข้อมูลซึ่งกำลังจะมาเข้ากับข้อมูลก่อนหน้า (Just & Carpenter, 1992) งานวิจัยชิ้นนี้มีประโยชน์แก่วงการวิจัยด้านการประมวลผลภาษาที่สองด้วยการแสดงให้เห็นถึงการที่ผลกระทบของความจำขณะปฏิบัติการขึ้นอยู่กับประเภทของแบบทดสอบและความสัมพันธ์ระหว่างทรัพยากรปริชานของผู้เรียนภาษาที่สองและความเร็วในการประมวลผล งานวิจัยนี้ยังนำเสนอการชี้บ่งเป็นนัยทางทฤษฎีและทางการสอนด้วย

สาขาวิชา	ภาษาอังกฤษเป็นภาษานานาชาติ	ลายมือชื่อนิสิต .....
ปีการศึกษา	2565	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6187794820 : MAJOR ENGLISH AS AN INTERNATIONAL LANGUAGE
KEYWORD: second language processing, working memory, participial reduced relative clause, relative clause, salience

Supakit Thiamtawan : EFFECTS OF SALIENCE AND WORKING MEMORY ON L2 PROCESSING OF ENGLISH RELATIVE CLAUSES WITH PAST PARTICIPLES AND PAST PARTICIPIAL REDUCED RELATIVE CLAUSES BY L1 THAI LEARNERS. Advisor: Assoc. Prof. NATTAMA PONGPAIROJ, Ph.D.

The present study explored effects of working memory (WM), structure, and salience on the processing of irregular past participial forms in English relative clauses (RCs) and participial reduced relative clauses (PRRCs) among L1 Thai learners. Based on Bayley's research (1994), the salience in this study was related to phonological changes from the past tense form of English irregular verbs into their past participial form. The research included two groups of past participles with different salience degrees, i.e., an internal vowel change plus an addition of the syllabic [ən] morpheme and an internal vowel change plus an affixation of *n*. The research participants were seventy Thai undergraduate students with high English proficiency. The research instruments comprised a reading span task and a self-paced reading task. The reading span task was used to classify the learners according to WM degree into two groups: higher and lower WM groups. The self-paced reading task looked into the participants' processing of the two past participial forms. The study hypothesized that the two participant groups with different levels of WM would manifest different fashions for online and offline processing. Moreover, the higher WM learners were predicted to take as similar amounts of reading time for RCs as their lower WM counterparts and spend more time reading PRRCs than the participants with fewer cognitive resources. The research findings partially supported the first hypothesis, but refuted the second hypothesis. That is, the distinction between the cognitive capacity levels of the two participant groups tended to affect their online processing, but not offline processing. This suggested that WM effects could depend on task types, which was consistent with the findings of Hopp (2015) and Zhou et al. (2017). Furthermore, the higher WM participants were more likely to read the two constructions faster than the lower span ones. The finding indicated that a high level of cognitive capacity could increase L2 learners' speed of combining the upcoming with the preceding information (Just & Carpenter, 1992). This study made a contribution to L2 processing research by substantiating the dependence of WM impact on the task type as well as the relationship between L2 learners' cognitive resources and their processing speed. The research also provided theoretical and pedagogical implications.

Field of Study:	English as an International Language	Student's Signature .....
Academic Year:	2022	Advisor's Signature .....

ACKNOWLEDGEMENTS

I am genuinely indebted to many people who have contributed to the completion of this dissertation.

First of all, I would like to express my deepest gratitude towards my dissertation advisor, Associate Professor Dr. Nattama Pongpairoj, who has provided me with not only insightful academic guidance, but also tremendous mental support. Whenever I was stuck with problems, she was always there to calm me down and guide me through the difficulties with patience, kindness, and understanding. She also motivated me to harvest more knowledge outside books and papers, including attending conferences and having an academic visit to the Institute of Cultural Sciences, Chuo University, Japan. Without her, I might not have gained as much invaluable experience as I have from my Ph.D. journey.

I am enormously thankful to my dissertation committee members: Professor Dr. Pornsiri Singhapreecha, Associate Professor Dr. Wirote Aroonmanakun, Associate Professor Dr. Supakorn Phoocharoensil, and Assistant Professor Dr. Theeraporn Ratitamkul, whose agreement to be the committee members was profoundly appreciated. Their constructive comments and feedback made this study more comprehensive.

I wish to convey my sincere appreciation to Professor Dr. Shigenori Wakabayashi, who generously accepted my request to supervise me during my academic visit to Chuo University, kindly facilitated the visit, as well as read and gave helpful comments about this study. My heartfelt gratitude also goes to all the professors in the Graduate Program in English as an International Language, Graduate School, Chulalongkorn University, the Master of Arts Program in English (English linguistics), Department of English, Faculty of Arts, Chulalongkorn University, and the Bachelor of Arts Program in English, the English Program, Faculty of Liberal Arts, Mahidol University, for the knowledge and experience which have played an essential role in my academic and professional life.

I truly thank Surachate Phinitkit, the Director of Wonnapasub School, Chonburi, Thailand, for sharing his reading span task and suggestions about how to employ the task. Furthermore, I am grateful to David Duesler, Andrew Matthews, Stephen Lorriman, Marc Darlington, Ruth Whitehouse, Richard Lemarie, Robert Horgan, Christopher Chapman, Sean Balme, Alan Connolly, Robert Allen, and Christine Inhulsen, who rated plausibility of the sentences in the self-paced reading task. This study involved online data collection which necessitated technical trials. Therefore, I wish to extend my deep gratitude to Chalatip Charnchairerk, Peeriya Pongsarigun, Chansak Siengyen, Choedphong Uttama, Kulthida

Nityasuddhi, Apapan Ruengkul, Joey Andrew Lucido Santos, Mintra Suratha, Supapitch Kaewlee, and Supapen Kaewlee for their technical assistance ensuring success in carrying out the experiments. My thanks also go to the research participants, whose participation made the research possible.

This dissertation was financially supported by National Research Council of Thailand (NRCT): NRCT5-RGJ63001-021 under the Royal Golden Jubilee Ph.D. Program, Ministry of Higher Education, Science, Research and Innovation, Thailand, the 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund), and Chulalongkorn University Language Institute. The institutions' support has earned them my appreciation.

My sincere thanks go to the dissertation commentators at the EIL Doctoral Dissertation Seminars and the audiences from the AFELTA and CULI International Conference 2022, TAAL's Applied Linguistics Graduate Forum 2022, and the 57th RELC International Conference - Rethinking English Language Teaching and Learning for a COVID-19 Endemic World: Global, Glocal and Local Perspectives. All the feedback I received from them helped enhance the quality of the discussion part.

Special thanks are due to my close friends: Chalatip Charnchairerk, Peeriya Pongsarigun, Chansak Siengyen, Chanisa Sa-nguantoikam, Sirinun Charoenpipitaporn, and Nattharath Leenakitti for their considerable encouragement throughout the course of my Ph.D. study. In addition, I am so thankful to the staff in the EIL program and Chulalongkorn University Language Institute, who offered me support in a number of ways.

Finally, I owe a great debt to my mother and my father, who have given me unconditional love and unwavering support. All the achievements I have obtained, including this dissertation, are dedicated to them.

Supakit Thiamtawan

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF IMAGES

Page

LIST OF ABBREVIATIONS

CCPM	Capacity Constrained Parsing Model
L1	first language
L2	second language
LTM	long-term memory
MV/RR	main verb/reduced relative
NP	noun phrase
PP	Past participle
PRRC	participial reduced relative clause
RC	relative clause
RST	reading span task
SLA	second language acquisition
SPRT	self-paced reading task
STM	short-term memory
WM	working memory

CHAPTER I
INTRODUCTION

This chapter consists of 8 sections. Section 1.1 provides the background of the study, followed by the research questions (1.2), the objectives of the study (1.3), and the statement of hypotheses (1.4). Then, the scope of the study, the definitions of terms, and the significance of the study are described in 1.5, 1.6, and 1.7, respectively. The summary of the chapter is presented in Section 1.8.

1.1 Background of the study

One of the most serious problems among learners of a second language (L2) involves the use of inflectional morphemes in the L2. It has even been found that a large number of advanced L2 learners are likely to have difficulties with their use of such morphemes in L2s, including English. Several research studies have been carried out to look into production and comprehension of English inflectional morphemes by learners from different L1s (See Akande, 2003, for Nigerian; Alotaibi, 2016, for Kuwaiti; Mansbridge and Tamaoka, 2018, for Japanese). The acquisition of the English inflection was also explored in a number of studies focusing on L1 Thai learners, for example, all the eight types of inflectional morphemes[1] in Yordchim and Gibbs (2014) and plural, 3rd person singular present tense, progressive, and possessive morphemes in Chumkamon (2017).

The L2 acquisition of English inflectional morphemes has been examined in relation to various variables, such as L2 proficiency (e.g., Rungrojsuwan, 2015; Carneiro, 2017; Kimppa et al., 2019), age-related differences (e.g., Jia & Fuse, 2007; Zhang & Widyastuti, 2010; Pfenninger, 2011), and L1 interference (e.g., Goldschneider & DeKeyser, 2001; Hawkins & Liszka, 2003; Murakami & Alexopoulou, 2016). Two factors which have been investigated with respect to the acquisition of the L2 English inflectional morphemes are working memory (WM)

---

[1] Ismai (2016) states that English language contains eight types of inflectional morphemes: plural, possessive, comparative, superlative, 3rd person singular present tense, past tense, progressive, and past participle.

(e.g., Rungrojsuwan, 2015; Service & Maury, 2015) and salience (e.g., Wolfram & Hatfield, 1984; Wolfram, 1985; Bayley, 1994; Solt et al., 2003; Klein et al., 2004).

WM is defined as a limited capacity system which embraces temporary storage and manipulation of information (Baddeley, 2012). More specifically, McDonough and Trofimovich (2016) state that WM plays an important role in how well individuals can hold, update, and manipulate information over short delays, which necessitates executive attention or the ability to control responses, especially in situations where many responses are possible. Similarly, Hofmann et al. (2008) explain that a person's WM encompasses her storage capacity as well as ability to allocate attentional resources and resist distraction. In summary, WM is the ability to employ attention in order to retain or inhibit information. As a result, differences in WM have been connected with distinctions between individuals in terms of how well they can allocate attention for cognitive activities. That is, people with higher WM can control their attention better than those with lower WM, which makes them more likely to succeed in doing a complex task although the input includes distracting or irrelevant information (e.g., Conway et al., 2001; Kane et al., 2001; Unsworth et al., 2004).

Unlike WM relevant to individuals' cognitive differences, salience is more related to items or stimuli. Salience of an item refers to the quality which makes it more prominent than its neighbors. The salience degree of a stimulus is associated with humans' attention paid to the stimulus and perceptions of it. As Zarcone et al. (2016) point out, humans' brain recruits relevant information in order to detect interesting or unexpected parts which should be given more attention than uninteresting or predictable ones. This has been claimed to help them "quickly identify and react to potentially dangerous or rewarding stimuli" (Zarcone et al., 2016: 11). The attention given to a stimulus in turn affects how easily the stimulus is perceived. As stated by Bordalo et al. (2012), the more prominent items are more likely to be perceived and to enter the following cognitive processing than those that are less so.

WM and salience have been used to look into the L2 acquisition of the English inflectional morphemes in different aspects. A lot of studies investigated WM's impact on language learners' processing of English inflectional morphemes (See Rungrojsuwan, 2015, for L1 Thai learners' processing of the plural, 3rd person singular present tense, past participle, progressive, and past tense morphemes; Service & Maury, 2015, for L1 Finnish learners). By contrast, salience has been included as a factor to account for L2 learners' likelihood to produce grammatical forms such as regular past tense morphemes in Solt et al. (2003) and Klein et al. (2004), and both regular and irregular past tense morphemes in Wolfram and Hatfield (1984), Wolfram (1985), and Bayley (1994). Yet, none of the previous research has studied effects of both WM and salience on L2 learners' acquisition of an English inflectional morpheme. Despite their different roles in research on language acquisition, one second language acquisition (SLA) aspect which seems to involve both WM and salience in the inflectional morpheme acquisition is the processing of an English structure called participial reduced relative clause (PRRC).

PRRCs are a reduced form of relative clauses (RCs) or dependent clauses that modify nouns or noun phrases. According to Azar (1999), a PRRC is an RC whose relative pronoun, including *who*, *which*, and *that*, and verb *be* are omitted. For example, the RC in the noun phrase *A lot of the people* <u>*who were invited to the party*</u> can be reduced to its PRRC form *A lot of the people* <u>*invited to the party*</u>. The PRRCs especially those with regular verbs whose past participle ends in the *–ed* suffix can lead to main verb/reduced relative (MV/RR) ambiguities, namely they can be interpreted as either the past tense form or the past participial form of the verbs. For instance, the form *invited* in *A lot of the people* <u>*invited*</u> *me to the party* serves as the past tense form of the verb *invite*, and thus means that the subject *A lot of the people* performs the action of inviting someone; however, *invited* in *A lot of the people* <u>*invited to the party*</u> *cannot come* functions as the past participial form, namely the subject receives the action of inviting.

So far, previous studies on the PRRC processing can be divided into two main groups. Firstly, a myriad of studies looked into how native English speakers' processing of PRRCs with respect to MV/RR ambiguity resolution was affected by

various factors, including the participants' WM. PRRCs with regular verbs were emphasized in most of the studies, including Just and Carpenter (1992), MacDonald et al. (1992), and Eastwick and Phillips (1999). The second group of research compared L2 English learners' processing of the PRRCs with regular verbs and those with irregular verbs without any measurement of WM (e.g., Juffs, 1998; Rah & Adone, 2010).

An important study which dealt with the relationship between WM and processing of English PRRCs was MacDonald et al. (1992). They examined how native English speakers processed the structure through three self-paced reading experiments. The researchers initially proposed a language processing model called Capacity Constrained Parsing Model (CCPM). The gist of the CCPM was that readers' WM capacity influenced the number of representations they could keep during their processing of ambiguous sentences. The readers, regardless of their WM level, should carry the unambiguous RC construction in memory, and should spend similar reading times on the structure. The WM degree was apt to play a role when it came to the more complex PRRC. The readers with higher WM span were likely to keep more interpretations of the ambiguity, which might demand a lot of their cognitive resources. This could lead the higher WM individuals to spend longer reading times on PRRCs than those on RCs. In contrast, the lower WM readers tended to keep only the structurally simpler and more frequent interpretation, so they might have adequate cognitive capacity for normal processing, and thus, spend as similar reading times on PRRCs as those on RCs. Yet, their differences in the number of interpretations they could retain might lead to different rates of errors in answering comprehension questions about the ambiguous structure. The higher WM participants should make fewer errors than the lower WM ones as the former were more likely to maintain the correct interpretation. MacDonald et al. (1992) found that the research participants with various levels of WM showed different processing behaviors, as predicted by the CCPM. When experiencing the PRRCs, only the individuals with higher WM spent more time reading the ambiguous parts. This indicated that the higher WM participants could maintain both interpretations, i.e., the main verb and the reduced relative readings, longer than the lower WM ones (See more details of the study in Subsection 2.4.2 of Chapter II).

As stated earlier, there were two groups of previous research on the PRRC processing. The first group examined native English speakers' processing of the structure whereas the second one drew a comparison between L2 learners' processing of the reduced RCs with regular verbs and those with irregular verbs. However, to the best of my knowledge, none of the previous studies have explored how WM could modulate L2 learners' processing of the structure. Moreover, although the past participial forms of many irregulars frequently occur within the PRRCs, irregular verbs have been examined in relation to the processing of the structure in a handful of studies, including Juffs (1998) and Rah and Adone (2010).

When it comes to the irregulars, one cognitive factor which might influence L2 learners' processing of the PRRCs with such verbs is salience of the past participial form of the verbs. Several SLA studies have extensively examined the relationship between salience and English irregular verbs in connection with past tense marking (e.g., Bayley, 1994; Tajika, 1999; Solt et al., 2003). Regarding marking past tense in English, salience refers to the extent to which the past tense form of a verb is phonologically different from its present tense form. The greater the phonological difference between the present tense and past tense forms of a verb is, the more salient the past tense form of the verb tends to be (Minow, 2010). The verb's salience level is then assumed to determine its tendency of being marked for tense, namely the more salient verbs are more likely to be marked for past tense than the less salient ones. For example, *leave* requires three changes in becoming *left*: the change of its internal vowel from /i/ to /e/, the change of its final segment from /v/ to /f/, and the addition of the final stop /t/. In contrast, *lead* changes only its internal vowel in order to become *led*. Then, *leave* is more phonologically salient than *lead*, and thus, being more apt to be past-tense inflected. The effects of salience on past tense marking have been well-attested in previous studies. As an example, Wolfram and Hatfield (1984), Wolfram (1985), and Bayley (1994) similarly demonstrated that their non-native participants' past tense marking for English irregular verbs was enormously influenced by a salience level of the past tense forms of the verbs. In other words, the greater the difference between the present tense and the past tense forms of a verb was, the more likely the verb was to be marked for tense. The

research participants most frequently marked past tense for the suppletives or the verb classes whose present tense and past tense did not share any segments in common, such as *go-went* and *am-was*; however, they showed a lower rate of past tense marking for the verbs with a lower salience degree, such as ablauts, i.e., the verbs which inflected by changing their internal vowel, including *come-came* and *lead-led* or replacives, namely the verbs whose past and present tense forms differed only in the voicing of the final consonant, e.g., *send-sent* and *make-made*.

Apart from past tense marking for irregular verbs, the concept of salience should play a role in the L2 processing of the irregulars in English PRRCs. As aforementioned, the PRRC processing involves distinguishing between past simple and past participle forms of the verbs. As a result, the success in processing the structure could be determined by a salience degree of a particular past participle, i.e., the extent to which the past participial form of an irregular verb phonologically differs from its past simple form. That is to say, the greater the difference between the past simple and past participial forms of an irregular is, the more apt an L2 learner is to successfully identify the given form she is processing. To illustrate, *gave* requires two changes in becoming *given*, namely the internal vowel change from /eɪ/ to /ɪ/ and the addition of the syllabic [ən] morpheme. On the other hand, *wore* only changes the final segment from /r/ to /n/ in inflecting to *worn*. Accordingly, *given* is more perceptually salient than *worn*, having a greater tendency to be successfully processed by L2 learners.

Despite potential effects of their prominence, past participial forms of irregular verbs have never been categorized by the salience level. The lack of such classification has probably been caused by the assumption that the irregulars have the same form for the past simple and the past participial forms, as shown by *bring-brought-brought*, *leave-left-left*, and *hold-held-held*. It is true that the past tense and the past participial forms of some irregular verbs are exactly the same, but the two forms of a much larger number of irregulars phonologically differ from each other, such as *tear-tore-torn*, *sing-sang-sung*, *draw-drew-drawn*, *break-broke-broken*, and *write-wrote-written*. So, it is worth investigating whether salience is involved with the

phonological differences between the past tense and past participial forms of the irregular verbs.

It should be noted that salience can be considered a kind of processing cues which could help a reader process a sentence. Kim and Christianson (2017) claimed that readers' sensitivity to a processing cue or a particular type of information was dependent on the availability of sufficient cognitive resources (p. 374). As confirmed by a number of previous studies (e.g., Dussias & Piñar, 2010; Foote, 2011; Kim & Christianson, 2017), a reader's sensitivity to a processing cue was reflected as longer reading times on the critical regions, i.e., the regions in a sentence where the cue's effects were observed, and individuals with different levels of cognitive capacity seemed to have different levels of sensitivity to the cue. Specifically, the higher WM readers were more likely to have adequate cognitive resources, and therefore, they were more sensitive to the presence of a processing cue, which was reflected through their higher reading times, compared to when the cue was absent. On the contrary, the individuals with lower WM did not show contrast in their reading times for the presence and absence of the cue. If divergent salience degrees of the past participial forms of English irregular verbs can bring about varying levels of difficulties in processing the PRRC structures in which they appear, L2 learners might show various processing patterns when tackling irregulars with different degrees of prominence. Then, the present study might help language teachers and SLA researchers identify the cause of problems the learners may have when processing certain irregular verbs in PRRCs. At the same time, WM's effects on L2 syntactic processing are still controversial. Even though a number of studies confirmed the role of WM in L2 processing (e.g., Havik et al., 2009; Zhou et al., 2017), some researchers found no correlations between research participants' WM level and their language performance (e.g., Rodríguez, 2008; Hopp, 2015). It is then important to explore how WM could modulate the difficulties caused by various salience levels of the past participial forms of irregulars. Consequently, the present study aims to examine WM's influence on L1 Thai learners' processing of the PRRC forms of irregular verbs with different salience degrees. By doing this, the study hopes to make a contribution to SLA studies on the processing of the English structure.

1.2 Research questions

The research questions of the study were as follows:

1) To what extent do the L1 Thai learners' WM levels and salience of the past participial forms of irregulars affect the learners' processing of English RCs and PRRCs which contain past participles?

2) How do the L1 Thai learners with different WM levels, i.e., higher and lower WM, differ in the level of comprehension accuracy?

3) How do the L1 Thai learners with different WM levels, i.e., higher and lower WM, differ in the amount of time they spend on processing English RCs and PRRCs with past participles?

4) How does the classification of English irregular verbs according to the salience of their past participial forms affect the processing of English RCs and PRRCs among the L1 Thai learners with different WM levels, i.e., higher and lower WM?

1.3 Objectives of the study

The objectives of the study were as follows:

1) To examine the extent to which the L1 Thai learners' WM levels and salience of the past participial forms of irregulars will affect the learners' processing of English RCs and PRRCs which contain past participles.

2) To look into how the L1 Thai learners with different WM levels, i.e., higher and lower WM, differ in the level of comprehension accuracy.

3) To explore how the L1 Thai learners with different WM levels, i.e., higher and lower WM, differ in the amount of time they spend on processing English RCs and PRRCs with past participles.

4) To investigate how the classification of English irregular verbs according to the salience of their past participial forms affects the processing of English RCs and PRRCs among the L1 Thai learners with different WM levels, i.e., higher and lower WM.

1.4 Statement of hypotheses

The formulated hypotheses were as follows:

1) The L1 Thai learners' WM levels and salience of the past participial forms of irregulars will affect the learners' processing of English RCs and PRRCs which contain past participles.

2) The L1 Thai learners with higher WM will have a higher degree of accuracy in answering the comprehension questions than those with lower WM.

3) The reading times the L1 Thai learners with higher WM spend on PRRCs will be significantly greater than those on RCs whereas the reading times the learners with lower WM spend on PRRCs will not be significantly greater than those on RCs.

4) The reading times the L1 Thai learners with higher WM spend on less salient irregulars will be significantly greater than those on more salient irregulars whereas the reading times the learners with lower WM spend on less salient irregulars will not be significantly greater than those on more salient irregulars.

1.5 Scope of the study

The present study is in the area of L2 processing. The scope of the research comprises the following points.

1) Research participants

The present study recruited two groups of research participants: a native control group and a group of L1 Thai learners. The native control group included ten native English speakers who were undergraduates, graduate students or faculty members at Chulalongkorn University, Bangkok, Thailand. They were to provide baseline data about the processing of irregular verbs in English PRRCs and RCs. The group of L1 Thai learners contained seventy Thai undergraduates studying in various faculties at Chulalongkorn University. The learners were chosen based on the scores they had obtained from one of the three English proficiency tests, i.e., International English Language Testing System (IELTS), Test of English as a Foreign Language Internet-based Test (TOEFL iBT), and Chulalongkorn University Test of English Proficiency (CU-TEP). This study included only the students in the 7.0-8.0 IELTS

score range, the 95-120 TOEFL iBT score range, or the 99-120 CU-TEP score range, which was mapped to the C1 level of the Common European Framework of Reference for Languages or CEFR (See details of the mapping between CU-TEP, IELTS, and TOEFL iBT scores and CEFR levels in Appendix A). All the research participants must be at least 18 years of age at the time of participation and must have normal or corrected-to-normal vision.

2) Target grammatical structures and forms

The research looked into the L1 Thai learners' processing of two English structures: participial reduced relative clauses (PRRCs) and relative clauses (RCs) with past participles. The emphasis was placed upon different forms of irregular verbs divided into classes according to the salience of their past participial forms, such as *broken*, *drunk*, and *worn*.

3) Tasks for data collection

The present study embraced two computerized tasks, i.e., a reading span task (RST) and a self-paced reading task (SPRT). While the RST was designed to measure the L1 Thai participants' WM, the SPRT aimed at exploring how the research participants processed various types of irregulars in English PRRCs and RCs.

1.6 Definitions of terms

1) **Relative clauses (RCs)**: RCs are dependent clauses which modify the noun phrase preceding them; they may or may not begin with a relative pronoun, e.g., *who*, *whom*, *whose*, *which*, and *that* (Letourneau, 2001).

2) **Participial reduced relative clauses (PRRCs)**: PRRCs refer to relative clauses which lack a relative pronoun and a finite form, but contain a non-finite predicate which comprises either a present participle or a past participle instead (Sleeman, 2017). They are considered post-nominal modifiers.

3) **Past participial reduced relative clauses (Past PRRCs):** Past PRRCs are PRRCs which contain a past participle, but neither relative pronoun nor finite verb (Sleeman, 2017). Past PRRCs, especially those with regular verbs whose past participle ends in the –ed suffix, can be more syntactically ambiguous since they can

be interpreted as either the past tense form or the past participial form of the verbs (Carroll, 2008).

4) **Working memory (WM)**: WM is a limited capacity system which involves temporary storage and manipulation of information (Baddeley, 2012).

5) **Salience**: Salience of an item refers to the state or quality which makes it more prominent than its neighbors. A more salient item is said to attract greater attention and to be more easily perceived (Chiarcos et al., 2011). In the present study, salience refers to the extent to which the past participial form of an irregular verb phonologically differs from its past simple form.

6) **English irregular verbs**: English irregular verbs are English verbs which can inflect to their past tense and past participial forms in several ways, except ending in the *–ed* suffix. Three main irregular inflection patterns are transforming the stem of the verb itself (e.g., *lead-led-led*), attaching an irregular suffix to the verb (e.g., *burn-burnt-burnt*), and both (e.g., *bring-brought-brought*) (Young, 1984).

7) **An online processing experiment**: An online processing experiment is an experiment in which a dependent variable is examined during sentence processing, such as reading time and eye movement (Omaki, 2005).

8) **An offline processing experiment**: An offline experiment refers to an experiment where a dependent variable is explored after the processing of the whole sentence, such as grammaticality judgment and comprehension question (Omaki, 2005).

9) **L1 Thai learners of English**: L1 Thai learners of English in the present study were seventy Thai undergraduates studying at various faculties at a university in Bangkok, Thailand in the academic year 2021.

1.7 Significance of the study

Little attention has been given to irregular verbs in relation to the processing of English RCs and PRRCs although the past participial form of many irregulars commonly occurs in the two structures. Should the salience level of the past

participial form of irregular verbs has effects on the processing, the L2 learners might manifest different processing patterns when tackling irregulars with unequal salience degrees. Furthermore, the impact of WM on the success in processing RCs and PRRCs with irregulars has not been much studied. If WM comes into play, various groups of L2 learners with different WM levels might differ in how they process the two constructions. Then, the present study might help language teachers and SLA researchers identify possible causes of difficulties the learners may have when processing certain irregular verbs in RCs and PRRCs.

1.8 Summary

This chapter started with discussing the background of the study, the research questions, and the objectives of the study. The research was aimed to explore WM's effects on the L1 Thai learners' processing of English RCs and PRRCs with irregular verbs and to study whether their processing could be involved with the salience hierarchy of the past participial forms of irregulars. The research hypotheses were formulated in accordance with the research questions and objectives. Also, the chapter provided the scope of the study concerning the population and sample, the target grammatical structures and forms, and the tasks for data collection. The last two sections concerned the definitions of terms employed in the research and the significance of the study.

The dissertation is organized as follows. Chapter 2 provides a literature review of the main areas relevant to the present study, namely the human brain and working memory, English past participial reduced relative clauses and Thai reduced relative clauses, salience degrees of past tense and past participial forms of English verbs, and previous studies on the related fields. Chapter 3 involves the research methodology of the study. Chapter 4 presents and discusses the research findings. Finally, Chapter 5 offers conclusions, theoretical and pedagogical implications, and recommendations for further studies.

CHAPTER II
LITERATURE REVIEW

This chapter presents a literature review regarding major areas which are associated with the present study. Section 2.1 concerns the human brain and working memory. Section 2.2 provides information about English past participial reduced relative clauses and Thai reduced relative clauses. Section 2.3 gives a detailed explanation about salience levels of past tense and past participial forms of English verbs. Section 2.4 addresses previous studies on the fields relevant to the current research. The summary section, i.e., Section 2.5, summarizes the areas reviewed in this chapter.

2.1 Human brain and working memory

This section discusses two related topics: the human brain and working memory (WM). 2.1.1 deals with the human brain and its main components, and 2.1.2 looks into WM and theories relevant to it.

2.1.1 Human brain

According to Bailey (2016), the brain is a complicated organ with distinct, but related parts. It works as the control center of the body, responsible for transmitting, receiving, processing, and directing sensory information throughout the body. The brain can be anatomically divided into parts in several ways. Two common methods are the division based on embryonic development and that on hemispheres of the brain.

The first way to divide the brain into regions is related to the embryonic development (Barclay, 2019). The embryo of vertebrates, including humans, has an undeveloped form of the brain called neural tube which later leads to various layers of the organ when the fetus develops. Barclay (2019) points out that the organ is made up of three major layers: forebrain (also called Prosencephalon), midbrain (Mesencephalon), and hindbrain (Rhombencephalon). The three regions have

different patterns of development. As Burke (2016) states, whereas the hindbrain does not enlarge as the embryo develops, the forebrain and hindbrain become larger and differentiate into divisions. The different development patterns of the three layers of the brain during the embryonic growth are presented in Figure 1.

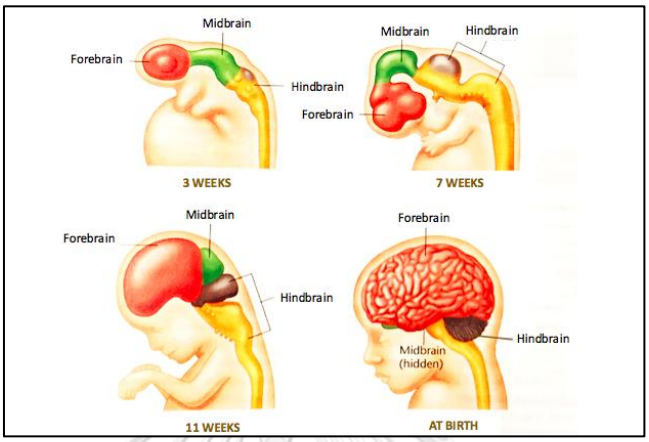


Figure 1: Development patterns of forebrain, midbrain, and hindbrain (Burke, 2016)

The first cerebral component is the forebrain. As the largest part of the brain, it covers the uppermost area of the brain from the front all the way back. As Bailey (2016) claims, the area accounts for numerous uniquely human abilities. The forebrain embraces six subparts which are responsible for different functions: thalamus, hypothalamus, amygdala, hippocampus, basal ganglia, and cerebral cortex (George & Williams, 2017). The thalamus relays sensory information to the cerebral cortex for higher cognitive processing. The hypothalamus results in distribution of hormones throughout the body. The amygdala and hippocampus are linked to emotion and formation of memories, respectively. The basal ganglia deals with intentional movements' speed and smoothness. The cerebral cortex comprises four lobes claimed to process information from internal and external sources. The four lobes are frontal lobe, parietal lobe, occipital lobe, and temporal lobe. Grice and Greenan (2009) state that the frontal lobe is related to decision-making, problem-solving, planning, and personality forming whereas the parietal lobe copes with locating objects and understanding language. They further explain that the occipital lobe plays a role in visual and kinetic perception, and the temporal lobe is associated with auditory perception, smelling, and memory. The components of the forebrain are shown in Figure 2.

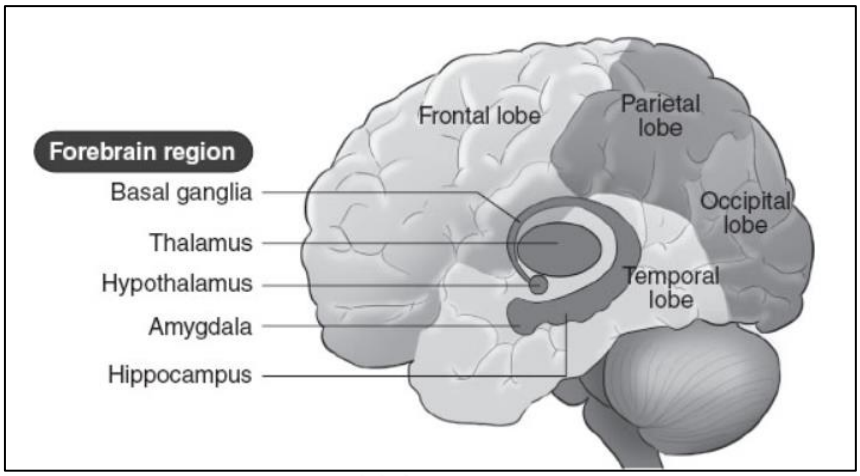


Figure 2: The components of the forebrain (George & Williams, 2017: 11)

The second part is the midbrain or the area connecting the forebrain to the hindbrain. George and Williams (2017) state that the midbrain controls physical movements and facilitates the processing of visual and auditory information. The region of the brain includes four major parts: oculomotor and trochlear cranial nerves, which are connected with eye movements; tectum or the posterior area of the midbrain, which brings about auditory and visual reflexes; and substantia nigra, the part which produces dopamine, i.e., the neurotransmitter regulating motions and emotions (Bailey, 2016).

The last cerebral part is the hindbrain. As its name suggests, the hindbrain is placed near the rear of the brain. As explained by George and Williams (2017), the area contains three subparts: medulla oblongata, pons, and cerebellum. The medulla oblongata and pons are essential to several automatic behaviors that keep humans alive, including breathing, controlling heartbeat and blood pressure, and sleeping. The cerebellum plays an important role in encoding and memorizing the information which is required for doing complicated movements. It also deals with sensory information concerning the bodily positions and motions. Figure 3 illustrates the parts of the midbrain and hindbrain.

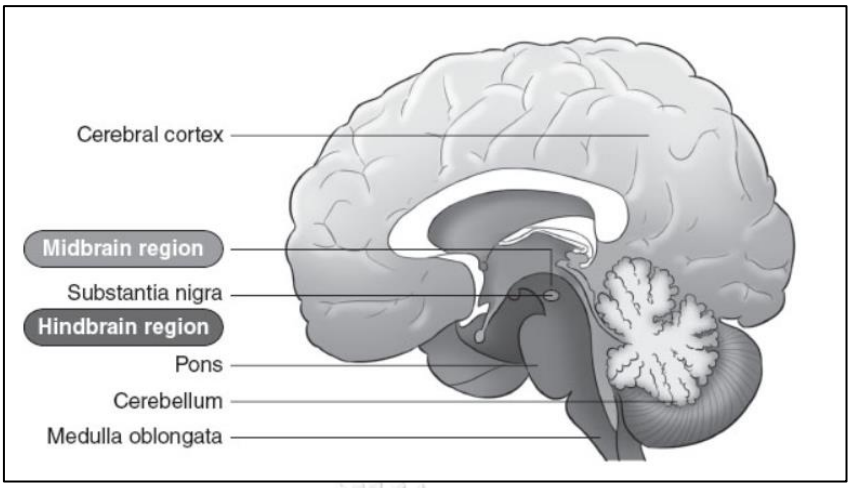


Figure 3: The components of the midbrain and hindbrain (George & Williams, 2017: 10)

Apart from the division associated with the embryonic development, the brain can also be divided according to its hemispheres or sides: left and right hemispheres. The two halves are connected together by nerve fibers called corpus callosum (George & Williams, 2017). Figure 4 displays the cerebral hemispheres divided by the corpus callosum.

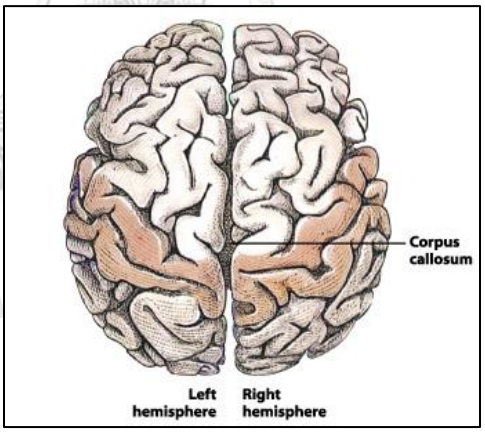


Figure 4: The brain hemispheres and the corpus callosum (Foong, 2013).

As Sherman (2019) notes, the right hemisphere receives sensory information from sensory receptors in and regulates movements of the body's left side whereas the left side of the brain performs the same functions for the right bodily side. Sherman further explains that the two cerebral hemispheres are claimed to tackle tasks which require different cognitive skills. The left hemisphere involves analysis, logic, and calculations. It is also important for linguistic abilities. Burgess (2018) confirms that the left hemisphere encompasses the two major language-related areas, i.e., Broca's

area and Wernicke's area, responsible for speech production and speech understanding, respectively. On the contrary, the right cerebral side is related to creativity, imagination, and emotion. Individuals have been thought to have one cerebral side that is dominant and shapes the way they think and behave (Burgess, 2018). Left-brain dominant people are believed to be more analytical, logical, and fact-oriented while the right-brain dominant ones are characterized as artistic, creative, and intuitive. Nevertheless, the findings of recent studies seem to contradict the theory of left and right brain dominance. For instance, Nielsen et al. (2013) used a magnetic resonance imaging (MRI) scan to assess their participants' cerebral hemispheres. They found that their research participants tended to employ both sides of the brain, depending on the cognitive capabilities needed by the task they carried out. This indicated that none of the hemispheres was dominant.

To conclude, the brain is a complex organ which comprises a number of subparts making several uniquely human abilities possible. There are many ways of sectioning the brain anatomically, including the division based on the embryonic development and that on the cerebral hemispheres.

2.1.2 Working memory

As mentioned in Subsection 2.1.1, the brain has been proved to play a role in several significant aspects of human life, among which is memory or the capacity to remember the past. George and Williams (2017) point out that memory storage has been subdivided into three types describing the duration for which different kinds of information can be retained in the brain: sensory memory, long-term memory (LTM), and short-term memory (STM) or primary memory. Sensory memory retains sensory information for a short period of time; LTM is capable of storing salient information for years or decades; STM holds verbal and visuospatial information from the immediate past for approximately 15 to 20 seconds. STM is often linked to the term working memory or WM.

WM has been widely considered one of the cognitive individual differences. Robinson (2012) refers to cognitive individual differences as variability in terms of "mental functioning, such as memorizing and remembering; inhibiting and focusing

attention; speed of information processing; and spatial and causal reasoning" (p. 17). Wilhelm et al. (2013) defines WM as a cognitive system which provides access to information that ongoing cognitive process needs for carrying out cognitive tasks. Baddeley (2012) states that WM is a modified version of STM. Although the two terms are sometimes interchangeably used, they differ in that STM involves a unitary temporary information storage whereas WM refers to a limited capacity system which includes temporary storage and manipulation of information. To put it simply, STM only maintains information, but WM both holds and uses information. As an example, STM would allow a person to figure out what another person has just told her, but WM could enable her to recite the statement backwards or mention the first letter of each word in the sentence (George & Williams, 2017). In a similar vein, Newell (1973) considers WM as an active part of the human processing system assumed to have storage and processing functions. It acts as the site for executing processes and for retaining the output of these processes simultaneously (e.g., Baddeley & Hitch, 1974; LaBerge & Samuels, 1974). More specifically, McDonough and Trofimovich (2016) state that WM plays an important role in how well individuals can hold, update, and manipulate information over short delays, which necessitates executive attention or the ability to control responses, especially in situations where many responses are possible. In a similar way, Hofmann et al. (2008) explain that a person's WM involves her storage capacity as well as ability to allocate attentional resources and resist distraction. In summary, WM is the ability to employ attention in order to retain or inhibit information. For this reason, differences in WM have been related to distinctions between individuals in terms of how well they can allocate attention for cognitive activities. That is, people with high WM can regulate their attention better than those with low WM, which makes them more likely to successfully perform a complex task even if the input contains distracting or irrelevant information (e.g., Conway et al., 2001; Kane et al., 2001; Unsworth et al., 2004).

WM has been widely regarded as an expansion of Atkinson's and Shiffrin's (1968) multi-store model of memory, which proposes that STM or primary memory is a single system without any subsystems, and that all information enters the unified store. Baddeley and Hitch (1974), however, argue that the concept of the unitary

system is too simple to account for STM, which they believe to comprise various components for storing different types of information. They then come up with the first model of WM, stating that there are three distinct subsystems in STM, i.e., a phonological loop, a visuospatial sketchpad, and a central executive component. The central executive, a higher-level regulatory system, is responsible for controlling the phonological loop and the visuospatial sketchpad which are slave subsystems dealing with verbal and visuospatial information, respectively. The original WM model of Baddeley and Hitch (1974) is presented in Figure 5.

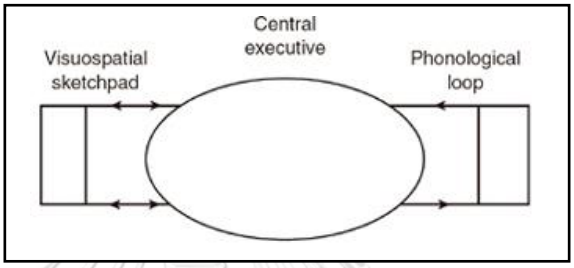


Figure 5: The original working memory model (Baddeley & Hitch, 1974)

The model is later advanced by Baddeley (2000) adding a new element, namely the episodic buffer, which represents a link between the three WM systems and LTM. The revised model has been claimed to emphasize the processes of integrating information, rather than the isolation of the subsystems. Figure 6 provides the new model proposed by Baddeley (2000).

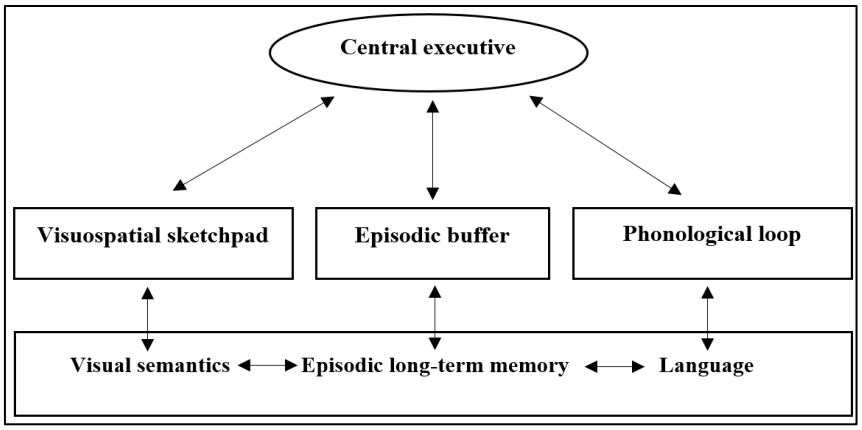


Figure 6: The revised working memory model (Baddeley, 2000: 421)

Baddeley's (2000) modified WM model consists of four parts: phonological loop, visuospatial sketchpad, central executive, and episodic buffer. Consequently,

this section contains four subsections involved with each of the components. Subsection 2.1.2.1 discusses the phonological loop, followed by Subsections 2.1.2.2 and 2.1.2.3 dealing with the visuospatial sketchpad and central executive, respectively. This section ends with Subsection 2.1.2.4 which concerns the episodic buffer.

2.1.2.1 Phonological loop

The phonological loop, which is initially termed as the articulatory loop by Baddeley and Hitch (1974), stores acoustic or speech-based content, namely sound or phonological information. It embraces a temporary storage system where verbal information, both spoken and written material, is retained in the form of memory traces. The duration for which a piece of information can be maintained is affected by whether the information is repeated or rehearsed. As Gathercole (2008) illustrates, the representations in the phonological loop are usually assumed to decay rapidly; however, via rehearsal, the representations re-enter the storage system, and thus, the duration of the representations' existence is lengthened.

Gathercole and Baddeley (1993) propose a model of the phonological loop, claiming that the loop comprises two components: phonological short-term store and subvocal rehearsal. The model is illustrated in Figure 7.

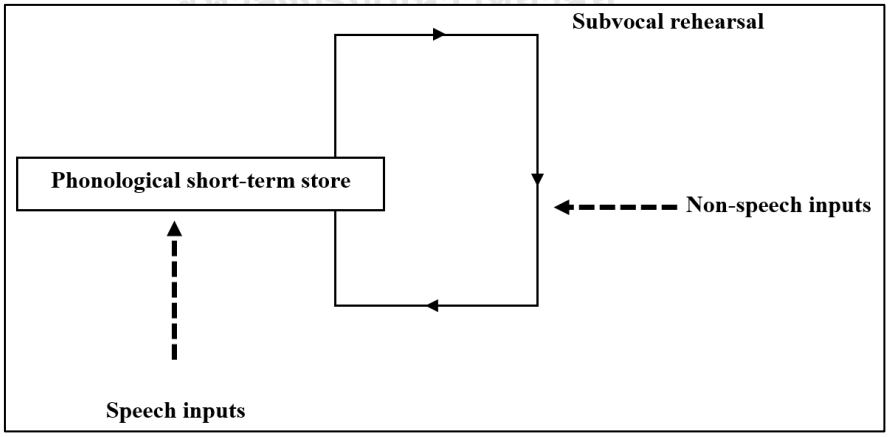


Figure 7: The phonological loop model (Gathercole & Baddeley, 1993: 8)

Related to speech perception, the phonological short-term store is responsible for holding information in a speech-based form. Both auditory and visual verbal

information are assumed to enter the phonological short-term store. The auditorily presented information or the speech inputs get direct access to the store while the visually presented one or the non-speech inputs must be changed by subvocalization into an articulatory spoken code and later encoded into the phonological store. The subvocal rehearsal is related to speech production. The component reactivates the verbal information from the phonological store in order to prevent it from fading away. As long as the information is repeated over and over, it can be maintained in memory indefinitely. The subvocal rehearsal also helps facilitate the transformation of the written information by producing the phonological representations of the information from stored lexical knowledge. Gathercole (2008) associates the phonological loop and its components with the left hemisphere of the brain. That is, the phonological short-term store is in connection with the inferior parietal lobe of the left hemisphere while the subvocal rehearsal is linked to Broca's area in the left premotor frontal region. The relationship between the phonological loop and the left hemisphere of the brain is supported by evidence from patients whose damaged left cerebral hemisphere impairs their own verbal short-term memory.

The components of the phonological loop and the phenomena with respect to it are verified by several studies using serial recall tasks which visually or auditorily present lists of digits, letters or words to the participants, and ask them to immediately repeat the items in the order they are presented. For example, Conrad (1964) found evidence which supported the notion that verbal information was stored in the form of phonological representations. Presenting a group of visual letters to his participants, he observed the phonological similarity effect or the phenomenon in which individuals recalled the items which were phonologically different (e.g., /k/ and /z/ which differed in voicing and manner and place of articulation) better than those which were phonologically similar (e.g., /d/ and /b/ which differed in only place of articulation). Compared to the phonologically dissimilar letters, the phonologically similar items were more difficult to memorize since they contained fewer phonological distinguishing features, making them easier to be forgotten (Baddeley, 1996b). The effect of phonological similarity indicated that the visual information was converted and encoded into a phonological speech-based code according to acoustic

features. In addition, the auditory verbal information's direct access to the phonological short-term store is manifested by research findings in which the phonological similarity effect is minimized by the irrelevant speech effect, namely the phenomenon where recall of visually presented items is affected by auditorily presented items which are unrelated to the target stimuli. For instance, Surprenant et al. (1999) conducted a study on how irrelevant speech impacted immediate recall of verbal sequences. They did three experiments manipulating three factors: modality of presentation (auditory or visual), inclusion of irrelevant speech (absent or present), and phonological similarity (different or similar). In the experiments which excluded irrelevant speech, the participants recalled the phonologically different items better than the phonologically similar ones in both auditory and visual presentations. In contrast, in the experiments which included irrelevant speech, the researchers observed the absence of the phonological similarity effect for visual, but not for auditory items. When irrelevant speech was presented during the visual presentation of the items, the participants correctly recalled both phonologically dissimilar and similar items almost equally. However, during the auditory presentation, they recalled the phonologically different items better than the similar ones. The results suggested that irrelevant speech inhibited visual items from the access to the phonological store since such items must be first transformed into auditory information. This explained why the phonological similarity effect was lessened for visual items. On the contrary, the auditory items had direct access to the store; therefore, the phonological similarity effect was found with the auditory items regardless of the presence or absence of irrelevant speech.

2.1.2.2 Visuospatial sketchpad

Visuospatial sketchpad tackles visual and spatial information, such as word shape and letter shape. According to Gathercole (2008), the sketchpad is closely related to the activities in the right hemisphere regions of the brain, including the inferior prefrontal cortex in the frontal lobe, anterior cortex in the occipital lobe, and posterior cortex in the parietal lobe. Therefore, if the regions of the brain are damaged, the ability to hold visuospatial information will be worsened. The visuospatial sketchpad has been investigated via a wide range of tests, including

memorizing filled squares' pattern, retaining the order in which a set of blocks are tapped, and remembering the direction drawn through a maze (Pickering et al., 2001).

Like the fractionation of the phonological loop, the visuospatial sketchpad consists of two separate subsystems which cope with visual and spatial information separately. Logie (1995) proposes that the visuospatial sketchpad contains a visual store or cache and a spatial or sequential component. The visual store is assumed to store visual characteristics of entities. The store can be affected by decay and new incoming information's interference. The spatial component plans movement and rehearses the contents of the visual store, similar to responsibilities of the subvocal rehearsal in the phonological loop.

Pickering et al. (2001) explain that the visuospatial sketchpad is originally considered a single storage system; however, two sources of evidence from recent studies contradict the concept of a unitary sketchpad. First, much research investigates the notion under the dual task or selective interference paradigm, which features the use of two tasks claimed to employ similar or different cognitive structures. The studies are mainly based on two predictions made in relation to the multicomponent sketchpad concept. When research participants take two tasks which rely on different components, i.e., visual and spatial information, they should successfully perform both tasks together because the two types of information are separately employed. In contrast, when two tasks employing similar components are administered, the participants should have problems doing the tasks simultaneously since the same kind of information tends to disrupt each other and confuse the subjects, leading to poorer performance on one of the tasks. Findings of several studies substantiate the two predictions. For instance, Logie and Marchetti (1991) provided their participants with two primary tasks and two secondary tasks. The primary tasks were temporary retention tasks in which subjects retained a sequence, i.e., a stimulus, for 10 seconds and then determined if it matched a test sequence to be shown later. The sequences in the visual primary task contained square patches in different shades of the same color whereas those in the spatial primary task comprised square patches of the same color shade, but shown at different locations. During a 10-second interval, the participants took a secondary task which was either a visual task, i.e., an irrelevant-pictures task,

where they observed black and white line drawings of objects and animals, or a spatial task, namely a hand-movement task, which consisted of a hand movement following a zigzag trajectory. The irrelevant-pictures task was found to disrupt the participants' performance on the visual primary task, but not the spatial one. On the other hand, the hand-movement task interfered with memory for the locations of the square patches in the spatial primary task, but not for the color shades of the patches in the visual primary one. The separation of the visual and spatial storage systems is also borne out by evidence in relation to neuroanatomy, namely the structure and organization of the nervous system. As an illustration, De Renzi (1982) examined two groups of patients with different impaired cerebral areas: the first group suffering from parietal occipital lesions and the second one having inferior temporal lesions. The findings showed that the patients in the first group failed to determine the specified locations, indicating that damage to the parietal occipital area of the brain negatively affected the spatial processing only. On the contrary, the patients with inferior temporal impairment were observed to have only difficulties identifying items, namely a deficit in visual processing.

2.1.2.3 Central executive

The central executive is a higher-level regulatory system. It performs different functions with the assistance from its two slave components: the phonological loop and visuospatial sketchpad. As stated by Gathercole (2008), while the loop and the sketchpad are more passive, the central executive system is dynamic in that it regulates and coordinates information from the slave systems, links the information to other parts of the cognitive system, and retrieves the material from LTM into WM.

The central executive has been found to be associated with the frontal lobes of both cerebral hemispheres in that the areas are activated by activities which require the regulatory system (e.g., Gathercole, 2008; Baars & Gage, 2013). Due to its connection with the frontal lobes, the central executive has been assumed to involve decision-making, problem-solving, and planning (See detailed discussions of the frontal lobes in Section 2.1.1).

One essential function of the central executive is the allocation of attention, i.e., the ability to selectively process information in a particular environment (Johansen, 2008). Baddeley (1996a) proposes that it is an attentional controlling system which accounts for how individuals can separate attention for different activities, switch attention among tasks, and concentrate close attention on a particular task. In other words, it makes decisions about which issues deserve attention and which should be ignored. To illustrate, when a person engages in two activities, such as driving a car and talking, the central executive would pay greater attention to driving over talking because doing both activities can be burdensome and overload her cognitive resources.

Baddeley (2000) suggests that the central executive in the original WM model lacks short-term multimodal storage for making an integrated form of complex representations. This leaves several experimental phenomena unexplained, and leads to a serious modification to the WM model, i.e., the addition of episodic buffer.

2.1.2.4 Episodic buffer

Episodic buffer refers to a limited capacity system that temporarily stores information in a multimodal form. As Baddeley (2000) claims, the buffer mainly conjoins representations from the two slave systems in WM and other parts in the cognitive system into a single episodic representation. This would integrate visual, spatial, and verbal information with time sequencing, contributing to the memory of an event or a story. Moreover, the episodic buffer is assumed to gain access to information from LTM. According to Baddeley (2000), how the episodic buffer retrieves information from LTM is heavily dependent on the central executive because the buffer's retrieval occurs via conscious awareness which is an attention-demanding process.

The episodic buffer is proposed by Baddeley (2000) mainly in order to modify the original WM model of Baddeley and Hitch (1974) which fails to account for two experimental phenomena linked to limitations of the phonological loop on supporting individuals' serial recall. The first phenomenon is the resistance to articulatory

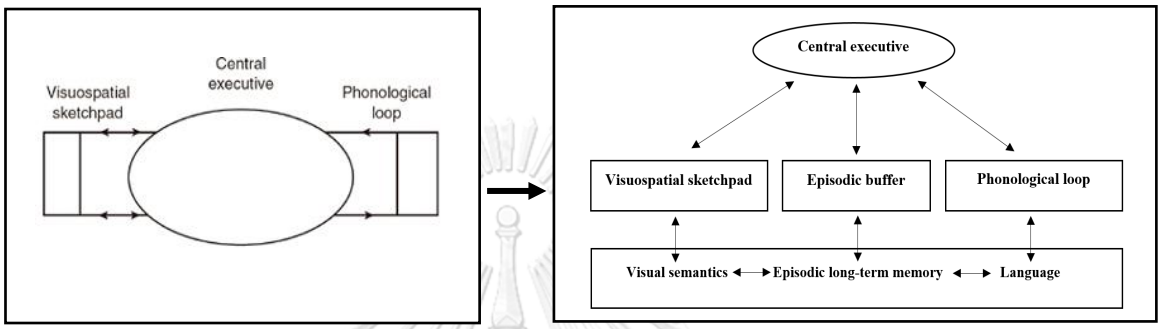
suppression[2] during a presentation of visual stimuli in a recall test. According to the original model, the suppression is assumed to disrupt the articulatory rehearsal, namely to inhibit verbal materials (i.e., the digits, letters or words in a serial recall test) from being encoded into a person's phonological loop, and thus, her recall performance should be dramatically worse than when she is under non-suppressed conditions. Surprisingly, several studies found that subjects, despite the articulatory suppression, still easily and accurately recalled the written information (e.g., Besner et al., 1981; Wilding & White, 1985; Besner, 1987; Nickels et al., 1997). The second phenomenon is the lack of correlation between the auditory memory span and the recall performance with visual presentation, which is observed among amnesiac patients whose short-term phonological memory is damaged. The patients have an auditory span of only one digit; nevertheless, when they are asked to recall visually presented digits, they can memorize approximately four digits.

Given the research findings related to these two phenomena, visual coding might be involved. Yet, Baddeley (2000) argues that the visuospatial sketchpad is suitable for storing only visual or spatial data, but not good at performing multimodal tasks that require both phonological and visual information, such as serial recall. Based on the earlier version of WM model, a person whose phonological memory is impaired or negatively affected should have a poor performance of serial recall. What Baddeley finds in several studies, however, is opposite to the original model's assumption. Despite the articulatory suppression or impaired short-term phonological memory, the research participants still performed well on the recall test. This indicated that they recruited separate phonological representations from a back-up store which combined data from the subsidiary systems into a single episodic representation. Baddeley (2000) asserts that the episodic buffer fulfills the function. The buffer is responsible for not only linking information from the three WM parts, but also facilitating communication between the three components of WM and other cognitive systems, including LTM.

---

[2] According to Baddeley (2000), articulatory suppression refers to a process of inhibiting an individual's memory performance by having her say an irrelevant word out loud while she is remembering and repeating numbers which are visually presented.

To summarize, the extended WM model is different from the original model in two ways. Firstly, the modified version adds the episodic buffer, which acts as a back-up store integrating information from different sources into episodes or chunks. Secondly, the developed model features a close interaction between the WM components and other cognitive systems, including LTM. Figure 8 illustrates a comparison between the original WM model and the modified one.



The original working memory model **The modified working memory model**

Figure 8: Comparison between the original working memory model (Baddeley & Hitch, 1974) and the modified working memory model (Baddeley, 2000: 421)

A myriad of studies have looked into whether WM can affect how individuals carry out cognitive activities, such as math problem solving and decision-making. A cognitive task which has been thoroughly explored in relation to WM is language processing. As regards linguistic comprehension, WM mainly concerns individual differences in terms of the ability to process syntactic and pragmatic connections between words in phrases, sentences, and discourses. Previous research on language processing has analyzed the processing strategies employed by native speakers and those by second language (L2) learners. A surge in interest in the mechanism which underlined how readers processed sentences has led to the analysis of how the processing strategies of the two groups of participants could be influenced by cognitive differences, including WM. The impact of WM has been investigated in respect of numerous aspects of language processing, including resolution of syntactic ambiguity (e.g., MacDonald et al., 1992; Just & Carpenter, 1992; Eastwick & Phillips, 1999; Felser et al., 2003; Juffs, 2004; Kim & Christianson, 2017), morphological processing (Cohen-Mimran et al., 2013; Rungrojsuwan, 2015), analysis of sentences with filler-gap dependency (Roberts et al., 2007; Dussias & Piñar, 2010; Hestvik et

al., 2012), and sensitivity to grammatical violation (Sagarra & Herschensohn, 2010; Coughlin & Tremblay, 2013).

The next section describes English participial reduced relative clauses and Thai reduced relative clauses.

2.2 English participial reduced relative clauses and Thai reduced relative clauses

This subsection provides a comparison between participial reduced relative clauses (PRRCs) in English and their nearest equivalent in Thai, i.e., Thai reduced relative clauses (RRCs). Subsections 2.2.1 and 2.2.2 examine English PRRCs and Thai RRCs, respectively.

2.2.1 English participial reduced relative clauses

Before the English participial reduced relative clause is addressed, participles, which are the core component of the construction, should be discussed first. Lee (2007) states that a participle is a non-finite verb, namely a verb which never changes its form based on any noun phrase (NP) or tense of a sentence. Consequently, it cannot work as the main verb or finite verb in the predicate of the sentence. According to Ballard (2001), participles are a verb form which generally ends with either of two inflectional suffixes: *–ed* or *–ing*. The participial form is derived from a verb, and thus, having the same meaning as the tense form of the verb (Gove, 1965).

Participles usually have two characteristics. Firstly, they are both verbal and adjectival (Meltzer-Asscher, 2010). Huddleston and Pullum (2002) define a participle as a word which is formed from a verb, and serves as or like an adjective. A basic property of adjectives is that they can modify a head NP by being placed in two main positions. As Greenbaum and Nelson (2002) specify, adjectives can occur attributively, i.e., preceding the noun they modify, or predicatively, that is, following the subject and the verb *be* as part of the predicate, as the words *beautiful* and *thick* in *the beautiful girl* and *The book is thick*, respectively. Likewise, participles, such as *cooked*, can modify a noun, and occur either attributively or predicatively, as in *the cooked ham* and *The ham was cooked*. On the one hand, these forms, therefore, can be considered adjectives. Nevertheless, there are certain ways of using participles which

apply to verbs only. Meltzer-Asscher (2010) claims that participles of transitive verbs are verbal since they check accusative Case, as shown in *The girls saw Dina supporting him* (Meltzer-Asscher, 2010: 2213). Moreover, Laskova (2007) assumes that, in English, only verbs, not adjectives, can be post-modified by adverbs. Consequently, participles of intransitive verbs are verbal because they allow post-modification by adverbs, as in *I saw him walking idly* or *I saw the diamond glimmering magnificently* (Meltzer-Asscher, 2010: 2213). Hence, it can be concluded that the definite function of participles is still controversial. The second characteristic of participles is that they can be used with an auxiliary in order to express a tense, aspect or voice, as in *have cleaned* (tense)[3], *is cleaning* (aspect)[4], and *are cleaned* (voice).

As Loberger and Shoup (2009) point out, English encompasses two types of participles: past participles and present participles. Past participles are verbs in their base form ending with the *-ed* suffix (e.g., *created*, *requested*, and *assigned*) while present participles are those ending with the *–ing* suffix (e.g., *talking*, *cooperating*, and *enjoying*). Two fundamental distinctions between these two participial forms are the number of ways of inflecting verbs to the forms and the meaning in relation to the modified NP's thematic role. Regarding the first difference, all verbs inflect to their present participial form via the same way, namely attaching the *–ing* suffix to the base form; however, there are several ways of inflecting verbs to the past participial form, depending on the type of a particular verb, i.e., regular and irregular verbs. As stated by Cao (2013), regular verbs inflect by attaching the *–ed* suffix to themselves whereas irregular verbs require various changes, resulting in many inflected forms, e.g., *made*, *written*, *risen*, and *bought*. The two types of participles also differ in meaning with

---

[3] The English tenses which involve only present participles are present progressive, past progressive, and future progressive whereas those with past participles only are present perfect, past perfect, and future perfect. The tenses which include both present and past participles are present perfect progressive, past perfect progressive, and future perfect progressive. The last three tenses are formed using the past participial form of the copula *been* plus the present participial form of the finite verb. The tenses differ in the auxiliary verb which precedes the copula, namely *has* and *have* for present perfect progressive, *had* for past perfect progressive, and *will have* for future perfect progressive.

[4] There are two types of aspects in English: perfect and progressive (Mittwoch, 1988). The perfect aspect is expressed via the auxiliary verbs *has*, *have* or *had* plus a past participle. The progressive aspect is formed with the verbs *be*, *is*, *am*, *are*, *was*, *were* or *been* and a present participle.

respect to the modified NP's thematic role determined by the voice of the sentence[5]. That is, while past participles are derived from passive voice constructions in which the thematic role of the modified NP is either theme or patient, namely the recipient of the verbal action, present participles are derived from the active voice construction where the modified NP's thematic role is agent, i.e., the doer of the action.

In connection with the place in which they occur, English participles are generally found in participial phrases or phrases which begin with either a present or past participle. Being able to occur in a number of sentential positions, participial phrases can behave adverbially or adjectivally, according to what they modify in a particular sentence: a verb or a noun (Al-Momani, 2019). For instance, the participial phrases in (0), (1), (2), and (3) provide information about the verb in the sentences, expressing the concept of reason, simultaneousness of two events, method, and cause and effect, respectively.

(0) *Obscured by the hedge*, Grover was not detected by the police officer.

(Loberger & Shoup, 2009: 213)

Sentence (0) is reduced from *Because he was obscured by the hedge, Grover was not detected by the police officer* by omitting *Because he was*.

(1) *Speeding down the highway*, Bob did not notice the police car.

(Al-Momani, 2019: 71)

Sentence (1) is reduced from *While he was speeding down the highway, Bob did not notice the police car* by deleting the adverbial phrase of time *While he was*.

---

[5] For past participles, the difference applies to only cases where they are used to indicate passive meaning. According to Huddleston and Pullum (2002), past participles mainly appear in two grammatical structures: perfect and passive, in which they are preceded by the auxiliaries *have* and *be*, as in *I have written him a long letter* and *The letter was written by her secretary*, respectively. The two constructions indicate different meanings; the perfect construction expresses the completion of an action, event or situation at a specific time while the passive one is applied when the subject in a sentence receives an action's effects. The past participial forms used in both structures are usually identical; ergo, the two constructions "involve different uses of the same inflectional form, not different forms" (Huddleston & Pullum, 2002: 78).

(2) *Running five miles a day*, the woman improved her health.

(Al-Momani, 2019: 71)

Sentence (2) is reduced from *By running five miles a day, the woman improved her health* by taking out the preposition *By*.

(3) The volcano erupted, *burying the city in ashes*.

(Behrens, 1998: 93)

Sentence (3) is reduced from *The volcano erupted, so it buried the city in ashes* by removing *so it* and adding the *–ing* suffix to the verb *bury*.

One grammatical context in which English participial phrases commonly appear is reduced relative clauses (RRCs). Since RRCs are reduced from adjective clauses, which are more widely known as relative clauses (RCs), it is necessary to clarify the full form first. RCs are subordinate clauses which give more information about a head noun in the main clause (Al-Momani, 2019). According to Alotaibi (2016), RCs are mainly used to "restrict the possible set of individuals, objects, events, etc. to the subset the speaker intends to talk about" (p. 58). Iwasaki and Ingkaphirom (2005) consider RCs as a kind of nominal modifier which takes the form of a clause. Therefore, it is possible to conclude that the function of RCs is similar to that of adjectives, i.e., providing information concerning the modified noun. Parrott (2000) points out two main characteristics of English RCs: following the NP they modify, and beginning with a relative pronoun[6] or a pronoun which links the RCs to an independent clause. The sentences in (4) instantiate English RCs.

(4) a. The students did not read the book *that the teacher asked them to read*.

b. The judge sentenced the suspect *who robbed the shop*.

(Alroudhan, 2016: 49)

---

[6] Parrott (2000) notes that English relative pronouns include *who, which, that, what, whom, where, when, whose,* and *why*. According to Endley (2010), the relative pronouns in English are usually selected according to the animacy status of the modified noun, such as 'who' for antecedents which are human or human-like animals, 'whom' for human nouns, 'which' for human collectives and animate or inanimate antecedents, and 'that' for human, animate or inanimate head nouns.

c. Ann is the woman *who is responsible for the error*.

d. The boy *who is playing the piano* is Ben.

e. The ideas *which are presented in that book* are good.

(Azar, 1999: 290)

The five sentences in (4) demonstrate that the relative pronouns can be followed by two major groups of grammatical components. The RC in (4a) comprises an NP and its predicate, i.e., *the teacher asked them to read*. By contrast, the RCs in (4b) to (4e) consist of the predicate of the relative pronoun, ranging from a verb phrase *robbed the shop*, a predicative adjective *responsible*, to predicative participles *playing* and *presented*.

There are two main ways of categorizing English RCs. The first way is based on the relationship between the relative pronoun and the verb in the clauses (Lin, 2018). The taxonomy includes two subtypes of RCs: subject-extracted RCs (SRCs) and object-extracted RCs (ORCs). Azar (1999) points out that SRCs are the RCs whose relative pronoun is the subject of the adjective clauses while the subordinate clause marker in ORCs is used as the object of the verb in the clauses.

(5) I thanked the woman *who helped me*.

(6) The movie *which we saw last night* wasn't very good.

(Azar, 1999: 268)

As an example, the RC in (5) is an SRC because the relative pronoun *who* refers to the NP *the woman*, which is the subject of the RC, whereas that in (6) is an ORC since the pronoun *which* modifies the NP *The movie*, which is the object of the adjective clause.

The second way to divide English RCs involves the extent to which they are required to identify a particular NP. Under the categorization, RCs can be classified into two groups: restrictive and non-restrictive RCs (Greenbaum & Nelson, 2009). Alotaibi (2016) states that restrictive RCs are important to the identification of the NP they modify, and as a result, the deletion of the clauses can eliminate readers' understanding of the mentioned NP. On the contrary, non-restrictive RCs provide

optional information about an NP, so they can be omitted without preventing the readers from successfully identifying the noun. In writing, the importance of information in an RC can be marked by the use of commas. Specifically, no commas are employed in the restrictive RCs whereas, in the non-restrictive ones, two commas are placed before and after the RCs.

(7) Mary laughed at the boys *who hadn't done their homework*.

(8) Mary, *who works in the shop downstairs*, is coming tomorrow to the party.

(Alotaibi, 2016: 58)

For instance, the restrictive RC in (7) specified *the boys* by referring to those who did not do their homework, and not those who did; consequently, the omission of the RC made it impossible to identify the head noun. On the other hand, the non-restrictive RC in (8) provided unnecessary information about the mentioned NP. Even though the clause was removed, the readers were still able to identify the individual being mentioned, i.e., the woman named Mary.

As noted by Parrott (2000), English RCs have one essential characteristic, i.e., they can be made shorter via the deletion of the relative pronouns. The reduced form of RCs is called reduced relative clauses or RRCs (Stanton, 2011). With respect to the reduction into their RRC form, RCs can be categorized into two main groups, depending on the grammatical element which immediately follows the relative pronoun: (i) an NP and its predicate, and (ii) the predicate of the relative pronoun. The RCs in these two groups are reduced in different ways.

The first group of RCs features the relative pronoun which is immediately followed by an NP or pronoun and its predicate. The RCs in this group can be shortened by simply removing the subordinate clause marker only, and no other change is made. As explained by Azar (1999), such reduction applies to two grammatical conditions: when the relative pronoun modifies the object of the verb in the RC, and when the RC specifies the time, the place or the reason for which a particular event occurs via the relative pronouns *when*, *where*, and *why*, respectively. However, Azar (1999) points out that there is one exception where the relative

pronoun preceding an NP and its predicate cannot be deleted, namely the RCs beginning with *whose*.

Relative Clauses	Reduced Relative Clauses
(9) The banker *who the lawyer irritated* played tennis every Saturday. (Bulut et al., 2013: 61)	(15) The banker *the lawyer irritated* played tennis every Saturday.
(10) The pitcher *that the coach likes the best* broke a glass. (Lin, 2018: 788)	(16) The pitcher *the coach likes the best* broke a glass.
(11) The time *when the enemy bombed the military base the other day* was around 5 pm. (Lin, 2018: 790)	(17) The time *the enemy bombed the military base the other day* was around 5 pm.
(12) The place *where the guard caught the suspect* was at the basement of a tall building. (Lin, 2018: 789)	(18) The place *the guard caught the suspect* was at the basement of a tall building.
(13) The reason *why the legislators cut the budget* was difficult to accept. (Lin, 2018: 789)	(19) The reason *the legislators cut the budget* was difficult to accept.
(14) Mr. Catt has a painting *whose value is inestimable*. (Azar, 1999: 274)	(20) *Mr. Catt has a painting value is inestimable.

Table 1: Reduction of RCs followed by an NP and its predicate

For example, in Table 1, the RCs in (9), (10), (11), (12), and (13) can be reduced into their RRC form in (15), (16), (17), (18), and (19) by leaving out the relative pronouns *who*, *that*, *when*, *where*, and *why*, respectively. Nevertheless, the RC in (14) includes *whose*; consequently, the omission of the relative pronoun results in an ungrammatical sentence in (20).

Concerning the RCs in the second group, the relative pronoun immediately precedes its own predicate. Simply put, the pronoun refers to the subject of the verb in the RC. The reduction of such RCs necessitates not only the deletion of relative pronouns, but other changes as well. The adjective clauses in this group can be

shortened in two ways, according to the occurrence of the verb *be* in the predicate following the subordinate clause marker. The first way of shortening the RCs in this group requires the deletion of the relative pronoun and the verb *be*. The process of reduction is referred to as WHIZ Deletion (Stanton, 2011). WHIZ Deletion applies to a wide range of contexts where the RC encompasses the verb *be*, including the clauses which involve a prepositional phrase, adjective phrase, past participle or present participle.

Relative Clauses	**Reduced Relative Clauses**
(21) The books *that are on that shelf* are mine. (Azar, 1999: 290)	(25) The books *on that shelf* are mine.
(22) Ann is the woman *who is responsible for the error*. (Azar, 1999: 290)	(26) Ann is the woman *responsible for the error*.
(23) The IAFP recently assembled industry groups to discuss common standards *that are applied to planners*. (McKoon & Ratcliff, 2003: 503)	(27) The IAFP recently assembled industry groups to discuss common standards *applied to planners*.
(24) Oppenheimer had the best scientists *who were working with him*. (Steer & Carlisi, 1998: 169)	(28) Oppenheimer had the best scientists *working with him*.

Table 2: Reduction of RCs whose relative pronoun precedes Be

To illustrate, in Table 2, the RCs in (21), (22), (23), and (24) can be shortened into their reduced form manifested in (25), (26), (27), and (28), respectively.

The second way of reducing the RCs whose relative pronoun immediately precedes its own predicate is used with the adjective clauses which do not have the verb *be*. The RCs can be shortened by leaving out the pronoun and changing the verb in the predicate from the finite form into the present participial form (e.g., Azar, 1999; Beare, 2019). Stanton (2011) states that the omission of the subordinate clause marker and the addition of the *–ing* suffix to the finite form of the verb are called together as Stuff-ing.

Relative Clauses	Reduced Relative Clauses
(29) The professor *who teaches Chemistry 101* is an excellent teacher. (Azar, 1999: 281)	(31) The professor *teaching Chemistry 101* is an excellent teacher.
(30) The fence *which surrounds our house* is made of wood. (Azar, 1999: 291)	(32) The fence *surrounding our house* is made of wood.

Table 3: Reduction of RCs whose relative pronoun precedes verbs other than Be

For instance, in Table 3, the RCs in (29) and (30) can be reduced into their RRC form in (31) and (32) by omitting the relative pronoun *who* and *which*, and attaching the *-ing* suffix to the verb *teach* and *surround* in the RCs.

According to McKoon and Ratcliff (2003), an RRC and RC have the same meaning because the former is derived from the latter. Therefore, in Tables 1, 2, and 3, the sentences in the left column are identical to their counterpart in the right column in terms of meaning.

As shown in (27) and (28) in Table 2, and (31) and (32) in Table 3, the RRCs involving participial phrases are derived from two subgroups of RCs whose relative pronoun refers to the subject of the verb in the RCs: the adjective clauses which encompass the verb *be* plus a past or present participle, and those which do not embrace the verb *be* (e.g., Azar, 1999; Hewings, 2000). Stanton (2011) confirms that both past and present participles can be included in the participial phrases in RRCs, as seen in the examples mentioned above. The RRCs which feature a participial phrase are alternatively called “participial reduced relative clauses” or PRRCs (Sleeman, 2008: 1).

According to Huddleston and Pullum (2005), PRRCs are subordinate clauses which contain no subject, but include a participle as their head. The occurrence of the word *participial* in the name results from the existence of a participle in the structure. Participial reduced relative clauses have two main characteristics. Firstly, they are considered a type of non-finite clauses. As stated by Sleeman (2017), PRRCs do not include any finite verb. Secondly, such subordinate clauses are regarded as a kind of

post-head modifiers. Reduced from an RC, a PRRC occurs in the same position as an RC does, i.e., coming after the head of the NP it modifies (Sleeman, 2017: 4).

PRRCs can be categorized into two groups according to the type of the participles in the clauses: present PRRCs and past PRRCs. Present PRRCs are PRRCs which comprise a present participle whereas past PRRCs are those whose head verb is a past participle. Sleeman (2017) demonstrates that a present PRRC can replace an RC written in active voice in which the relative pronoun performs the action in the subordinate clause whereas a past PRRC can be substituted for an RC written in passive voice where the relative pronoun acts as the object of the past participle. Simply put, PRRCs with a present participle are commonly linked to an active meaning while those with a past participle are associated with a passive meaning. Examples of present PRRCs and past PRRCs are provided in Table 4.

Relative Clauses	**Participial Reduced Relative Clauses**
(33) Trains *which arrive at this station* are always late.	(35) Trains *arriving at this station* are always late. (Sleeman, 2017: 3)
(34) I like all books *which were published by this company*.	(36) I like all books *published by this company*. (Sleeman, 2017: 3)

Table 4: Reduction of RCs to present PRRCs and past PRRCs

In (33), the relative pronoun *which* in the RC *which arrive at this station* performs the action expressed by the finite verb *arrive*; therefore, the RC can be reduced into the present PRRC *arriving at this station* in (35). In (34), on the contrary, the pronoun *which* in the RC *which were published by this company* serves as the object of the past participle *published*. As a consequence, the adjective clause can be curtailed into the past PRRC *published by this company* in (36).

It is important to note that not all RCs can be curtailed. The reduction of RCs into a PRRC is possible in two contexts. Murphy (2004) specifies two cases where an RC can be reduced into a PRRC with a present participle, i.e., when the RC refers to a particular action a person or an object is or was doing at a given time and when the

RC involves a permanent characteristic of something or an event which happens all the time.

To begin with, an adjective clause can be curtailed into a PRRC with the *–ing* suffix as the RC concerns a particular action a person or an object is or was doing at a given time. Examples are provided in (37) and (38):

(37) Police *investigating the crime* are looking for three men. (reduced from *Police who are investigating the crime*)

(38) I was woken up by a bell *ringing*. (reduced from *a bell which was ringing*)

(Murphy, 2004: 194)

The RCs in (37) and (38) can be shortened into a PRRC since they discuss what *Police* and *a bell* are doing at a particular time, that is, investigating the crime and ringing, respectively.

The second case in which an adjective clause can be reduced into a PRRC with a present participle is when the RC involves an enduring characteristic of something or an event which happens perpetually. Consider (39) and (40):

(39) The road *connecting the two villages* is very narrow. (reduced from *The road which connects the two villages*)

(40) I have a large room *overlooking the garden.* (reduced from *a large room which overlooks the garden*)

(Murphy, 2004: 194)

The RCs in (39) and (40) describe a permanent feature of the modified NPs *The road* and *a large room*: connecting the two villages and overlooking the garden. Thus, they can be curtailed into a PRRC.

Nevertheless, Hewings (2000) clearly mentions two cases in which an RC cannot be reduced into a PRRC with the *–ing* suffix, i.e., when the event or action in the RC chronologically precedes the event or action in the main clause and when the RC informs readers about a single completed action.

The first circumstance where it is impossible to reduce an RC into a PRRC with a present participle is when the event or action in the RC is chronologically followed by the event or action in the main clause, except when the former event or action is the cause of the latter one. Compare (41) and (42):

(41) The snow *which fell overnight* has turned to ice. (not **The snow falling overnight has turned to ice*.)

(42) The snow *which fell overnight* has caused traffic chaos. (or *The snow falling overnight has caused traffic chaos*.)

(Hewings, 2000: 148)

In (41), the action in the RC *falling overnight* of the modified NP *The snow* occurs before the action in the main clause *turning to ice*, so the PRRC *The snow falling overnight* in this sentence is ungrammatical. On the contrary, in (42), the same PRRC is possible because the event in the main clause *the traffic chaos* is the result of that in the RC.

Secondly, RCs cannot be reduced into PRRCs with a present participle as they discuss a single completed action, rather than a continuous action. Contrast (43) with (44):

(43) The girl *who fell over on the ice* broke her arm. (not **The girl falling over on the ice*)

(44) I pulled off the sheets *which covered the furniture*. (or *the sheets covering the furniture*)

(Hewings, 2000: 148)

The event in the RC *falling over on the ice* in (43) is a single completed action; consequently, the RC cannot be reduced into a PRRC. However, the incidence *covering the furniture* in (44) describes an action which continues for a particular amount of time, so it is possible for the RC to be shortened into its PRRC form.

Clearly, Hewings' (2000) second exception complements Murphy's (2004) two cases where the reduction of an RC into a PRRC with a present participle is possible. That is, it can be concluded that RCs which describe a continuous action or a

permanent characteristic of the modified NP can be curtailed into PRRCs with a present participle whereas those which involve a single finished event cannot.

Regarding the reduced RCs with a past participle, Hewings (2000) broadly states that the reduction into a PRRC with the *–ed* suffix is usually relevant to RCs with a passive verb conveying a passive meaning. Yet, he adds that there is one case where RCs cannot be reduced into PRRCs with a past participle: when the RCs encompass a modal verb, other than *will*. Compare (45) and (46):

(45) There are a number of people *who should be asked*. (not **a number of people asked*)

(46) There are a number of people *who will be asked*. (or *a number of people asked*)

(Adapted from Hewings, 2000: 148)

Moreover, Marvin (2002) points out that the state of the modified NP must be taken into account when an RC is shortened into a PRRC with a past participle. In order for an adjective clause to be reduced, the head NP's state expressed through the past participle in the RC must be true at the time of utterance. In other words, the modified NP's state in the RC must not differ from that in the main clause. To illustrate, in (47), the state of the NP *The apples* in the main clause *being back on the table* is different from the state in the RC *being fallen from the table*. For this reason, the reduction of the RC in (47) is unacceptable.

(47) *The apples *fallen from the table* are back on the table.

(Marvin, 2002: 151)

Present PRRCs and past PRRCs are both similar and different to one another. There are three similarities and one distinction between them.

The first similarity is that both present PRRCs and past PRRCs can be derived from only subject-extracted RCs (SRCs), i.e., the RCs whose relative pronoun syntactically functions as the subject of the subordinate clauses. However, they do not apply to object-extracted RCs (ORCs), namely the RCs in which the subordinate clause marker serves as the object of the verb in the clauses. This similarity concerns the intervention of a noun within an RC. An RC cannot be shortened into a PRRC if

another noun intervenes between the relative pronoun and the finite verb in the clause (Quirk, Greenbaum, Leech, & Svartvik, 1985: 1263; Foley & Hall, 2004: 149). In other words, the reduction of an RC is allowed when the relative pronoun is immediately followed by the finite verb of the clause.

Relative Clauses	**Participial Reduced Relative Clauses**
(48) The man *who lives upstairs* is very noisy. (Foley & Hall, 2004: 149)	(52) The man *living upstairs* is very noisy. (Foley & Hall, 2004: 149)
(49) The portrait *which was painted by my brother* was lovely. (Foley & Hall, 2004: 149)	(53) The portrait *painted by my brother* was lovely. (Foley & Hall, 2004: 149)
(50) The house *which we live in* is over a century old. (Foley & Hall, 2004: 149)	(54) *The house *living in* is over a century old. (Foley & Hall, 2004: 149)
(51) The man *who Trudy was engaged to* has disappeared. (Foley & Hall, 2004: 149)	(55) *The man *engaged to* has disappeared. (Foley & Hall, 2004: 149)

Table 5: Reduction of SRCs and ORCs

For instance, in Table 5, the RCs in (48) and (49) can be reduced into their PRRC form since the relative pronouns *who* and *which* immediately precede the finite verbs *lives* and *was*. In contrast, the pronoun *we* and the proper noun *Trudy* intervene between the relative pronouns and the finite verbs in the RCs in (50) and (51), respectively. So, the reduction of such RCs to a PRRC gives rise to ungrammatical forms in (54) and (55).

The two types of PRRCs also share a similarity involving the two types of RCs mentioned earlier: restrictive and non-restrictive RCs. Quirk et al. (1985) explained that present PRRCs and past PRRCs could replace both restrictive and non-restrictive RCs.

Relative Clauses	Participial Reduced Relative Clauses
(56) The dog *which was barking next door* sounded like a terrier. (Quirk et al., 1985: 1263)	(60) The dog *barking next door* sounded like a terrier. (Quirk et al., 1985: 1263)
(57) A report *that was written by my colleague* appeared last week. (Quirk et al., 1985: 1265)	(61) A report *written by my colleague* appeared last week. (Quirk et al., 1985: 1265)
(58) The apple tree, *which was swaying gently in the breeze*, was a reminder of old times. (Quirk et al., 1985: 1270)	(62) The apple tree, *swaying gently in the breeze*, was a reminder of old times. (Quirk et al., 1985: 1270)
(59) The substance, *which was discovered almost by accident*, has revolutionized medicine. (Quirk et al., 1985: 1270)	(63) The substance, *discovered almost by accident*, has revolutionized medicine. (Quirk et al., 1985: 1270)

Table 6: Reduction of restrictive and non-restrictive RCs into PRRCs

As an example, the restrictive RCs in (56) and (57) and the non-restrictive RCs in (58) and (59) are curtailed into their PRRC counterpart in (60), (61), (62), and (63), respectively.

The third similarity between the two types of PRRCs involves their comparability to various tensed forms of the finite verb in the RCs. Both present PRRCs and past PRRCs can be derived from a group of RCs with different tenses. According to Quirk et al. (1985), the participle in a PRRC can be equivalent to several tensed forms of the finite verb in an RC.

Relative Clauses	Participial Reduced Relative Clauses
(64) The person *writing reports* is my colleague. (Quirk et al., 1985: 1263)	(66) The person *who writes reports* is my colleague. (Quirk et al., 1985: 1263)
	(67) The person *who is writing reports* is my colleague. (Quirk et al., 1985: 1263)
	(68) The person *who wrote reports* is my colleague. (Quirk et al., 1985: 1263)
	(69) The person *who was writing reports* is my colleague. (Quirk et al., 1985: 1263)
	(70) The person *who will write reports* is my colleague. (Quirk et al., 1985: 1263)
	(71) The person *who will be writing reports* is my colleague. (Quirk et al., 1985: 1263)
(65) the car *repaired by that mechanic*… (Quirk et al., 1985: 1264)	(72) the car *that will be repaired by that mechanic*… (Quirk et al., 1985: 1264)
	(73) the car *that is (being) repaired by that mechanic*… (Quirk et al., 1985: 1264)
	(74) the car *that was (being) repaired by that mechanic*… (Quirk et al., 1985: 1264)

Table 7: PRRCs' comparability to tensed forms of the finite verb in RCs

To exemplify, in Table 7, the present PRRC *writing reports* in (64) can be interpreted as one of the tensed forms of the verb *write* in the RCs from (66) to (71), depending on the given context. Similarly, the past PRRC *repaired by that mechanic* in (65) could be interpreted as one of the three tensed forms of the verb *repair* in the

RCs from (72) to (74). This suggests that RCs written in different tenses can be reduced into the same PRRC form.

In association with the difference, present PRRCs and past PRRCs differ in the degree to which they apply to RCs with an intransitive verb. Because intransitives are usually employed with active voice, not passive voice, RCs which include an intransitive verb can be reduced to a present PRRC only (Quirk et al., 1985).

Relative Clauses	**Participial Reduced Relative Clauses**
(75) The teacher *who is standing in front of us* graduated from the University of Cambridge.	(77) The teacher *standing in front of us* graduated from the University of Cambridge.
(76) The train *which has arrived at platform 1* is from York. (Quirk et al., 1985: 1265)	(78) ?*The train *arrived at platform 1* is from York. (Quirk et al., 1985: 1265)

Table 8: Reduction of RCs with an intransitive verb

In Table 8, the verbs *stand* and *arrive* in the RCs in (75) and (76) are intransitive verbs and, as a result, the RCs can be shortened to present PRRCs only. So, the past PRRC with an intransitive verb in (78) is considered ungrammatical.

To summarize, there are three similarities and one difference between present PRRCs and past PRRCs. Concerning the similarities, both of the types of PRRCs can be derived from only SRCs, can replace both restrictive and non-restrictive RCs, and can be interpreted as one of the several tensed forms of the finite verb in the RCs. As for the distinction, present and past PRRCs differ in the extent to which they apply to RCs with an intransitive.

Table 9 tabulates the similarities and difference between present PRRCs and past PRRCs.

No	Characteristic	Present PRRCs	Past PRRCs
1	Being derived from only SRCs	+	+
2	Replacing both restrictive and non-restrictive RCs	+	+
3	Being interpreted to one of the various tensed forms of the finite verb in the RCs	+	+
4	Being reduced from RCs with an intransitive verb	+	-

Table 9: Similarities and difference between present PRRCs and past PRRCs

Presented above is the primary information about the English PRRC structure. The following subsection discusses Thai reduced relative clauses.

2.2.2 Thai reduced relative clauses

The English PRRC does not have any exact Thai counterpart. According to Yaowapat and Prasithrathsint (2006), the nearest Thai equivalent is the reduced relative clause (RRC) or the RC which has no relative pronoun[7]. More importantly, Thai is an isolating language or a type of language which has no inflectional morphemes (Pongpairoj & Mallikamas, 2004); therefore, the Thai reduced RCs do not have a past participle, a main feature of English PRRCs. Since the Thai RRC is derived from the Thai RC, the latter will be first presented in this subsection.

As Iwasaki and Ingkaphirom (2005) explain, there are three syntactic similarities between Thai and English RCs. First, the RCs in the two languages are preceded by the noun they modify. Second, the modified NP and the RC are linked by a relative pronoun which is generally placed between the two grammatical elements. Last, English and Thai adjective clauses can be divided into two subtypes: SRCs or the RCs whose relative pronoun is the subject of the verb in the clauses, and ORCs or

[7] Iwasaki and Ingkaphirom (2005) state that three common relative pronouns in Thai include /thîi, sîŋ, and ʔan/, all of which are the Thai counterparts of the English relative pronoun *that*. One difference between these three relative pronouns is the contexts in which they appear. /thîi/ is the most common, and usually occurs in a number of contexts whereas /sîŋ/ and /ʔan/ are often found in formal contexts.

those in which the subordinate clause marker refers to the object of the verb in the RCs. Demonstrated in (79) and (80) are examples of the Thai SRC and ORC, respectively:

(79) nîi kɔ̂ mii ɛ̀p khon phûan [thîi phûŋ maa à mày-mày]
DM[8] LP[9] have HES[10] person friend SBR[11] ASP[12] come PP[13] new

'Now, there were some people – my friends who had just arrived (in LA).'

(Iwasaki & Ingkaphirom, 2005: 243)

(80) kháw pen lûuk [thîi phɔ̂ɔ mɛ̂ɛ hŭaŋhɛ̌ɛn mâak]
3[14] COP[15] child SBR father mother treasure much

'She is a child that her parents treasure very much.'

(Iwasaki & Ingkaphirom, 2005: 249)

As aforementioned, the English PRRC has no exact Thai equivalent. The lack of Thai counterparts to the English structure might be attributed to three major differences between English and Thai.

The first distinction is about the contexts which permit the relative pronoun omission. The relative pronouns in English, i.e., *who*, *which*, and *that*, can be omitted in most cases regardless of whether the pronouns are the subject or object of the verb in the clauses. Yet, the relative pronouns in Thai can be deleted only when they modify the subject of the RC (Iwasaki & Ingkaphirom, 2005). In addition, not all Thai SRCs can be shortened. Iwasaki and Ingkaphirom further state that there are two factors which determine if a Thai SRC can be reduced into an RRC: the specificity in

[8] DM = Discourse marker (Iwasaki & Ingkaphirom, 2005)

[9] LP = Linking particle (Iwasaki & Ingkaphirom, 2005)

[10] HES = Hesitation (Iwasaki & Ingkaphirom, 2005)

[11] SBR = Subordinator (Iwasaki & Ingkaphirom, 2005)

[12] ASP = Aspect auxiliary (Iwasaki & Ingkaphirom, 2005)

[13] PP = Pragmatic particle (Iwasaki & Ingkaphirom, 2005)

[14] 3 = Third-person pronoun (Iwasaki & Ingkaphirom, 2005)

[15] COP = Copula (Iwasaki & Ingkaphirom, 2005)

the description of the modified NP and the possibility of considering the head NP as a definable category of people.

The first factor is the specificity in the information about the modified NP. Iwasaki and Ingkaphirom (2005) claim that a Thai subordinate clause marker in an RC can be omitted when the RC provides a general description regarding the head NP. However, the adjective clauses which identify a specific event cannot be reduced. Compare (81), (82), and (83):

(81) rót-mee [(thîi) pay sayăam] cɔ̀ɔt pâay níi máy khráp
bus (SBR) go Siam Square stop board this QP[16] SLP[17]
'Does the bus that goes to Siam Square stop at this bus stop?'

(Iwasaki & Ingkaphirom, 2005: 250)

(82) èk pen dèk [(thîi) rian kèŋ]
(name) COP child (SBR) study well

'Ek is a child who studies well.'

(Iwasaki & Ingkaphirom, 2005: 250)

(83) măa [thîi kàt dèk mûa-waan-níi] thùuk câw-nâa-thîi càp pay lɛ́ɛw
dog SBR bite child yesterday PASS[18] officer catch go/DIR[19] ASP

'The dog which bit the child yesterday was captured by the officers.'

(Iwasaki & Ingkaphirom, 2005: 249)

In (81), the RC /pay sayăam/ *going to Siam* gives a general quality of the NP /rót-mee/ *bus*. Therefore, it is possible to omit the relative pronoun /thîi/ in the clause. By the same token, in (82), the RC /rian kèŋ/ *studying well* shows a general characteristic of the head NP /dèk/ *child*; consequently, the relative pronoun is optional here. In contrast, in (83), /kàt dèk mûa-waan-níi/ *biting the child yesterday* offers more specific details about the modified NP /măa/ *dog*, making it impossible for the RC to be curtailed.

---

[16] QP = Question particle (Iwasaki & Ingkaphirom, 2005)

[17] SLP = Speech level particle (Iwasaki & Ingkaphirom, 2005)

[18] PASS = Passive (Iwasaki & Ingkaphirom, 2005)

[19] DIR = Directional auxiliary (Iwasaki & Ingkaphirom, 2005)

The second factor is whether the NP modified by an RC can be included in a definable group of people who have a particular role. That is to say, it is possible to reduce an RC when the head NP can be conceived as a specific category of people, and vice versa. Compare (84), (85), and (86):

(84) khon [(thîi) tham kàp-khâaw mûa-waan-níi] pen khray
person (SBR) make dishes yesterday COP who

'Who is the person who cooked yesterday?'

(Iwasaki & Ingkaphirom, 2005: 250)

(85) tɛ̀ŋ kàp khon [(thîi) tham ɛɛ]
marry with person (SBR) do/make air conditioner

'(She) is married to a man who builds and repairs air conditioning system.'

(Iwasaki & Ingkaphirom, 2005: 251)

(86) khon [thîi yuun troŋ nán] pen khray
person (SBR) stand right there COP who

'Who is the person who stood over there?'

(Iwasaki & Ingkaphirom, 2005: 250)

/thîi/ in (84) and (85) can be omitted since the NPs /khon tham kàp-khâaw/ or *a person who fixes a meal* and /khon tham ɛɛ/ or *a person who builds and repairs air conditioning system* can be considered a definable person who has a specific role, i.e., a cook and an air conditioner technician, respectively. On the other hand, /thîi/ in (86) is required because the NP /khon thîi yuun troŋ nán/ *a person who is standing there* cannot be included in a category of people with a particular role.

Apparently, there are much fewer contexts where the Thai subordinate clause markers can be deleted than those in which the English relative pronouns can. Besides, although it is possible to delete the subordinate clause markers in their L1, Thais usually do not omit them, which is supported by Lekawatana et al. (1969) stating that "Relative pronouns are never deleted in Thai" (p. 102). For this reason, L1 Thai learners might be puzzled when learning about English PRRCs.

In addition to the number of contexts where relative pronouns can be omitted, Thai and English differ in the existence of inflectional affixes. English possesses the inflectional affixes *–ing* and *–ed* attached to the verbs for conveying the active and passive meanings, respectively. In contrast, Thai does not have such affixes. In order to express grammatical meanings, the language uses an independent word. According to Iwasaki and Ingkaphirom (2005), /yùu/ and /yaŋ/ which mean *still* or /kamlaŋ/ which means *presently* can be employed to indicate the continuous aspect while /thùuk/, /doon/ or /dây-ráp/ can convey the passive meaning. Shown in (87) and (88) are examples of how the continuous and passive meanings are expressed through the words /yùu/ and /thùuk/, respectively.

(87) pôo kháw kɔ̂ lian phasăa yîipùn yùu
(name) 3 LP study language Japanese stay/ASP

'Poo is studying Japanese.'

(Iwasaki & Ingkaphirom, 2005: 153)

(88) mɛ̂ɛ thùuk nám-rɔ́ɔn lûak
mother contact/PASS hot.water burn

'My mother was burnt by the hot water.'

(Iwasaki & Ingkaphirom, 2005: 314)

In short, English inflectional affixes *–ing* and *–ed* might be confusing to L1 Thai learners because, in their L1, grammatical information is usually provided for a statement via using a lexical word.

Thirdly, the RCs in Thai and those in English differ in how they are curtailed. To explain, the RC reduction in Thai seems much simpler than that in English. As mentioned above, the reduction of some English RCs into a PRRC requires only the omission of the subordinate clause marker whereas that of the others needs both relative pronoun deletion and other changes, i.e., either deleting the verb *be* or adding the *–ing* suffix to the verb in the RCs, depending on the grammatical elements which follow the relative pronoun. Yet, the reduction of Thai RCs necessitates only the omission of the Thai subordinate clause marker.

To conclude, there is no Thai equivalent for the English PRRC structure probably due to Thai's three properties mentioned above: the fewer contexts in which Thai relative pronouns are optional, the non-existence of inflectional affixes, and the simpler RC reduction which needs the relative pronoun deletion only. The three English-Thai differences are tabulated in Table 10.

No	Characteristic	English	Thai
1	The scarcity of contexts in which relative pronouns are optional	-	+
2	The existence of inflectional morphemes	+	-
3	The RC reduction which requires the relative pronoun omission only	-	+

Table 10: The three English-Thai differences accounting for the lack of Thai PRRCs

The section which follows is about perceptual salience levels of past tense and past participial forms of English verbs.

2.3 Salience degrees of past tense and past participial forms of English verbs

This section is related to salience levels of past tense and past participle forms of English verbs. Subsection 2.3.1 is connected with salience in the field of linguistics. English regular and irregular verbs and their past tense and past participle forms are described in Subsection 2.3.2. Subsection 2.3.3 shows some well-established classifications of English verbs according to salience degrees of their past tense forms. This section ends with the application of Bayley's (1994) taxonomy in categorizing English irregulars by salience of their past participial forms described in Subsection 2.3.4.

2.3.1 Salience in linguistics

In literature on psychology, salience or saliency of an item or stimulus refers to the state or quality which makes it stand out among its neighbors. Chiarcos et al. (2011) state that a more salient item is said to attract greater attention and to be more easily perceived; therefore, a stimulus' salience degree is strongly associated with

humans' attention paid to the stimulus and perceptions of it. As Zarcone et al. (2016) demonstrate, humans' brain recruits relevant information in order to detect useful, interesting or unexpected parts which should be prioritized or given more attention than obviously uninteresting or predictable ones. This has been claimed to help them "quickly identify and react to potentially dangerous or rewarding stimuli" (Zarcone et al., 2016: 11). The amount of attention given to a stimulus in turn affects how easily the stimulus is perceived. That is, the more prominent items have a greater tendency to be perceived, to be realized, and to enter the following cognitive processing than those that are less so (e.g., Bordalo et al., 2012; Cintrón-Valentín & Ellis, 2016).

Blumenthal-Dramé et al. (2017) broadly categorize salience in the attention literature into two types: top-down and bottom-up. Top-down salience is driven by knowledge and cognition, i.e., depending on what the brain knows and what it expects to perceive. That is, it is experience-based and varies among individuals. A stimulus is top-down salient when it is cognitively anticipated. The expectation of the stimulus might occur either because it is part of an individual's cognitive routine or because it is previously referred to. As put by He et al. (2016), top-down salience also involves high-level cognitive activities, such as intentionally looking for a particular object. As an example, a person receives a training session on finding two items placed in the same location, and in a test session, one item is put in the same place as it was in the training session whereas another is placed in a different location. The former item has a higher degree of top-down salience because the person anticipates the item to be located there as a result of her knowledge gained from the training session. Unlike top-down salience, bottom-up salience is stimulus- and feature-driven. To be specific, an object's bottom-up salience is determined by its feature contrast or distinctiveness (e.g., Jingling & Zhaoping, 2008; Van der Stigchel et al., 2009). According to Van der Stigchel et al. (2009), a stimulus has high bottom-up salience when it differs in one or more features from its neighbors. On the other hand, if the item resembles its neighbors, it is said to have low bottom-up salience. Clark (2013) explains that bottom-up salience of a stimulus could be caused by its intrinsic physical qualities or violation of social or probabilistic expectations. To illustrate, in a row of five cars in

which one is yellow and the other four are blue, the yellow car is more bottom-up salient than the rest since it differs from them in color.

Various factors have been shown to be related to perceptions of salience. Cintrón-Valentín and Ellis (2016) point out three major factors which could modulate how salience is perceived: humans' sensory systems, their world knowledge, and particular stimuli's predictability. The first factor is people's sensory systems. Their ability to perceive the physical world makes some sensations more intense than the others. Given their sensory perception, they consider a particular object heavier, brighter or louder. Secondly, an item's salience has an association with a person's world knowledge about the item and environment that surrounds her. When a person experiences the world and learns from it, she would gain knowledge which leads her to prioritize certain associations over others. In other words, she tends to be aware that some stimulus cues are related to important results whereas others could be ignored. Lastly, perceptions of a stimulus' salience degree could be affected by predictability of the stimulus. Usually, perceivers are likely to make predictions about what is going to occur next. Zarcone et al. (2016) state that the human brain keeps being aware of the events or entities it has encountered, gets more familiar with regularities, and anticipates upcoming stimuli according to the recent context. In case perceivers' expectations are violated, their brain would locate and respond to unexpected stimuli. They would be surprised, and thus, giving more attention to the unpredictable cues (Ranganath & Rainer, 2003). Therefore, the unexpected stimuli have been assumed to be more salient than the expected ones.

Salience has been considered a factor which accounts for phenomena in a number of fields, including politics (e.g., Transue, 2007; Etzioni, 2016; Han & Wackman, 2017), marketing and economics (e.g., Bordalo et al., 2012, 2013), and linguistics. As explained by Zarcone et al. (2016), salience in the field of linguistics can be divided into two broad groups: perceptual salience and pragmatic salience.

Perceptual salience involves prominence related to human perception and sensory systems. More specifically, Goldschneider and DeKeyser (2001) define perceptual salience as the ease of perceiving a particular linguistic unit, feature or structure. Such salience is assumed to be determined by the input's characteristics,

such as morphemes' visual prominence, the amount of phonetic substance, lexical stress level, and serial position of a word in a sentence (Brown, 1973). For example, among the three allophones of the English regular past *–ed* morpheme, the syllabic [ɪd] as in *participated* and *embedded* is considered more prominent than the non-syllabic [t] and [d] in *cooked* and *absorbed*. The [ɪd] is more salient because it involves a syllable assumed to contain a vowel and thus gaining more stress than the [t] and [d]. Pragmatic salience is basically dependent on meaning and surrounding context. Næss (2011) points out two groups of semantic-pragmatic salience: referent-determined salience and speaker-determined salience. Referent-determined salience is associated with the types of differences in argument-marking systems, such as animacy, referentiality, and definiteness. This type of pragmatic salience concerns an argument's inherent characteristics (e.g., animacy and referentiality) or its status in current discourse (e.g., definiteness and established referent identity). Speaker-determined salience, on the other hand, refers to a quality which the speaker indicates in order to focus the hearer's attention on certain aspects of discourse, namely something new or unexpected. Such pragmatic salience relates to types of information which are encoded in topic-marking and focus-marking systems, i.e., systems which obviously mark arguments for their pragmatic status as either the topic or focus of a sentence. A sample of speaker-determined salience is prominence of the recently mentioned topical referents.

Several studies explored impact of these two types of linguistic salience on SLA, and most of them focused on language learners' processing of linguistic components and phenomena in various L2s, including reduction of English definite article or a dialectal variable in the North of England (Rácz, 2012), English derivational suffixes (Lázaro et al., 2020) and inflectional morphemes (e.g., Romano, 2015; Simoens et al., 2017), tense marking in Italian (Behney et al., 2017), and noun-adjective agreement in Latin (Sarkissian & Behney, 2017).

The concept of salience has also been shown to affect L2 learners' processing of the past tense forms of two types of English verbs: regular and irregular verbs. The two groups of English verbs are discussed in the following subsection.

2.3.2 Salience and English regular and irregular verbs

Each English verb possesses a paradigm of inflection under which it varies from its base form or the form without any inflection to its four inflected forms (Young, 1984). The five main forms of verbs are the base form, the third person singular or the *–s* form, the present participle or the *–ing* form, the past simple, and the past participle, as shown in Table 11.

Base Form	**3rd Person Singular**	**Present Participle**	**Past Simple**	**Past Participle**
accept	accepts	accepting	accepted	accepted
marry	marries	marrying	married	married
drink	drinks	drinking	drank	drunk
awake	awakes	awaking	awoke	awoken
give	gives	giving	gave	given
fight	fights	fighting	fought	fought
hit	hits	hitting	hit	hit

Table 11: The five forms of English verbs

As shown in Table 11, the base form of all verbs requires the *–s* and *–ing* suffixes in order to change to the third person singular and present participle forms, respectively; however, their past simple and past participle forms vary. Variation patterns of English verb forms have been broadly categorized into two main groups according to the changes they require in inflecting to the past simple and past participle forms: regular and irregular patterns.

Young (1984) demonstrates that the regular patterns of variation apply to most English verbs, and the verbs which follow such variation patterns are called regular verbs. The main characteristic of the regular verbs is that they generally inflect from their base form to the past simple and past participle forms by fastening the *–ed* suffix to the base form (Azar, 1999). Many regular verbs require various slight changes in spelling before the suffix is attached; however, their inflected forms are predictable. Examples of possible variation patterns of English regular verbs are provided in Table 12.

Base Form	Past Simple	Past Participle
walk	walked	walked
modify	modified	modified
stop	stopped	stopped

Table 12: Variation patterns of English regular verbs

The verbs in Table 12 differ in the changes they need before inflecting into the past simple and past participle forms, such as the change from *modify* to *modifi*, the change from *stop* to *stopp* or no change required by *walk*. Despite differences in terms of the changes they require, all of the regular verbs inflect by attaching the *–ed* suffix to them.

On the contrary, simple past and past participle forms of several verbs do not end in *–ed*. Such verbs fall into the irregular variation patterns, and are called irregular verbs. Irregular verbs differ from regular verbs in two ways. The first distinction concerns how to inflect. Unlike the regular verbs which inflect by attaching the *–ed* suffix to themselves, the irregulars can inflect in three main ways: transforming the stem or internal vowel of the verb itself (e.g., *lead-led* and *rise-rose*), attaching a suffix to the verb (e.g., *burn-burnt*) or both (e.g., *bring-brought*, *buy-bought*, and *sweep-swept*) (Young, 1984). The second difference is about the similarity between the past simple and past participle forms. While the past simple and past participle forms of all regular verbs are exactly the same, the degree of similarity between the two forms of the irregulars tremendously varies. Some irregular verbs have identical past simple and past participle forms while the two forms of other irregulars bear no resemblance to each other. Regarding the verbs whose past simple and past participle forms are different, some inflect to the two forms by changing their stem (e.g., *drink-drank-drunk*) whereas others need different changes for inflecting to the two forms. For the verbs in the latter group, the past simple form of most verbs requires only a vowel change (e.g., *bite-bit* and *give-gave*) while the past participial one necessitates either both a vowel change and an addition of the *–en*/*–n* suffix (e.g., *awake-awoken*) or only adding the *–en*/*–n* suffix (e.g., *give-given*). For the verbs whose past simple and past participle forms are the same, inflecting to the two forms needs various adjustments, such as the change of the internal vowel (e.g., *fight-fought*), the change

of the last consonantal sound (e.g., *lend-lent* and *send-sent*) or the retention of the base form (e.g., *hit* and *set*). Numerous variation patterns of irregular verbs are illustrated in Table 13.

Base Form	Past Simple	Past Participle
be	was	been
go	went	gone
know	knew	known
set	set	set
lend	lent	lent
forget	forgot	forgotten
bring	brought	brought

Table 13: Variation patterns of English irregular verbs

In conclusion, there is a variety of patterns of irregularity, and the way irregular verbs in English inflect is unpredictable. The next subsection addresses some well-established divisions of the verbs according to their past tense forms' perceptual salience.

2.3.3 Classifications of English verbs according to perceptual salience of past tense forms

As seen above, verbs in English have a variety of inflected forms, and the different forms have been claimed to vary in perceptual salience degree. The extent to which the past tense form of a verb is phonologically different from its base form could determine the perceptual salience level of the past simple form. As Minow (2010) points out, the greater the phonological difference between the present tense and past tense forms of a verb, the more salient the past tense form of the verb is. For instance, *bring* needs three changes in becoming *brought*: (a) the internal vowel /ɪ/ is changed to /ɔ/, (b) the final segment /ŋ/ is deleted, and (c) the final stop /t/ is added. In contrast, *run* requires only the change of the internal vowel in becoming *ran*. Therefore, *brought* is more phonologically salient than *ran*.

Based on Minow's statement, variations in the perceptual salience degree possibly involve two aspects in connection with English verbs: the regular-irregular distinction and differences between the irregular verbs. Firstly, the irregular verbs

whose past simple form is much phonologically different from the present tense form are likely to be more perceptually salient than the regular verbs whose past simple form slightly differs from the present tense form, i.e., simply having the *–ed* suffix attached to the present tense form. In addition to the regular-irregular distinction, there seems to be a variation in the perceptual salience level among various past tense inflection patterns of the irregular verbs.

English verbs have been categorized by perceptual salience of their past tense forms. Wolfram (1985), Bayley (1994), and Tajika (1999) classified the verbs according to the extent to which their past tense form phonologically differed from the present tense one.

Wolfram (1985) established a salience hierarchy of irregular past tense forms, which contained five groups of English irregular verbs: a) suppletives, b) doubly-marked verbs, c) strong verbs[20] changing the internal vowel, d) modal verbs, and e) replacives. The most salient type of verbs is suppletives or the verbs whose past and present tense forms do not have any phonological segments in common, including *go-went* and copulas. The second most prominent group of verbs is doubly-marked verbs, namely the verbs that inflect by changing their internal vowel and changing their final sound to /t/ or /d/, e.g., *leave-left* and *sell-sold*. The strong verbs which inflect by changing the internal vowel only are ranked third in the hierarchy. Samples of the verbs in the class are *come-came*, *lead-led*, and *begin-began*. According to Leppänen (2019), such verbs are alternatively called ablauts. The modal verbs *can* and *will* whose past tense inflection necessitates an internal vowel change and substitution of /d/ for the final /n/ and /l/ take the fourth place in the taxonomy. The least salient verbs are replacives whose past and present tense forms are different only in the voicing of the final consonant, e.g., *send-sent* and *make-made*.

Bayley (1994) made revisions to Wolfram's (1985) classification system. His coding scheme for English verbs is provided in (89).

---

[20] According to Hogg (2002), there are two major morphological groups of verbs in Old English: weak and strong verbs. The former are verbs which indicate person, number, and tense by attaching an ending to the verb stem, such as *love/loved* while the latter are verbs which change the vowel in the stem to indicate tense, like *sing*/*sang*.

(89) a. suppletives, i.e., *go-went* and the first person singular copula *am-was*;

b. doubly-marked verbs, e.g., *leave-left*;

c. verbs whose past tense form is formed by changing the internal vowel, deleting the final segment(s), and affixing *t/d* to them, e.g., *bring-brought, think-thought*;

d. strong verbs whose past tense is formed by changing the internal vowel, e.g., *come-came*;

e. copulas apart from the first person singular, e.g., *is-was, are-were*;

f. replacives, e.g., *have-had, send-sent*;

g. regular syllabics[21], e.g., *want-wanted, yield-yielded*;

h. regular non-syllabics, e.g., *play-played, talk-talked*;

i. the modals *can-could, will-would*.

Bayley (1994: 43)

The categorization identifies nine types of English verbs arranged according to their salience degree, from (89a), i.e., the most salient, to (89i), namely the least salient. Bayley made three major alterations to Wolfram's (1985) classification system. The first change is a subcategorization of the doubly-marked verbs. Bayley subdivided the doubly-marked verbs in Wolfram's taxonomy into two subclasses. Both subclasses are similar in that they require an internal vowel change and addition of the /t/ or /d/ suffix; however, they differ in one facet regarding their final segment, i.e., one group changes the final segment (e.g., the segment /v/ in *leave* [liːv] changes to /f/ in *left* [left]) and the other deletes the final segment (e.g., the segment /ŋ/ in *bring* [brɪŋ] gets omitted in *brought* [brɔːt]). The verbs which change the final segment are included in the doubly-marked verb class, and regarded as more salient than those which delete the final sound. The second modification is about the copulas. That is, only the first person singular copula is considered a suppletive since *am* [æm] and *was* [wɒz] do not share any common segments. On the contrary, the other copulas, namely *is* [ɪz] and *are* [ɑːr], share the final sound with their inflected forms

[21] As Khumdee and Pongpairoj (2014) point out, the syllabic [ɪd] sound is an allophone of the regular past tense suffix *–ed* that marks past tense by adding one more syllable to the base form of the verbs which end with the /t/ or /d/ sound; therefore, the inflected verb *waited* contains two syllables: [weɪt] and [ɪd].

was [wɒz] and *were* [wɜːr], so the past tense forms of *is* and *are* are less salient than that of the first person singular copula, occupying the fifth position on the hierarchy. The last alteration is an addition of regular verbs divided into two groups: regular syllabics and regular non-syllabics. The regular verbs are thought to be less salient than the irregular verbs since the past tense inflection of the former encompasses only an addition of a regular past tense suffix, and no change is made to the stem of the verbs. Regarding the order of the regular verbs, the regular syllabics precede the non-syllabics because "A complete syllable, after all, would seem to be more salient than a segment" (Bayley, 1994: 51). To summarize, Bayley refined Wolfram's classification in three ways: the subcategorization of the doubly-marked verbs, the subdivision of the copulas, and the addition of the regular verbs. The three changes result in four more classes of verbs in the revised scheme: verbs that form the past tense by an internal vowel change, deletion of the final segment(s), and affixation of t/d as in (89c), copulas other than the first person singular in (89e), regular syllabics in (89g), and regular non-syllabics in (89h).

Tajika (1999) made a similar classification including three main categories of English verbs: irregulars, regulars, and modals, as shown in (90).

(90) **Irregulars:**

More salient: suppletive irregulars (*go-went*; *am-was*)

irregulars with vowel change and consonant suffixation (*leave-left*; *buy-bought*)

irregulars with vowel change only (*fly-flew*; *eat-ate*)

copula and auxiliary *be*

Less salient: replacive irregulars with consonant change only (*have-had*; *send-sent*)

Regulars:

More salient: non-syllabic regulars (*play-played*; *talk-talked*)

Less salient: syllabic regulars (*want-wanted*; *start-started*)

Modals:

Not classified: modals (*can-could*; *will-would*; *may-might*)

(Adapted from Tajika, 1999: 84)

Tajika's salience hierarchy is different from the previous classifications of English verbs in two ways: the exclusion of the modals from the irregulars and the rearranged order of the two regular verb types. Firstly, the modal verbs are excluded from the irregulars. Due to their internal vowel change plus an addition of a suffix, the modals might be argued to be considered a class of irregular verbs on a phonological basis; however, Tajika (1999) points out that the modals' meaning is not salient in terms of tense because the present and past tense forms of the verbs could indicate the future time. Furthermore, Bayley (1994) explains that *could*, *would*, and *might* can refer to events in the present or the past. Given their vague temporal function, the modals are considered a special class of verbs in the categorization. Apart from the exclusion of the modal verbs from the irregulars, Tajika's classification regards the non-syllabic regulars as more salient than the syllabic ones, which differs from Bayley's order of regular verbs. Tajika states that the non-syllabic markings, such as *play-played* and *talk-talked*, have higher salience since the past tense suffix is attached to a stressed syllable. By contrast, the syllabic markings, such as *want-wanted*, lead to unstressed syllables, so they are less prominent.

Although the three classifications made by Wolfram (1985), Bayley (1994), and Tajika (1999) vary in the number of verb classes included, they share at least two similarities. First, they reach mutual agreement on the salience degrees of four main classes of irregular verbs, i.e., suppletives, doubly-marked verbs, ablauts, and replacives. That is, the suppletives are the most salient, followed by the doubly-marked verbs and the ablauts, respectively. The replacives are the least salient irregulars. The second similarity between the three classifications is that they do not include identical forms or irregular verbs whose past tense form is exactly the same as the present tense one, e.g., *cut-cut*, *set-set*, *cast-cast*, *burst-burst*, *quit-quit*, and *put-put* (Prapobaratanakul & Pongpairoj, 2016: 81).

Similarities and differences between the three classifications of past tense forms of English verbs by Wolfram (1985), Bayley (1994), and Tajika (1999) are encapsulated in Table 14 below.

Study	Inclusion of Modals in Irregulars	Subcategorization of Copulas	Inclusion of Regular Verbs	Subcategorization of Doubly-marked Verbs
Wolfram (1985)	+	-	-	-
Bayley (1994)	+	+	+	+
Tajika (1999)	-	+	+	-

Table 14: Comparison of the three classifications of past tense forms of English verbs by Wolfram (1985), Bayley (1994), and Tajika (1999)

The next subsection is in connection with the application of Bayley's (1994) classification in categorizing English irregular verbs by salience level of their past participial form.

2.3.4 The application of Bayley's (1994) classification in categorizing English irregular verbs by perceptual salience of past participial forms

The present study aims to examine how salience of the past participial form of English irregulars affects L1 Thai learners' processing of the RC and PRRC structures; however, to the best of my knowledge, English past participles have never been categorized by their salience degree. Therefore, it is reasonable to create a salience hierarchy of the past participial forms for the current research. As shown in the classifications of the past tense forms, the phonological differences between the present and past tense forms were taken into account. So, it can be assumed that making a salience hierarchy of the past participial forms should also involve how they phonologically differ from their past simple form, from which they are derived.

Nevertheless, before the past participle forms of the irregular verbs are grouped, it should be noted that the division of the past tense forms is now well-established because of the three classifications by Wolfram (1985), Bayley (1994), and Tajika (1999) as discussed in 2.3.3. Based on the comparison of the three classifications in Table 14, Bayley's categorization is complete and more detailed since it includes all the three characteristics related to the irregular verbs, i.e., inclusion of modals in the irregulars, subcategorization of copulas, and subdivision of doubly-marked verbs. As a result, it seems to account for a wider range of major phonological differences between the present tense and past tense forms of the irregular verbs. Moreover, the phonological distinctions between the present and past simple forms in Bayley's classification might be able to account for those between the past simple and past participial forms. Thus, it is worthwhile to explore how the types in Bayley's division could apply to phonological differences between the past participle and the past tense forms of the irregular verbs.

After an examination of the extent to which his classification of the past tense forms related to the differences between past simple and past participial forms of the irregulars, it was found that Bayley's taxonomy tended not to perfectly apply to the distinctions between several past participles and their past simple counterpart of such verbs because of two issues: 1) in the present study, the past participles needed to be contrasted with their past simple form in order to determine their salience level, and 2) some changes which were required for inflecting to the past participial forms did not exist in Bayley's categorization of the past tense forms.

The first reason why Bayley's categorization of the past tense forms of the irregular verbs failed to be used with several past participles was about the form to which the latter should be compared in the present study. In Bayley's classification, the past tense forms were phonologically contrasted with the present tense ones since the differences between the two forms were assumed to have effects on L2 learners' tendency to mark past tense. That is, the greater the distinction between the past and present tense forms of an irregular verb was, the more likely L2 learners were to mark past tense for the verb. However, processing the verb in the PRRC structure was claimed to involve distinguishing between the past simple and past participle forms.

For example, the form *sent* could be interpreted into two possible forms, i.e., the main verb as in *The florist sent the flowers to the woman* or the PRRC as in *The florist sent the flowers was very pleased*. The extent to which the past tense form of an irregular verb differed from the past participial one could determine the likelihood of successfully identifying the given structure. To put it simply, the greater the distinctions between the past tense and past participial forms of the verb were, the more easily the given form could be identified. As a result, the classification of the past participles should be based on the differences between the past participial and the past simple forms, which Bayley's classification of the past tense forms failed to account for.

Choosing the form to be contrasted with the past participles was crucial because comparing a past participial form to the other two forms, namely the present and the past tense forms, could result in different salience levels of the past participle. In other words, the degree of a past participle's salience depended on the form to which it was compared. Some past participles had a higher salience degree when they were compared to their present tense form than to the past tense one; however, the others were more salient when compared to the past tense form than to the present tense one. As an example, when the past participle *broken* was phonologically compared to its present tense form *break*, the inflection involved two changes: changing the internal vowel from /eɪ/ to /oʊ/ and an addition of the syllabic [ən] morpheme. In contrast, the transformation from the past tense form *broke* to the past participle *broken* needed only one change, i.e., the addition of the syllabic [ən]. Accordingly, the two forms differed in only the number of syllables: one syllable for *broke* and two syllables for *broken*. Obviously, upon being compared to the present tense form *break*, the past participle *broken* was more salient than when it was contrasted with the past tense form *broke*. Another example was the past participial form *become* which was identical to its present tense counterpart *become*, but different from its past tense form *became* in terms of the internal vowel. So, the past participle *become* had a higher degree of salience when contrasted with its past tense form than with its present tense one. It should be noted that the variation of a past

participle's salience degree did not apply to the identical forms whose three forms were exactly the same.

The second reason was that certain changes which many irregular verbs required for inflecting to the past participial forms did not exist in Bayley's classification of the past tense forms. The alterations were an addition of the syllabic [ən] morpheme and an affixation of *n*. The first change was adding the syllabic [ən]. A large number of verbs underwent such change in their inflection, including *give-gave-given*, *eat-ate-eaten*, *break-broke-broken*, and *fall-fell-fallen*. The second change was affixing an *n* to the end of the verb, which was applicable to such verbs as *grow-grew-grown*, *draw-drew-drawn*, *fly-flew-flown*, and *blow-blew-blown*.

Yet, the past participial forms of some irregular verbs were not restricted by the two limitations mentioned above, and therefore, could be explained by Bayley's taxonomy. The past participles still maintained the same degree of salience regardless of the form with which they were contrasted. In addition, all the changes required for the verbs' inflection appeared in Bayley's classification of the past tense forms. Such irregular verbs could apply to two types in Bayley's categorization of the past tense forms: suppletives and ablauts. The suppletives in Bayley's taxonomy included *go-went* and *am-was*. However, when the past participles were considered, only the first person singular *am-was-been* was relevant because the past participle *been* did not share any common segments with both *am* and *was*. The verb *go* was set aside from the category as the past participle *gone* shared the /g/ segment with the present tense form *go*. Regarding the ablauts, many verbs are considered members in the class, e.g., *begin-began-begun*, *sing-sang-sung*, and *drink-drank-drunk*. Both the present and past tense forms *begin-began*, *sing-sang*, and *drink-drank* necessitated an internal vowel change in order to inflect to their past participial forms *begun*, *sung*, and *drunk*.

To conclude, Bayley's categorization of the past tense forms according to their salience level failed to account for the past participial forms of a lot of irregulars as a result of two restrictions: 1) the past participles' requirement for a different form to which they will be compared in the present study, and 2) the non-existence of certain alterations needed for inflecting to the past participial forms in Bayley's classification. However, the two issues did not affect a group of irregular verbs, and the verbs

applied to two classes in Bayley's division of the past tense forms: suppletives and ablauts.

2.4 Previous studies

This section specifically describes three major groups of previous studies which are relevant to the present study. Subsection 2.4.1 addresses previous studies on WM and cognitive processing among native speakers and L2 learners from several L1 backgrounds. Then, processing research on the English participial reduced relative clause structure among native English speakers and L2 English learners is discussed in Subsection 2.4.2. Subsection 2.4.3 involves studies on L2 acquisition of English regular and irregular verbs.

2.4.1 Previous studies on working memory and cognitive processing among native speakers and L2 learners

It should be noted first that most research works on WM's role in linguistic processing dealt with syntactic processing whereas some involved other linguistic subfields, including morphology, vocabulary, and phonology. Thus, this section consists of three subsections. Subsection 2.4.1.1 discusses WM studies on syntactic processing of L1, followed by those of L2. Subsection 2.4.1.2 looks into WM research on other linguistic aspects and that on language learning. Then, cognitive processing studies carried out with L1 Thai learners are addressed in Subsection 2.4.1.3. The research with the L1 Thai participants needs to be in a separate subsection because many studies in this group examined native Thai speakers' processing patterns without WM's involvement.

2.4.1.1 Previous studies on working memory's effects on syntactic processing among native speakers and L2 learners

The study of the role of WM in language processing is of fairly recent origin. WM was first introduced as a factor to analyze L1 syntactic processing. Felser et al. (2003) explored native English speakers' resolution of RC attachment ambiguity,

looking into their listening span[22]. An example of RC attachment ambiguity is shown in (91):

(91) The student photographed the fan of the actress who was looking happy.

Felser et al. (2003: 52)

Sentence (91) is temporarily ambiguous since the RC *who was looking happy* can be considered a modifier of either the first noun phrase or NP1 (the direct object *the fan*) or the second noun phrase or NP2 (the embedded noun *the actress*). Gilboy et al. (1995) examined RC attachment preferences in relation to NPs which included prepositions *of* and *with*, and found that the preferences could be influenced by structural and semantic reasons. For instance, native English readers demonstrated NP1 attachment preference for genitives of substance NPs which were formed by the preposition *of* (e.g., *a sweater of wool*). The preference was associated with the existence of determiners. That is, introducing a determiner before NP1 would make the NP referential whereas NP2 in the construction strongly resisted determiners, and thus, being non-referential. However, no clear preference was observed for genitives of occupational relation NPs joined by *of* (e.g., *the assistant of the inspector*). The case-marker *of* did not assign a thematic role of its own; consequently, both NP1 and NP2 belonged to the same processing domain. Both NPs were then referential and available as hosts for the RC, depending on the context. Regarding the two NPs joined by the thematic-role assigning preposition *with*, the RC following the NPs was likely to be attached to NP2 since "the current processing domain contains only NP2 when the relative clause occurs since the prepositional phrase dominating the preposition will define the domain" (p. 141). Felser et al. (2003) included L1 English children and adults as their research participants. The participants first took a grammaticality judgment task in order to ensure their sensitivity to violations of number agreement between an NP and the auxiliary in the RC which modified the NP because number agreement was a key part in solving the ambiguity of the target sentences. They then took a self-paced listening task which manipulated 2 factors: the modified NPs (NP1

[22] There were some WM studies investigating individuals' listening span, such as Felser et al. (2003), Shanshan and Tongshun (2007), and Fay and Buchweitz (2014); however, most research on WM examined working memory's effects on reading span.

and NP2) and prepositions (*of* and *with*). Sentences (92a) and (92b) show samples of the experimental items.

(92) a. Of – NP1: The doctor recognised *the nurse of* the pupils who was feeling very tired.

b. With – NP2: The doctor recognised the pupils *with the nurse* who was feeling very tired.

(Felser et al., 2003: 53)

The results showed that WM seemed to affect only the children's RC attachment preferences. The high listening span children had a tendency to prefer attaching RCs to NP1, but those with low span were likely to show a preference for NP2 attachment. Felser et al. (2003) attributed the children's processing to their reliance on structural information, namely structure-based locality principles. That is, the children with lower span appeared to employ the Recency strategy[23], favoring NP2 attachment while those with higher span possibly used Predicate Proximity[24] favoring NP1 attachment. Unlike the children, the adult participants' attachment preferences were generally affected by the types of prepositions combining the two NPs preceding the RCs: *of* and *with*. Specifically, they showed NP1 attachment preference and NP2 attachment preference for the noun phrases (NPs) linked with *of* and those combined by *with*, respectively.

Roberts et al. (2007) investigated whether WM differences among adults and children led to individual differences concerning antecedent reactivation in filler-gap constructions. They analyzed how the participants reactivated the relativized NPs in double object constructions, in which the gap-position t_i was far from the verb. A sample of the structure is shown in (93):

(93) John saw [the peacock]$_i$ to which the small penguin gave the nice birthday present t_i in the garden last weekend.

(Roberts et al., 2007: 8)

---

[23] Recency is a parsing principle which prefers an incoming part to be attached to the most recently processed phrase (Gibson et al., 1996).

[24] Predicate Proximity is a parsing principle which favors attaching a modifier as structurally close as possible to the head of a predicate phrase (Felser et al., 2003).

The authors employed a cross-modal picture priming task or the task providing the participants with two pictures for each experimental sentence: a related picture (e.g., a picture of peacock for sentence (93)) and an unrelated picture (e.g., a carrot for sentence (93)). During the auditory presentation of the target sentences, the pictures appeared on a computer screen and the participants had to judge whether the animal or object in the pictures was alive or not alive by pressing a button on a box. Their response times were assessed from the point where the picture was displayed on the screen to when they pressed the button. The results revealed that the participants with high WM demonstrated antecedent reactivation priming at the gap-position t_i in the task, but the low WM participants did not. According to Roberts et al. (2007), the participants with low WM displayed a delay in gap filling; as a result, they might need "more time to integrate the filler at the gap position and reactive the filler only later during the sentence" (p. 18). The researchers concluded that the low span participants' antecedent reactivation might have been found if it had been assessed at a later point in time after the experiment.

Hestvik et al. (2012) explored the impact of WM on adults' processing of object RCs. They also addressed one question left unanswered by Roberts et al.'s (2007) study: if low WM participants show a delay in gap-filling, how much are they delayed? They employed an event-related potentials (ERPs)[25] paradigm in order to examine whether the listeners filled a gap by measuring the latency or the amount of time required for producing automatic brain responses to expectancy violations. The college-aged research participants first took a listening span test in order to have their WM measured. The participants whose span was less than or equal to the median of the group were assigned to the low span group, and those with the span greater than the median to the high span group. Then, they completed a listening comprehension task which included two sentence conditions: ungrammatical sentences and grammatical sentences, as exemplified in (94).

[25] Event-related potentials are small voltages which are generated in the brain structures in response to particular events or stimuli (Blackwood and Muir, 1990).

(94) a. Grammatical: The weekend that the hippo kissed *the camel* on the nose he ran far away.
b. Ungrammatical: The zebra that the hippo kissed **the camel* on the nose ran far away.

(Hestvik et al., 2012: 428)

In sentence (94a), the gap was placed after the verb *kissed*; therefore, the presence of *the camel* after the verb was grammatical. In contrast, since the gap in sentence (94b) was not placed after the verb *kissed*, the existence of *the camel* made the sentence ungrammatical. To investigate the delay in gap-filling, Hestvik and colleagues compared the participants' reading times on *the camel* in the ungrammatical condition to those on the same NP in the grammatical condition. WM's effects were supported by the research findings. Compared with their higher WM counterparts, the low WM adults were slower in establishing a filler-gap dependency while processing object RCs, exhibiting an onset latency delay of about 200 milliseconds in brain responses to syntactic violations after the gap site.

Apart from L1 syntactic processing, WM's impact has been studied in connection with learners' processing of L2 sentence structures. Most WM research looked into a single group of L2 learners with the same degree of proficiency while few compared two groups of participants with different L2 proficiency levels. The research works with the L2 learners of the same proficiency level will be discussed first, and then followed by those with two groups of participants who had different L2 proficiency levels.

In L2 processing studies, the research findings on the extent to which WM affects L2 learners' processing are not consistent. Many studies confirm WM's certain role in L2 comprehension. For example, Dussias and Piñar (2010) looked into the correlation between WM of L1 Chinese advanced learners of L2 English and their use of information about plausibility or naturalness in linguistic description (Langacker, 1987) in processing English long-distance *wh*-extractions. Dussias and Piñar designed a task which included two variables: extractions (subject and object extractions) and plausibility (plausible and implausible conditions), as in sentences (95a) – (95d).

(95) a. Subject extraction – Plausible: Who did the police know killed the pedestrian?

b. Subject extraction – Implausible: Who did the police declare killed the pedestrian?

c. Object extraction – Plausible: Who did the police know the pedestrian killed?

d. Object extraction – Implausible: Who did the police declare the pedestrian killed?

(Dussias & Piñar, 2010: 471)

The L1 Chinese subjects generally found subject extractions more difficult to process than object extractions. However, only the high WM participants processed the *wh*-extractions similarly to the native English speakers did. Both native English speakers and high span L2 learners showed slower reading times on the regions after the verbs in the plausible condition. This indicated that the two groups were successful in using plausibility cues for recovering from an initial misanalysis. On the other hand, the low WM group had more difficulty processing the verbs in the implausible condition, suggesting that they recruited plausibility information in a different way from the native speakers and their high-span counterparts. Therefore, the research findings demonstrate that individual differences in WM come into play during L2 sentence processing and that L2 and L1 sentence processing can bear striking similarities in case adequate cognitive resources are available. In addition, one interesting aspect of the results was that the lower WM participants spent similar reading times on the critical regions in both plausible and implausible sentences; however, they spent longer reading times on the disambiguating regions which followed the critical regions in the plausible sentences than on the implausible ones, suggesting that plausibility caused a delayed effect on their processing. This indicated that the lack of effects of a factor on the critical regions did not necessarily mean that they did not exist at all. A variable's impact on reading times of a WM group, however, might occur in other regions apart from the critical regions, especially the post-critical regions. The post-critical regions where delayed effects of a factor occur are known as spillover regions (Keating & Jegerski, 2015).

Williams (2006) examined WM's impact on how native and non-native speakers of English applied plausibility information in performing incremental processing[26] of *wh*-questions in English. The subjects took two different tasks: a stop-making-sense task and a memory probe task. Regarding the stop-making-sense task, the subjects were instructed to press a button when they thought the sentence they were reading had stopped making sense. The second one was a memory probe task used to divide the non-native subjects into two groups according to their WM level: high and low WM participants. In the memory probe task, the subjects were asked to supply the missing word in sentences using a word that had appeared in the previously displayed target *wh*-questions. Each target question had two versions resulting from the manipulation of the plausibility factor: implausible and plausible objects for the verb. Two versions of a test item are shown in (96):

(96) a. Plausible: Which bucket did the lady wash the very large shirt in early this morning?
b. Implausible: Which soap did the lady wash the very large shirt with early this morning?
Probe: The lady washed a ____.

(Williams, 2006: 77)

WM's impact was observed in how the subjects employed plausibility information in the stop-making-sense task. Only the high WM participants showed processing patterns similar to those of the native speakers in that they made earlier responses to the sentences where the *wh*-phrase was an implausible object for the verb (i.e., bucket) than to those with the *wh*-phrase as a plausible object (i.e., soap). Unlike the first two groups, the reading times on all regions of the lower WM L2 learners in both plausible and implausible conditions did not differ, indicating that they did not use plausibility information. In other words, no effect of plausibility was found in this group. Moreover, similar to the results of Dussias and Piñar (2010), Williams found that plausibility exerted delayed effects on the processing of a WM group. The higher WM participants spent similar RTs on the critical regions in both conditions; however, they

[26] Incremental processing refers to a processing method which involves processing only an incoming word newly added to a sentence when the existing words are already processed, instead of re-processing the complete sentence (Williams, 2006).

spent longer RTs on the regions which followed the post-critical regions in plausible conditions than on those in implausible ones, indicative of their use of plausibility information. This suggests a delayed effect of plausibility on the higher WM readers, showing that the information did not immediately affect subsequent processing.

Suda (2015) examined effects of WM and L2 English proficiency on L1 Japanese learners' online processing of English subject-extracted RCs (SRCs) and object-extracted RCs (ORCs). A self-paced reading task was administered to elementary and intermediate learners who had different WM capacity levels. The reading time data showed that the learners had more difficulties reading and understanding ORCs. Moreover, WM seemed to play a pivotal role in processing L2 sentences because the learners who had higher WM capacity were faster in reading the embedded verbs than those who had lower cognitive capacity. Regarding SRC and ORC asymmetries, the participants spent more time processing the verb regions in the ORCs than those in the SRCs. This was in line with previous studies on L1 processing of English SRCs and ORCs in which native English processors were found to require more reading times for reading the ORCs than for the SRCs (e.g., Just & Carpenter, 1992; King & Just, 1991).

Kim and Christianson (2017) analyzed the effects of WM on advanced L1 Korean learners' processing of ambiguous RCs in English and Korean. They conducted two self-paced reading experiments where the subjects processed experimental sentences created to test the impact of the modified noun's position. The factor included two sentential positions of nouns: subjects and objects. Samples of the RCs modifying the subject and those modifying the object in English and Korean are shown in (97a) and (97b).

(97) a. Subject-modifying RC:

Cayphan-cwung-ey cungin-ul moyok-han pyunhosa-uy kokayk-un ttoktttok-hayss-ta.
Trial-during-LOC witness-ACC insult-MOD lawyer-POSS client-TOP intelligent-PST-DECL

'The lawyer of the client who insulted the witness during the trial was intelligent.'

b. Object-modifying RC:

Phansa-nun caypahn-cwung-ey cungin-ul moyok-han pyunhosa-up kokayk-ul thail-ess-ta.
Judge-TOP trial-during-LOC witness-ACC insult-MOD lawyer-POSS Client-ACC rebuke-PST-DCL

'The judge rebuked the lawyer of the client who insulted the witness during the trial.'

(Kim & Christianson, 2017: 370-371)

Referring to the Dependency Locality Theory or DLT[27] proposed by Gibson (1998, 2000), Kim and Christianson (2017) assumed that the relative processing difficulty of a sentence could be proportional to the integration distance or the distance between the subject and the finite verb. Such distance could be reflected by the number of words intervening between subject-verb integration. As seen in (97a) and (97b), English and Korean were different in the extent to which the subject-verb integration distance could affect the processing of the two RC types: subject-modifying RCs and object-modifying RCs. In English, the subject and the finite verb in the subject-modifying RCs were separated by the adjective clause whereas those in the object-modifying one were adjacent. On the contrary, in Korean, the subject and the finite verb in the subject-modifying RCs were close to each other, but those in the object-modifying ones were intervened by a number of words. The interlingual contrast[28] in the degree to which the processing of subject-modifying RCs and object-modifying RCs could be influenced by the subject-verb integration distance might

[27] Gibson's (1998, 2000) Dependency Locality Theory proposes that the syntactic complexity of a sentence can be determined by two elements: storage cost and integration cost. Storage cost is concerned when a parser expects the number of additional syntactic heads which are necessitated in order to make a grammatical sentence. Integration cost is related to the cognitive resources required for connecting a new word to words which precede and have dependent relations with it. Nilsson (2006) claims that the cost of integrating a new word with a previous word correlates with the number of discourse referents that intervene between the new word and the syntactic item constructed in the structure so far. The cost has been assumed to be higher as the linear distance between the new word and the nearest head or dependent which attaches to it becomes larger. A huge distance is assumed to have the activation of words worsen and make integration more difficult.

[28] Kim and Christianson (2017) point out that the contrast between the RC constructions in Korean and those in English results from the difference in the two languages' head-directionality property. That is, Korean is a head-final language while English is a head-initial language.

lead readers to have different difficulties when processing the two types of RCs in the two languages. In English, the subject-modifying RCs should have a higher integration cost than the object-modifying ones, and thus, imposing greater processing difficulties. On the other hand, in Korean, the object-modifying RCs were predicted to be more difficult to process than the subject-modifying ones. Kim and Christianson proposed that high WM readers had a larger storage capacity, and could better activate and maintain more information than the lower WM ones, so they were assumed to be more sensitive to structural dependency between the subject and the finite verb. This led the comprehenders with higher WM to have more difficulties processing the RCs with a higher subject-verb integration cost, which was reflected through their higher reading times. Consequently, the research participants with higher WM should have more problems processing the English subject-modifying RCs and Korean object-modifying adjective clauses while those with lower WM would not show contrast in their reading times for both subject- and object-modifying adjective clauses. The research findings confirmed the predictions.

Furthermore, some research works reveal the relationship between WM's effects and the task types employed in the studies (e.g., Havik et al., 2009; Zhou et al., 2017). That is, WM's impact is more likely to be observed in some experimental tasks than the others. For instance, Havik et al. (2009) analyzed WM's impact on how L1 German advanced learners of L2 Dutch processed subject-object ambiguities in Dutch RCs. The authors were also interested in whether syntactic processing procedures in L1 and L2 processing were comparable, so they selected Dutch RCs because it has been found that both native speakers of Dutch and German have the subject-over-object preference for ambiguous RCs in their own language. They are likely to have more difficulty processing when such ambiguous structures are disambiguated toward an object RC, compared to a subject RC. Consequently, the two languages are comparable. Havik et al. (2009) recruited two groups of subjects: native speakers of Dutch and L1 German learners. After being divided into groups according to their WM level via a reading span test in Dutch, the subjects participated in two self-paced reading experiments. In Experiment 1, they had to read the target sentences presented word by word, and then make a truth-value judgment and determine the argument

roles of the ambiguous nouns in each sentence. In Experiment 2, half of the experimental items asked the subjects to either verify the target sentences or interpret subject-object ambiguities. In general, all groups of research participants displayed subject preference, which was evidenced by higher accuracy for the subject-RC items, compared to the object-RC ones. However, the research findings indicated that different levels of demand for cognitive resources in different experimental tasks could modulate WM's impact on the subjects' processing. When encountering the high demand task, namely the task which focused their attention on the subject-object ambiguities, the high WM subjects, similar to the native speakers, showed subject-over-object preference which was reflected in the less amount of time they spent on reading the subject-RCs than the object-RCs whereas the low WM learners showed similar reading times on both types of RCs. On the contrary, with the low demand task, i.e., the task requiring them to read for either verification or subject-object interpretation alone, WM seemed to have no influence on the L2 learners' processing. Overall, both groups of the L2 learners spent longer time reading some experimental items and showed the subject-over-object preference.

Zhou et al. (2017) directly looked into whether the task types could influence WM's effects on the processing of *wh*-extractions by L1 Chinese intermediate learners of L2 English. A memory span task was first administered to the research participants in order to divide them into groups according to their WM level. To test the task type's effects, the researchers used two different tasks, namely a grammaticality judgment task and a translation task. In the first task, the participants read the target sentences presented on a computer screen, and then judged whether the sentences were grammatical or not. In the second task, the subjects were asked to translate English sentences they read on the computer screen into Chinese verbally, and their answers were collected via a digital voice recorder. Zhou and colleagues employed a self-paced reading paradigm to obtain data concerning the participants' response times and accuracy rates for the two tasks. The results of the first task exhibited WM's effects in only the response times. That is, the participants with high WM demonstrated faster grammaticality judgment, but the accuracy rates of the two subject groups were not significantly different. The inverse pattern was shown in the

findings of the second experiment where the high span subjects translated *wh*-extractions with higher accuracy than the low span ones without significant differences between their response times. The different patterns of the two tasks' results substantiated the effects of task types on the subjects' processing of *wh*-extractions.

Despite a number of studies confirming the role of WM in L2 processing, some researchers found no correlations between research participants' WM level and their language performance.

Juffs (2004) explored the connection between processing of subject-object ambiguities and WM of Chinese, Japanese, and Spanish learners of English. The subjects' WM was measured in both the L1 and the L2, and they were divided according to their median WM score. A reading and judgment task was administered to the participants in order to examine both their accuracy in grammaticality judgment and reading times on sentences with subject-object ambiguities. An example of the experimental items is shown in sentence (98).

(98) Before the student guessed the answer appeared on the next page.

(Juffs, 2004: 225)

Sentence (98) is temporarily ambiguous since the subject of the main clause *the answer* might be misinterpreted into the direct object of the verb in the subordinate clause. Juffs analyzed the collected data to see whether the participants with different WM levels showed differences in processing of the disambiguating verb, i.e., *appeared*. Juffs did not find significant correlation between the subjects' WM span and their reading times. In other words, different levels of WM tended not to affect the participants' processing.

Omaki (2005) carried out an investigation into the role of WM in L1 and L2 processing by highly proficient Japanese-English bilinguals. Five experiments were conducted with native speakers of English and L1 Japanese learners to analyze their

RC attachment preferences both offline and online[29]. Two comprehension tasks in the L1 and L2, two reading span tasks in the L1 and L2, and an English cloze test were administered to the research participants. Omaki found WM's effects on the native speakers' RC attachment in offline experiments, but not in the online ones. However, no connection was observed between the L2 learners' WM and their RC attachment in English, both offline and online. That is to say, the L1 Japanese subjects' cloze test scores and reading times on the ambiguous RCs were not correlated with their WM level. Omaki suggested the lack of the correlations between the L2 learners' WM and their processing was possibly because the participants in general did not fully acquire the grammatical properties of the genitive construction.

Rodríguez (2008) compared resolution of subject-object ambiguities, wh-movement, and coreference in English by advanced L1 Spanish subjects to that by native speakers of English. Samples of the experimental items are provided in sentence (99).

(99) a. Subject-object ambiguity: After the woman cleaned the stove began to heat up.

(Rodríguez, 2008: 144)

b. Wh-movement: The patient who the doctor assumed that the imported drug had cured will stay in the hospital.

(Rodríguez, 2008: 145)

c. Coreference: He slowly drank cheap beer while the bachelor sang bad karaoke, but Jake didn't want to go home late.

(Rodríguez, 2008: 148)

Rodríguez assessed the subjects' WM using a reading span task in their L1 and conducted three self-paced reading comprehension experiments. Due to differences in their WM levels, the two groups of L2 learners were hypothesized to process the three structures differently. The results showed no influence of WM in the

[29] According to Omaki (2005), an offline experiment refers to an experiment where a dependent variable is investigated after the processing of the whole sentence (such as grammaticality judgment and comprehension question) whereas an online experiment is an experiment in which a dependent variable is examined during sentence processing (such as reading time and eye movement).

reading comprehension tasks. Most non-native speakers similarly made use of parsing in processing L2 complex sentences. They also had difficulties accessing and recruiting syntactical information while reading some experimental items.

Hopp (2015) also investigated how WM affected L1 German advanced learners' processing of subject-object ambiguities in English. The subjects first completed an English reading span task where they were asked to memorize one capitalized noun in each target sentence and to judge the plausibility of all sentences. Then, the participants took a reading comprehension task involving subject-object ambiguities. A sample of the experimental items is provided in sentence (100).

(100) When the girl was playing the piano made some funny noises.

(Hopp, 2015: 135)

The findings revealed that WM was not correlated with the reading times in the task. Hopp attributed the absence of WM's effects to the low demand of cognitive resources required by the target stimuli. To be specific, the regions of ambiguity (e.g., the subject in the main clause *the piano* in sentence (100)) and disambiguation (e.g., the finite verb in the main clause *made* in sentence (100)) were close to each other, and thus, not posing much of cognitive load. Most research participants were likely to spend similar reading times on the items. Hopp further suggested that significant effects of WM might have been found if the subjects had taken a task with higher demand of cognitive resources, e.g., experimental items whose distance between the subject and the finite verb in the main clause was longer.

As aforementioned, most previous WM research included a single group of L2 learners with the same degree of proficiency. This is because, in those studies, strong emphasis has been placed on how individuals' different WM levels affect their processing. In order to have the effects of WM examined, research participants must take a reading span task to be divided into groups according to their WM scores. The use of only one subject group from one proficiency level helps make sure that the research findings are due to the differences in WM level. However, as Havik et al. (2009) explained, the employment of participants with different proficiency levels might mask some potential impact of WM on processing. That is, the results might be

modulated by the differences in the subjects' language proficiency level rather than their WM level.

Yet, some WM studies looked into two groups of research participants with different L2 proficiency levels since the authors aimed to determine the role of the subjects' proficiency in language processing as well. For example, Sagarra and Herschensohn (2010) explored how language proficiency and WM affected adults' L2 acquisition by examining the correlation between their beginning and intermediate L2 Spanish learners' WM measured in their L1 English and their sensitivity to violations of gender and number agreement. They also investigated similarities and differences between gender and number processing in order to explore two UG-related language acquisition approaches, namely representational deficit approach and representational accessibility approach. The former proposes that L2 learners cannot access features unavailable in L1 after puberty whereas the latter holds that late learners may acquire all L2 grammatical features. Number and gender were different for the L1 English subjects in that the first was existent in their L1, but the second was not. Both the L2 learners and native speakers of Spanish took both online and offline tasks, i.e., a self-paced reading task and a grammaticality judgment task, respectively. They were asked to read Spanish target sentences which manipulated the gender/number agreement (agreement and disagreement) between nouns and adjectives. Samples of the experimental sentences are provided below.

(101) a. Gender and number agreement:
El ingeniero presenta el prototipo famoso en la conferencia.
The engineer presents the prototype-MS famous-MS at the conference.

b. Gender disagreement (feminine for masculine):
*El ingeniero presenta el prototipo famosa en la conferencia.
The engineer presents the prototype-MS famous-FS at the conference.

c. Number disagreement (plural for singular):
*El ingeniero presenta el prototipo famosos en la conferencia.
The engineer presents the prototype-MS famous-MP at the conference.

(Sagarra & Herschensohn, 2010: 619)

It was found that all research participants showed high accuracy in the grammaticality judgment task, but only the intermediate L2 learners and the native speakers were sensitive to gender and number violations in the self-paced reading task. Moreover, among the intermediate learners, only those with higher WM were more accurate on certain comprehension questions in the online task. Sagarra and Herschensohn suggested that it was possible for late learners to employ processing patterns similar to those of native speakers and that their L2 acquisition could be modulated by language proficiency and WM.

Coughlin and Tremblay (2013) analyzed how L2 proficiency and WM influenced processing short- and long-distance number agreement dependencies between object clitics and their antecedents in French by intermediate and advanced English-French bilinguals. The research participants first took two reading span tasks measuring their WM in both English and French. Their performance on the WM task in French was observed to correlate with their proficiency level. Overall, the advanced L2 learners were found to have higher WM than their intermediate counterparts. Then, the subjects completed an acceptability judgment task and a self-paced reading task. The research findings showed that both intermediate and advanced learners were able to identify and correct number agreement violations in object clitics in the acceptability judgment task. Nevertheless, in the self-paced reading task, only the advanced bilinguals were sensitive to number agreement violations. Given the advanced learners' higher WM, the results indicated that L2 learners tended to be more sensitive to agreement violations in sentence processing as their proficiency and WM in the target language increased. Furthermore, the subjects' response times and words recalled on the WM task in French correlated with their response times and words recalled on the WM task in English. Therefore, Coughlin and Tremblay concluded that WM seemed to depend on proficiency, rather than the language.

Table 15 summarizes details of the previous studies on WM's impact on syntactic processing among native speakers and L2 learners.

Study	Investigated Topic/WM Assessment (+/-)	Participants	Research Instruments (what they measured)	Results and Implications
Felser et al. (2003)	English RC attachment ambiguity (+)	- Native speakers of English (children and adults)	- A listening span task (WM) - A grammaticality judgment task (sensitivity to number agreement violations) - A self-paced reading task (online processing of RC attachment ambiguity)	- WM seemed to affect only the children's processing. The high WM children tended to prefer attaching RCs to NP1, but those with low span showed a preference for NP2 attachment.
Roberts et al. (2007)	Antecedent reactivation in filler-gap constructions in English (+)	- Native speakers of English (children and adults)	- A reading span task (the adults' WM) - A listening span task (the children's WM) - A cross-modal picture priming task (response times)	- The subjects with high WM showed antecedent reactivation priming at the gap-position, but the low WM participants did not. - The low span subjects demonstrated a delay in gap filling. Their antecedent reactivation might have been found if it had been assessed after the experiment.
Hestvik et al. (2012)	Delay in gap-filling in English (+)	- Native speakers of English	- A listening span task (WM) - A listening comprehension task (response times)	- The low WM adults were slower in establishing a filler-gap dependency, displaying an onset latency delay in brain responses to syntactic violations.
Dussias & Piñar (2010)	The use of plausibility information in processing English long-distance *wh*-extraction (+)	- L1 Chinese advanced learners - Native speakers of English	- A reading span task in English (WM) - A self-paced reading task (online processing of long-distance *wh*-extraction)	- Only the high WM subjects processed the *wh*-extractions similarly to the native English speakers. - The native English speakers and the high WM participants showed slower reading times in the plausible condition whereas the low WM subjects found it more difficult to process the verbs in the implausible condition.
Williams (2006)	The use of plausibility information in processing English *wh*-questions (+)	- L2 learners from various L1 backgrounds - Native speakers of English	- A memory probe task (WM) - A stop-making-sense task (online processing of *wh*-questions)	- The high WM participants and the native speakers made earlier responses to the sentences where the *wh*-phrase was an implausible object for the verb than to those with the *wh*-phrase as a plausible object. On the contrary, the low WM subjects were found to use the plausibility information later in the implausible sentences.
Suda (2015)	Processing of English subject-extracted RCs (SRCs) and object-extracted RCs (ORCs) (+)	- L1 Japanese elementary and intermediate learners	- A reading span task in Japanese (WM) - A self-paced reading task (online processing of English SRCs and ORCs)	- The higher WM learners were faster in reading the embedded verbs than their lower WM counterparts. - The learners had more difficulties processing ORCs than SRCs.
Kim & Christianson (2017)	Ambiguous RCs in English and Korean (+)	- L1 Korean advanced learners	- A reading span task (WM) - Two self-paced reading tasks (online processing of RC attachment ambiguity)	- The high WM subjects had more difficulty processing the English subject-modifying RCs and Korean object-modifying RCs which had a higher subject-verb integration cost, but those with lower WM did not show contrast in their reading times for both subject- and object-modifying adjective clauses.

Havik et al. (2009)	Subject-object ambiguity in Dutch (+)	- L1 German advanced learners - Native speakers of Dutch	- A reading span task in Dutch (WM) - A truth value judgment and argument role assignment task (offline processing of subject-object ambiguity) - An either-verification-or-subject-object-interpretation task (offline processing of subject-object ambiguity)	- Different levels of demand for cognitive resources in different tasks could influence WM's effects on the L1 German subjects' processing. - When taking the high demand task, the high WM participants and the native Dutch speakers showed subject-over-object preference while the low WM subjects demonstrated similar reading times on both types of RCs.
Zhou et al. (2017)	Processing of *wh*-extractions in English (+)	- L1 Chinese intermediate learners	- A memory span task (WM) - A grammaticality judgment task (response times and accuracy rates) - A translation task (response times and accuracy rates)	- The findings showed the effects of task types on the L2 learners' processing of *wh*-extractions. - The results of the grammaticality judgment task showed WM's effects in only the response times whereas those of the translation task manifested WM's impact in only the accuracy rates.
Juffs (2004)	Subject-object ambiguity in English (+)	- L1 Chinese, Japanese, and Spanish learners - Native speakers of English	- A reading span task (WM) - A reading and judgment task (online and offline processing of subject-object ambiguity)	- Differences in WM tended not to affect the subjects' online processing. Correlation between the participants' WM span and their processing was not observed.
Omaki (2005)	English RC attachment ambiguity (+)	- L1 Japanese advanced learners - Native speakers of English	- Two reading span tasks in the L1 and L2 (WM) - Two comprehension tasks in the L1 and L2 (online-processing of RC attachment ambiguity) - an English cloze test (offline processing of RC attachment ambiguity)	- WM appeared to affect the native speakers' RC attachment in offline experiments, but not in the online ones. - No connection was found between the L2 learners' WM and their RC attachment in both offline and online experiments.
Rodríguez (2008)	Three English ambiguous constructions: subject-object ambiguity, *wh*-movement, coreference (+)	- L1 Spanish learners	- A reading span task (WM) - Three self-paced reading tasks (online processing of the three English ambiguous structures)	- No influence of WM was observed. - Most of the L2 learners similarly made use of parsing in processing the target sentences.
Hopp (2015)	Subject-object ambiguity in English (+)	- L1 German advanced learners	- A reading span task in English (WM) - A reading comprehension task (online processing of subject-object ambiguity)	- No impact of WM was shown. - Most research participants spent similar reading times on the target stimuli. - The absence of WM's effects was related to the low demand of cognitive resources required by the target stimuli.
Sagarra & Herschensohn (2010)	Sensitivity to violations of gender and number agreement in Spanish (+)	- L1 English learners (intermediate and low proficiency) - Native speakers of Spanish	- A reading span task (WM) - A Spanish proficiency test (Spanish proficiency) - A self-paced reading task (online processing of gender and number agreement violations) - A grammaticality judgment task (offline processing of gender and number agreement violations)	- Among the intermediate learners, only those with higher WM were more accurate on some comprehension questions in the online task. - Late learners' L2 acquisition can be affected by their language proficiency and WM.
Coughlin & Tremblay (2013)	Processing of short- and long-distance number agreement dependencies between	- L1 English learners (advanced and intermediate proficiency)	- Two reading span tasks in in the L1 and L2 (WM) - A self-paced reading task (online processing of number agreement	- The subjects' WM correlated with their proficiency levels. The advanced learners had higher WM than their intermediate counterparts. - L2 learners tended to be more sensitive to

	object clitics and their antecedents in French (+)		violations in object clitics) - A grammaticality judgment task (offline processing of number agreement violations in object clitics)	agreement violations when their proficiency and WM in the target language increased.

Table 15: Previous studies on working memory's effects on syntactic processing among native speakers and L2 learners

2.4.1.2 Previous studies on working memory's effects on processing of other linguistic aspects or language learning among native speakers and L2 learners

In addition to the processing of sentence structures, many studies examined WM's impact on processing of other linguistic subfields or language learning success. One difference between the WM research on syntactic structures and that on other linguistic aspects and language learning was that the former commonly involved only comprehension while the latter included either only comprehension or both comprehension and production. To the best of my knowledge, no previous studies have looked into merely production so far. Similarly to the processing research works on syntactic structures, some studies in this subsection were conducted with L1 speakers whereas the others were aimed to analyze L2 learners' processing patterns or language learning. Based on the previous research, the studies with L1 speakers usually tested WM's influence on a wider range of aspects, including lexical or phonological processing and language learning success, but those with L2 learners mainly addressed how WM affected L2 learning with a great emphasis on vocabulary and spelling skills.

Some research focused on how individuals' WM was related to their processing and use of vocabulary in their native language. For example, Daneman and Green (1986) explored if there was a correlation between L1 English undergraduates' WM and their abilities to comprehend the meanings of unknown words in context and to produce synonyms for words presented in context. The researchers suggested that it was crucial to employ a variety of approaches to examine WM, particularly when different domains were addressed. Involving two skills, namely verbal comprehension and production, the study used two verbal measures of WM: a reading span task and a speaking span task. In the reading span task, the participants read aloud a set of 70

unrelated English sentences and recalled the last word of each sentence. The sentences varied in length, ranging from 13 to 17 words, each ending with a different word. A sample sentence is "*He had patronized her when she was a schoolgirl and teased her when she was a student*" (p. 3). In the speaking span task, the participants silently read a series of 70 unrelated words displayed individually on a computer video screen. They were then instructed to use each word to generate aloud a sentence containing that word. For instance, when presented with the set, *QUARTER*, *BATTLED*, a participant might generate the following two sentences: "*I put a QUARTER into the juke box*;" "*He BATTLED to save his country*." After that, the subjects were administered two vocabulary tasks: a contextual vocabulary-production task and a contextual vocabulary-comprehension task. The contextual vocabulary-production task required the subjects to generate synonyms of target words that fitted the given sentence contexts. Each item was provided with a context which was a sentence fragment such as *The chef tossed the Caesar salad with great …* (p. 12), followed by a single word such as *artistry*. When they saw the word *artistry*, they had to immediately utter aloud a word that was the closest to *artistry* in meaning in the given sentence context. For the second task, the participants had to define the meaning of new words in a context which provided adequate cues for inferring the precise intended meaning. A sample passage with the target word *qualtagh* is provided in (102).

(102) Mr. Greene was a very early riser. Everyday his wife would get up to have breakfast with him and then would return to bed when Mr. Greene set off for work. He had made a practice of walking to work since he did not live that far away and he enjoyed the exercise. There was no one really up at that time except for Mrs. Finn, who lived nearby. Mrs. Finn was usually out walking her dog at the same time as Mr. Greene was on his way to work. They would always stop and talk for a minute or two. The rest of the way to work Mr. Greene would walk in silence as it appeared that most people had not ventured out of their houses at such an early hour. One day Mr. Greene set off to work at his usual time after breakfast, but this time

> he did not encounter Mrs. Finn. He continued on his way to work as usual without seeing anyone along the way. At work he ran into a fellow employee and greeted him. The other man grumbled “Good morning” and headed towards the coffee machine. Mr. Greene believed rather superstitiously that one’s *qualtagh* would determine the quality of the rest of the day. Therefore, he would much rather that it had been Mrs. Finn, as usual, as opposed to this miserable, unfriendly man at work. The following day Mr. Greene was glad to see Mrs. Finn out walking her dog, as usual.
>
> (Daneman & Green, 1986: 1)

The findings revealed that the participants’ speaking span better predicted their performance in the contextual vocabulary production task. On average, the small span speakers took 2464 milliseconds to produce a context-appropriate lexical replacement for the target word, which was 110 milliseconds slower than the speakers with intermediate spans, and 948 milliseconds slower than those with large spans. Likewise, the subjects’ reading span was strongly correlated with their ability to learn new word meanings in the contextual vocabulary comprehension task. The readers with small spans, those with intermediate spans, and those with large spans scored on average 1.58, 1.83, and 2.47 out of 4 for their definitions of a target word, respectively. The researchers noted that the two span tasks’ differential predictive power reflected their different processing requirements: verbal production processes for speaking span and verbal comprehension ones for reading span. Daneman and Green concluded that WM was not a system with a unitary capacity. Rather, WM would vary depending on how efficient the individual is at the specific processes required by the task to which WM is being applied. Therefore, the WM for comprehending words and that for producing words might be different from each other. That is, an individual’s WM for comprehending words in context is associated with her efficiency at sentence comprehension processes and is reflected by her performance on the reading span task. In contrast, her WM for producing a context-appropriate word from a pool of known words is related to how efficient she is at sentence production processes and is reflected by her performance on the speaking span task.

Miyake et al. (1994) conducted two experiments in order to test their own notion regarding WM's role in lexical processing. They proposed that individuals' WM tended not to affect their access to ambiguous words' meanings since the activation of multiple meanings automatically occurred regardless of the WM level. This indicated that both high- and low-span readers could activate multiple meanings of an ambiguous word. However, individuals' WM seemed to play a role when they needed to keep multiple meanings activated for a period of time. To be specific, when the ambiguity remained unresolved over a period of time, only high-span individuals were able to maintain many representations. On the contrary, those with low-span would fail to maintain multiple meanings, which would cause them confusion once the ambiguity was finally resolved. In exploring their proposal, Miyake and colleagues first administered a reading span test to their L1 English participants which were later classified into groups according to their WM level: high-span and low-span. Then, they provided their subjects with a series of ambiguous sentences where the ambiguous word followed a neutral context and preceded a disambiguating cue. A sample of the experimental items is "*Since Ken really liked the boxer, he took a bus to the nearest pet store to buy the animal*" (p. 181). They manipulated two factors: the distance between the ambiguous word and the disambiguating cue (short distance vs. long distance) and the disparity between the frequencies of usage of the homograph's two interpretations (dominant interpretation or the more common interpretation vs. subordinate interpretation or the less common interpretation). As regards the word "boxer', the "fighter" meaning was the dominant interpretation whereas the "dog breed" meaning was the subordinate interpretation. The results appeared to be consistent with the researchers' proposal. That is, the subjects with high WM could maintain both meanings activated over longer periods of time until the ambiguity was resolved; however, those with lower WM were able to maintain the dominant meaning, and gave up the subordinate one because they had inadequate cognitive resources. As a result, when the subordinate meaning of the ambiguous word turned out to be the correct interpretation, the subjects with high WM would not have much difficulty resolving the ambiguity because they still maintained the subordinate meaning. On the contrary, because the low-span participants did not have the subordinate meaning active, they would be much affected, showing increased reading

times in the disambiguating region of the sentence, while the higher WM subjects did not. The researchers further explained that having both meanings activated might help decrease the amount of time required to exploit the disambiguation cue regardless of whether it matched the dominant or the subordinate meaning. In case of the individuals with low WM, they lost the information about the subordinate meaning. Thus, they would require "supplementary strategic search in long term memory in order to retrieve the lost information" (p. 94). The mechanism accounted for the low WM participants' need for more time to resolve lexical ambiguity.

Van Petten et al. (1997) carried out an ERP study in order to investigate native English speakers' sensitivity to semantic associative priming[30] for word pairs that were embedded in congruent and anomalous sentences. The subjects were first classified into groups with low, medium, and high WM according to their performance on a reading span task. Then, the research participants were administered a probe recognition task in which they read target sentences containing a pair of critical words which were matched for length, frequency of usage, and positions within their sentences. Four target sentence types were created by manipulating two factors: lexical association and sentential congruence. An example of the four conditions is shown below, with the italic words as the pairs of critical words.

(103) a. [Congruent-Associated] When the *moon* is full it is hard to see many *stars* or the Milky Way.

b. [Anomalous-Associated] When the *moon* is rusted it is available to buy many *stars* or the Santa Ana.

c. [Congruent-Unassociated] When the *insurance* investigators found that he'd been drinking they *refused* to pay the claim.

d. [Anomalous-Unassociated] When the *insurance* supplies explained that he'd been complaining they *refused* to speak the keys.

(Van Petten et al., 1997: 239)

[30] Burt et al. (1993) define associative priming as the facilitation of lexical decisions to a target word (e.g., butter) when it is preceded by an associated prime word (e.g., bread).

In the Congruent-Associated condition (CA), two critical words related to each other were included in a meaningful sentence. In processing the second word, readers could use clues from the overall sentence context and from its lexical-associative relationship to the first word. In the Anomalous-Associated condition (AA), the same pair of words in the CA condition appeared in a sentence which was syntactically acceptable but semantically anomalous. The processing of the second critical word could be facilitated by only the preceding lexical associate. In the Congruent-Unassociated condition (CU), the critical words were related only through the sentence context. In the Anomalous-Unassociated condition (AU), the same words in the CU condition had no relationship, given as a no-context control. The subjects were asked to read the sentences for comprehension, and also to decide whether a single word presented after each sentence had appeared in the sentence. The findings revealed that all the three groups of subjects were similar in how they processed the lexical-associative relationships. They were able to use lexical association to interpret sentences' meaning, which was evidenced by the difference between their brain activities in response to associated words in congruent sentences and those in anomalous sentences. However, individual differences in WM tended to play a significant role in the use of sentence-level context, i.e., sentential congruence. In processing sentences that contained no lexical associations, namely those in the CU and AU conditions, the participants with medium or high WM spans manifested differences between the brain activity in response to congruent sentences and that to anomalous sentences. Compared to those with greater WM, the readers with low WM were less likely to show such differences in the brain activities, indicating they were less efficient in making the sentential context available for use. Van Petten et al. (1997) suggested that the availability of WM resources could determine the extent to which the sentence-level context (but not necessarily lexical-level) could be exploited in interpreting a sentence's meaning.

Boudewyn et al. (2013) also carried out an ERP study to explore individuals' sensitivity to discourse congruence and lexical associations. Unlike Van Petten et al. (1997) which addressed reading comprehension, they focused on how WM differences would modulate native English speakers' processing when they listened to

short passages. The subjects were administered an ERP task and a listening span task. In the ERP task, the subjects had to process the final word of target sentences which manipulated discourse congruence and lexical association in order to explore the N400[31] effects in relation to their processing of the two factors. The sentences' final word had two properties. First, it was either congruent or incongruent with the preceding discourse context. Second, it was either associated or unassociated with a preceding prime word. This resulted in four conditions of the target sentences: Congruent-Associated (CA), Congruent-Unassociated (CU), Incongruent-Associated (IA), and Incongruent-Unassociated (IU). The samples of the four conditions are provided in Table 16:

Condition	Context	Target Sentence
CA	Rick was unaware that his sister had submitted his poem in the prestigious contest. He was shocked when he won the award and the hefty cash prize.	He was not prepared for the fame and FORTUNE.
CU	Rick was unaware that his sister had submitted his poem in the prestigious contest. He was shocked when he won the award and the hefty cash prize.	He was not prepared for the fame and PRAISE.
IA	Rick was mortified when the videotape of his arrest was shown on the news. After the news show aired, he was ridiculed by the entire neighborhood.	He was not prepared for the fame and FORTUNE.
IU	Rick was mortified when the videotape of his arrest was shown on the news. After the news show aired, he was ridiculed by the entire neighborhood.	He was not prepared for the fame and PRAISE.

Table 16: Samples of stimulus sets in the ERP task (Boudewyn et al., 2013)

(Boudewyn et al., 2013: 6)

In the listening span task, the subjects had to listen to sets of sentences for comprehension, and then justify if each sentence was true or false immediately after hearing the whole sentence. Then, they were asked to memorize the final word of each sentence in the set after the whole set was shown. Boudewyn et al. (2013) observed that the subjects differed in their sensitivity to local lexical associations

[31] N400 is an event-related brain potential which is generally thought to reflect the difficulty of semantic access (Cheyette & Plaut, 2017).

within discourse context as a result of their differences in WM span level. The subjects with lower WM span showed bigger N400 word-level association effects than those with higher WM span. This indicated that the individuals with lower WM had greater sensitivity to the presence of word-level associations within discourse context. The local, word-level context was possibly more influential or salient for the lower WM participants. This was possibly because the subjects may have "less of the discourse context actively maintained and available in WM" (p. 11), and thus, the word-level context which was followed by the target words or the associated primes would be a prominent feature in the context that was active. Also, in interpreting the results, Boudewyn and colleagues looked into the size of N400 effects in two cerebral areas: the frontal and the posterior regions of the brain, in order to analyze the distribution of WM's effects on the processing of discourse congruence and lexical association. The researchers observed differences between the two participant groups in the cerebral areas where the effects of discourse congruence were maximal. Specifically, while N400 effects of congruence were maximal for the high-span participants at the frontal electrode sites, the effects were maximal for the low-span participants at the posterior ones. Previous studies found that frontal ERP effects indicated the use of more WM to maintain relevant information (e.g., Kiss et al., 2007); however, a more posterior distribution suggested greater sensitivity to word-level meaning relations among single words (e.g., Swaab et al., 2011). Consequently, the findings of the study indicated that the participants with higher WM employed more WM in keeping relevant information active whereas those with lower WM were more sensitive to the word-level meaning relations among single words. The participants' differences were attributed to their different WM levels.

Most research on phonological processing focused on the relationship between individuals' WM and phonological awareness, i.e., the ability to recognize, differentiate, segment, and manipulate words' constituent sounds: syllables, phonemes, onsets or the initial sound of a syllable, and rimes, i.e., a syllable's part consisting of its vowel and any following consonantal sounds. Such awareness also included the ability to abstract sound units with different extensions and recognize them in new words, and even produce new words. As an example, Oakhill and Kyle

(2000) examined British children's phonological awareness by employing two types of tasks: one WM task, namely a sentence span task, and two phonological awareness tasks, i.e., a sound categorization task and a phoneme deletion task. As regards the sentence span task, the subjects were provided with sets of simple and short sentences which included a missing word at the end. The participants were asked to fill in the blank with short answers, namely either one or two syllables in length. A sample of the test items is "*A car has four* _____", in which "*wheels*" is the target answer (p. 157). At the end of each sentence set, the subjects were instructed to memorize the words they answered in the order in which they were shown. Then, the children took the sound categorization task where they had to listen to lists of four words, and to determine which one was different from the others in terms of either the initial or the final sound. An example of the word lists contained *plum, plane, drum, plod*, in which *drum* was the answer (p. 156). The phoneme deletion task required the subjects to identify what a word would look like when a particular phoneme was taken out, for example, "What is *ramp* without the /p/ sound on the end?" (p. 156). The results showed that the participants' WM tended to correlate with their performance on the categorization task. However, weaker correlation was observed between their WM and their performance on the phoneme deletion task. The differences in the correlation between the subjects' performance on the phonological awareness tasks and that on the sentence span task were attributed to the extent to which the tasks' memory demands were similar to those of a WM test. The categorization task's demands for memory were more similar to those of a WM test in that they required more WM than the phoneme deletion task did. Oakhill and Kyle explained that the categorization task may involve both storage and processing of task items. That is, it asked the subjects to store the words in memory and to compare them for phonological similarity at the same time.

Apart from its influence on linguistic processing, WM has been studied with respect to how it affects language learning. To illustrate, Service (1992) carried out a longitudinal study to look into the relationship between L1 Finnish primary school students' phonological WM and their English learning over the following three years. The phonological WM's role in English as a foreign language learning was evaluated

through the subjects' pronunciation in an auditory pseudoword repetition task administered to them each year at the beginning of the English instruction. The task required the students to listen to two lists of pseudowords, a list of English-sounding words (e.g., *rendence* and *plander*), and a list of Finnish-sounding words (e.g., *hinto* and *meski*), and to repeat aloud the pseudowords they heard as quickly as possible. The accuracy of the repetition responses to the pseudowords was measured by counting the number of the correctly repeated syllables, namely the ones containing no phoneme replacements, omissions or additions. Service compared the participants' scores for the repetition task with their performance on English tests of listening, reading comprehension, and writing rated by their teacher on a six-point scale usually employed in Finnish school reports. The findings revealed that the students' repetition of the non-words was strongly correlated with their academic progress in English classes nearly three years later. The subjects with higher verbal memory spans were found to be better at language learning than those with shorter spans in terms of vocabulary. Service then concluded that the phonological WM spans were a significant predictor of success in L2 learning, particularly the acquisition of new vocabulary items.

A language learning aspect which has been extensively investigated in relation to WM is literacy and reading success, including the abilities to spell, learn, and use vocabulary words. Ellis and Sinclair (1996) explained that reading abilities involved "sequencing the phonological properties of the language: the categorical units, syllable structure, and phonotactic sequences" (p. 234). For this reason, some research examined the correlation between WM, phonological awareness, and particular aspects of reading. For instance, Rohl and Pratt (1995) conducted a longitudinal study in order to see whether phonological awareness and verbal WM made independent contributions to reading and spelling. Seventy-six pre-reading children from lower-middle class areas in South Australia were administered a number of tests three times within 2 years: the beginning of Grade 1, the end of Grade 1, and the end of Grade 2. The tests could be divided into three groups: verbal WM tests, phonological awareness tests, and reading and spelling tests. The first group included memory for letters test, memory for words test, and memory for sentences test. The tasks

involving memory for letters and words required the participants to perform simple repetition (i.e., repeating the items exactly the same as shown to them) and backwards repetition (i.e., repeating the items in the reverse order) whereas the one dealing with memory for sentences had the subjects repeat two groups of target sentences (i.e., the semantically acceptable sentences and the anomalous ones) exactly as read by the tester. The phonological awareness group consisted of tests of sound categorization, phonemic segmentation, and phoneme deletion. The sound categorization task provided the children with sets of three words, and they were instructed to identify the word whose onset or rime was different from the other two's (e.g., *pig*, *pin*, *lot* and *book*, *fish*, *dish*). In the phonemic segmentation test, the participants had to segment English-sounding pseudowords into phonemic units (e.g., the pseudoword *fland* could be segmented into /f/, /l/, /a/, /n/, and /d/). Then, the children took the phoneme deletion task which tested their ability to delete three groups of phonemes from words: initial phoneme (e.g., *j-am*), final phoneme (e.g., *star-t*), and medial phoneme (e.g., *ha-n-d*). Finally, the participants were administered five reading and spelling tests, namely Neale Analysis of Reading Ability, Real Word Decoding Test, Pseudoword Decoding Test, Real Word Spelling Test, and Pseudoword Spelling Test. The results manifested that phonological awareness was a consistent predictor of reading and spelling even when the effects of verbal WM were controlled. By contrast, verbal WM did not always make accurate literacy-related predictions independently of phonological awareness' effects. It was then concluded that verbal WM may be subsumed under the phonological awareness tasks as the awareness tasks have been claimed to require the operation of verbal WM (Tunmer & Rohl, 1991). Furthermore, as the findings in connection with the phonological awareness tests' impact on the reading and spelling tests were closely examined, the tests were likely to highly contribute to reading pseudowords and spelling real words, but failed to make consistent contributions to spelling pseudowords. This was possibly because the cognitive demands of the nonsenseword spelling task were extremely high for the participants.

Gindri et al. (2007) explored whether L2 learners' WM correlated with their spelling and phonological awareness. Their research participants included two groups of L1 Brazilian children: preschoolers and first graders, who had the average age of six and seven, respectively. Two repetition tasks were deployed to explore the participants' WM span: the Auditory Sequential Test of Illinois Test of Psycholinguistic Abilities (IPTA) and the Test of Repetition of Nonsense Words. The first task contained 28 digits divided into lists varying from two to seven digits per list. The researchers read the lists at a fast rate of two digits a second, and the participants had to immediately repeat the digits in the order as presented. In the second task, they were asked to memorize and repeat 30 meaningless words following the phonological structure of Portuguese. The words were divided into six lists which each consisted of five words varying according to the number of syllables from one to six. Examples of the words are *lum*, *tonasso*, and *dojabefari*. The participants had to repeat the words immediately after the examiner had presented them. Only the number of the correctly repeated words was counted. When the participants omitted, substituted or failed to reproduce words as presented to them, their utterances were regarded as incorrect. Concerning the investigation of the children's spelling, the researchers employed a description task where the participants were asked to describe situations given to them. As an example, for a situation which featured a skeleton living in a castle, the children were motivated to write such words as "castle" and "skeleton". Lastly, Gindri and colleagues examined the participants' phonological awareness using the Sequential Evaluation Instrument (CONFIAS), which contained two parts assessing the participants' performance at the syllabic and phonemic levels. The first part examined the syllabic awareness that consisted of nine items: synthesis, segmentation, initial syllable identification, rhyme identification, word production with the given syllable, medial syllable identification, rhyme production, exclusion, and transposition. The second part looked into the phonemic awareness with seven items: production of words that began with a given sound, identification of initial phoneme, identification of final phoneme, exclusion, synthesis, segmentation, and transposition. The correct answers scored one point each whereas the incorrect ones had no points. The analysis of the participants' spelling performance and phonological awareness was based on Spelling Hypothesis (Ferreiro and Tebrosky, 1999) which

identified four spelling hypotheses that children would form during their development towards literacy: pre-syllabic, syllabic, syllabic alphabetic, and alphabetic[32]. The findings revealed that the first graders got higher WM span (i.e., 5.06 digits and 4.56 syllables) than the preschoolers (i.e., 4.80 digits and 4.30 syllables). Furthermore, the participants' different WM levels could account for the differences in their phonological awareness and spelling. To be specific, most preschoolers were likely to be in the pre-syllabic stage while the majority of the first graders were in the alphabetic stage. The researchers explained that the features of WM were a crucial base for longer representations of new words. The higher an individual's WM span was, the more successful she tended to be in learning and spelling vocabulary items. They also attributed the differences between the two subject groups' spelling stages to their age and education. That is to say, the first graders, which were usually older than the preschoolers, received formal instruction of writing in which the alphabetic system was formally introduced. Consequently, the first graders had a higher tendency to get alphabetic spelling knowledge and develop their phonological awareness abilities. Gindri et al. (2007) concluded that WM, phonological awareness, spelling level, age, and education were mutually related.

Bandini et al. (2013) conducted two experiments to explore relationships between L1 Portuguese first-grade students' phonological awareness, their phonological WM, and their lexical ability or the ability to name objects in their native language. The first experiment addressed the correlation between the students' phonological awareness abilities and their phonological WM. Two research instruments were used in this experiment. Firstly, a phonological awareness test was

---

32 According to Spelling Hypothesis proposed by Ferreiro and Tebrosky (1999), in the pre-syllabic stage, children have difficulty distinguishing writing from drawing, and can interpret only their own writing. They also hypothesize that words must correspond in size to the objects they represent. That is, they make connections between objects and words. For example, they assume that the word *bear* is longer than the word *duck* because a bear is larger than a duck. When they proceed to the syllabic stage, they begin trying to assign a sound value to each of the letters. They understand that each letter stands for one syllable. In the syllabic alphabetic stage, they move from the syllabic understanding of writing to the beginning of regarding writing as based on an alphabetic code. The children discover the need for an analysis that goes beyond the syllable, and realize that a minimum number of letters are adequate to represent some words. In the alphabetic stage, children understand that writing is based on an alphabetic system, and that each written character corresponds to a sound value which is smaller than a syllable. They are also able to carry out systematic analyses of the phonemes of the words they are writing.

administered to evaluate the ability to manipulate the speech sounds in three different levels: suprasegmental, syllabic, and phonemic levels. The second instrument was a Brazilian repetition of pseudowords (BCPR). Measuring the participants' phonological WM abilities, the test consisted of 40 pseudo words varying in the number of syllables, from two to five. Each word was said aloud, and the participants had to repeat the word. The researchers observed a variation in the level of correlation between different phonological awareness and phonological WM abilities. That is, suprasegmental abilities were less correlated with the phonological WM abilities than phonemic and syllabic abilities were, which implied that the suprasegmental abilities were less dependent on the phonological WM abilities than the phonemic and syllabic abilities were. The weak relationship between the phonological WM and suprasegmental abilities might be associated with the nature of the tasks in the study since the suprasegmental tasks, i.e., rhyme and alliteration comparison, seemed to require less WM ability than the phonemic and syllabic ones, namely synthesis, segmentation, manipulation, and transposition. The second experiment concerned the lexical ability of the research participants with respect to levels of phonological awareness and phonological WM. The experiment employed the same group of research participants as the first one did. They were classified according to their scores on the phonological awareness and phonological WM tests in the first experiment. The participants were divided into two groups: one group with high scores and the other group with low scores. The research instrument in the experiment was the Vocabulary Test of ABFW Child Language Test[33] which examined the participants' expressive vocabulary. The students were instructed to name figures presented on cards grouped according to nine semantic categories, i.e., clothing, animals, food, transportation, furniture and utensils, professions, places, shapes and colors, and toys. According to the findings, the participants with low phonological awareness and phonological WM got lower scores on the ABFW test than those with higher abilities. This indicated that phonological WM and phonological awareness may directly affect the learners' lexical ability.

---

33 According to Medeiros et al. (2013), ABFW is a language test for children in Brazil. There are two types of ABFW: the Phonology Test and the Vocabulary Test, which are used to assess speech and expressive vocabulary, respectively.

Summarizing so far, WM's effects on processing of other linguistic aspects or language learning are still controversial. The impact particularly depends on task-related factors, such as the tasks' demands for cognitive resources and the tasks' similarity to WM tests in terms of memory demands. The processing studies are recapitulated in Table 17.

Study	Investigated Topic/WM Assessment (+/-)	Participants	Research Instruments (what they measured)	Results and Implications
Daneman & Green (1986)	Lexical processing and production in English (+)	- Native speakers of English	- A reading span task (WM) - A speaking span task (WM) - A contextual vocabulary-production task (vocabulary production) - A contextual vocabulary-comprehension task (vocabulary comprehension)	- The subjects' speaking span better predicted their performance in the vocabulary production task. - The two span tasks' different predictive power reflected their different processing requirements. - WM's effects varies depending on how efficient the individual is at the specific process required by the task to which WM is being applied.
Miyake et al. (1994)	Lexical processing in English (+)	- Native speakers of English	- A reading span task (WM) - A self-paced reading task (access to ambiguous words' meanings)	- The high WM subjects could keep both dominant and subordinate meanings over longer periods of time whereas the low WM ones could retain only the dominant meaning and gave up the subordinate one as they had inadequate cognitive resources.
Van Petten et al. (1997)	Sensitivity to sentential congruence and lexical association in English (+)	- Native speakers of English	- A reading span task (WM) - A probe recognition task (sensitivity to sentential congruence and lexical association)	- WM tended to affect the use of sentential congruence. - In processing sentences lacking lexical associations, the medium and high WM subjects showed differences between their response to congruent sentences and that to anomalous sentences; however, the low WM participants did not show such differences.
Boudewyn et al. (2013)	Sensitivity to sentential congruence and lexical association in English (+)	- Native speakers of English	- A listening span task (WM) - An event-related brain potential task (sensitivity to sentential congruence and lexical association)	- The subjects' WM seemed to affect their sensitivity to local lexical associations within discourse context. - The high WM subjects used more WM in maintaining relevant information whereas the low WM ones had more sensitivity to the word-level meaning relations among single words.
Oakhill & Kyle (2000)	Phonological awareness in English (+)	- Native speakers of English (children)	- A sentence span task (WM) - A sound categorization task (the ability to manipulate speech sounds) - A phoneme deletion task (the ability to manipulate speech sounds)	- The participants' WM tended to correlate with their performance in the sound categorization task, not the one in the phoneme deletion task. - The different levels of correlations were linked to the extent to which the tasks' memory demands were similar to those of a WM test. - The categorization task's demands were more similar to those of a WM test.
Rohl & Pratt (1995)	Relationship between phonological awareness, verbal WM and English reading and spelling (+)	- Native speakers of English (children)	- Three verbal WM tests (WM) - Three phonological awareness tests (the ability to manipulate speech sounds) - Five reading and spelling tests	- Verbal WM may be subsumed under the phonological awareness tasks. - The phonological awareness tasks tended to highly contribute to reading pseudowords and spelling real words, but failed to account for

			(reading and spelling skills)	pseudoword spelling.
Bandini et al. (2013, Experiment 1)	Relationship between phonological awareness and phonological WM (+)	- Native speakers of Portuguese (children)	- A Brazilian repetition of pseudowords (phonological WM) - A phonological awareness test (the ability to manipulate speech sounds)	- The researchers observed a variation in the level of correlation between different phonological awareness and phonological WM abilities.
Bandini et al. (2013, Experiment 2)	Relationship between phonological awareness, phonological WM, and lexical ability (+)		- The Vocabulary Test of ABFW Child Language Test (expressive vocabulary)	- The subjects with low phonological awareness and phonological WM got lower scores in the ABFW test than those with higher abilities.
Service (1992)	Relationship between phonological WM and English learning (+)	- L1 Finnish learners	- An auditory pseudoword repetition task (WM) - English tests of listening, reading comprehension, and writing (English learning)	- The learners' repetition of the non-words were strongly correlated with their academic progress in English classes. - The subjects with higher verbal memory spans seemed better at language learning than those with shorter spans in terms of vocabulary.
Gindri et al. (2007)	Relationship between WM, phonological awareness, and English spelling (+)	- L1 Portuguese learners	- The Auditory Sequential Test (WM) - The Test of Repetition of Nonsense Words (WM) - A description task (spelling skills) - The Sequential Evaluation Instrument (the ability to manipulate speech sounds)	- The subjects' WM was related to their phonological awareness and spelling. - The higher one's WM span was, the more successful they tended to be in learning and spelling vocabulary items.

Table 17: Previous studies on working memory's effects on processing of other linguistic aspects or language learning among native speakers and L2 learners

2.4.1.3 Previous studies on cognitive processing among L1 Thai learners

So far, a handful of L2 processing studies have been carried out with L1 Thai learners. They could be divided into two groups according to the degrees of WM's involvement. The first group directly assessed native Thai speakers' WM span and examined the correlations between their WM and linguistic abilities (i.e., Boonmaton, 2000; McDonough & Trofimovich, 2016; Rattanasak et al., 2022). The other group did not measure WM, but either employed the notion in explaining the participants' processing patterns or explored the data without WM's involvement (i.e., Trenkic & Pongpairoj, 2013; Austin et al., 2015; Pongpairoj, 2015; Rungrojsuwan, 2015).

The first group of L2 processing research studies dealing with native speakers of Thai investigated the relationship between the participants' WM span and language learning. Boonmaton (2000) examined the correlation between verbal WM, English listening, and reading comprehension abilities of L1 Thai secondary students. The research instruments included a listening comprehension test, a reading

comprehension test, and a verbal WM-span test. The listening test and the reading test consisted of 30 multiple-choice items each. In the tests, the participants were asked to read and listen to a variety of texts. The verbal WM-span test addressed three levels of memory span: letters (8 sets of English letters ranging from 3 to 10 letters per set), familiar words (8 sets of English words ranging from 3 to 10 words per set), and sentences (8 sets of English sentences which contained words ranging from 3 to 10 words per sentence). The findings revealed that the students' verbal WM was positively correlated with their English listening and reading comprehension abilities, which indicated a strong relationship between the verbal WM and the abilities. That is, individuals with higher WM were able to store more data in their memory than those with lower WM, and thus, being able to comprehend the input better. As regards the three levels of the span test, the researcher found that the scores in the sentence span part were the most correlated with the reading and listening abilities, but those in the word span section were the least correlated with the abilities. She attributed the results to the different degrees of meaningfulness and length of words and sentences. Sentences consisted of a group of related words which were meaningfully placed. The meaningful organization of the words in the sentences made them easy to memorize. On the other hand, the words in the word span part were put in an unorganized and meaningless way, which might lead to more difficulty and confusion among the participants. In addition, sentences were a longer chunk of information which provided readers or listeners with more time to recall than the individual words. Boonmaton (2000) suggested that English teachers should find ways of improving students' verbal WM in order to help increase their English reading and listening skills.

McDonough and Trofimovich (2016) looked into whether WM could influence L1 Thai learners' success in pattern learning or the ability to identify recurrent morphosyntactic patterns. The participants' WM was assessed in their L1 via a spoken backward digit span task in which they were asked to repeat each sequence of numbers (e.g., 0–4–2–9–6–3–1) in the reverse order (i.e., 1–3–6–9–2–4–0). The researchers mainly aimed to investigate if the participants' WM could account for their pattern learning across diverse stimuli and different learning conditions.

Therefore, they manipulated two factors in three experiments: the participants' familiarity with the language of the stimuli (familiar and unfamiliar) and exposure to the stimuli (exposed and unexposed). The first factor was involved with experiment 1 and experiment 2 whereas the second factor was tackled in experiment 2 and experiment 3. With respect to the participants' familiarity, experiment 1 focused on the transitive construction in Esperanto, a language with which the participants were unfamiliar (e.g., the suffix *–n* added to mark nouns as objects, such as the word *cevalo* (horse) in *tauro batas cevalon* (p. 428), "*bull hits horse*"); however, experiment 2 examined the double-object dative construction in English, a language familiar to the participants. Concerning the exposure level, experiment 2 and experiment 3 similarly dealt with the participants' learning of a nonprototypical double-object dative construction in English. McDonough and Trofimovich (2016) pointed out that the difference between the prototypical and nonprototypical forms of the double-object dative structure involved the animacy status of the recipient of the sentence. The prototypical construction featured the transfer of possession of an object to a goal, which was a pronoun referring to an animate recipient (e.g., *Mr. Smith enjoyed teaching students. But they had a lot of problems with the exam, so he told them the answers*) whereas the nonprototypical one had inanimate nouns as both the object and the recipient of the sentence (e.g., *John's children broke a table. It was his favorite table, so John built the table a leg*). The difference between experiment 2 and experiment 3 was that, in the former, the participants got exposure to both prototypical and nonprototypical constructions, but in the latter, they were exposed to only the prototypical form. This was to explore whether the learners' WM could affect how they identified the pattern of the nonprototypical form under two different learning conditions, i.e., getting exposed and not getting exposed to the form.

Each of the three experiments comprised two phases: the exposure phase and the test phase. Experiment 1 involved whether WM could predict the participants' ability to correctly identify the meaning of the Esperanto transitive structure. In the exposure phase, the participants listened to 24 Esperanto transitive sentences (12 SVO, 12 OVS) and selected one of two images that correctly depicted each sentence. Including lexical items appearing in an immediately preceding vocabulary activity,

the sentences were organized in four sets in order to direct the participants' attention to different components of the two pictures given: different nouns (set 1), different verbs (set 2), different subjects (set 3), and different objects (set 4). As an example, set 1 showed the sentence *cevalo pelas katon* (SVO [horse chases cat]) paired with a picture of a bull chasing a goat and a horse chasing a cat, but set 4 showed the sentence *cevalon batas kapro* (OVS [goat hits horse]) paired with a picture of a goat hitting a horse and a goat hitting a cat. Before listening to each item set, the participants were told what elements of the sentences to focus on. The test phase provided 12 spoken sentences (6 SVO, 6 OVS) paired with images of reversible events. For instance, the sentence *tauro batas kapron* (bull hits goat) was paired with 2 pictures: the first picture showing a bull hitting a goat and the second one showing a goat hitting a bull. The exposure items required the participants' lexical knowledge to select the correct pictures, but the test items needed knowledge about morphological and structural features of the Esperanto transitive. Experiment 2 examined the participants' learning of the nonprototypical double-object dative construction in English. For the exposure phase, the participants listened to double-object dative sentences in a short context, and chose one of the two images which correctly depicted each sentence. Both prototypical sentences and nonprototypical ones were provided and organized into four sets designed to direct the participants' attention to different elements of the two picture alternatives: environmental or contextual features (set 1), subjects (set 2), objects (set 3), and recipients (set 4). For example, in set 1, the nonprototypical item "*John borrowed Grace's truck to go mountain biking for the weekend. When he returned it, Grace found a big scratch on the door. So she brought the truck some paint*" (p. 435) was paired with two pictures of a woman who was holding a can of spray paint and approaching a pickup truck which contained either mountain bikes or ski equipment. In set 2, the prototypical item "*Johnny played on his school baseball team. Today he couldn't play because he forgot part of his uniform. So the coach offered him a hat*" (p. 435) was paired with images of a boy being handed a baseball hat either by a coach or a friend. The test phase presented sentences with nonprototypical double-object datives. Each sentence was paired with images of reversible events. For example, the item "*Irene's daughter thought her new dress was boring. But Irene couldn't afford another one. So she cut the dress some*

ribbons" (p. 435) was paired with images of a woman cutting either the dress or the ribbons. In the exposure phase, the participants could identify the pictures by relying on animacy cues for the prototypical items (i.e., the recipient was human whereas the object was inanimate) and contextual clues for the nonprototypical items whereas the test phase required them to differentiate the functions of two inanimate NPs based on the word order. Experiment 3 looked into how WM could affect the learners' learning of the nonprototypical English construction without exposure to the structure. The exposure items in this experiment were similar to those in experiment 2 except they did not contain nonprototypical datives. The items in the test phase included nonprototypical sentences.

The results showed that WM was correlated with the participants' performance in the exposure phase of experiment 2, but it did not account for their performance in the test phase. Furthermore, no effect of WM was observed when they dealt with the Esperanto structure in experiment 1 and the nonprototypical English structure in experiment 3. McDonough and Trofimovich (2016) associated WM's effect on the participants' performance on the exposure items in experiment 2 with the increasing processing demands of the items. Previous studies (e.g., Roberts et al., 2007; Havik et al., 2009) found that WM played a role only when processing costs were elevated. In experiment 2, the presence of both prototypical and nonprototypical items may pose higher processing demands, compared to the presence of only the prototypical constructions in experiment 3. Moreover, the researchers stated that WM was mostly relevant to learning that involved an explicit intentional component (e.g., memorizing patterns) rather than an implicit one (e.g., generalizing rules or patterns). Literature on L2 processing has exhibited evidence that WM could predict individuals' ability to memorize particular patterns, but did not account for their ability to generalize the learned patterns to new exemplars. McDonough and Trofimovich (2016) claimed that the learning involved in their study, namely the tasks in the exposure phase, was implicit and complex in that the participants had to assign appropriate argument roles by attending to utterance meaning. This provided an explanation for the null finding for WM in the test phase of all three experiments.

Rattanasak et al. (2022) investigated impact of WM and distance-based complexity on L1 Thai learners' use of morphosyntactic information for processing long-distance subject-verb number agreement dependencies in English RCs. The research participants in this study, namely L1 Thai learners and native speakers of English, 40 each, first took a lexical-decision based task called LexTALE to determine their English proficiency. After that, they were administered a reading span task (RST) to have their working memory capacity measured, and a self-paced reading task (SPRT), which explored their processing of number agreement violations. The SPRT consisted of 2 groups of test items manipulated by distance between the subjects and the verbs, i.e., the short-distance subject-extracted RCs and the long-distance object-extracted RCs. Samples of the 2 groups of experimental items are provided in (104).

(104) Short-distance subject-extracted RC: The guys that know the driver want(s) to buy a new car.

Long-distance object-extracted RC: The guys that the driver knows want(s) to buy a new car.

(Rattanasak et al., 2022: 21)

The native speakers were found to show sensitivity to agreement-violations in both types of RCs whereas the L2 learners tended to be less sensitive to the long-distance RCs than to the short-distance ones. The results indicated the effects of L1 co-activation interfering with the L2 grammatical knowledge. That is, L2 learners' lower sensitivity to the long-distance RCs might be because their cognitive resources were barely adequate for solving the more complex long-distance RCs. It was also observed that the higher WM learners were more sensitive to agreement violations than their lower WM counterparts, suggesting a relationship between the participants' processing fashions and their cognitive capacity.

Besides the research assessing WM of native speakers of Thai, a group of studies on L1 Thai learners either used the WM notion to account for their processing patterns or analyzed the participants' processing without WM's involvement. Trenkic and Pongpairoj (2013) examined how L2 article production was affected by the effect

of referent salience[34] in relation to article omissions. Previous literature has found that L2 learners were more likely to omit articles when they referred to entities that were more salient or stood out in memory than those with less salience or less prominence in memory. The study aimed to examine whether referent salience could have impact on the participants' article production regardless of articles' existence in their first language and their L2 proficiency levels. Thus, the researchers recruited two groups of L2 learners having different L1 backgrounds: native Thai speakers with the article-lacking L1 background and native French speakers whose native language had articles. Besides, each learner population included two subgroups divided according to their English proficiency levels: advanced and intermediate, determined by the 2004 version of Oxford Placement Test or OPT (Allan, 2004). The research instrument was an animated film which consisted of 32 sequences of events. The film featured two fish of different colors which swam to each other, and one of the fish ate the other fish. To make sure it was clear enough for the participants to realize that one fish was more salient than the other, salience was marked by a visual cue, i.e., a flashing arrow which was placed above one of the fish. In other words, the salient stimulus was the fish above which the arrow was seen. In half of the trials, the visual cues were given to the agent fish or the fish which ate the other, and in the other half, the cues were provided for the patient fish or those which were eaten. The participants were predicted to omit articles at a higher rate with the agent fish than the patient fish when the former was more salient (i.e., in the active construction), and they were expected to drop more articles with the patient fish than with the agent fish when the eaten fish was the focus of attention (i.e., in the passive construction). The results

---

34 According to Trenkic and Pongpairoj (2013), referent salience is alternatively called memory salience of discourse referents. The term refers to the extent to which a referential representation in memory/discourse model is accessible at the moment of utterance formulation. Generally, the degree of referent salience is closely related to the choice of referential expressions since referential forms determine the referent's memory accessibility. To illustrate, the phonologically salient complete NP *your sister* in "I saw your sister yesterday" is employed in reference to new information, namely an entity that was not salient in the discourse model. Selecting such referential form makes the NP itself stand out from the context and attract the audience's attention. Thus, it helps "promote the referent's salience in memory" (p. 153). On the other hand, referential forms with lower semantic content (e.g., pronouns or zero anaphora) are often used to refer to an entity which is already salient and in the focus of attention because the entity is easier to be accessed by less salient linguistic means. In "I saw your sister yesterday, and she looked great", the pronoun *she* with less phonological prominence is employed to refer to an entity which is well-established by the more salient NP *your sister*.

showed that referent salience had effects on the L1 Thai learners only. Both intermediate and advanced L1 Thai participants had a stronger likelihood to omit articles with more salient referents than with less salient referents. However, article omissions were not found among both groups of the L1 French learners. The findings were linked to grammatical differences between Thai, French, and English in terms of what their L1 grammar allowed. French and English had articles, and thus, only *Det + NP* (e.g., *the black fish*) could be used to refer to countable entities. However, Thai was an article-less language, so it allowed both *Det + NP* and *bare NPs* (e.g., *black fish*) to refer to countable nouns. If both patterns were allowed in Thai, an L1-L2 structural competition could come into play. The two patterns might compete for selection, leading to the article omissions among the L1 Thai learners. This explained why the participants with article-lacking L1 background showed less accurate use of English articles than those with article-having L1 background. Trenkic and Pongpairoj (2013) further pointed out that the L1 Thai participants' greater tendency to drop articles with more than less salient referents was possibly related to their WM resources. The referents with a greater salience degree were highly accessible and activated referents in memory, and thus, occupying more representational resources than the less salient referents. That is, they put higher burden on WM resources. When the highly salient referents were involved, fewer WM resources were left available for the suppression of L1 alternatives, i.e., the bare NPs. The weaker inhibition of the L1 alternatives led to the higher probability of the bare NPs being chosen to refer to more salient referents.

Austin et al. (2015) analyzed English functional morphology omissions among L1 Thai learners with intermediate English proficiency determined by the OPT (Allan, 2004). The researchers focused on whether the level of structural complexity of immediate linguistic context could affect the use of the definite article (*the*) and the regular plural (adding *–s* to a noun, as in *cats*), which were non-existent in the participants' L1. They used three groups of target NPs which differed in structural complexity level: bare plurals (e.g., *planes*), definite singulars (e.g., *the drum*), and definite plurals (e.g., *the trucks*). The three groups of target NPs were interspersed

within twelve short story texts, each including two target NPs. A sample of the story texts is provided below.

> (105) Jenny went to a toy shop to buy presents for her son. First of all, she purchased a drum which was made in Korea. A shop assistant wrapped it for her in colourful paper. Jenny bought **the drum** for her son because he likes music. After that, she bought four trucks for him to play with as well. She chose them because he loves playing with toy vehicles. Jenny put **the trucks** very carefully into a lovely bag. But her son didn't like anything that she had bought for him.
>
> (Austin et al., 2015: 695)

The participants were first asked to read and hear the short story texts, and then to take two oral production tasks based on the texts: keyword-prompted story recall and elicited imitation. In the story recall task, the participants were instructed to employ written keywords as prompts in retelling the story they had read or heard. In order to explore the functional morphology production, all nominal and verbal keywords were given in their bare forms. A sample of the prompts for the story text in (105) is "*Jenny / go / toy shop / to buy / present / her son*" (target answer: "*Jenny went to a toy shop to buy presents for her son*"). The elicited imitation task showed the participants sentences from the stories, and they were asked to regenerate the sentences. Austin and colleagues made two predictions concerning the participants' production of the definite article and the regular plural. As aforementioned, the three groups of target NPs were different in terms of structural complexity level. The definite plurals contained three morphological components, i.e., Article + N + s; however, the definite singulars and the bare plurals comprised two parts, namely Article + N and N + s, respectively. That is, the definite plurals were considered more structurally complex than the other two. Therefore, the participants were hypothesized to omit *the* more frequently in definite-plural target NPs (Article + N + s) than in definite-singular target NPs (Article + N). They were also predicted to produce the plural marker *–s* less frequently in definite-plural target NPs (Article + N + s) than in bare-plural target NPs (N + s). The results partially bore out the two predictions, showing differences in the extent to which the two grammatical markers were

dropped in the two oral production tasks. With respect to the definite article, in the elicited imitation task, the L1 Thai learners supplied it at a high rate with both the more complex NPs (i.e., plural NPs) and the less complex ones (i.e., singular NPs). However, in terms of production, article omissions were observed in the story-recall task where the participants omitted the article more often with the plural NPs (51.79%) than with the singular ones (36.64%). Concerning the regular plural, in the story-recall task, it was dropped at similar rates in both the more complex NPs (i.e., definite NPs) and the less complex NPs (i.e., indefinite NPs). On the contrary, in the elicited imitation task, the plural morpheme was omitted more frequently in definite NPs than in indefinite NPs. Austin et al. (2015) provided alternative explanations for the results. First, they stated that the article omissions among the participants could be accounted for by the L1-L2 structural competition model, which assumed that L1-licensed patterns (i.e., article-less) were more likely to be used in more cognitively demanding than in less cognitively demanding contexts. Secondly, the findings were attributed to the frequencies of the constructions in question. The participants supplied the definite article more accurately with singular NPs than with plural NPs. This was possibly because definite singulars in English appeared more frequently in the input than definite plurals did. In a similar vein, indefinite plurals' frequencies in the input were greater than definite plurals', and this may lead to the participants' accurate use of the former at a higher rate.

Pongpairoj (2015) looked into advanced L1 Thai learners' article omissions in two contexts, namely first and second mention definite referential contexts. She aimed to see whether the article omissions among the participants could be explained by either of two opposing perspectives: target-like or non-target-like syntactic representations. The former account proposed that omissions of an L2 structure were caused by difficulties in accessing the representations or syntax-morphology mapping problems. Under the notion, L2 learners' syntax was fully specified; therefore, the omissions in L2 production did not necessarily mean that the learners' grammar was impaired. By contrast, the perspective of non-target-like syntactic representations assumed that L2 learners' omissions of a target feature occurred as a result of syntactic impairment, i.e., non-existence of the feature in their native language. L2

grammatical features which did not exist in language learners' L1 could result in unsuccessful acquisition of the features. Regarding the research instruments, the participants were administered a grammaticality judgment task and a translation task, which examined English article drops in their grammatical representation and production, respectively. In both tasks, half of the test items involved the use of the definite article in the first mention contexts while the other half addressed the second mention contexts. In the grammaticality judgment task, the participants had to judge whether the underlined part in each item was grammatically correct or not. A sample of the experimental items is "*The team won again. Now people are crazy about the goalkeeper*" (p. 40). The translation task required the L2 learners to translate the test items from Thai into English. Two predictions made about the subjects were based on the two views. Based on the specified syntax notion, the participants would not manifest article omissions in their production and representation in both first and second mention definite contexts. That is, definite article omissions should not be found in both contexts**.** However, if the syntactic impairment account was the case, they were expected to show article omissions in their production and representation in one context rather than the other. The results from the two tasks revealed that the L1 Thai learners' article omission rate with the subsequent mention contexts was dramatically greater than that with the first mention definite referents. Confirming the second prediction, the findings could be supported by the notion of non-target-like syntactic representations in which the subjects' article drops resulted from deficit syntax, i.e., non-existence of articles in their L1. The omissions of articles with the subsequent mention contexts at a higher rate than with the first mention ones were claimed to be caused by the differences in referent salience degree of the two contexts. The second mention referents (*the + NP*) followed their antecedent which was imposed by the indefinite linguistic encoding (*a + NP*) into the previous discourse context. Determined by an anaphoric referring to textually activated referents, the subsequent mention referents' definiteness was assumed to be more salient in memory than that of the first mention referents, which was identified through context or non-linguistic factors. This was possibly because the referents whose definiteness was expressed via linguistic contexts "have already been activated on the surface level of the texts" (p. 51). Pongpairoj (2015) included WM as a factor

in accounting for the subjects' L2 acquisition problems. She stated that the effect of referent salience varied, depending on the number of limited cognitive resources required for marking the referents' identifiability. Specifically, whereas less salient referents needed less cognitive resources, more salient ones had greater need, but the need was suppressed by limited cognitive resources. This explained why article drops were observed with the second mention definite referents rather than the first mention ones.

Rungrojsuwan (2015) explored morphological knowledge and morphological processing behaviors of 200 L1 Thai undergraduates. The subjects were divided into two groups as to their English proficiency levels: the intermediate proficiency group (IL group) and the low proficiency group (LL group). They were administered two tests investigating both derivational and inflectional morphemes. The first test was an error identification test looking into the participants' knowledge of morphology by having them read twelve sentences and identify the grammatical error in each sentence. The first six sentences had incorrect use of inflectional morphemes (e.g., the misuse of singular-plural nouns as in '…*those* *six horse*') while the other six contained errors as regards derivational morphemes (e.g., the misuse of word forms in relation to parts of speech as in '…*how a horse and a donkey are* *difference*'). Under each test item, two points were given if the subjects could identify the morphological error and provide the grammatical form. If they only identified the error, only 1 point would be given. Then, a memory retrieving test was used to examine the subjects' morphological processing behaviors. They were asked to memorize and write on pieces of paper the sentences shown to them. The results of the error identification test showed that although the IL participants possessed more morphological knowledge than the LL ones in general, some subjects in both groups received 0 in the test, indicating their difficulties with the morphemes. It was also found that both IL and LL participants had more problems with the derivational morphemes than with the inflectional ones. This was associated with different characteristics of the two morpheme types. Specifically, inflectional morphemes were more easily recognized because they were usually "fixed additional forms attached to the base" (p. 80), such as the plural marker *–s* and the past tense marker *-ed*; however, the use of the

derivational morphemes required the learners to select the appropriate form out of a wide variety of forms (e.g., noun-forming suffixes *-ion*, *-ness*, *-ship*, and *–ity*) and to change the forms to the correct parts of speech (e.g., *protect*, *protective*, and *protection*), which might put higher burden on their cognitive resources. Also, the analysis of their answers revealed that the IL and LL participants made different kinds of errors. The former ones were likely to delete an inflection (e.g., *start* instead of *started*), add an unnecessary inflection (e.g., *stars* instead of *star*), and change the forms of the target words to an ungrammatical form (e.g., *take* instead of *took*). This indicated that although they had some morphological knowledge, they still had difficulties selecting the proper inflection. On the contrary, the subjects in the LL group omitted the whole word or deleted a function word and left the content word only (e.g., *playing* instead of *was playing*), suggesting that they paid attention to lexical meanings rather than English grammatical rules, which were different from their L1's. In respect of the memory retrieving test, the IL subjects had a greater tendency to memorize the whole sentences correctly than the LL ones. This was linked to their different morphological processing behaviors. The subjects with lower proficiency used the one-by-one word matching technique which led them to match the input with their long-term memory slowly. In contrast, the participants with intermediate proficiency mostly preferred chunking a package of information and recognized the chunks as concepts rather than forms. Rungrojsuwan (2015) then concluded that English teachers should raise students' awareness of how words were morphologically composed.

To summarize, as for the Thai context, very few language processing studies have been conducted with different degrees of WM's involvement. Some assessed the correlations between the subjects' WM and their language processing patterns whereas others used WM only to account for the participants' processing. Table 18 and Table 19 recapitulate the processing studies on L1 Thai learners with WM measurement and those without any assessment of WM, respectively.

Study	Investigated Topic	Participants	Research Instruments (what they measured)	Results and Implications
Boonmaton (2000)	Relationship between verbal WM, English listening, and reading comprehension abilities	- L1 Thai learners	- A verbal WM span task consisting of three levels of memory span: letters, words, and sentences (WM) - An English listening comprehension test (English listening comprehension skills) - An English reading comprehension test (English reading comprehension skills)	- The participants' WM positively correlated with their English listening and reading abilities. - The high WM subjects could store more data in their memory than the low WM ones, and thus, being able to understand the input better. - The sentence span scores were the most correlated with the reading and listening abilities, but the word span ones were the least correlated. This was related to the different degrees of meaningfulness and length of words and sentences.
McDonough & Trofimovich (2016, Experiment 1)	Pattern learning about the transitive construction in Esperanto	- L1 Thai learners	- A spoken backward digit span task in L1 (WM) - Three listening and picture matching tests (pattern learning)	- WM was partly correlated with the subjects' performance in experiment 2. - No effects of WM were found in experiment 1 and experiment 3. - WM's effects observed in experiment 2 were attributed to the increasing processing demands of the test items in the experiment. - WM was possibly relevant to explicit learning, rather than implicit one. The learning involved in this study was implicit, and thus, leading to minimal effects of WM observed in the experiments.
McDonough & Trofimovich (2016, Experiment 2)	Pattern learning about the double-object dative construction in English			
McDonough & Trofimovich (2016, Experiment 3)	Pattern learning about a nonprototypical double-object dative construction in English			
Rattanasak et al. (2022)	Effects of WM and distance-based complexity on processing long-distance subject-verb number agreement dependencies	- Native speakers of English - L1 Thai learners	- LexTALE (English proficiency) - A reading span task (WM) - A self-paced reading task (processing of long-distance subject-verb number agreement dependencies)	- The L1 Thai learners were more sensitive to agreement-violations in the short-distance RCs than to those in the long-distance ones while the native speakers showed sensitivity to both RC types, indicating the effects of L1 interfering with the L2 grammatical knowledge. - The higher WM learners were more sensitive to agreement violations than their lower WM counterparts. The findings suggested a correlation between the participants' processing and their WM level.

Table 18: Previous processing studies on L1 Thai learners with WM measurement

Study	Investigated Topic	Participants	Research Instruments (what they measured)	Results and Implications
Trenkic & Pongpairoj (2013)	Relationship between English article production and referent salience	- L1 Thai learners (advanced and intermediate proficiency) - L1 French learners (advanced and intermediate proficiency)	- The 2004 version of Oxford Placement Test (English proficiency) - An animated film with 32 sequences of events (English article production)	- Compared to the L1 French learners, the L1 Thai subjects were more likely to omit articles with more salient referents than with less salient referents. This was linked to grammatical differences between Thai, French, and English in terms of what their L1 grammar allowed. - The L1 Thai subjects' greater tendency to drop articles with more than less salient referents was related to their WM resources. The more salient referents put higher burden on WM resources than the less salient ones.

Austin et al. (2015)	Omissions of English definite article and regular plural suffix	- L1 Thai intermediate learners	- Two oral production tasks based on twelve short story texts: keyword-prompted story recall and elicited imitation (production of English definite article and regular plural suffix)	- The findings showed differences in the extent to which the two grammatical markers were omitted in the two oral production tasks. - The subjects had a greater tendency to drop the definite article in the story-recall task than in the elicited imitation task. On the contrary, they tended to supply the regular plural in the story-recall task rather than in the elicited imitation task. - The omissions could be supported by the L1-L2 structural competition model, which assumed that L1-licensed patterns (i.e., article-less) were more likely to be used in more cognitively demanding than in less cognitively demanding contexts.
Pongpairoj (2015)	Article omission in two contexts: first and second mention definite referential contexts	- L1 Thai advanced learners	- A grammaticality judgment task (knowledge about how to use English articles in first and second mention contexts) - A translation task (English article production)	- The results seemed to be associated with the referent salience degree of the first and second mention contexts. - The second mention referents' definiteness was assumed to be more salient in memory than that of the first mention referents. More salient referents had greater need suppressed by limited cognitive resources whereas the less salient ones needed less cognitive resources. This accounted for the findings in which article drops were observed more frequently in the second mention contexts than in the first mention ones.
Rungrojsuwan (2015)	Morphological knowledge and morphological processing behaviors	- L1 Thai learners (intermediate and low proficiency)	- An error identification test (morphological knowledge) - A memory retrieving test (morphological processing behavior)	- Both groups of the subjects had more problems with the derivational morphemes than with the inflectional ones, which was related to different characteristics of the two morpheme types. - The intermediate learners tended to memorize the whole sentences better than those with low proficiency. This was associated with their different morphological processing behaviors.

Table 19: Previous processing studies on L1 Thai learners without WM measurement

2.4.2 Processing studies on English participial reduced relative clauses among native English speakers and L2 learners

This subsection addresses the processing studies on English participial reduced relative clauses or PRRCs (See detailed discussions of the PRRC structure in Section 2.1).

English PRRCs, particularly those with a past participle, have been one of the most extensively examined structures in language processing literature. Carroll (2008) states that past participial reduced relative clauses, especially those with regular verbs whose past participle ends in *-ed*, can be more syntactically ambiguous because they can cause main verb/reduced relative (MV/RR) ambiguities, i.e., they can be

interpreted as either the past tense form or the past participial form of the verbs. A sample of MV/RR contrast is provided in (106):

(106) a. A lot of the people invited me to the party.

b. A lot of the people invited to the party cannot come.

For instance, the verb *invited* in (106a) serves as the past tense form of the verb *invite,* and thus means that the subject *A lot of the people* performs the action of inviting someone; however, *invited* in (106b) works as the past participial form, namely the subject receives the action of inviting.

Previous studies put a great emphasis on PRRCs which included a past participle with attempts to explore the subjects' resolution of MV/RR ambiguity caused by the construction. The research can be classified into two major groups. The studies in the first group were carried out with native English speakers, and looked into WM's effects on their ambiguity resolution; however, those in the second group were done with L2 learners of English, and did not employ WM to account for the participants' processing.

The first group of studies on processing of English PRRCs were conducted with native speakers of English and explored WM's influence on the subjects' processing patterns. This group of research included MacDonald et al. (1992), Just and Carpenter (1992), and Eastwick and Phillips (1999).

A crucial research study among this group was MacDonald et al. (1992), who carried out three self-paced reading experiments investigating native English speakers' processing of English PRRCs in order to examine how the research participants dealt with MV/RR ambiguities. They employed two research instruments: a reading span task and a self-paced reading task. The reading span task was first administered in order to classify the participants into two groups according to their reading span score: higher span subjects or the subjects with higher WM, and lower span participants or those with lower WM. The task consisted of 100 unrelated English sentences divided into 25 sets. The participants were asked to read the sets of sentences loudly, and at the end of each set, they had to memorize the final words of all sentences in the set. To illustrate, for the two sentences: *When at last his eyes*

opened, there was no gleam of triumph, no shade of anger. The taxi turned up Michigan Avenue where they had a clear view of the lake (p. 64), the stimuli to be remembered were the words *anger* and *lake*. In the beginning, the subjects were provided with five sets, each of which included two sentences. If they accurately recalled both last words from three out of the five sets, they were then given five three-sentence sets, four-, five-, and six-sentence sets, respectively. Therefore, the participants' reading span referred to "the largest set for which they correctly recalled all of the final words from three of the five sets" (p. 64). The subjects then took the self-paced reading task, which examined their reading times spent on processing the MV/RR ambiguities. As mentioned, MacDonald et al. (1992) designed three self-paced reading experiments tackling different factors, but only two involved WM's impact. The two WM-related experiments are worth mentioning here. In experiment 1, the researchers created four types of experimental sentences resulting from their manipulation of two variables: interpretation (i.e., main verb or reduced relative clause interpretation) and ambiguity (namely unambiguous or temporarily ambiguous). After reading each ambiguous sentence, the subjects had to answer a yes-no comprehension question concerning which interpretation they assigned to the ambiguous verb. Sentences (107a) – (107d) present samples of the four patterns of target sentences and the comprehension questions.

(107) a. MV – Unambiguous: The experienced soldiers spoke about the dangers before the midnight raid.

b. MV – Temporarily ambiguous: The experienced soldiers warned about the dangers before the midnight raid.

Comprehension question: Did someone tell the soldiers about dangers?

c. RR – Unambiguous: The experienced soldiers who were told about the dangers conducted the midnight raid.

d. RR – Temporarily ambiguous: The experienced soldiers warned about the dangers conducted the midnight raid.

Comprehension question: Did the soldiers speak about dangers?

(MacDonald et al., 1992: 61)

In order to explore how the MV/RR ambiguities were processed, the experimental sentences were presented in three regions, i.e., the participial phrase

region, the disambiguating region or the region where the ambiguity was resolved, and the wrap-up region. As an example, in (108), the participial phrase, the disambiguating, and the wrap-up regions are [warned about the dangers], [conducted the midnight], and [raid], respectively.

(108) The experienced soldiers [warned about the dangers] [conducted the midnight] [raid]

(MacDonald et al., 1992: 65)

Experiment 2 featured an addition and investigation of one more factor: the sentence length. The research instrument in the experiment was similar to that in experiment 1, except the PRRCs which had two versions: long and short. The long PRRCs included six words (e.g., *warned about surprise enemy guerrilla attacks*) while the short ones contained three words (e.g., *warned about attacks*).

In order to formulate hypotheses about the subjects' processing, MacDonald et al. (1992) at first claimed that individuals' WM capacity played a role in how they read and comprehended ambiguous or complicated sentences. They proposed a language processing model titled Capacity Constrained Parsing Model (CCPM). The essence of the CCPM was that a reader's WM capacity affected the extent to which she could retain many interpretations or representations while processing ambiguous sentences. The unambiguous sentences, namely RCs, were syntactically simpler, so they should be less capacity demanding, relative to the more structurally complex PRRCs, which could result in MV-RR ambiguities. Accordingly, the subjects, regardless of their WM span, should carry the RC construction in memory. When processing an RC online, both higher and lower span groups should spend similar reading times on the structure. It was only when they experienced a PRRC that the processing patterns among the higher and the lower span readers differed. When encountering the structural ambiguity, the readers with higher WM span were more likely to maintain both possible interpretations of the ambiguity (i.e., the main verb and the reduced relative) for longer periods than their lower WM counterparts, who preferred keeping only one reading, which was structurally easier, more plausible or more frequently encountered, namely the main verb reading. As a result, the higher WM subjects could choose the correct reading once they got disambiguating cues;

however, carrying many representations might consume their cognitive resources, and there may be inadequate capacity left for other computational processes. Such processes might be delayed and activated later when they continued the sentence. Therefore, maintaining several structural interpretations could lead the higher WM readers to spend much longer reading times on PRRCs, compared to those on the simpler RCs. On the contrary, the readers with lower WM tended to keep only the preferred MV interpretation, so they might have enough cognitive resources for normal processing, and thus, spend as similar reading times on a PRRC as those on an RC. Simply put, the higher WM subjects would spend longer reading times on PRRCs than their lower WM counterparts. Concerning the offline processing, when the PRRCs were encountered, all readers should make comprehension errors because the reduced relative interpretation was more capacity demanding. However, the higher WM subjects should make fewer errors than the lower WM ones since the former spent more time processing the ambiguous past participial forms, and were more likely to have maintained the correct interpretation, along with the more preferred one. So, they had a higher tendency to figure out the given forms successfully. On the other hand, the participants with lower WM spent shorter time reading the construction and tended to have difficulties retaining the correct interpretation in memory and distinguishing the past participial form from the past simple one. Thus, they would make a higher number of comprehension errors. In terms of RCs, both groups should perform equally well because the structure was more frequently encountered and structurally simpler. Table 20 encapsulates the details about the online and offline processing behaviors of the higher WM readers and the lower WM ones proposed by the CCPM.

Type of processing	**Structure**	**WM span group**	
		Higher WM	**Lower WM**
Online processing	**PRRC**	They should spend longer reading times on PRRCs than those on RCs.	They should spend as similar reading times on a PRRC as those on an RC.
	RC	Both groups should spend similar reading	

		times on the construction.	
Offline processing	**PRRC**	They should make fewer errors in comprehension accuracy.	They should make more errors in comprehension accuracy.
	RC	Both groups should achieve equally high comprehension accuracy.	

Table 20: The processing behaviors of the higher WM readers and the lower WM readers proposed by the Capacity Constrained Parsing Model (MacDonald et al., 1992)

Based on the CCPM, MacDonald and colleagues hypothesized that the variation in language processing by individuals with different levels of WM lay in the duration of which they could maintain the two interpretations (i.e., the main verb reading and reduced relative reading) to resolve structural ambiguities. That is, the higher WM readers would tend to be able to keep both interpretations for a longer period of time than the lower WM readers, who were likely to retain the preferred main verb interpretation only. The research findings of the two experiments implied that WM played a role in the readers' processing, supporting the CCPM. Upon encountering ambiguities, only the higher span individuals spent more reading times at the disambiguating region. This indicated that the higher WM subjects could maintain both interpretations longer than the lower WM ones while processing the ambiguous sentences.

The CCPM has been considered as having proposed precise language processing patterns among individuals with different WM levels. While the patterns were originally used to support native English speakers' processing of PRRCs only, they have also been found applicable to processing behaviors of non-native speakers across various ambiguous or complex grammatical constructions (e.g., L1 Chinese learners' processing of *wh*-dependencies in Dussias & Piñar, 2010; L1 Korean learners' globally ambiguous RC attachment in Kim & Christianson, 2017).

Just and Carpenter (1992) conducted an eye-tracking experiment in order to investigate WM level's effects on how their L1 English subjects recruited pragmatic information, specifically animacy, in resolving MV/RR ambiguities. The MV/RR target sentences manipulated two factors: ambiguity (ambiguous PRRCs and

unambiguous RCs) and animacy (animate nouns and inanimate nouns). Samples of the experimental items are shown below.

(109) a. Ambiguous – Animate: The defendant examined by the lawyer shocked the jury.

b. Unambiguous – Animate: The defendant who was examined by the lawyer shocked the jury.

c. Ambiguous – Inanimate: The evidence examined by the lawyer shocked the jury.

d. Unambiguous – Inanimate: The evidence that was examined by the lawyer shocked the jury.

(Just & Carpenter, 1992: 126-127)

Although both sentences (109a) and (109c) were syntactically complex, the PRRC modifying the inanimate noun *the evidence* in the latter sentence tended to be more ambiguous than that modifying the animate noun *the defendant* in the former due to a semantic reason. Trueswell (1994) pointed out that living nouns were usually considered agents, namely the doer of an action, whereas non-living nouns were generally assigned the role of theme, i.e., the entity which received an action. That is, inanimate nouns were not expected to perform actions. As a result, sentence (109a) was less likely to be ambiguous for the readers because *the defendant* could perform the action of examining. However, in (109c), *the evidence* as the subject of the action of examining would sound semantically strange. The results of the experiment revealed that the high span participants' sentence processing was influenced by the pragmatic cue of animacy while the low span participants' was not. This was reflected by the fact that the high WM subjects showed longer fixation times on the disambiguating *by* phrase in reduced RCs modifying animate nouns (e.g., *the defendant* in sentence (109a)) than in those modifying inanimate nouns (e.g., *the evidence* in sentence (109c)) whereas this was not the case for the low WM subjects. The high span participants were assumed to have enough processing resources to use the pragmatic cue of animacy as well as syntactic structure to understand the experimental sentences. On the contrary, the individuals with low span did not have sufficient WM to keep both syntactic and pragmatic information activated.

Consequently, only the high WM participants successfully employed animacy information in resolving the MV/RR ambiguities. Just and Carpenter concluded that the research participants' differences in the efficiency of sentence processing were associated with individual differences in WM.

Eastwick and Phillips (1999) looked into whether increased syntactic complexity affected native English speakers' use of animacy cues in processing sentences. After being divided by a reading span task into groups according to their WM level, the research participants took a self-paced reading task which consisted of two groups of experimental sentences differing in terms of embedding: embedded and non-embedded. Similar to the experimental items in Just and Carpenter (1992), the non-embedded sentences manipulated ambiguity and animacy. The embedded items, however, included a subordinate clause, and thus, were more syntactically complex. Samples of the non-embedded and embedded test items are provided in sentences (110a) and (110b), respectively.

(110) a. The evidence recently examined by the lawyer was not reliable.

(Eastwick & Phillips, 1999: 5)

b. The judge knew that the evidence examined by the witness was unreliable.

(Eastwick & Phillips, 1999: 12)

According to the research findings, WM's effects manifested themselves in the less complex target sentences. When dealing with the non-embedded experimental items, only the high WM participants recruited semantic cues when processing MV/RR ambiguous sentences. On the contrary, when tackling the embedded items which were more structurally complicated, both high and low WM participants did not use animacy cues during processing. The differences between the subjects with different levels of WM were assumed to result from different degrees of exposure to complex sentence structures. That is, the high WM participants possibly had more experience with MV/RR ambiguities and were more likely to deal with the structures successfully than those with low WM. In addition, the fact that both high and low span readers had difficulty processing the embedded structure probably reflected their

low exposure to the construction which was quite rare in English. The results of the study suggested that the increased syntactic complexity could lead to similarities in processing between readers with different WM levels in that they did not employ animacy cues when they processed embedded experimental items.

As for the research on L2 learners' processing of English PRRCs, three studies, to the best of my knowledge, have been carried out thus far, i.e., Juffs (1998), Rah and Adone (2010), and Yang and Shih (2013)[35]. They are similar in that they do not involve WM in accounting for the participants' processing. Juffs (1998) explored the MV/RR ambiguity resolution by English native speakers and advanced ESL learners from various L1 backgrounds, i.e., Chinese, Japanese, Korean, Romance languages, including Spanish, Italian, French, and Portuguese. The L2 learners' English proficiency level was determined via Michigan Test, University of Richmond. Juffs aimed to see whether and how the subjects' processing was influenced by two factors: verb subcategorization and post-ambiguity cue. Verb categorization included three subfactors: irregular verbs (e.g., *drawn*, *eaten*, and *chosen*), transitive regular verbs (e.g., *criticized*, *invited*, and *killed*), and regular verbs which were optionally transitive (e.g., *watched*, *painted*, and *attacked*). Post-ambiguity cue consisted of good cues, i.e., the cues which eliminated the transitive interpretation of the target sentences by placing an adjunct immediately after the verb (e.g., *during the morning*), and poor cues or the cues which left open the transitive reading until the last word of that region was shown (e.g., *almost every day*). The two factors were manipulated, resulting in six types of experimental sentences, each of which was provided with four sentences. Samples of the six sentence types are presented in sentences (111a) – (111f).

(111) a. Unambiguous – Good post-ambiguity cue: The bad boys seen during the morning were playing in the park.

b. Unambiguous – Bad post-ambiguity cue: The bad boys seen almost every day were playing in the park.

c. Transitive – Good post-ambiguity cue: The bad boys criticized during the morning were playing in the park.

[35] To the best of my knowledge, none of the previous studies on processing of English PRRCs have been conducted with L1 Thai learners.

d. Transitive – Bad post-ambiguity cue: The bad boys criticized almost every day were playing in the park.

e. Optionally transitive – Good post-ambiguity cue: The bad boys watched during the morning were playing in the park.

f. Optionally transitive – Bad post-ambiguity cue: The bad boys watched almost every day were playing in the park.

(Juffs, 1998: 122)

The research instrument was a self-paced reading task in which the subjects were asked to process the target sentences presented in four chunks, i.e., the subject, the verb categorization and the cue region, the disambiguating finite verb, and the wrap-up region. After reading an entire sentence, the participants had to judge the grammaticality of the sentence. A sample of the experimental sentences divided into four segments is shown in (112).

(112) [The bad boys] [criticized almost every day] [were playing] [in the park]

(Juffs, 1998: 122)

Juffs took into consideration the subjects' accuracy of grammaticality judgments and reading times. It was found that the Romance-speaking subjects were more accurate and spent less reading times than the three non-European participant groups. Juffs stated that English and Romance languages belonged to the same head-directionality subtype: SVO. Such similarity put the Romance learners at an advantage. He further explained that the head-final construction of RCs in Chinese, Japanese, and Korean probably made the subjects from these three languages have difficulties judging grammaticality of PRRCs in English, which was a head-initial language. Moreover, the participants from the three non-European L1s showed different processing patterns when reading the disambiguating verb region. The Chinese learners spent longer reading times for the region than the other two groups did. The L1 Japanese and Korean learners' speed advantage over the Chinese ones was possibly linked to the SOV structure of Japanese and Korean[36]. These two

[36] Japanese and Korean are head-final languages (Tanaka et al., 2011; Shin, 2015). On the contrary, Chinese is a mixture of head-final and head-initial constructions (Lee et al., 1991). In Chinese, noun phrases are head-final whereas the head/complement ordering is head-initial.

languages featured head-final phrase structure, and thus, parsers in the two languages did not have to wait to see the verb (which offered information about the theta role and case) in order to make parsing decisions. Nevertheless, since the parsers could quickly make the decisions without crucial information from the verb, they tended to frequently misanalyze a sentence. The high frequency of misanalyses was claimed to equip the L1 Japanese and Korean subjects with the ability to rapidly reanalyze sentences with an MV/RR ambiguity. As Juffs (1998) pointed out, the Romance-speaking subjects' speed and accuracy advantage over the non-European participants and the L1 Japanese and Korean learners' less reading times than the L1 Chinese ones' indicated that the ESL participants' L2 processing was affected by typological properties of their L1s. Furthermore, all the ESL learners seemed to have sensitivity to the interaction between the verb categorization and post-ambiguity cues, particularly while they were processing the disambiguating region in the target sentences. This was strongly supported by the fact that the participants' reading times on the disambiguating verb region in the transitive reduced relative and optionally transitive reduced relative with a poor cue were significantly longer than those in both the unambiguous good cue and the transitive with a good cue.

Rah and Adone (2010) examined how MV/RR ambiguities were processed by native English speakers and L1 German learners classified into two groups by the OPT (2007) according to their English proficiency level: intermediate and advanced. They used a self-paced reading task and a grammaticality judgment task in order to investigate the subjects' online and offline processing, respectively. In connection with the self-paced reading task, Rah and Adone emphasized two factors: ambiguity level of the PRRCs and post-ambiguity cue. The first factor included the unambiguous PRRCs derived from irregular verbs and the ambiguous ones derived from regular verbs. The post-ambiguity cue in this study, similar to that in Juffs' (1998) instrument, consisted of good cues and poor cues. The participants were presented three groups of experimental sentences resulting from the manipulation of the two factors mentioned: unambiguous sentences, ambiguous sentences with a good cue, and ambiguous sentences with a poor cue. Ten sentences were provided for each

of the three conditions, leading to 30 target sentences interspersed with 30 distracters. Examples of the three sentence types are shown in sentences (113a) – (113c).

(113) a. Unambiguous – No post-ambiguity cue: The brown sparrow seen by the hungry cat pecked at an insect.

b. Ambiguous – Good post-ambiguity cue: The brown sparrow noticed on an upper branch pecked at an insect.

c. Ambiguous – Poor post-ambiguity cue: The brown sparrow noticed almost every day pecked at an insect.

(Rah & Adone, 2010: 90)

Unlike Juffs' (1998) segmentation of his target sentences, Rah and Adone (2010) divided each target sentence into five chunks, namely the subject, the ambiguous verb, the post-ambiguity cue, the disambiguating finite verb, and the wrap-up regions. A sample of the experimental sentences divided into five segments is presented in (114).

(114) [The brown sparrow] [noticed] [almost everyday] [pecked] [at an insect]

(Rah & Adone, 2010: 90)

After finishing the self-paced reading task, the subjects were administered the grammaticality judgment task which required them to judge whether or not 30 English sentences with a PRRC were grammatical. The research findings revealed a separation between the subjects' processing mechanism and their grammatical knowledge. In the grammaticality judgment task, the grammatical knowledge of the native English speakers and the L1 German learners about the MV/RR did not differ significantly. Both groups of participants successfully judged the grammaticality of the sentences. In the self-paced reading task, however, they seemed to demonstrate different processing patterns. Specifically, the L2 learners' reading times for the ambiguous sentences were longer than those for the unambiguous sentences whereas the native English speakers did not manifest such differences. Rah and Adone (2010) attributed the results in the self-paced reading task to L1-L2 differences, explaining that the L2 learners spent longer times reading certain target sentences possibly because they had problems with the reduced RC construction that was non-existent in their native language. Regarding the effects of the L2 learners' proficiency level, the

advanced learners appeared to recover from misanalyses faster and more successfully than the intermediate ones. This suggested that the differences between the non-native participants' processing patterns were associated with their different L2 proficiency levels.

Yang and Shih (2013) employed a grammatical judgment task and a self-paced reading task in exploring L1 Taiwanese learners' processing of RCs and PRRCs. They included four groups of participants differing in English proficiency level: elementary, intermediate, advanced, and native English speakers. The target sentences were created by manipulating reduction (reduced and unreduced clauses), animacy (animate and inanimate NPs), and ambiguity (ambiguous and unambiguous past participial forms), resulting in a total of 6 item conditions, as illustrated in (115).

(115) Ambiguous animate reduced: The boy kissed by the girl was cute.
Unreduced: The boy who was kissed by the girl was cute.
Inanimate reduced: The apple kissed by the girl was cute.
Unreduced: The apple that was kissed by the girl was cute.
Unambiguous inanimate reduced: The apple seen by the girl was cute.
Unreduced: The apple that was seen by the girl was cute.

(Yang & Shih, 2013: 1120)

The findings as regards the native speakers revealed that when they experienced the target sentences with animate NPs (e.g., the boy kissed…), they tended to assign the main verb interpretation to the ambiguous forms (i.e., kissed). This was probably because living NPs performed a good role of agent. They had no processing problems until they reached the preposition 'by,' which confirmed the PRRC interpretation for the *-ed* forms. In contrast, the difficulties with the preposition were less severe when they read the sentences with inanimate NPs (e.g., the apple kissed…) since non-living nouns usually play a role of patient or theme. Therefore, they could expect 'by' to appear later, and spent less time processing the prepositions for inanimate nouns than those for animate nouns. The results suggested the native speakers' sensitivity to both thematic information indicated by noun animacy cues and syntactic information from the preposition 'by'. Pertaining to L2 processing, the

L1 Taiwanese learners' resolution of the MV/RR ambiguities varied according to their proficiency level. The advanced learners, who were claimed to have larger lexical access than the other two learner groups, could build the correct PRRC interpretation regardless of the animacy status of the modified NPs. The intermediate learners, similar to the native speakers, employed both the thematic and syntactic information from the noun animacy cues and the preposition 'by', respectively. They were more likely to assign the PRRC interpretation to the ambiguous forms in the target sentences with inanimate NPs than in those with animate NPs. However, compared to the native speakers, they tended to have more processing problems with the reduced RCs than with the unreduced ones. Likewise, the L2 participants with elementary proficiency were affected by the reduction effect. That is, when encountering inanimate NPs, they spent longer time reading the PRRC sentences than reading their RC counterparts. Brief information about the processing studies on the PRRC structure is tabulated in Table 21.

Study	**Participants/WM Assessment (+/-)**	**Investigated Factor(s)**	**Research Instruments (what they measured)**	**Results and Implications**
MacDonald et al. (1992, Experiment 1)	Native speakers of English (+)	- Interpretation (main verb and reduced relative interpretations) - Ambiguity (ambiguous PRRCs and unambiguous RCs)	- A reading span task (WM) - A self-paced reading task (online processing of PRRCs)	- Only higher span subjects spent more reading times at the disambiguating region. - The higher WM participants could maintain both MV/RR interpretations longer than those with lower WM.
MacDonald et al. (1992, Experiment 2)		- Interpretation (main verb and reduced relative interpretations) - Ambiguity (ambiguous PRRCs and unambiguous RCs) - Sentence length (long and short PRRCs)		
Just & Carpenter (1992)	Native speakers of English (+)	- Ambiguity (ambiguous PRRCs and unambiguous RCs) - Animacy (animate and inanimate nouns)	- A reading span task (WM) - An eye-movement experiment (online processing of PRRCs)	- Only higher WM readers showed longer fixation times on the disambiguating region in reduced RCs with animate nouns than in those with inanimate nouns. - Only higher WM subjects' processing was affected by the pragmatic cue of animacy.

Eastwick & Phillips (1999)	Native speakers of English (+)	- Syntactic complexity (embedded and non-embedded) - Animacy cue (animate and inanimate nouns)	- A reading span task (WM) - A self-paced reading task (online processing of PRRCs)	- WM's effects manifested themselves in the less structurally complex items, i.e., the non-embedded items. Only the high WM participants used semantic cues in processing ambiguities. - With the embedded items which were more structurally complex, both high and low WM subjects did not use animacy cues in processing.
Juffs (1998)	- Advanced ESL learners from various L1 backgrounds (i.e., Chinese, Japanese, Korean, Romance languages) - Native speakers of English (-)	- Ambiguity level: ambiguous (regular verbs) & unambiguous (irregular verbs) - Post-ambiguity cues: good cues (prepositional phrases, such as noticed on a tree) and bad cues (adverbial phrases, such as noticed almost every day)	- A self-paced reading task (online processing of PRRCs)	- The Romance-speaking subjects were more accurate and spent less reading times than other three participant groups. - Among the participants from the three non-European L1s, the Chinese learners spent longer reading times for the region than the other two groups did. - The research findings were linked to typological properties of the subjects' L1s.
Rah & Adone (2010)	- Two groups of L1 German learners with different L2 proficiency levels: intermediate and advanced - Native speakers of English (-)		- Oxford placement test (English proficiency) - A self-paced reading task (online processing of PRRCs) - A grammaticality judgment task (offline processing of PRRCs)	- In the grammaticality judgment task, the grammatical knowledge of the native English speakers and the L1 German learners about the MV/RR did not differ significantly. - In the self-paced reading task, the L2 learners' reading times for the ambiguous sentences were longer than those for the unambiguous sentences. The results were attributed to L1-L2 differences. - The advanced L2 learners recovered from misanalyses faster than the intermediate ones, indicating the relationship between the L2 learners' proficiency level and their processing pattern.
Yang and Shih (2013)	- Three groups of L1 Taiwanese learners with different L2 proficiency levels: elementary, intermediate, and advanced - Native speakers of English	- Reduction (reduced and unreduced clauses) - Animacy (animate and inanimate NPs) - Ambiguity (ambiguous and unambiguous past participial forms)	- A self-paced reading task (online processing of PRRCs) - A grammaticality judgment task (offline processing of PRRCs)	- The native speakers had more processing difficulties with the preposition 'by' in the target sentences with animate NPs than with the preposition in the sentences with inanimate NPs. - The results suggested the native speakers' sensitivity to both thematic information and syntactic information.

	(-)			- The L1 Taiwanese learners' processing of the MV/RR ambiguities varied according to their proficiency level. The advanced learners, who were claimed to have larger lexical access than the other two learner groups, could build the correct PRRC interpretation regardless of the animacy status of the modified NPs. The intermediate and elementary learners were affected by the reduction effect, taking longer time reading the PRRC sentences than reading their RC counterparts.

Table 21: Previous studies on the processing of English PRRCs with a past participle among native English speakers and L2 learners

2.4.3 Previous studies on L2 acquisition of English regular and irregular verbs

The previous research on L2 acquisition of English regular and irregular verbs mainly addresses whether the past tense form of the verbs is acquired by L2 learners. The research works can be divided into two groups: the studies which investigated both regular and irregular verbs and those examining only regular verbs.

The studies on L2 acquisition of the past tense forms of English regulars and irregulars can be classified into two main groups. The first group of research looked into salience effects on L2 learners' past tense marking for the verbs whereas the second one explored the learners' omissions of the past tense form of the verbs.

In a myriad of previous studies, the contrast between English regular and irregular verbs in terms of salience degrees has been shown to influence the L2 acquisition of past tense morphemes in English (e.g., Ellis, 1987; Bayley, 1994; Klein et al., 1995; Lafford, 1996; Salaberry, 2000; Housen, 2002). Many revealed that L2 learners tended to be more successful in marking past tense for the irregular verbs than for the regular ones.

Wolfram and colleagues carried out two studies widely referred to as the Vietnamese English (VE) research (Wolfram & Hatfield, 1984; Wolfram, 1985). These studies examined English past tense marking by L1 Vietnamese subjects living in Northern Virginia, the United States. The participants were divided into two groups according to their length of residency (LOR) in the United States, i.e., 1-3 years and 4-7 years. Analyzing the subjects' natural speech elicited via a sociolinguistic interview, the researchers focused on how the participants marked past tense for various types of the regular and irregular verbs, as displayed in (116a) and (116b):

(116) a. regular forms: 1) /ɪd/, 2) /d/, and 3) /t/

b. irregular forms: 1) suppletive forms, 2) internal vowel change plus a t/d suffix or doubly-marked verbs, 3) internal vowel change or ablauts, 4) modal verbs, and 5) replacives.

The findings showed that both LOR groups had similar past tense marking patterns involving the salience of the verbs. Wolfram observed an order in which different types of forms were arranged according to the frequency of being unmarked by the two groups of subjects. The frequencies of unmarking tense for various classes of verbs are presented in Table 22.

Verb Type	Residency			
	1-3 LOR No. Unmarked/Total	% Unmarked	4-7 LOR No. Unmarked/Total	% Unmarked
Regular	777/818	95	464/584	79.5
Replacive	351/381	92.1	131/255	51.4
Modal	131/158	82.9	53/124	42.7
Internal Vowel Change	495/930	53.2	177/557	31.8
Internal Vowel Change +	367/824	44.5	151/506	29.8

Regular Suffix				
Suppletive	283/643	44	131/760	17.2

Table 22: Incidence of unmarked tense for types of verbs by different length of residency (LOR) groups (Wolfram & Hatfield, 1984: 89)

Table 22 illustrates a hierarchy in the frequencies of unmarking past tense for different types of verbs. The results revealed that past tense marking was the most likely when the past tense form was the least similar to the non-past form. The most frequently unmarked type was regular verbs, followed by several types of irregular verbs, i.e., replacive final consonants, modals, internal vowel change, internal vowel change plus a regular suffix; marking is most likely with suppletives. Wolfram then came up with the Principle of Perceptual Salience, which proposed that "the more distant phonetically the past tense irregular form is from the non-past, the more likely it will be marked for tense" (p. 247). In conclusion, the research carried out by Wolfram and his associates suggested that verbs' salience could have effects on past tense marking in two ways: 1) the similarity between the phonological shape of the past tense and that of the present tense of the verbs could modulate the tendency of past tense marking, and 2) irregular verbs had a higher tense marking rate than regular verbs.

Bayley (1994) examined the English past tense marking of L1 Mandarin learners living in California. Bayley used the participants' English proficiency levels determined by their TOEFL (Test of English as a Foreign Language) scores to classify them into two groups: high and low proficiency levels. The subjects had two sociolinguistic interviews: an individual interview with the researcher and a pair interview with another participant. Bayley looked into the participants' past tense marking for regular and irregular verbs divided into groups as shown in (117a) and (117b):

(117) a. regular forms: 1) non-syllabics and 2) syllabics

b. irregular forms: 1) suppletive forms, 2) doubly-marked verbs, 3) ablauts, 4) copulas *is* and *are* (except *am*), 5) replacives, and 6) modal verbs.

The participants marked past tense for the verb classes in the following order of frequency: suppletives > doubly-marked verbs > ablauts > copulas (except the first person singular) > regular non-syllabics > replacives > regular syllabics > modal verbs. The results of the study were similar to those of Wolfram and Hatfield (1984) in that past tense was more likely to be marked for the irregular verbs than for the regular ones. However, the tense marking for replacives and modals was less frequent than that for other irregulars. The low frequency of marking for replacives was attributed to the verbs' low salience resulting from the only difference between their present and past tense forms in terms of the last consonantal sound. The modals *could* and *would* were less frequently marked since they could be employed as either present or past tense forms. An interesting point observed in the research findings involved the order of the regular verb types. That is, the syllabics, which had been assumed to have higher salience, were less frequently marked than the non-syllabics. Bayley claimed that, in the non-syllabic markings, the past tense suffix was attached to a stressed syllable (e.g., *play-played*); however, the syllabic markings formed unstressed syllables (e.g., *started* and *yielded*). This probably made the subjects in the study consider the non-syllabics more prominent than the syllabics.

The acquisition of regular and irregular past tense morphemes in English has also been investigated in relation to omissions of the inflections among L2 learners. A number of studies accounted for such omissions using either of two opposing perspectives: the Missing Surface Inflection Hypothesis (MSIH) and the Failed Functional Features Hypothesis (FFFH). The former perspective attributed L2 learners' failure to consistently supply L2 inflectional morphemes to post-syntactic mapping to morphophonological form rather than the lack of L2 syntactic knowledge. That is to say, L2 learners were assumed to have the syntactic knowledge, but they might omit the past tense morphemes as a result of their processing problem which occurred as a surface level of derivation (e.g., Haznedar & Schwartz, 1997; Lardiere,

1998; Prévost & White, 2000; White, 2003). On the contrary, the FFFH proposed that an L2 learner's omissions of an L2 morpheme resulted from the morpheme's non-existence in the learner's L1 instead of the extra-syntactic factors or the syntax-morphology mapping. The essence of the perspective was that a particular L2 functional category was underspecified in L2 learners' grammar due to differences between the L2 and their L1 in respect of the feature. Simply put, the morphosyntactic features that were absent in the L1 grammar were never acquired by the learners in their L2 (e.g., Hawkins & Chan, 1997; Franceschina, 2001; Hawkins & Liszka, 2003).

Hawkins and Liszka (2003) conducted a cross-sectional study in order to look into how past tense was marked for English regular and irregular verbs by advanced L2 learners from various L1 backgrounds, i.e., Japanese, German, and Chinese. The research instruments included a morphological test and a spontaneous oral production test which comprised two subparts: retelling a film and describing the informants' own experience.

Regarding the morphological test, all groups of L2 learners performed similarly to the native controls of the research did, indicating that the learners had some morphological knowledge. In the oral production test, all the three groups of non-native subjects overall tended to mark past tense for the irregular verbs more frequently than for the regular ones. More importantly, when the results were closely analyzed, the L1 Chinese participants were shown to have a significantly lower rate of past tense marking in the past contexts than the other two groups did. Then, Hawkins and Liszka examined three accounts which might explain the L1 Chinese subjects' lower past tense marking rate: the mapping between fully specified syntactic phrase markers and surface morphophonology, performance pressure, and the non-existence of the feature [±past] in Chinese.

The first account concerned the mapping problem at the interface between syntax and morphology. The mapping difficulty referred to the problem of accessing morphological forms containing 'layers' of features (Hawkins & Liszka, 2003; 23). Morphological forms which comprised more inflectional features, i.e., a greater number of feature layers, were more likely to cause production problems to L2 learners than those having fewer features. Regarding the past tense marking, non-

native learners were required to determine whether or not the morphological component with a terminal T node was [+past] or [-past], and in case it was [+past], they had to choose between a particular irregular or a regular with the *–ed* suffix. The mapping issue might also be exacerbated by complicated phonological difficulties of certain morphological forms resulting from L1-L2 phonotactic differences, such as word final clusters (e.g., *–kt* and *–skt* in the past tense forms of *waked* and *asked*) which were permitted in English, but disallowed in some languages. That is, the learners had to map phonological forms with layers of morphological features onto terminal nodes which were the output of the syntactic computations. Hawkins and Liszka stated that if the mapping problem were the case, all the three groups of subjects should have shown similarities between their performance on the oral production test. Yet, only the L1 Chinese learners were different from the other two groups; therefore, the syntax-morphology mapping should not have played a role. Furthermore, Hawkins and Liszka investigated the L1 phonological interference by comparing the /t/ and /d/ absence in regular past tense marking with that in monomorphemic words, such as *most* and *kind*. The effect of L1 phonological constraints was unlikely because if it were involved, both the L1 Japanese and L1 Chinese participants should have had poor performance on both monomorphemic words and past tense marking since word-final consonant clusters were disallowed in the two languages. The L1 Chinese subjects, however, manifested lower suppliance of the /t/ and /d/ in regular past tense marking and monomorphemes than the L1 Japanese participants. Moreover, the Chinese learners produced the word-final /t/ and /d/ in monomorphemic words more frequently than in their regular past tense marking, indicating that the L1-L2 phonotactic differences did not give rise to their low suppliance of the past tense marking.

Hawkins and Liszka assumed that the L1 Chinese subjects' lower tendency to mark past tense in the oral production test could be caused by an extra-syntactic factor, i.e., performance pressure. Prévost and White (2000) pointed out that spontaneous production tests might lead L2 learners to feel uncomfortable or worried, inhibiting them from accessing the inflected past tense verb forms in real-time. If the pressure had come into play, it should have led to two consequences. Firstly, all the

three groups of participants would have had similarly low performance on the production test which held performance pressure. Secondly, the L1 Chinese participants should have had similar difficulties producing regular past participles (e.g., *be sliced* and *is released*) whose surface form was identical to the regular past tense forms'. Their production of regular past participles should have been similar to their production of the regular past tense forms in terms of accuracy. However, as mentioned above, only the L1 Chinese speakers supplied the regular past tense marking much less frequently than the L1 German and the L1 Japanese ones. In addition, the L1 Chinese participants supplied the regular past participles with 100% accuracy. Thus, the assumption about performance pressure was disproved.

Hawkins and Liszka concluded that the lower rate of suppliance of regular past tense marking by the L1 Chinese learners was due to the absence of the abstract feature [±past] in Tense in the subjects' native language. On the other hand, the feature was existent in Japanese and German, which accounted for the higher rate of past tense marking by the L1 Japanese and L1 German participants. The third account supported the FFFH in which the essence was that an L2 learner whose native language lacked an abstract feature would never fully acquire the feature in the L2.

As mentioned, the L1 Chinese speakers had a lower degree of success in supplying the regular past tense verb forms than producing the irregular past tense verb forms and the past participles. Hawkins and Liszka claimed that such different success rates were probably because the three groups of forms had a different morphological status in the research participants' L1 grammars. The regular past tense forms were related to a syntactic feature missing from T whereas the past participles were brought about by a verb-internal word formation process, which was not associated with T. Consequently, the subjects whose L1 lacked the feature [±past] in Tense were more likely to have problems producing the simple past tense forms than the past participles. Regarding the past tense forms of the irregulars, the L1 Chinese learners tended to regard the forms as "items independent from the equivalent bare V forms" (p. 37). That is, the past tense forms of the irregulars were considered a separately acquired word form for the L2 learners. The assumption was supported by two patterns of usage of the irregular past tense verb forms, namely using them as a

non-finite verb and attaching the –ed suffix to them. First, the native speakers of Chinese used the past tense irregulars as a non-finite verb, for example, *You should ran away together* and *She could not ran any more* (p. 37). Secondly, the L1 Chinese participants attached the past tense suffix –ed to the past tense irregulars, and used them in clearly non-past contexts, as shown in *The girl ranned not far away* (p. 37). On the contrary, the Chinese speakers did not perceive regular verbs as independent lexical items since the regularity and the frequency of the inflected forms possibly made the subjects view the forms as rule-based variants of the bare verbs instead.

Khumdee and Pongpairoj (2014) looked into whether omissions of English past tense morphemes could be observed among two groups of L1 Thai learners with different English proficiency levels: intermediate and advanced. The participants were administered two types of tests: the representation test, i.e., a grammaticality judgment test, and the production tests, namely a cloze test and a story-telling test. One similarity between the three tests was that the test items addressed the acquisition of both regular and irregular verbs. The judgment test was employed to investigate the subjects' underlying knowledge of the past tense marking. The 40 test items in the test could be categorized into two groups according to the regularity of the finite verb of the sentences; the first group comprised regular verbs whereas the second one featured irregular verbs. Each group was further divided into two groups of test items: items which included adverbial phrases of time indicating past tense (e.g., *yesterday* and *in 1914*) and those without such phrases. Samples of the test items are *Maria made us coffee this morning* and *His hand knocked against the glass* (p. 130). The cloze test and the story-telling test explored the L1 Thai learners' production of the English past tense marking. The cloze test provided the subjects with sentences containing a blank each, such as *Last night fans ____ (pack) the hall to see the band* (p. 131), and they had to fill in the blank using the word given in parentheses in its grammatical form. Like the judgment test, the cloze test contained 40 test items resulting from a manipulation of the two factors: the regularity of the finite verb of the sentences and the presence of the past tense indicators. In the story-telling test, the subjects were asked to describe six illustration frames using a group of words provided in each frame. Among the given words were regular and irregular verbs

aimed to elicit the subjects' production of the English past tense marking. Each correctly pronounced verb scored 1 point. The researchers predicted that the subjects would omit the English past tense morphemes, and that the omissions could be explained via the FFFH. The two predictions were borne out by the results. The two groups of subjects omitted the English past tense morphemes in all the three tests. The omissions were strongly associated with the two variables involved: the regularity of the finite verb and the existence of the adverbial phrases indicating pastness. Both proficiency groups were found to supply irregular past tense marking more often than regular past tense marking. The omissions which involved the past tense indicators applied to only the grammaticality judgment test and the cloze test which included the adverbial phrases as a variable. In the two tests, the past tense marking suppliance rate for the sentences which had adverbial phrases of time tended to be higher than that for the sentences which lacked such phrases. In addition, the FFFH was apt to account for the subjects' omissions of the English past tense morphemes better than the MSIH. The findings revealed that the participants' past tense marking in both the representation test and the production tests was inaccurate. The results could be explained by the FFFH, which proposed that a morphosyntactic feature's non-existence in the L1 Thai subjects' mental representation made them unable to master the feature. However, the MSIH, which posited that L2 learners had intact syntactic knowledge, should not be the case; otherwise the past tense marking in the representation test should have been produced with high accuracy.

Prapobaratanakul and Pongpairoj (2016) analyzed the omissions of the English past tense morphemes by an L1 end-state Thai learner. They aimed to see whether the participant's omissions could be accounted for by the MSIH. The participant was asked to complete two tasks: a grammaticality judgment task and a spontaneous production task. The grammaticality judgment task comprised 80 multiple-choice questions, each of which included 4 choices. The task involved 40 test items and 40 distractors. The first 20 test items dealt with regular verbs whereas the other 20 items looked into various types of irregular verbs, including ablauts or the verbs which inflected to their past simple form by changing their internal vowel (e.g., *sing-sang*; *see-saw*; *break-broke*), pseudo-inflection forms or the verbs which

inflected by shortening the vowel (e.g., *meet-met*; *lead-led*; *leave-left*), suppletives (e.g., *is-was*; *go-went*), and identical forms (e.g., *cut*; *hit*; *put*). An example of the questions is *When he was 13, his parents _____ to the United States* (the four choices are *had moved*, *moves*, *moved*, and *have moved*, and the correct answer is *moved*) (p. 91). After finishing the judgment task, the participant took the spontaneous production task in which the researcher interviewed her with questions which elicited her English past tense morpheme production. A sample of the interview questions is *Could you please tell me your experience in teaching English*? (p. 94). The researchers made a prediction based on the MSIH; the L1 Thai learner was supposed to have the syntactic knowledge of English past tense morphemes, and thus, her omissions of English past tense morphology tended to be caused by extra-syntactic factors instead of the lack of syntactic knowledge. Overall, in connection with the two types of English verbs, namely regular and irregular verbs, the results of the two tasks showed that the participant's correct suppliance of regular past tense morphemes was lower than that of irregular past tense inflections. Furthermore, the MSIH was shown to account for the subject's omissions. The research findings demonstrated that the participant's correct use of the English past tense morphemes in the grammaticality judgment task and that in the spontaneous production task were 93% and 84%, respectively. Meeting Anderson's (1978) criterion of 80% suppliance in obligatory contexts, the participant's correct suppliance rate indicated that she had the syntactic knowledge of English past tense morphology. It was also found that the learner's correct use of the regular past tense morphemes on the grammaticality judgment task (85%) was significantly higher than that on the spontaneous production task (38%). Prapobaratanakul and Pongpairoj (2016) stated that the learner's lower correct suppliance of the regular past tense morphology in the production task might be associated with her omission of past tense inflections. To be specific, she frequently omitted the final sounds /t/, /d/, and /ɪd/ in the contexts where they were required. The results were linked to Lardiere's (2003) notion of consonant cluster reduction, which posited that L2 learners' incorrect use of regular past tense morphemes was due to extra-syntactic factors, i.e., their L1 lacked final consonant clusters so the learners failed to produce past tense morphemes correctly because the morphemes occurred as the final consonant cluster. The consonant cluster reduction also applied to the Thai

language, which had no final consonant cluster (Naksakul, 2002). Therefore, the problems found in the spontaneous production task were likely to be related to the extra-syntactic factors or the post-syntactic mapping to morphophonological form. The findings then supported the MSIH, namely the participant had the syntactic knowledge of English past tense morphology, and her inaccurate use of past tense morphemes in English was due to extra-syntactic factors rather than the lack of syntactic knowledge. Prapobaratanakul and Pongpairoj (2016) also offered an alternative explanation for the subject's omissions of the English past tense morphemes. The omissions might be caused by the differences between the pastness-related prosodic structures in English and Thai. That is, past tense in English was expressed via affixal clitic, but in Thai, pastness was conveyed through contexts, lexical words or temporal expressions. This could be explained by Prosodic Transfer Hypothesis, which attributed omissions of L2 functional morphology to the L1-L2 differences in prosodic structures (Goad et al., 2003).

As seen in the previous studies above, L2 learners were more likely to mark past tense for the irregular verbs than for the regular ones. The irregulars' greater tendency to be marked for past tense could be supported by two accounts related to the verbs themselves: L2 learners' perception of the irregular verbs as separate lexical items and the verbs' high level of cognitive salience.

The first reason which accounts for L2 learners' greater success in marking past tense for irregular verbs is according to the Words and Rules theory (e.g., Pinker & Ullman, 2002). This account assumes that L2 learners perceive and learn the past tense forms of regular and irregular verbs in different ways. Regular morphology is learned according to a rule whereas irregular morphology is simply memorized. According to this explanation, phonological properties which involve the past tense inflections are not related to the learners' acquisition of past tense morphology (Xu & Pinker, 1995). Instead, the learners are assumed to pay attention to the underlying rule and the memorized form for regular and irregular morphology, respectively. Similarly, Salaberry (2008) states that irregular verbs are represented as formulaic exemplars or lexical items that are stored or memorized as individual lexical entries.

In contrast, regular verbs are represented as the application of a generative rule (p. 114).

An alternative explanation is that the inflections of the irregular verbs have a higher degree of cognitive salience than those of the regular ones. The distinction between the cognitive salience levels of the inflected forms of the verbs is due to their differences in perceptual salience. The extent to which the past tense form of a verb phonologically differs from its present tense form has been claimed to determine its perceptual salience degree which in turn affects the tendency for the verb to be marked for past tense in a past context. As Minow (2010) points out, the greater the phonological difference between the present tense and past tense forms of a verb, the more salient the verb is, and the more likely past tense marking is to be done. Based on Minow's statement, irregular verbs whose past simple form is much phonologically different from the present tense form are assumed to be more perceptually salient than the regular verbs whose past simple form slightly differs from the present tense form, i.e., simply having the *–ed* suffix attached to the present tense form. Klein et al. (1995) support this point, explaining that the phonological differences between the past simple and present tense forms of the irregular verbs "are perceptually salient, compared to a regular ending such as *–ed*, which may be hard to process for many learners" (p. 271).

Besides the SLA research on the past simple forms of English regulars and irregulars, some studies have addressed the L2 acquisition of regular past tense morphemes only. For instance, Solt et al. (2003) examined perceptual salience effects on how L2 English learners of different L1 backgrounds produced three allophones of the English regular past *–ed* morpheme, i.e., the syllabic [ɪd] and the non-syllabic [t] and [d]. They also aimed to see whether the participants' production and perception could be assisted by contextualized lexical cues, such as adverbs of time and irregular verbs in the past simple form. The subjects of the study were native English speakers and L2 learners divided into two groups according to their L2 proficiency: high and low. The researchers used a perception task and a perception/production task in order to explore the subjects' abilities to perceive and to supply the three allophones of the regular past tense morpheme, respectively. In the perception task, the participants

were introduced to two native English speakers (NESs). The first NES stated the target sentences which were later repeated by the second NES. The second NES correctly pronounced the past tense morpheme in some occasions, but omitted it in the others. The participants were asked to judge whether the sentences the second NES spoke were identical to or different from those uttered by the first NES. (118) provides samples of the correctly repeated sentences and the incorrectly repeated ones in (118a) and (118b), respectively.

(118)

	The 1st NES	The 2nd NES
a.	The girl *walked* in the park.	The girl *walked* in the park.
b.	The girl *walked* in the park.	The girl *walk* in the park.

(Solt et al., 2003: 5)

In the perception/production task, the subjects had to fill in the blanks on an answer sheet based on sets of short stories to which they listened. Each short story consisted of two sentences. The first sentence included an adverbial phrase signaling pastness (e.g., *last year*) and an irregular verb in its past simple form (e.g., *had*) as contextual cues to determine the time frame. The second sentence contained a regular verb in its past simple form, namely the target word. The participants listened to the short stories read by a researcher, and wrote the target verbs on the answer sheets. (119a) offers two sentences of a short story, and (119b) shows the test item in the answer sheets based on the story.

(119) a. Last year the young man had a good job. He worked in a big store.

b. He _____ in a big store.

(Solt et al., 2003: 6)

Solt et al. (2003) made two predictions concerning the subjects' performance on the two tasks. Firstly, the two groups of participants were expected to perceive the syllabic allomorph better than the non-syllabic ones. Secondly, in the perception/production task, only the advanced learners were assumed to be able to employ contextual cues to aid in correctly producing the regular past tense morpheme. The research findings were shown to support the two hypotheses. For the first

prediction, the researchers reported that the syllabic [ɪd] was perceived to a significantly higher degree than the non-syllabic allomorphs were. They pointed out that most L2 learners had a systematic perceptual deficit or perceptual limitations which caused them difficulties of perceiving and producing the non-syllabic allomorphs of the past tense *–ed*, regardless of their level of proficiency. This account suggested that differences in the salience of the allomorphs of *–ed* helped explain omissions of the regular past tense morphemes. Solt et al. also reported a developmental pattern distinguishing the two non-syllabics. Among the higher proficiency level learners, [t] was perceived and produced at a higher mean rate of accuracy than [d] was. The results were attributed to the universally unmarked nature of [t], compared to the more marked nature of [d]. As a result, the learners perceived the *-ed* allomorphs in the following order of accuracy: [ɪd] > [t] > [d]. The hierarchy manifested the interaction between the allophones' salience degree and the success in producing the past tense morphemes correctly – the [ɪd] was the most salient and thus most likely to be accurately produced, followed by the [t] and [d], respectively. The second prediction was also substantiated by the findings. Despite the mentioned perceptual deficit, the more advanced learners could compensate for the limitations by resorting to the contextual cues to produce the morpheme in the perception/production task nearly as correctly as the native speakers of English whereas those with lower English proficiency performed poorly on the task. The low-proficiency participants' low accuracy was linked to "performance factors or issues of processing load" (p. 9).

Klein et al. (2004) proposed the Perceptual Salience Hypothesis (PSH), which stated that a syllable was more perceptually salient than a consonant or cluster of consonants; therefore, a syllabic grammatical suffix was more likely to be perceived and correctly produced than a non-syllabic grammatical suffix. In order to test their hypothesis, they investigated L2 English learners' production of two allophones of the regular past tense suffix *-ed*: the syllabic [ɪd] (e.g., *waited* and *guarded*) and the non-syllabic [d] (e.g., *closed* and *loved*). Based on the PSH, the [ɪd] was predicted to be more salient, and thus more likely to be accurately produced than the [d]. The research participants from various L1 backgrounds were administered a perception task where they had to write the regular verbs they had heard twice in their past tense

form. The perception task included two groups of test items: one testing the verbs with the [ɪd] ending and another involving those with the [d] ending. A sample of the experimental items is provided in (120), with the verb *waited* as the target word.

(120) The subject heard: "Yesterday the man went to the station. He waited at the station for a train. He waited at the station for a train."

The subject saw: "He _____ at the station for a train."

(Klein et al., 2004: 5)

Klein et al. (2004) observed a higher rate of accurate past tense marking for verbs which necessitated the syllabic allomorph [ɪd], compared to those needing the non-syllabic [d], supporting the PSH.

Table 23 provides a summary concerning the studies exploring L2 acquisition of the past tense forms of both English regulars and irregulars while Table 24 encapsulates those which look into only regular verbs.

Study	Investigated Topic	Participants	Research Instrument(s)	Results and Implications
Wolfram & Hatfield (1984); Wolfram (1985)	Salience effects on L2 learners' past tense marking for English regulars and irregulars	L1 Vietnamese subjects divided into two groups according to their length of residency in the United States: 1-3 years and 4-7 years	A sociolinguistic interview conducted to elicit the subjects' natural speech which showed how they marked past tense for regulars and irregulars	- Verbs' salience could have effects on past tense marking. - Past tense marking was the most likely when the past tense form was the least similar to the non-past form. - The two groups of participants marked past tense for the irregulars more frequently than for the regulars.
Bayley (1994)	Salience effects on L2 learners' past tense marking for English regulars and irregulars	L1 Mandarin learners living in the United States categorized into two groups by proficiency levels: high and low	Two sociolinguistic interviews conducted to elicit the subjects' natural speech which showed how they marked past tense for regulars and irregulars	- Verbs' salience could have effects on past tense marking. - The two groups of participants marked past tense for the irregulars more frequently than for the regulars.
Hawkins & Liszka (2003)	Omissions of the past tense forms of English regulars and irregulars by L2 learners	Advanced L2 learners from various L1 backgrounds: Japanese, German, and Chinese	- A morphology test - A spontaneous oral production test	- Concerning the morphology test, all the three groups of L2 learners performed as nearly well as the native controls of the study. - In the production test, the L1 Chinese subjects showed a significantly lower rate of regular past tense marking in the past contexts than the other two groups did. The lower rate of past tense marking was due to the absence of the feature [±past] in the subjects' native language, supporting the FFFH account.

Khumdee & Pongpairoj (2014)	L2 learners' omissions of the past tense forms of English verbs	Two groups of L1 Thai learners with different English proficiency levels: intermediate and advanced	- The representation test, i.e., a grammaticality judgment test - The production tests, namely a cloze test and a story-telling test	- The two groups of subjects displayed omissions of the past tense forms of English verbs in all the three tests. This could be accounted for by the FFFH proposal. - Both proficiency groups were found to supply irregular past tense marking more frequently than regular past tense marking.
Prapobaratanakul & Pongpairoj (2016)	L2 learners' omissions of the past tense forms of English verbs	An L1 end-state Thai learner	- A grammaticality judgment task (GJT) - A spontaneous production task (SPT)	- The L1 Thai participant's correct suppliance of regular past tense morphemes was lower than that of irregular past tense inflections. - The subject's correct use of the English past tense morphemes in the two tasks suggested that she had the syntactic knowledge of past tense morphology. - The participant's correct use of past tense morphemes in the GJT was much higher than that on the SPT. The omissions of the past tense inflections observed in the subject's performance on the SPT might be caused by an extra-syntactic factor, i.e., the non-existence of final consonant clusters in Thai. This substantiated the MSIH notion.

Table 23: Previous studies exploring L2 acquisition of the past tense forms of English regulars and irregulars

Study	**Investigated Topic**	**Participants**	**Research Instruments**	**Results and Implications**
Solt et al. (2003)	Perceptual salience effects on L2 learners' production of three allophones of the English regular past – *ed* morpheme, i.e., the syllabic [ɪd] and the non-syllabic [t] and [d]	L2 English learners of different L1 backgrounds divided into two groups according to their L2 proficiency: high and low	- A perception task - A perception/production task	- In the perception task, the two groups of subjects were shown to perceive the syllabic allomorph better than the non-syllabic ones. - In the perception/production task, only the more advanced participants could compensate for the limitations by using the contextual cues to produce the morpheme nearly as correctly as the native English speakers.
Klein et al. (2004)	Perceptual salience effects on L2 learners' production of three allophones of the English regular past – *ed* morpheme, i.e., the syllabic [ɪd] and the non-syllabic [d]	L2 English learners of different L1 backgrounds	- A perception task	- The researchers observed a higher rate of accurate past tense marking for the verbs needing the syllabic [ɪd] compared to those which required the non-syllabic [d].

Table 24: Previous studies exploring L2 acquisition of the past tense forms of English regulars

2.5 Summary

This chapter provides the literature review on four main areas: the human brain and working memory, English past participial reduced relative clauses and Thai reduced relative clauses, salience degrees of past tense and past participial forms of English verbs, and previous research on the three fields mentioned above.

The first section dealt with the components of the human brain and working memory. The literature review described two ways of dividing the brain anatomically: the division based on the embryonic development and that on the cerebral hemispheres. The reviewed working memory models were Baddeley and Hitch's (1974) and Baddeley (2000). In the following section, the similarities and differences between the English past participial reduced relative clauses and the Thai reduced relative clauses were reviewed. The third section elaborated on salience of English past tense and past participial verb forms. This section gave definitions of salience in the linguistics field, described some of the well-established salience hierarchies of English past tense forms, including Wolfram (1985), Bayley (1994), and Tajika (1999), and explained two limitations of Bayley's classification which made the hierarchy unable to account for salience levels of the English irregular past participial forms. The last section synthesized three groups of previous studies related to the present study. The first research group investigated the effects of working memory on L1 and L2 cognitive processing. Some studies observed the WM influence on readers' processing while others did not. The second group of studies explored how native speakers and L2 learners processed English past participial reduced relative clauses. The research on the L1 processing examined effects of WM on the processing whereas those on the L2 processing did not use WM to account for the subjects' processing. The third group of research tackled L2 acquisition of regular and irregular verbs in English. The production of the past tense forms was influenced by several factors, such as salience levels of the past tense forms, the verb types (i.e., the regular and irregular verbs), and the regular verb types (namely the syllabic [ɪd] and the non-syllabic [d]).

In the next chapter on research methodology, details about research instruments, research participants, data collection and analyses, and implications of the pilot study are presented.

CHAPTER III
METHODOLOGY

This chapter involves the methodology used in the present study. Section 3.1 gives information about research instruments, followed by research participants in 3.2. Sections 3.3 and 3.4 discuss data collection and data analyses, respectively. Section 3.5 concerns the implications of the pilot study. Next, information on recruitment of research participants and compliance with research ethics for research involving human participants is reported in Section 3.6. Finally, Section 3.7 summarizes the methodological information in this chapter.

3.1 Research instruments

The research instruments employed in this study include a reading span task (RST) and a self-paced reading task (SPRT). Since both tasks are computerized, the specific technical requirements for the two instruments must be discussed as well. Thus, this section comprises four subsections, i.e., Subsection 3.1.1, dealing with the technical requirements for the RST and the SPRT, Subsection 3.1.2, clarifying the RST and steps in using it, Subsection 3.1.3, providing details about the SPRT, the design of the task, and its usage, and Subsection 3.1.4, focusing on the validation of the salience hierarchy of the past participial forms of English irregulars as well as the research instruments.

3.1.1 Technical requirements for the research instruments

This subsection consists of three parts, namely Subparts 3.1.1.1, 3.1.1.2, and 3.1.1.3, which address technical specifications needed for laptops or personal computers (PCs), installation of the SuperLab 5.0 program, and installation of the Cedrus Data Viewer (CDV) program, respectively.

3.1.1.1 Technical specifications for the laptops or PCs

In order for a laptop or PC to run and use the RST and the SPRT, the SuperLab 5.0 program, i.e., a psychological experiment generator, and the CDV program, namely a data collection program, must be uploaded and installed in the

laptop or PC first. To ensure successful installation of the two programs, the laptop or PC should meet the minimum technical specifications outlined in Table 25.

Aspect	Minimum Requirement(s)
Operating system	Windows 7, 2000, XP (SP3) or Vista
Application programming interface	DirectX 9.0 or later versions of DirectX
RAM	1 GB
CPU Processor	Dual core processor or higher processors
Device	A mouse or touchpad

Table 25: Minimum technical specifications for the laptops or PCs (Version 5.0; SuperLab, 2014)

3.1.1.2 Installation of the SuperLab 5.0 program

As aforementioned, the SuperLab 5.0 program must be installed in a laptop or PC so that the RST and the SPRT can be applied. The steps in installing the program for the present study are as follows.

Step 1: To install the SuperLab 5.0 program, the access to the Internet was required. First, https://cedrus.com/superlab/download.htm was accessed. Then, the "Download Free Trial of SuperLab" screen (Image 1) appeared, revealing two versions of SuperLab for two different operating systems: Macintosh and Windows. The version which suited the operating system of the given laptop or PC was selected. For the present study, the Windows version was employed since it matched the technical specifications of the used laptop.

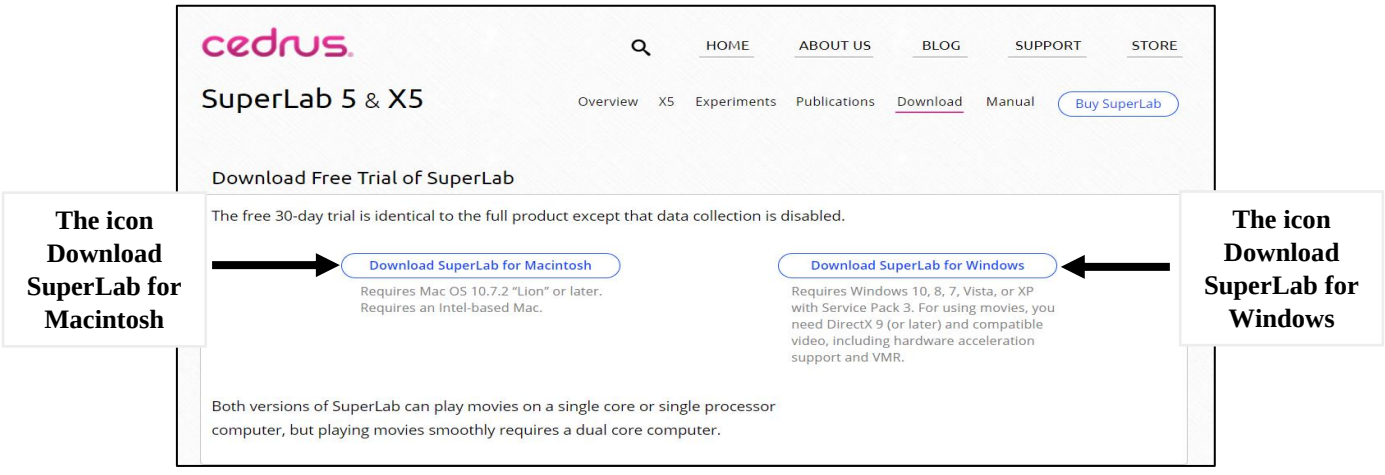


Image 1: The Download Free Trial of SuperLab Screen. Retrieved April 24, 2020, from https://cedrus.com/superlab/download.htm

Step 2: The downloaded file SuperLab was saved in a destination location in the laptop, namely Downloads. The file can be opened by double-clicking it in the destination location, as displayed in Image 2.

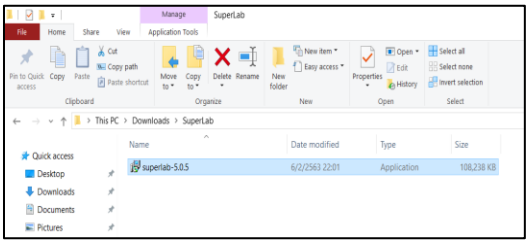


Image 2: A Sample of the Location of the Downloaded File SuperLab

Step 3: Then, a security warning box (Image 3) emerged. The “Yes” button was clicked in order to continue with the installation.

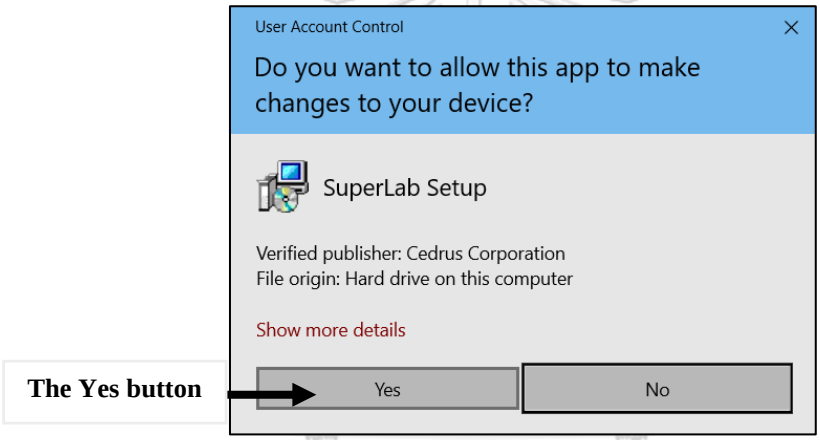


Image 3: The Security Warning Box

Step 4: After that, the “Setup Wizard” screen (Image 4) showed up. The “Next >” button was clicked.

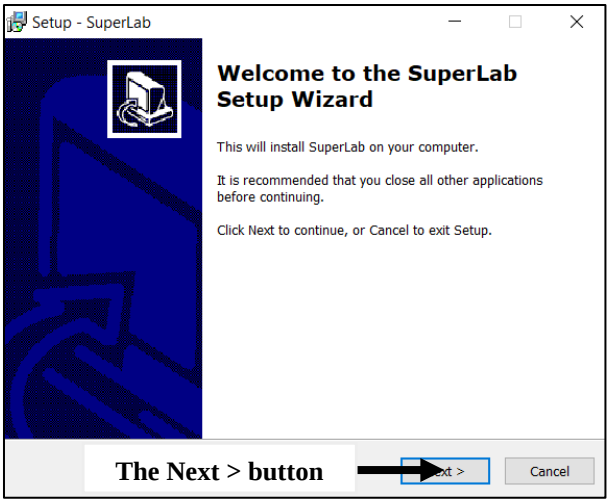


Image 4: The Setup Wizard Screen

Step 5: Next, the “License Agreement” screen (Image 5) appeared. The choice “I accept the agreement” was ticked, and then the “Next >” button was clicked.

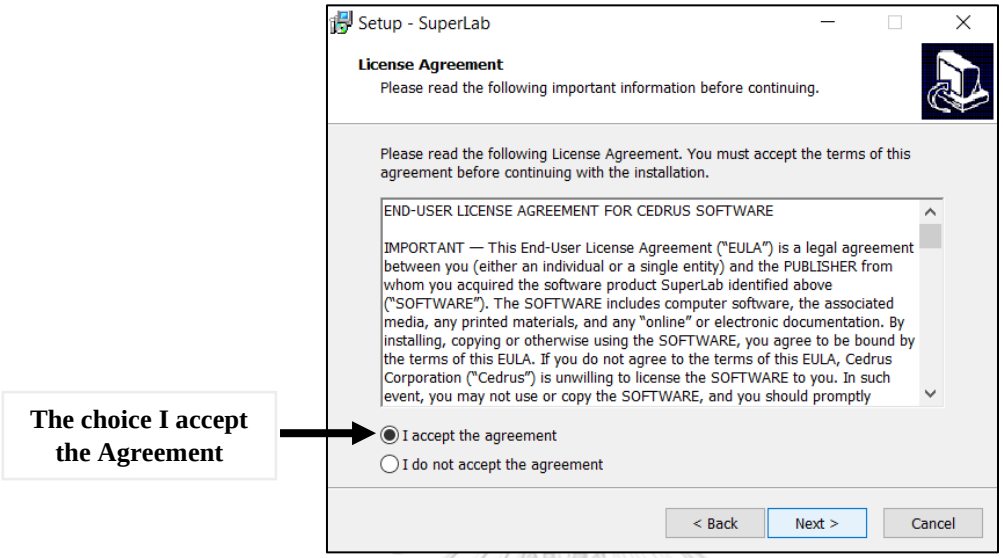


Image 5: The License Agreement Screen

Step 6: The “Select Destination Location” screen (Image 6) was shown. The destination location in which SuperLab would be installed was chosen by clicking the “Browse” button. After the location was selected, the “Next >” button was clicked.

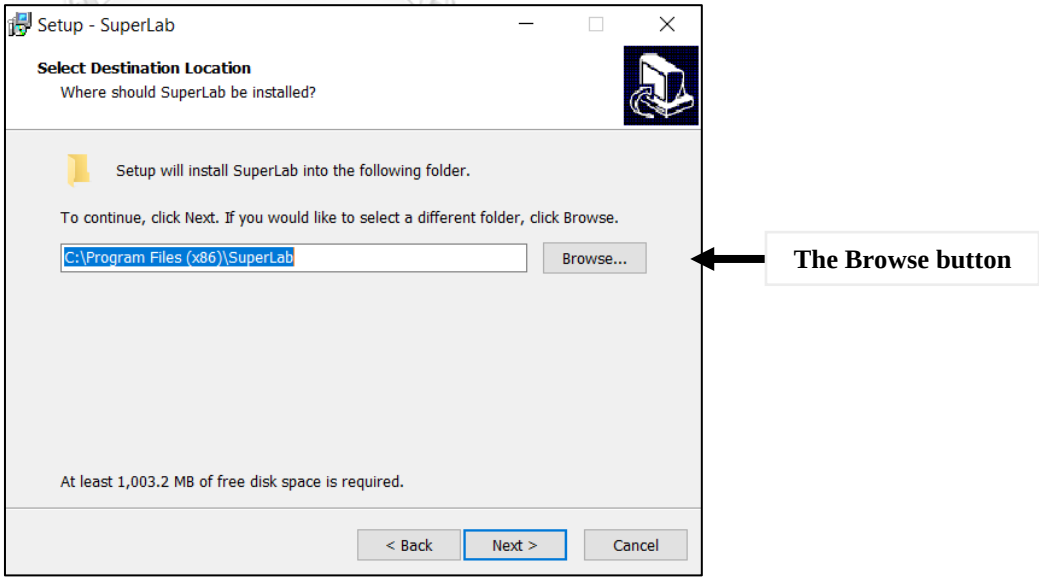


Image 6: The Select Destination Location Screen

Step 7: Then, the “Ready to Install” screen (Image 7) appeared. The “Install” button was clicked to continue with the installation.

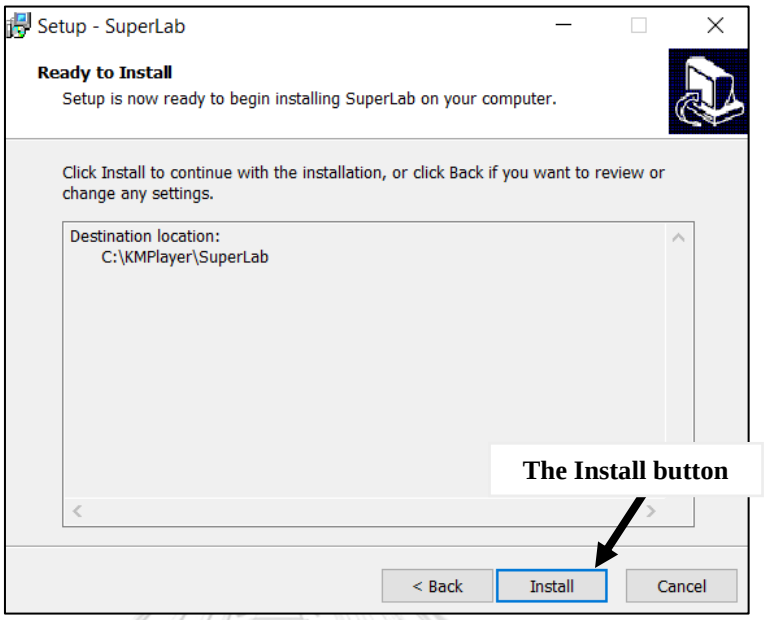


Image 7: The Ready to Install Screen

Step 8: The “Ready to Install” screen was followed by the “Installing” screen which showed that the SuperLab program was being installed in the selected destination location. The “Installing” screen is provided in Image 8.

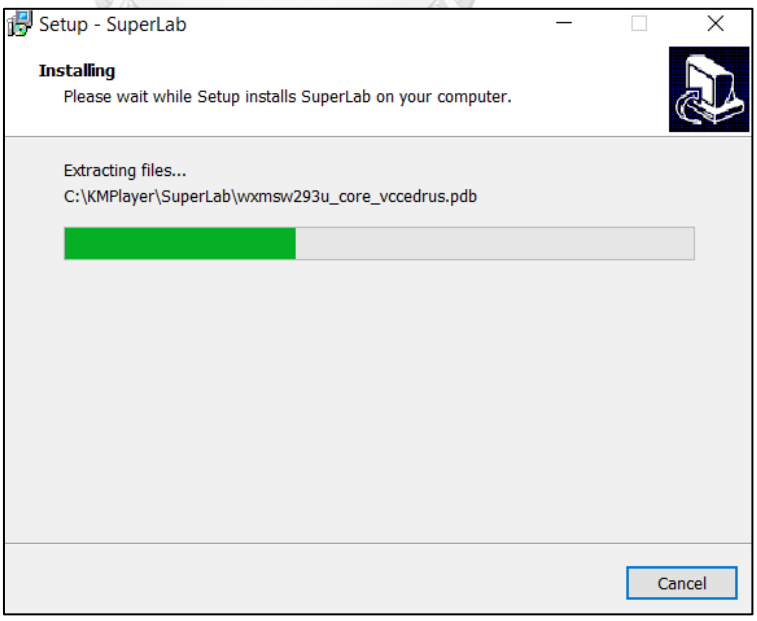


Image 8: The Installing Screen

Step 9: Next, the “Information” screen (Image 9) showed up. The “Next >” button was clicked.

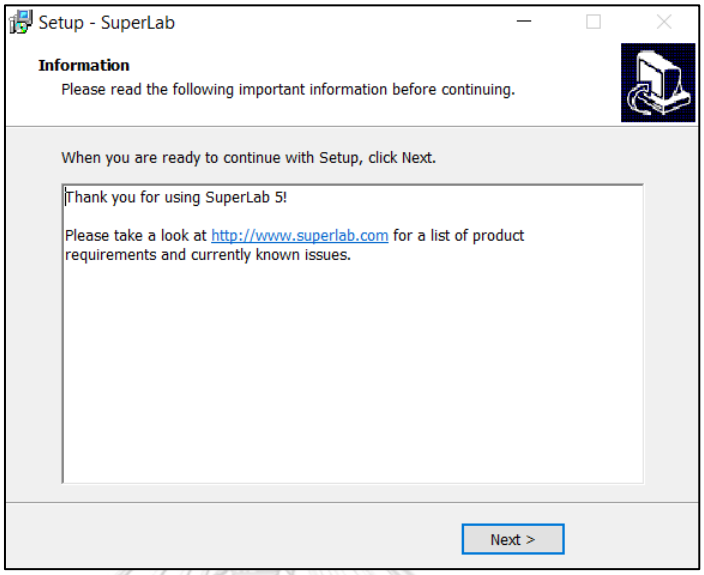


Image 9: The Information Screen

Step 10: Finally, the “Completing the SuperLab Setup Wizard” screen (Image 10) appeared. The “Finish” button was clicked to complete the installation.

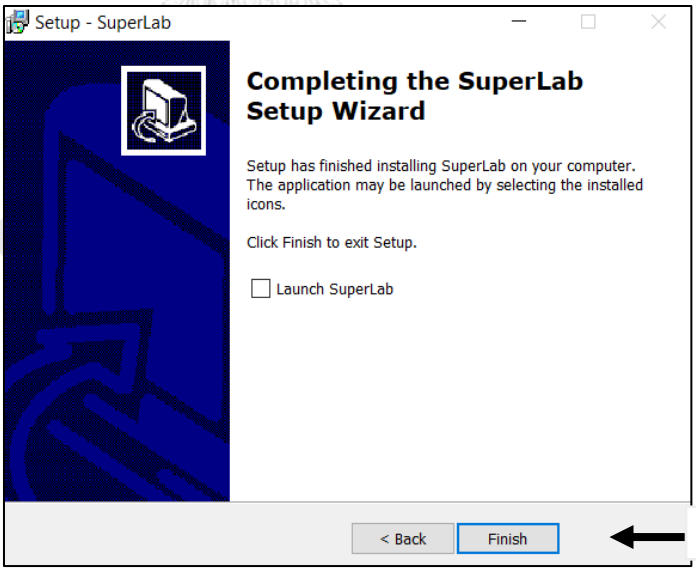


Image 10: The Completing the SuperLab Setup Wizard Screen

Step 11: The download free trial was available for 30 days. To obtain a perpetually available product, the researcher needed to purchase it at https://cedrus.com/store/superlab.html. When the “Shop SuperLab Licenses” screen

(Image 11) showed up, the “Add to Cart” button was clicked to have a product purchased. After the researcher had bought a product, a license key was emailed to him.

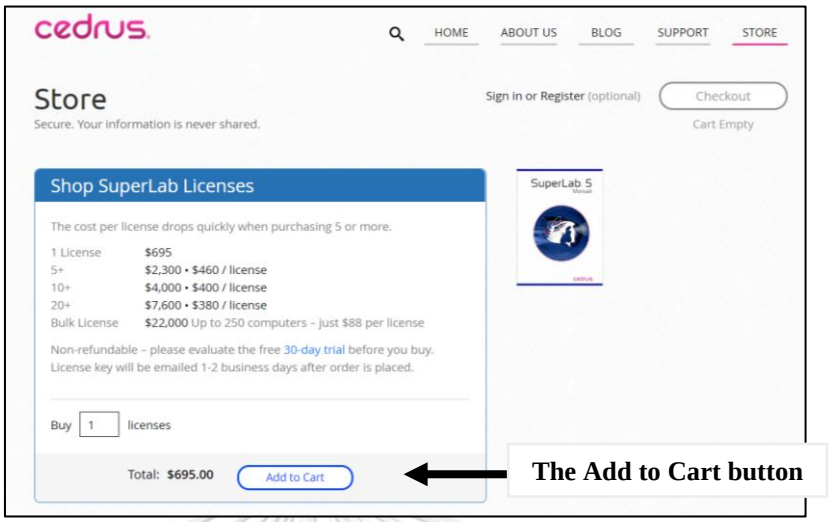


Image 11: The Shop SuperLab Licenses Screen. Retrieved April 24, 2020, from https://cedrus.com/store/superlab.html

Step 12: Then, the SuperLab program was opened. The “Help” menu was clicked, and the “License” button was chosen. After that, the “Activate SuperLab” screen (Image 12) appeared. For the first activation of a SuperLab license, the received license key was entered in the “License and Lease Key” blank. Next, a valid email address and password were keyed, and the “Next >” button was clicked. In case of the subsequent activation of the license, the email address and password are keyed, and the “Next >” button is clicked. Then, the on-screen instructions are followed.

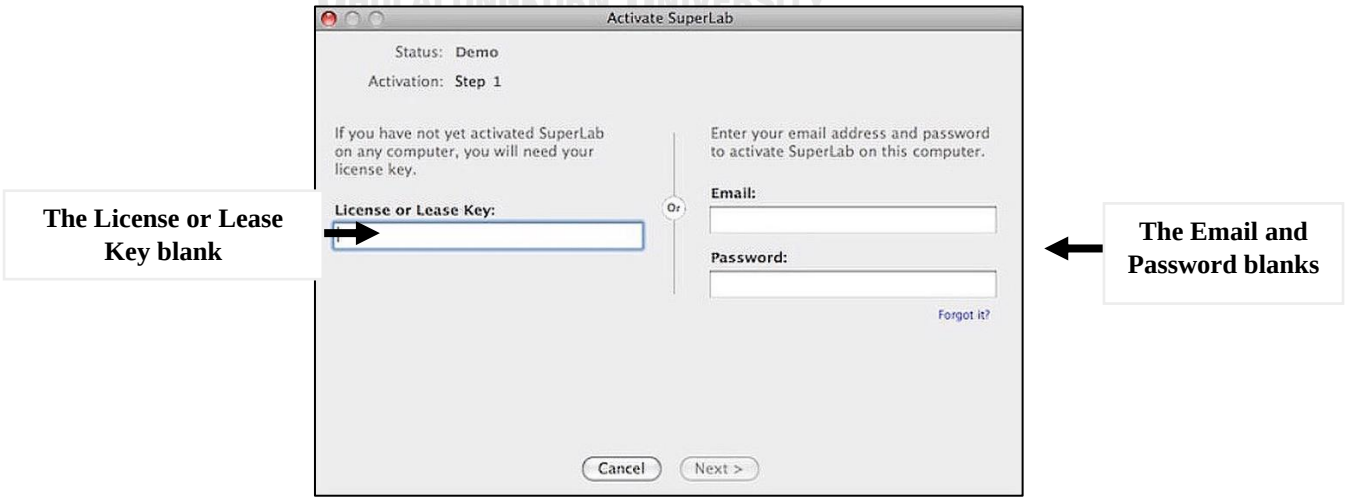


Image 12: The Activate SuperLab Screen

Step 13: After the license is activated, the “Create Lease Keys” screen (Image 13) emerges for the researcher to choose the activation period ranging from 1 day to a year. When the period ends, the activation can be freely renewed.

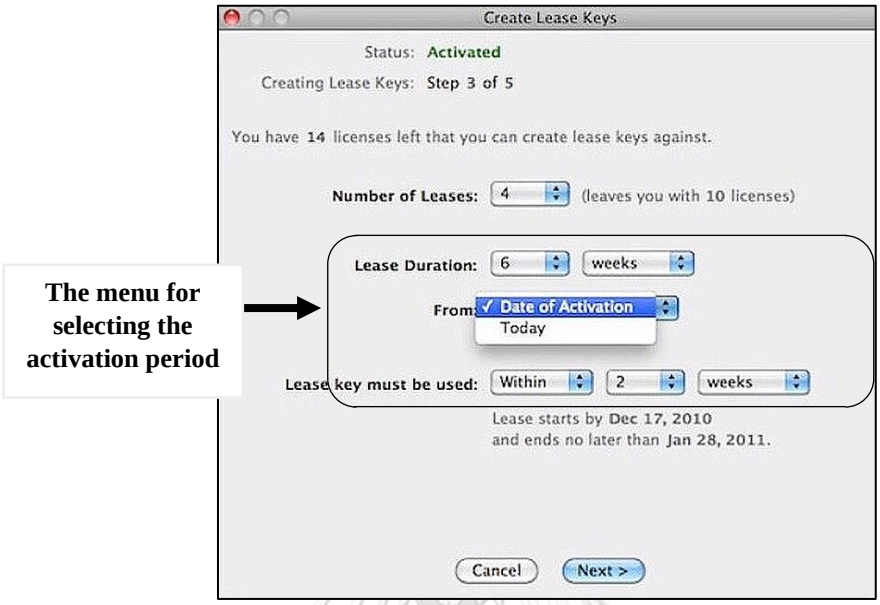


Image 13: The Create Lease Keys Screen

3.1.1.3 Installation of the Cedrus Data Viewer program

Cedrus Data Viewer (CDV) is a program used to see the evaluation results and statistical data of the RST and the SPRT. For the present study, the CDV program was installed in the given laptop by following the instructions below.

Step 1: First, https://cedrus.com/superlab/dataviewer.htm was visited. Then, the “Download Data Viewer” screen (Image 14) appeared, revealing two versions of the CDV for two different operating systems: Macintosh and Windows. Similarly to the selection of the SuperLab version, the CDV version suiting the operating system of the given laptop or PC has been chosen. For the present study, the Windows version will be employed.

Image 14: The Download Data Viewer Screen. Retrieved April 26, 2020, from https://cedrus.com/superlab/dataviewer.htm

Step 2: Next, the “Cedrus Data Viewer Setup Wizard” screen (Image 15) showed up. The “Next >” button was clicked in order to install the CDV.

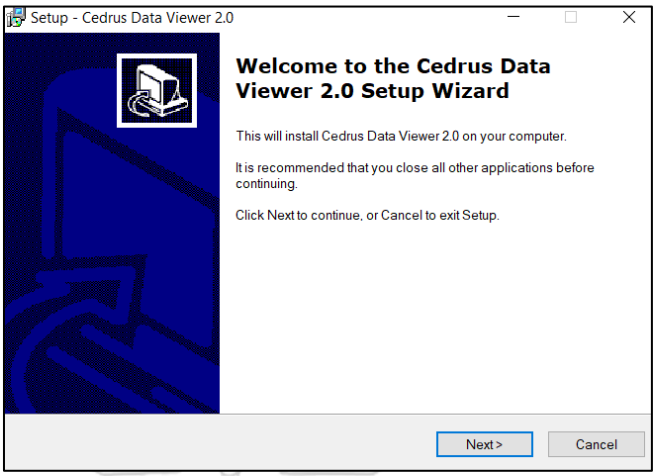


Image 15: The Celdrus Data Viewer Setup Wizard Screen

Step 3: After the installation was completed, the CDV has been available for use. The screen of the CDV program is displayed in Image 16.

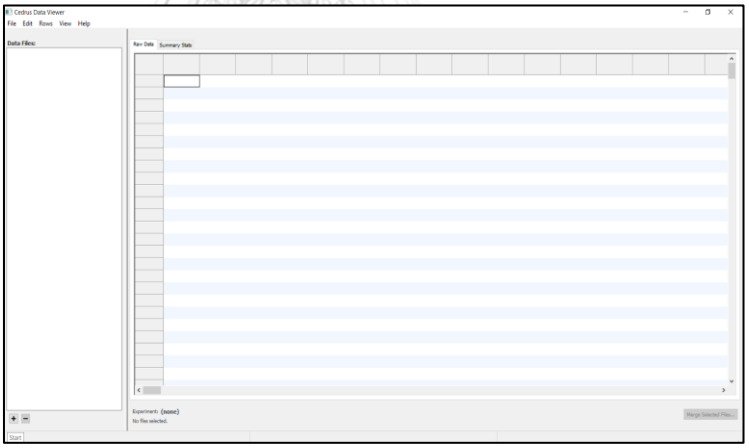


Image 16: The Screen of the Cedrus Data Viewer Program

3.1.2 Reading span task

A Thai reading span task (RST) was employed to evaluate the L1 Thai participants’ WM. This subpart contains two main parts: 3.1.2.1 and 3.1.2.2, which describe the design of the RST and the steps in employing the task, respectively.

3.1.2.1 The design of the RST

As seen in several L2 processing studies, WM could be assessed in either the native language (e.g., Felser et al., 2003; Roberts et al., 2007; Hestvik et al., 2012; Kim & Christianson, 2017) or the learnt language of the participants (e.g., Havik et al., 2009; Dussias & Piñar, 2010; Hopp, 2015). Measuring the participants' WM in their L1, however, has been claimed to prevent the problem of confounding effects between WM and L2 proficiency since an interaction between the research participants' WM assessed in their L2 and their language proficiency has been reported, for example, in Service et al. (2002), Omaki (2005), Van den Noort et al. (2006), and Coughlin and Tremblay (2013).

Concerning the stimuli of the RST, there are various types of to-be-remembered items, such as words, digits, and letters. Letters in the research participants' L1 are possibly the most appropriate in light of their two main properties which could reflect individuals' WM more clearly than digits and words, specifically the low degree of vulnerability to grouping and the lack of semantic load. The first property of letters which makes them suitable stimuli is that they are less vulnerable to chunking. As claimed by Zirk-Sadowski et al. (2013), the items which can be divided into meaningful chunks tend to be more easily recalled than those which cannot; therefore, an individual's high RST score obtained from chunkable items might indicate her bias in favor of meaningful stimuli rather than her high WM. According to Lezak et al. (2004), random letters are less susceptible to being grouped whereas digits can be more easily chunked into higher order units, for instance, 4-9-2-7 converted into "forty-nine, twenty-seven". The second property of letters is that they do not carry semantic burden, and thus, they should be commonly known. As a result, letters could minimize effects of variance in level of knowledge of the to-be-remembered items. On the contrary, Engle et al. (1990) revealed that the correlation between research participants' word span and a measure of higher order cognition, including reading comprehension, could be modulated by their word knowledge. In other words, differences in the participants' performance on word span tasks might not suggest their different WM degrees, but their varying levels of vocabulary knowledge instead.

The present study obtained Phinitkit's (2015) permission to employ his automated reading span task in Thai. The RST was used to classify the L1 Thai learners into two groups according to their WM span size: the higher WM participants and the lower WM ones. In his research, Phinitkit developed a computer program consisting of two memory span tasks, i.e., an operation span (OSPAN) task and the mentioned RST. The two tasks were primarily aimed to measure WM of L1 Thai upper secondary school students in Thailand in relation to their language capabilities. The memory span tasks are entirely driven by a mouse or touchpad, paced on the basis of each individual's time to finish calculating the math operations or reading the target sentences. The program automatically produces a score upon the task completion, and records the individual's response time in milliseconds. The test structure and presentation of stimuli in the tasks follow those in the Automated Complex Span Tasks (CSTs) developed by Unsworth et al. (2005) which have been claimed to make use of two main components of WM, namely manipulation and storage of information. Only Phinitkit's RST was included as the memory span task of the present study due to two reasons. Firstly, Phinitkit's RST was basically constructed to examine native Thai speakers' memory span with respect to language abilities, so it served an objective of the present study, i.e., exploring the correlation between L1 Thai learners' WM and their syntactic processing. Secondly, previous WM studies showed that an RST was adequate to examine WM in relation to language capabilities (e.g., Juffs, 2004; Rodríguez, 2008; Sagarra & Herschensohn, 2010; Kim & Christianson, 2017). However, some research employed more than one memory span task with certain purposes. For instance, the research participants in Coughlin and Tremblay (2013) took two RSTs assessing their WM in both their L1 and L2 because the researchers aimed to look into the correlations between the memory span in the two languages. Concerning Phinitkit's research, the RST and the OSPAN were created to assess their criterion-related validity, compared with those in the standard program, i.e., the CSTs.

In Phinitkit's RST, there were 75 unrelated Thai sentences, each of which consisted of 6-11 words, and the sentences were divided into 15 sets. The sentences were shown on the computer screen in Cordia New, size 66 font, in bold black letters.

Each sentence was put in a light grey box placed in the center of the screen against a white background. The participants were instructed to read the sentences silently without pausing between sentences since language-related data tend to access the memory system via silent reading better than via reading aloud (Keller et al., 2003). They read and judged plausibility of the sentences at their own pace. At the end of a series, they were asked to recall the Thai letter which appeared after each sentence in the set in the order they were presented. For example, consider the following set of three sentences in (121).

(121) a. "แม่ถือร่มไปตลาดเพราะฝนกำลังจะตก (Mom went to the market with an umbrella in her hand because it was going to rain) – ฟ,"

b. "ชินกรเติมน้ำตาลลงในก๋วยเตี๋ยวช่วยเพิ่มความเค็ม (Chinnagorn added sugar in the noodles in order to make them saltier) – ร,"

c. "สมบัติขับรถยนต์บนน้ำทะเล (Sombat is driving a car on the sea) – ม".

After reading the three sentences in (121), the participants were to recall the letters 'ฟ,' 'ร,' and 'ม' in their correct serial position by selecting them from a 4 x 3 matrix of twelve Thai letter alternatives which followed the series of the sentences. The participants were given all of the time that they needed to recall the letter sequence. One correctly recalled letter was given one point, so the full mark of the RST was 75. Any deviation was counted as an error. Thus, if a research participant recalled the order of the presented letters in (121) as 'ฟ,' 'ร,' and 'ม', she would get three points. By contrast, in case she recalled the letter sequence as 'ร,' 'ฟ,' and 'ม', one point would be given to her. After the participant finished recalling a set of sentence-letter strings, the computer provided feedback about the number of letters correctly recalled in the current set.

Initially, the subjects were given three sets with three sentences per set. Then, they were presented with three four-sentence sets, followed by five-, six-, and seven-sentence sets. Before the actual experiment, the participants took five two-sentence trials in order to ensure their comprehension of the procedure.

The design of the task was comprised of two main parts, i.e., the selection of the Thai letters and the design of the Thai sentences.

As far as the selection of the Thai letters was concerned, Phinitkit (2015) chose twelve Thai letters which were phonologically distinct to be stimuli of his RST, following the RSTs in earlier studies (e.g., Kane et al., 2004; Gass & Lee, 2011). The selection of the letters was based on Charunrochana's (2009) classification of the consonantal sounds in Thai into six groups according to the places of articulation where the sounds are made. Two sounds made at each of the six articulatory places were chosen in order to avoid phonological similarities among the letters. The six places of articulation and the two selected sounds from each group are shown in Table 26.

The Places of Articulation	The Selected Sounds
Velar	ก ง
Palatal	จ ย
Bilabial	บ ม
Labiodental	ฟ ว
Alveolar	ร ต
Glottal	อ ฮ

Table 26: The six places of articulation and the selected sounds from each articulatory place used in Phinitkit (2015)

At recall, the participants viewed a 4 x 3 matrix of the twelve letters. Regarding the sequence of the letters shown in the RST, the presented letters in each series were ordered in a way in which they did not make a meaningful word, a non-word which sounded similar to a word or an abbreviation in Thai, such as "รวย" (i.e., a Thai word meaning "rich"), "รฟม" (i.e., the abbreviation for การรถไฟฟ้าขนส่งมวลชนแห่งประเทศไทย, namely "Mass Rapid Transit Authority of Thailand"), and "องรวม" (i.e., a non-word which sounded exactly the same as the Thai word "องค์รวม" meaning "holism"). This was to make sure the participants' performance on the task was not influenced by meaningfulness resulting from the ordering of the letters.

With respect to the design of the Thai sentences, Phinitkit composed 75 unrelated Thai sentences for the participants to determine their semantic plausibility, i.e., whether they were logical and likely to be true. Thirty-eight sentences were plausible whereas the other thirty-seven sentences were implausible.

Examples of the plausible sentences and the implausible ones are shown in (122a) and (122b), respectively (See all the sentences in the RST in Appendix B).

(122) a. "สมหมายท่องสูตรคูณเพื่อเตรียมสอบวิชาคณิตศาสตร์ (Sommai is memorizing the multiplication table in order to get prepared for the math exam)"

b. "ปิติกำลังพายเรืออยู่บนถนน (Peeti is rowing a boat on the road)"

As mentioned, the RST was originally made to assess WM of upper secondary school students whose L1 was Thai; therefore, the content of the sentences in the task addresses events in the Thai context, involving Thai proper names of persons, Thai foods, and places in Thailand.

Phinitkit (2015) measured the content validity and the criterion-related validity of the RST. Details of the validation of the RST are provided in 3.1.4.

3.1.2.2 The steps in using the RST

Concerning the steps in using the RST for the present study, there are 16 steps as follows.

Step 1: The RST program was placed in a destination location in the given laptop. To open the program, the RST icon displayed in Image 17 is double-clicked.

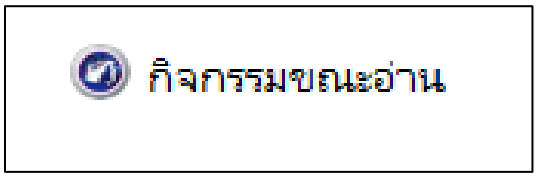


Image 17: The RST Icon

Step 2: Then, the RST box (Image 18) appeared. The “Start” icon in the box was clicked in order to start the experiment.

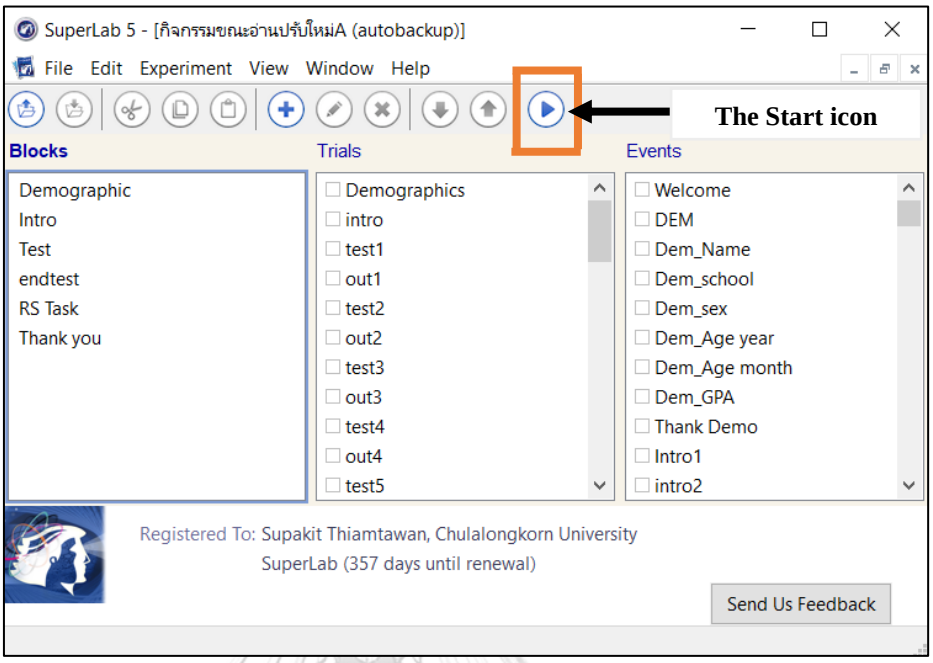


Image 18: The RST Box and the Start Icon

Step 3: Once the “Start” icon was clicked, the “Run Experiment” box with two blanks (Image 19) appeared for the research participant to fill in information about her name and institution. Next, the “Run” button was clicked.

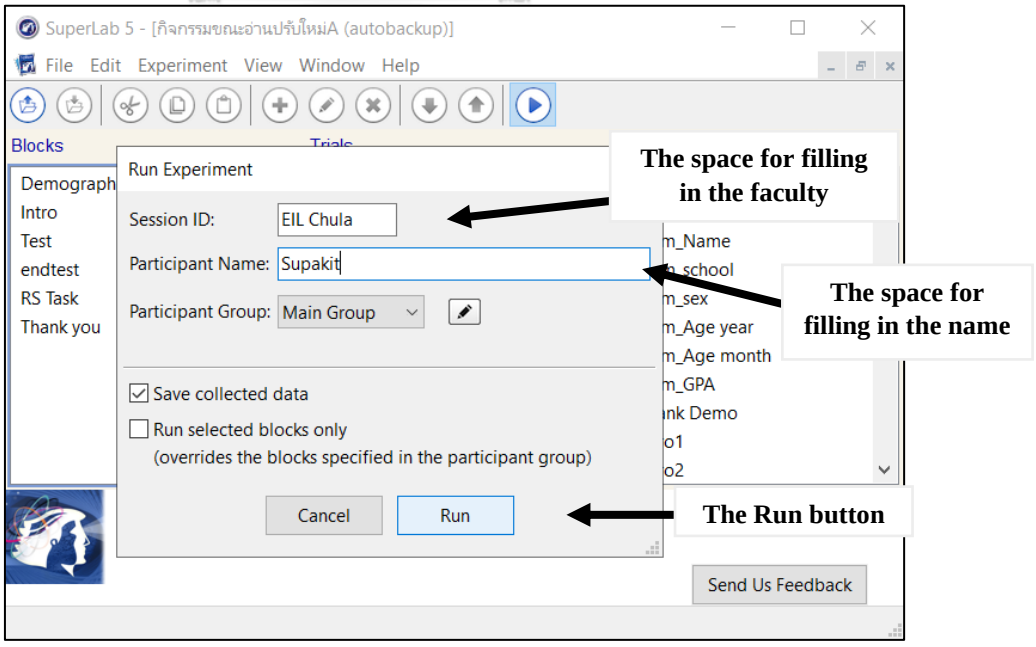


Image 19: The Run Experiment Box

Step 4: After that, the “Save the Collected Data File” box (Image 20) showed up so that the program created a text file which recorded the data about the WM assessment. The file was named by filling in the participant’s name in the “File Name” blank. A location in which the text file was saved was chosen. Then, the “Save” button was clicked.

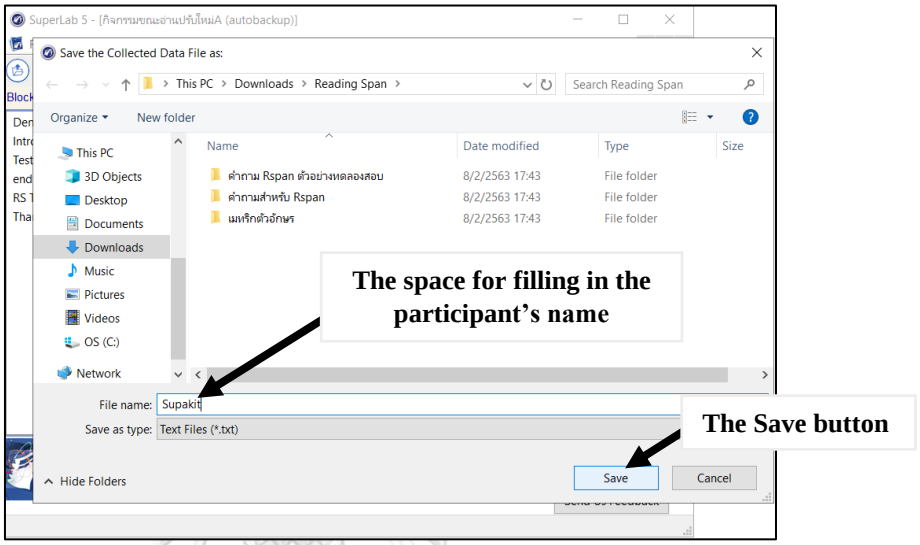


Image 20: The Save the Collected Data File Box

Step 5: Next, the “Welcome-to-the-RST” screen (Image 21) appeared.

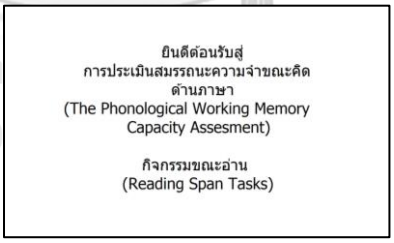


Image 21: The Welcome-to-the-RST Screen

Step 6: Then, the research participant was required to fill in personal information about her name, institution, gender, age in years, age in months, and grade point average (GPA) in the subsequent window screens, as shown in Image 22.

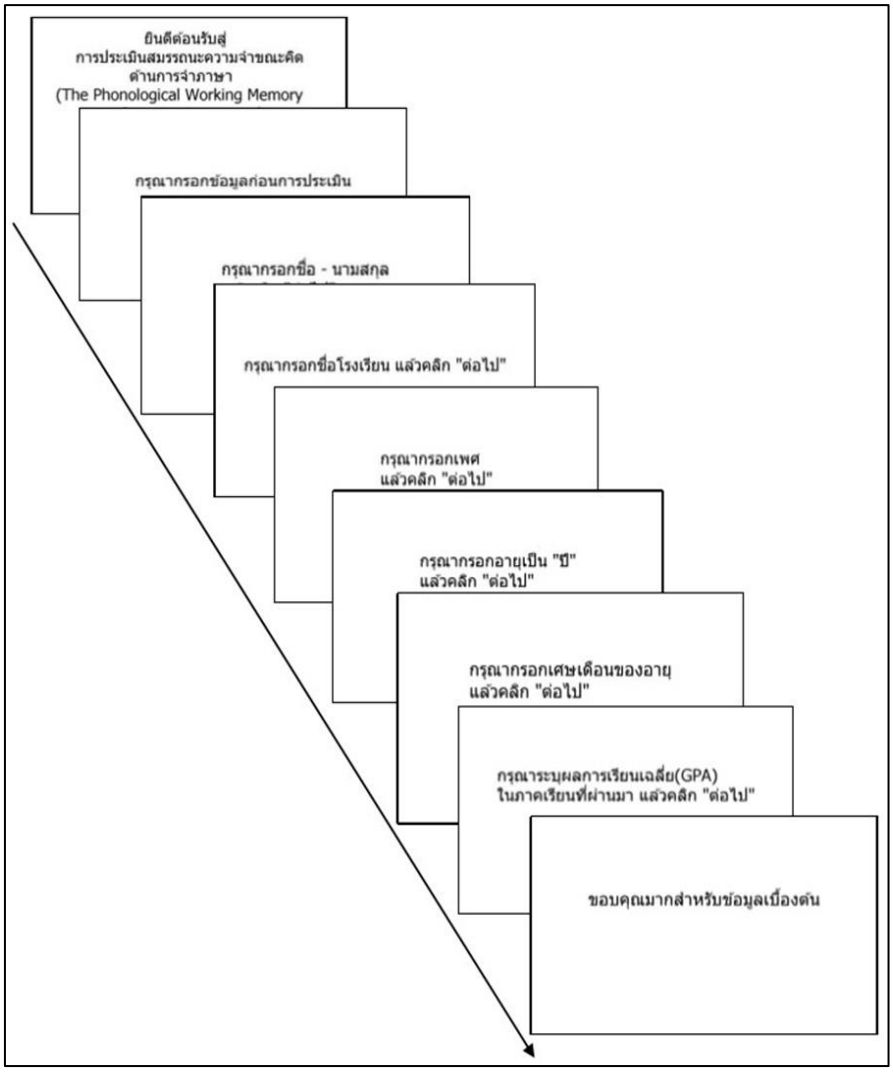


Image 22: The Window Screens for Filling in the Subject’s Information

Step 7: The following window screens showed the instructions on how to take the test and the scoring procedure, as revealed in Image 23.

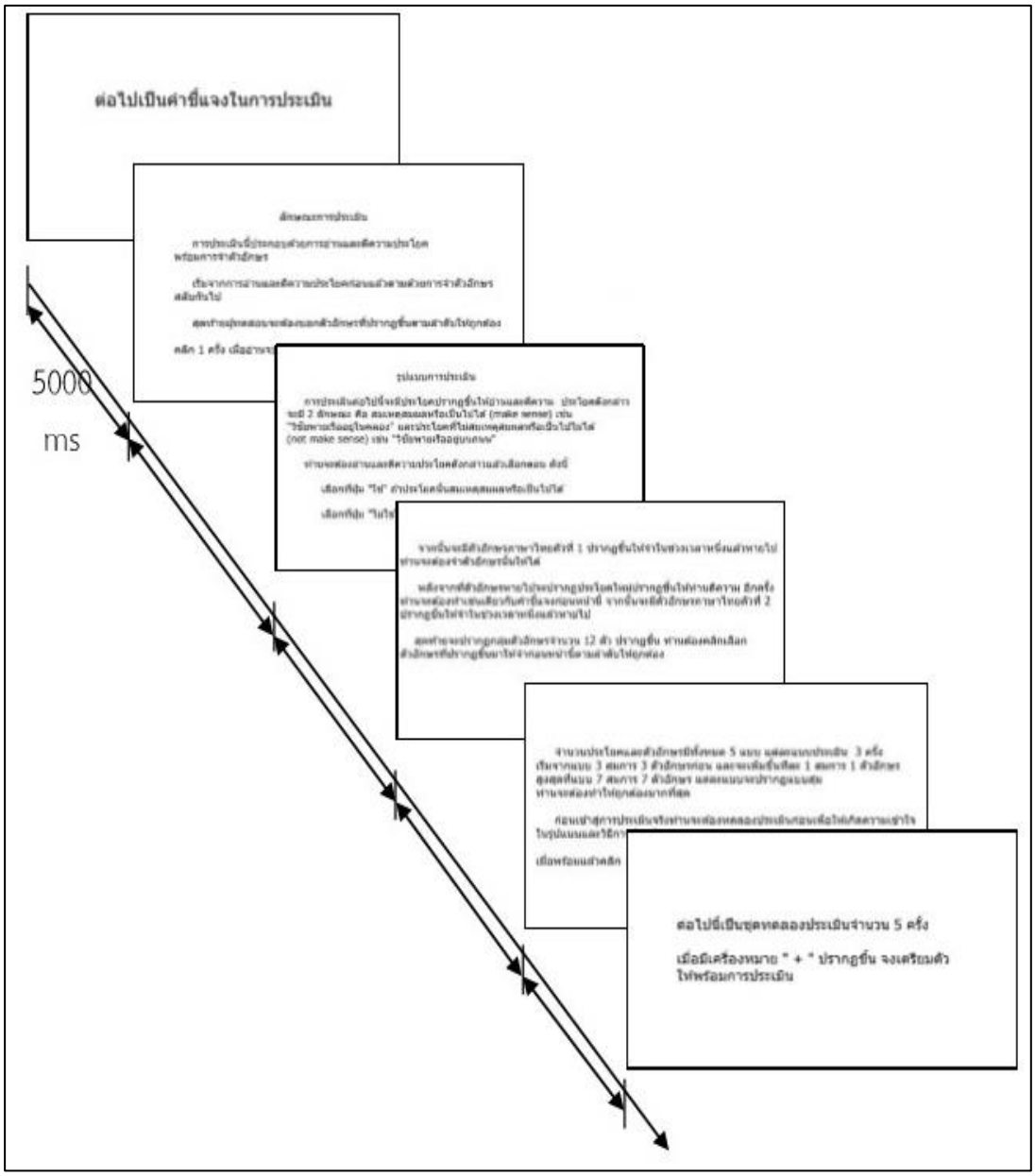


Image 23: The Window Screens on
the Test-taking Instructions and the Scoring Procedure for the RST

Step 8: Next, the research participant was required to take part in five two-sentence trials in order to ensure her comprehension of the test-taking procedure. The participant's performance on the trials was excluded from the data analyses. The window screen introducing the five trials is manifested in Image 24.

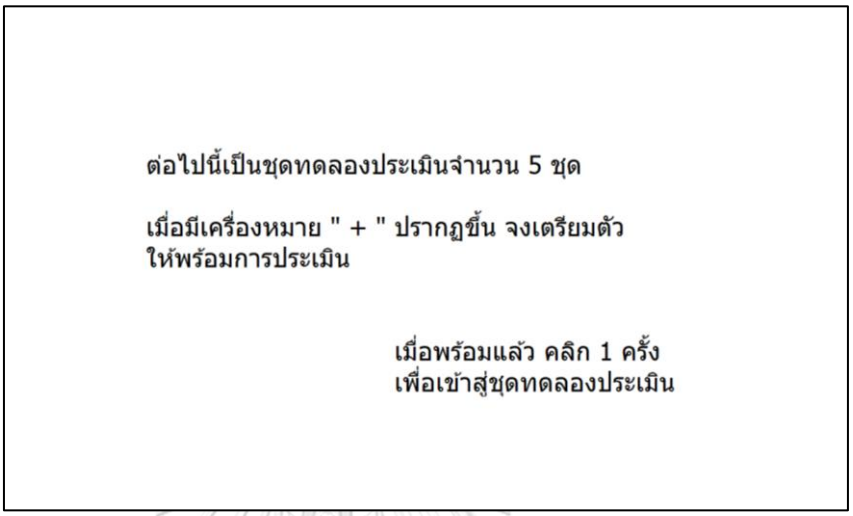


Image 24: The Window Screen Introducing the Test Trials

Step 9: After the research participant finished the five trials, the actual experiment began. The test contained 15 sets of unrelated Thai sentences ranging from three to seven, with 75 sentences in total. Before the first item of each set, the symbol + appeared at the center of the screen in order to cue the participant to get prepared for the experiment. The symbol + occurred for 800 milliseconds, and disappeared. Image 25 shows the window screen with the cue.

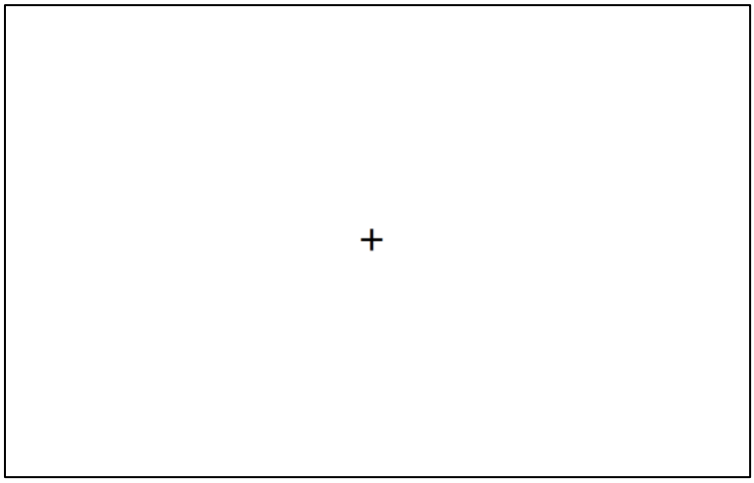


Image 25: The Window Screen with the Symbol +

Step 10: Then, a sentence showed up with two icons below, namely one with the Thai word “ใช่” (i.e., Yes in Thai) and the other with “ไม่ใช่” (i.e., No in Thai). If the participant thought that the sentence was plausible, she was supposed to click the icon “ใช่”. If she found the sentence implausible, she was instructed to click the icon “ไ ม่ ใ ช่ ”. Image 26 reveals the window screen showing a Thai sentence for the participant to judge its plausibility and the two icons.

Image 26: The Window Screen Showing a Thai Sentence for Plausibility Judgment

Step 11: After the participant clicked the icon that she thought was correct, the window screen with the Thai sentence disappeared. Then, a random Thai letter or the to-be-remembered stimulus appeared at the center of the screen. Each letter was shown for 800 milliseconds, and disappeared. The participant was instructed to recall the shown letter. The window screen showing a Thai letter is provided in Image 27.

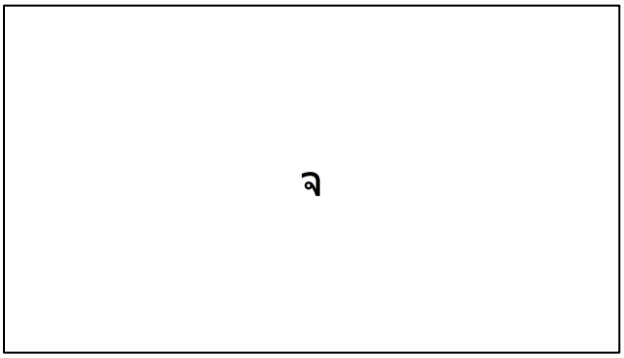


Image 27: The Window Screen Showing a Thai Letter

Step 12: Then, the following window screen showed the next sentence-letter string. Once the participant saw all the sentence-letter strings in the current set, a 4 x 3 matrix of twelve letter icons (ก, ง, จ, ต, บ, ฟ, ม, ย, ร, ว, อ, and ฮ) came next. Each icon showed a Thai letter, and the participant was required to click the Thai letters she saw in the set in the order as they were presented. The window screen showing the twelve letter icons is provided in Image 28.

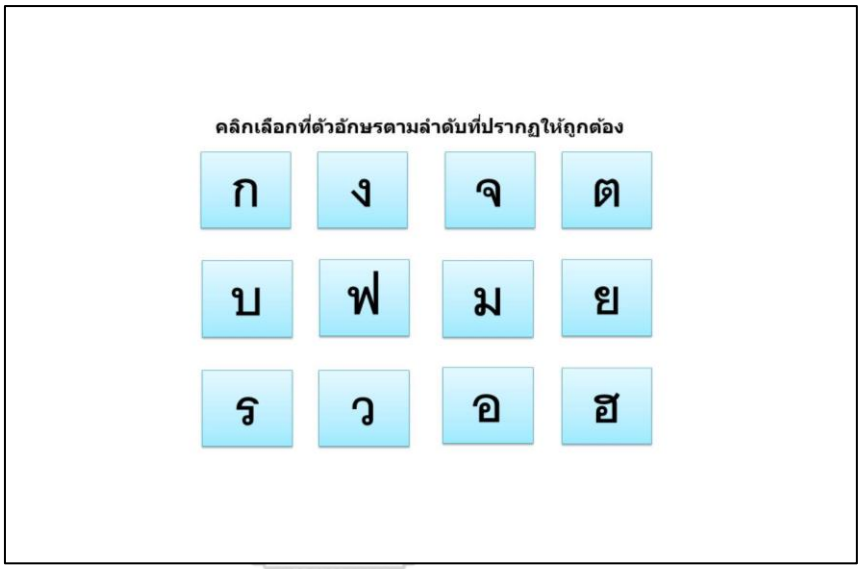


Image 28: The 4 x 3 Matrix of the 12 Thai Letters

Step 13: Next, the symbol + appeared to cue the participant for the next set of sentence-letter strings, and all the steps were repeated for the following sets.

Step 14: As the participant finished all the sentence-letter strings in a particular set, the following window screen revealed the total score or the number of the letters in the set which were correctly recalled in serial order. Image 29 shows the sample screen which presents the total score of a single set of test items.

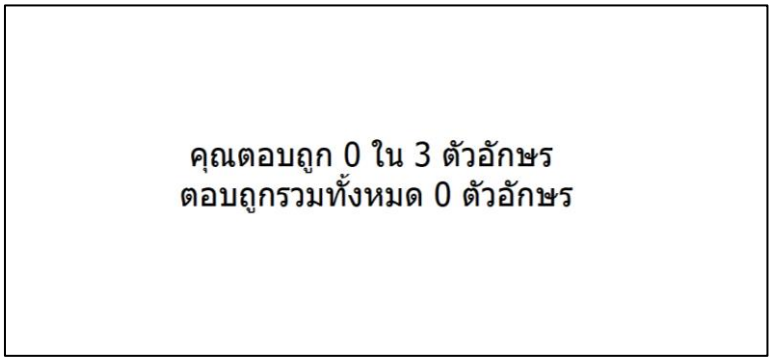


Image 29: The Window Screen Presenting the Total Score of a Test Item Set

Step 15: After the participant finished reading the first half of the task, namely the 36th sentence-letter string, the window screen which came next showed that he/she had to take a three-minute break before reading the rest of the test items. Image 30 shows the break signaling screen of the RST.

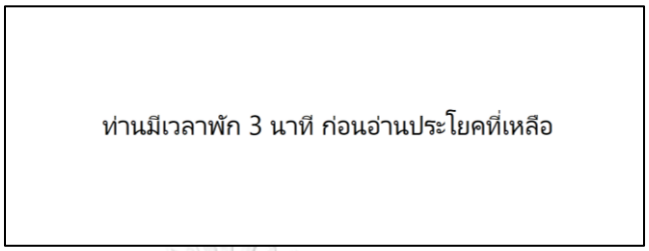


Image 30: The Break Signaling Window Screen of the RST

Step 16: When the participant finished all the 15 sets of sentence-letter strings, the window screen which followed showed the total score from the whole experiment, namely the number of the letters in all the 15 sets which were correctly recalled in serial order. The screen which manifests the total score from all the 15 sets of test items is provided in Image 31.

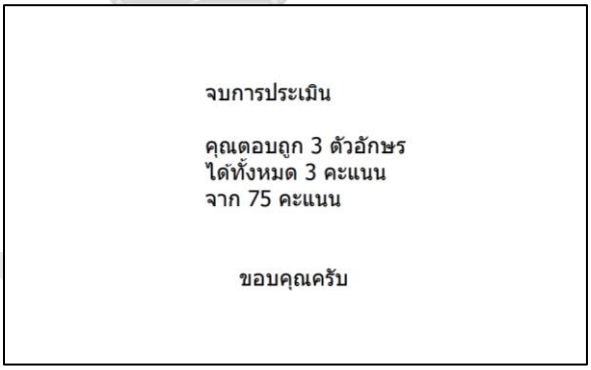


Image 31: The Window Screen Showing the Total Score from the Whole Experiment

After the participant completed the RST, she immediately took the second task, i.e., the SPRT. The next subsection discloses details about the SPRT.

3.1.3 Self-paced reading task

A self-paced reading task (SPRT) was aimed to investigate how the research participants processed various types of irregulars in English RCs and PRRCs. This subsection involves two main parts: 3.1.3.1 and 3.1.3.2, which tackle the design of the SPRT and the steps in using the task, respectively.

3.1.3.1 The design of the SPRT

The design of the SPRT consisted of two main steps: 3.1.3.1.1) the design of a salience hierarchy for the past participial forms of the English irregular verbs and 3.1.3.1.2) the construction of the sentences to be used as the test items and the distractors for the SPRT.

3.1.3.1.1 The design of the salience hierarchy for the past participial forms of the English irregular verbs.

Before the design of the SPRT, different English irregular verb forms needed to be arranged according to the salience level of their past participial forms so that the effects of salience on the processing of the PRRCs with the irregulars could be examined. Details of the classification of the irregulars are pointed out below.

The present study examined L1 Thai learners' processing of English PRRCs with irregular verbs, which might involve distinguishing between past simple and past participle forms of the verbs. The ease of processing the structure could be determined by the salience degree of a particular past participle, i.e., the extent to which the past participial form of an irregular verb phonologically differs from its past simple form. That is to say, the greater the difference between the past simple and past participial forms of a verb is, the more likely an L2 learner is to successfully identify the form she is processing. However, as mentioned in Subsection 2.3.4 of Chapter II, the past participial forms of irregular verbs have never been categorized by salience level. This is because it might have been assumed that the past tense and the past participial forms of such verbs are identical, as instantiated by *bring-brought-brought*, *build-built-built*, *leave-left-left*, *feed-fed-fed*,

and *hold-held-held*. Although some irregular verbs have the same form for the past simple and the past participial forms, the two forms of a greater number of irregulars are different from each other, and the past tense-past participle distinctions seem to considerably vary among the verbs. Therefore, it is important to classify irregular verbs according to salience degree of their past participial forms. In order to create a salience hierarchy, phonological distinctions between past simple and past participial forms must be explored.

After an investigation of how the past tense forms of the irregular verbs inflect to the past participial forms, various inflection patterns were identified and divided into two major groups of verb classes: classes from Bayley's (1994) classification and those specific to the past participles, which are presented in 3.1.3.1.1.1 and 3.1.3.1.1.2, respectively.

3.1.3.1.1.1 Verb classes from Bayley's (1994) classification of English irregular verbs according to salience of past tense forms

Two types in Bayley's (1994) classification were brought here because they could account for some phonological differences between past tense and past participial forms of several irregular verbs. The two classes are suppletives and ablauts. It is worth noting first that the two classes in the categorization of past participles in the present study and those in Bayley's taxonomy contain different members. The distinction is due to the fact that the two classifications compare different pairs of forms. To be specific, Bayley's categorization focuses on the comparison between the present and past tense forms of irregular verbs, but the classification of past participles in the present study examines past tense-past participle differences.

In order for a form to be called a suppletive, it must be totally different from the form to which it is compared. As a result, the members in the suppletive class here include the singular and plural copula because the past participle *been* /biːn/ bears no resemblance to the past tense forms *was* /wɒz/ and *were* /wɚ/. Unlike Bayley's categorization, the past participle classification excludes the verb *go* since its past tense and past participial forms *went* /went/ and *gone* /gɒn/ share the segment /n/.

Table 27 compares the suppletives in Bayley's categorization and those in the classification of past participial inflections.

Bayley's (1994) Classification of Past Simple Forms	**Classification of Past Participial Forms**
- *go-went* - *am-was*	- *was-been* - *were-been*

Table 27: Comparison between suppletives in Bayley's (1994) classification of past simple forms and those in classification of past participial forms in the present study

The ablaut class in the classification of past participles applies to a group of verbs, such as *drank-drunk, sank-sunk, became-become, came-come, and swam-swum.* Nevertheless, the number of the members in the ablaut class here is relatively much lower than that in Bayley's classification. For a large number of verbs in Bayley's ablaut class, their past tense forms, in order to inflect to the past participial forms, require one of the four main changes: 1) an internal vowel change plus an addition of a syllable, such as *write-wrote-written*, 2) an addition of a syllable, like *choose-chose-chosen*, 3) an internal vowel change plus an affixation of *n*, e.g., *blow-blew-blown*, and 4) an affixation of *n*, such as *swear-swore-sworn* (See details of the four major alterations in the next subsection, i.e., Subsection 3.1.3.1.1.2). To put it simply, the past tense inflection of many verbs is considered an ablaut, but their past participial inflection is not, and instead moves to other verb classes specific to the categorization of past participles, which is thoroughly addressed in the next subsection.

In conclusion, some phonological differences between past tense and past participial forms of several irregulars could be accounted for by two verb classes in Bayley's (1994) classification: suppletives and ablauts. Consequently, these two classes are included in the categorization of past participles in the present study.

3.1.3.1.1.2 New verb classes specific to classification of English irregular verbs according to salience of past participial forms

Apart from the two types of alterations from Bayley's (1994) salience hierarchy, three essential inflections were observed, and they are rather specific to how past tense forms of irregular verbs inflect to their past participial forms. They are an addition of the syllabic [ən] morpheme, an affixation of *n*, and identical forms. Even though these classes are not in Bayley's classification, they are heavily involved with the past participial inflection of the verbs, so they should be embraced in the present study's categorization.

Concerning the addition of the syllabic [ən] morpheme and the affixation of *n*, they occur either alone or in combination with an internal vowel change. This resulted in four classes: 1) an internal vowel change plus an addition of the syllabic [ən] morpheme (e.g., *wrote-written, drove-driven*, and *gave-given*), 2) an addition of the syllabic [ən] morpheme (e.g., *broke-broken*, *chose-chosen*, and *bit-bitten*), 3) an internal vowel change plus an affixation of *n* (e.g., *drew-drawn*, *knew-known*, and *saw-seen*), and 4) an affixation of *n* (e.g., *wore-worn*, *tore-torn*, and *swore-sworn*).

Compared to the first two alterations, the identical forms are less specific to the past participial inflections because the present tense forms of some verbs require no change for their past tense inflections as well. However, the identical forms should be encompassed in the past participial classification since many irregulars have the same form and pronunciation for the past and past participial forms. The identical forms class includes two main groups of verbs. The first group is the verbs whose present, past tense, and past participial forms are exactly the same, e.g., *cut-cut-cut*, *quit-quit-quit*, and *hit-hit-hit*. Another group is those whose past and past participle forms are identical, but different from their present tense form, e.g., *leave-left-left*, *bring-brought-brought*, *meet-met-met*, and *send-sent-sent*. Because of the complete lack of differences between the past tense and past participial forms, the identical forms should have the lowest salience degree among the irregulars.

The addition of the three alterations coupled with the two verb classes from Bayley's (1994) salience hierarchy gave rise to the occurrence of seven classes in the classification of past participial inflections. The seven types are as follows:

1) an internal vowel change plus an addition of the syllabic [ən] morpheme,

2) an addition of the syllabic [ən] morpheme,

3) an internal vowel change plus an affixation of *n*,

4) an affixation of *n*,

5) identical forms,

6) suppletives, and

7) an internal vowel change.

The next subsection provides a hierarchy of the seven irregular verb classes above and the criteria for the ordering.

3.1.3.1.1.3 Classification of English irregular verbs according to salience of past participial forms

Three criteria were employed in ordering the seven classes of English irregulars identified in Subsection 3.1.3.1.1.2 by salience of their past participial forms. The three criteria are a distinction degree, greater influence of the syllable addition over segment-related changes, and the number of changes in total. It should be first noted that the criteria are partly based on those in Bayley's (1994) classification.

The first criterion is a distinction degree or the extent to which a particular form of an English verb phonologically differs from the other form to which it is related. Bayley (1994) used this criterion in classifying his verb classes; however, the distinction degree in Bayley's categorization refers to the phonological distinctions between the present tense and the past tense forms of a verb whereas that in the present study's salience hierarchy involves differences between the past tense and the past participial forms of an irregular verb. This is because the PRRC processing concerns distinguishing between past simple and past participle forms of the verbs. The greater the distinction between the two forms of an irregular is, the more salient

the past participial form of the verb is, and the more likely an L2 learner is to successfully identify the given form she is processing. Accordingly, the suppletives should be the most salient irregular class since the past tense and past participial forms of the verbs do not have any segments in common. On the contrary, the identical forms should be the least prominent because no differences between the two forms of theirs are detected.

The second criterion is greater influence of the syllable addition over segment-related changes. The seven irregular verb classes could be divided into two major groups: 1) the verbs which inflect to the past participial form by adding a syllable to themselves and 2) those by changing or adding a segment to themselves. According to Bayley (1994: 51), the classes which are related to an addition of a complete syllable are assumed to be more perceptually prominent than those which undergo segment-related changes. Consequently, the two classes which have a syllable-related change, namely an addition of the syllabic [ən] morpheme and an internal vowel change plus an addition of the syllabic [ən] morpheme, should be ranked higher than the classes which involve alterations to segments, except the suppletives.

The last criterion is the number of changes in total. This criterion was specifically used in classifying three pairs of irregular verb classes, i.e., 1) an addition of the syllabic [ən] morpheme and an internal vowel change plus an addition of the syllabic [ən] morpheme, 2) an affixation of *n* and an internal vowel change plus an affixation of *n*, and 3) an internal vowel change and an internal vowel change plus an affixation of *n*. The two verb classes in each pair are similar in that they involve a particular change, but one class in the pairs contains one more alteration whereas the other does not. Based on the notion of salience, the classes which undergo two changes are more salient that those with one alteration. For this reason, an internal vowel change plus an addition of the syllabic [ən] morpheme should be more salient than an addition of the syllabic [ən] morpheme. In a similar vein, an internal vowel change plus an affixation of *n* should have higher salience than the sole occurrence of an affixation of *n* or an internal vowel change.

However, the three criteria mentioned above did not apply to ordering two verb classes: the ablauts and the affixation of *n*. Ordering the two classes was tricky because both of them need only one change for their inflections. However, based on the previous classifications of the past tense forms, the ablauts are considered more salient than the replacives, which are similar to the affixation of *n* in that they involve one change in their final consonantal sound. So, the ablauts are assumed to be more perceptually prominent than the affixation of *n*.

The combination and arrangement of the two groups of verb classes (that is, the classes from Bayley's (1994) taxonomy and those specific to the past participles) using the three criteria mentioned above lead to 7 types of past participial inflections with different salience degrees, ranging from 1 (most salient, and easiest to identify the given form) to 7 (least salient, and most difficult to identify the given form). The 7 classes of past participial inflections are revealed in Table 28.

Degree of Salience	**Types of Changes**	**Examples**
1	Suppletive	was-been were-been
2	an internal vowel change plus an addition of the syllabic [ən] morpheme	wrote-written drove-driven gave-given took-taken ate-eaten
3	an addition of the syllabic [ən] morpheme	broke-broken hid-hidden chose-chosen bit-bitten stole-stolen froze-frozen forgot-forgotten interwove-interwoven
4	an internal vowel change plus an affixation of *n*	drew-drawn blew-blown

		knew-known saw-seen threw-thrown
5	Ablaut (an internal vowel change)	sang-sung rang-rung sank-sunk drank-drunk
6	an affixation of *n*	swore-sworn tore-torn wore-worn bore-born
7	Identical form (no change)	cut-cut left-left lost-lost paid-paid bought-bought told-told

Table 28: Classification of English irregular verbs according to phonological differences between their past participial and past tense forms

Based on the categorization, the most salient irregular verbs are the suppletives whose past tense and past participial forms are totally different. The class comprises the past participial form *been* of the singular and plural copulas *was* and *were*.

The second most salient irregular verbs are those which inflect to their past participial form by changing the internal vowel and adding the syllabic [ən] morpheme, such as *wrote-written* and *gave-given*. The third most salient type of verbs requires only an addition of the syllabic [ən] morpheme, as in *broke-broken* and *chose-chosen*. The second and third classes differ in the number of the required changes, i.e., the second class needs more changes, and thus, has higher salience than the third one does.

The verbs which undergo both an internal vowel change and an affixation of *n*, like *knew-known* and *saw-seen*, occupy the fourth position because they need more alterations for their inflections than the verbs requiring merely an internal vowel change (e.g., *rang-rung*) and those necessitating an affixation of *n* only (e.g., *wore-worn*). The ablauts are ranked higher than the affixation of *n*, which is based on the fact that the ablauts are placed higher than the replacives in the three classifications of the past tense forms made by Wolfram (1985), Bayley (1994), and Tajika (1999).

The least salient class is the identical forms whose past simple and past participial forms are exactly the same, such as *lose-left-left* and *pay-paid-paid*.

The classification above excludes the verbs which have two forms of past participles, such as *beat* (*beat-beaten*), *dream* (*dreamt-dreamed*), and *get* (*got-gotten*). This is to avoid confusion resulting from the choice of the past participial forms of such verbs, which mainly depends on the set of varieties of the English language used by a particular L2 learner, i.e., American English or British English (Zhang & Jiang, 2008). To illustrate, *gotten* is more commonly employed in American English whereas *got* is more common in British English.

3.1.3.1.2 The construction of sentences as test items and distractors for the SPRT

The present study included two groups of obviously distinct irregulars in the classification of English irregular verbs according to salience of the past participial forms (See detailed discussions of the classification in Subsection 3.1.3.1.1), i.e., Group 2 (an internal vowel change plus an addition of the syllabic [ən] morpheme) and Group 4 (an internal vowel change plus an affixation of *n*).

The test items in the SPRT addressed 2 factors: *Structure* and *Salience*. *Structure* concerned different ambiguity degrees of two structures (ambiguous participial reduced relative clauses or PRRCs and unambiguous relative clauses or RCs) whereas *Salience* tackled two groups of irregular verbs with distinct salience levels (Group 2 and Group 4).

With respect to *Structure*, each experimental sentence had two versions: ambiguous PRRCs and unambiguous RCs. Each structure comprised 16 experimental sentences, leading to 32 test items in total.

As far as the ambiguous PRRC version was concerned, each experimental sentence contained 9 words. The sentences were presented in chunks on a computer screen in order to reduce processing load for these complex grammatical structures. The target sentences were segmented into 5 regions: *Subject*, *Past Participle* (*PP*), *Modifier of the PP*, *Main Verb* (*MV*), and *Object*. To control the length effects, the number of the words in a particular segment was identical across all target sentences.

The region *Subject* in each target sentence comprised two words which made a noun phrase modified by the PRRC in the sentence. The first word and the second word in the region were a definite article and a noun, respectively. Even though the region was not the focus of the present study, it was necessary to keep possible variables about the nouns constant because they immediately preceded the PRRCs and seemed to have effects on the processing of the construction. The variables which might impact the processing of noun phrases were the number of syllables, animacy[37], definiteness, concreteness, countability, and singularity. As a result, the modified nouns in the region *Subject* in all target sentences were disyllabic, animate, definite, concrete, countable, and singular. Regarding the number of syllables and animacy, the noun phrases were only two-syllable animate nouns, such as *baby*, *dancer*, and *postman*. The reason why only animate nouns were employed was because such nouns modified by a PRRC were more likely to cause MV/RR ambiguity than the inanimate ones. This was in line with the modified nouns in the target sentences of many previous PRRC processing studies (e.g., Just & Carpenter, 1992; Juffs, 1998; Rah & Adone, 2010). The definiteness of the nouns was expressed via the use of definite article *the*. The nouns modified by PRRCs were definite since

[37] Some previous studies on the PRRC processing included both animate and inanimate nouns in their experimental sentences, and they found that animacy could have some impact on how readers processed the structure. As an example, Ferreira and Clifton (1986) observed that the research participants had more problems processing the PRRCs with inanimate nouns than those with animate nouns. The results could be supported by a semantic explanation. Trueswell et al. (1994) stated that animate nouns were generally considered good agents, i.e., the initiators of an action, whereas inanimate nouns were usually assigned the semantic role of theme or the entity which underwent an action. That is, inanimate nouns were not expected to perform actions.

the construction was usually used with the nouns which were specified in a particular context, and thus, were definite to the listeners or readers.

As for the region *PP*, the present study included PPs in Group 2 and Group 4 in the salience hierarchy of past participial forms. Four PPs from each group were used, leading to eight target PPs in total. The eight past participial forms were taken from the list of the most frequently used past participles provided by Corpus of Contemporary American English (COCA)[38]. Using the highly frequent PPs in the corpus was to ensure that the target words were commonly used; therefore, the words should be familiar to L2 learners, and their longer reading times on the target words would not be ascribed to their ignorance about the words.

The four PPs from each of the two salience groups were chosen from the first ten most frequently occurring PPs in their own group. The selection of the PPs was based on three criteria: having transitive meaning, being transitively applicable to animate nouns, and having similar numbers of syllables. The first criterion was having transitive meaning. Since PRRCs involve transitive meaning of PPs, the present study included only the PPs which have transitive meaning (e.g., *given*, *shaken*, and *blown*) and excluded those with intransitive meaning (e.g., *risen*, *fallen*, and *flown*). Secondly, all the selected PPs could be used in a PRRC modifying animate nouns. That is, a PRRC which contained a chosen PP must sound semantically possible when it modified an animate noun. The second criterion eliminated some verbs in Group 2, such as *driven* and *written*. Last, the number of syllables of the PPs in a particular salience group must be identical in order to control the length effects. For example, the number of syllables of all PPs in Group 2, i.e., *given*, *taken*, *eaten*, and *shaken*, was 2, leading to the exclusion of more-than-two-syllable-words, e.g., *mistaken* and *undertaken*. The number of syllables for the PPs in Group 2 was 2 (e.g., *given* and *taken*) whereas that for the PPs in Group 4 was 1 (e.g., *drawn* and *blown*).

[38] The information about the most frequently occurring English past participles in COCA was updated on June 2nd, 2020.

The eight PPs from Groups 2 and 4 in the salience hierarchy which meet the three criteria are shown in Table 29.

Group	Selected Past Participles
2	given; taken; eaten; shaken
4	known; seen; drawn; blown

Table 29: The selected past participles from Groups 2 and 4 in the salience hierarchy of past participial forms of irregular verbs

The region *Modifier of the PP* in each target sentence contained a prepositional phrase. Some studies on the PRRC processing combined the *PP* and the *Modifier of the PP* into a single segment (e.g., *pushed through the doors, called in the hallway*, and *warned about the dangers*) because they explored the reading times on the PRRC overall (e.g., MacDonald et al., 1992); however, the present study aimed to analyze how the salience level of a particular PP could modulate the processing of the rest of the reduced relative clause, so the *PP* and the *Modifier of the PP* would be separately analyzed, for instance, *given-to that couple*, *known-for his kindness*, and *blown-off the ladder*. There were three words in the region *Modifier of the PP*. The first word of the phrases was a monosyllabic preposition, such as *from*, *in*, and *to*. The exception to the used prepositions was *by* which might lead the participants to have a bias in favor of PRRC interpretations, as instantiated by *taken by the police*, *given by the teacher*, and *drawn by the artist*. The second word and the third word were a monosyllabic determiner and a two-syllable noun, respectively; therefore, the two words altogether made a noun phrase. The nouns in the *Modifier of the PP* were definite and singular, such as *the forest*, *that hotel*, and *the battle*. There were both concrete nouns (e.g., *the kitchen*, *the village*, and *this clinic*) and abstract nouns (e.g., *her brilliance* and *his kindness*).

The region *Main Verb* or *MV* contained a monosyllabic regular verb in its past tense form, such as *planned*, *closed*, and *raised*. As suggested by the title itself, the region gave readers confirmation of the PRRC interpretation. The verb was always the third word from the end of the sentence.

The region *Object* contained two words making a noun phrase which was the object of the finite verb in the target sentences. The first word and the second word in the region were a monosyllabic determiner or article and a noun, respectively. The noun phrases in the regions were always the last two words of the sentences. Even though the noun phrases were not under investigation, the variables involved with the nouns should be kept as constant as possible since the factors might have effects on the data. Thus, the number of the syllables and singularity of the nouns were controlled by using only singular nouns which were either monosyllabic or disyllabic in the *Object* region, such as *toy*, *car*, *disease*, *nephew*, and *jacket*.

Table 30 encapsulates the details about the five regions in the PRRC version of experimental sentences of the SPRT.

Region	1st region – Subject (definite, concrete, singular, animate nouns)		2nd region - Past participle	3rd region - Modifier of the past participle (a prepositional phrase)			4th region - Main verb (regular verbs in their past tense form)	5th region – Object of the main verb	
Number of words and syllables	2 words		1 word (no. of syllables ranges between 1 and 2)	3 words			1 word (1 syllable)	2 words	
	Article "the" (1 syllable)	Noun (2 syllable)		Preposition (1 syllable) *No "by"	Det (1 syllable)	Noun (2 syllables)		Article/Det (1 syllable)	Noun (no. of syllables ranges between 1 and 2)
Group 2	The	baby	given	to	that	couple	loved	the	toy
Group 4	The	writer	known	for	his	kindness	joined	the	workshop

Table 30: Summary of the five regions in the PRRC version of target sentences of the SPRT

After reading each target sentence, the participants answered a yes-no comprehension question as to the noun modified by the PRRC to make sure they attentively read and comprehended the sentence. To make the participants unaware of the question pattern and the purpose of the experiment, the 32 comprehension questions were divided into two groups of sixteen. The first group had "yes" as the answer, and the second one had "no". The questions in the first group asked if the modified noun acted as the recipient of the action in the PRRC whereas those in the

second group asked whether or not the subject performed the action in the PRRC. The questions in the first group and those in the second one are exemplified by (123a) and (123b), respectively.

(123) a. Did someone give the rooster to my grandpa?

b. Did the writer see something near the river?

The unambiguous version of the target sentences had an RC interpretation. Each experimental sentence contained 11 words. They were exactly the same as their PRRC counterpart, except the noun in the *Subject* region was followed by the phrase *who was* or *which was* in order to make it clear that the past participial form was part of an RC. Regarding the relative pronouns, although "who" and "which" and "that" were interchangeable in defining RCs, the adjective clauses in the present study employed only "who" and "which" because the word "that" had several grammatical functions other than working as a relativizer[39], such as a complementizer[40] (e.g., *I think <u>that</u> he is fine*.) and a determiner (e.g., *<u>That</u> school is great.*); therefore, the RCs with "that" might lead to the amount of reading times which differed from those with "who" or "which". The phrases *who was* and *which was*, however, were not included in any of the three regions that would be analyzed, namely the regions *PP*, *Modifier of the PP*, and *MV*. The comprehension questions for the sentences with RCs were identical to the questions for those with PRRCs. Examples of the unambiguous RCs, how they have been split into regions, and their comprehension questions are shown in (124).

(124) a. The squirrel which was / given / to the painter / climbed / a tree.
Comprehension question: Did someone give the squirrel to the painter?
b. The merchant who was / seen / in the office / owned / a mansion.
Comprehension question: Did someone see the merchant in the office?
c. The builder who was / blown / off the ladder / sprained / his elbow.
Comprehension question: Did something blow the builder?

---

39 Relativizers are a class of subordinating conjunctions which introduces RCs (Schachter, 1985: 50).

40 Complementizers are a type of subordinating conjunctions used to mark a clause as the complement of a noun, verb or adjective (Schachter, 1985: 49).

According to Keating and Jegerski (2015), one main step in presenting target sentences to subjects was creating different lists which contained various versions of the sentences. Each participant would read only one version of each item. Different versions of an item required lexical matching, i.e., they were lexically identical except the words which were related to the examined factors. This helped create a high level of internal consistency within the item (Keating & Jegerski, 2015).

The creation of different versions of items addressed each investigated variable. Specifically, the number of the versions resulted from multiplying the number of subfactors under each variable. As aforementioned, the present study dealt with two subfactors under each of the two factors, i.e., *Structure* (PRRC and RC) and *Salience* (Group 2 and Group 4); therefore, multiplying 2 by 2 led to 4 versions of the items. The 4 versions are provided in Table 31.

No.	Structure	Salience
1	Participial reduced relative clauses	Group 2
2	Participial reduced relative clauses	Group 4
3	Relative clauses	Group 2
4	Relative clauses	Group 4

Table 31: The four versions of the test items resulting from the manipulation of Structure and Salience

However, *Salience* was excluded from the manipulation because of semantic constraints' impact on lexical matching. That is, it was difficult to change a PP in an item to a different one without changing the words which followed the PP. For example, if the PP *given* in the sentence *The baby given to that couple loved the toy* was changed to *shaken* or *seen*, the following prepositional phrase and the predicate of the sentence required some lexical modification in order to fit the meaning of the new PP, which could decrease internal consistency within the item. Consequently, each target sentence in the present study had 2 versions according to the structures: PRRC and RC. However, because the SPRT task involved the two classes of past participles with different salience degrees, the task included items from the four test conditions in Table 31: PRRC/Salience 2, RC/Salience 2, PRRC/Salience 4, and RC/Salience 4.

The researcher created two presentation lists of sentences: List A and List B. As aforementioned, the task contained 32 experimental items, with 8 items for each test condition in the two lists. Each of the 32 experimental items had two versions: PRRC and RC, which were presented across the two lists. In other words, an item presented in the PRRC version in List A was shown in the RC version in List B, and vice versa. For instance, the sentence *The dentist who was taken to the museum missed his flight* in List A was presented as *The dentist taken to the museum missed his flight* in List B. On the contrary, *The baby given to that couple loved the toy* in List A was shown as *The baby who was given to that couple loved the toy* in List B. The target items were pseudo-randomized[41] and distributed across the two different lists in the Latin Square design for 2 purposes: 1) each participant read only one version of each experimental item, and 2) two consecutive sentences of the same structure did not follow each other.

In each presentation list, the 32 experimental sentences were interspersed with 96 distractors included to divert the participants' attention from the target sentences. The number of the distractors was determined by the number of the target items. In sentence processing experiments, including self-paced reading tasks, distractors and test items usually accounted for 75% and 25% of all the items, respectively (Keating & Jegerski, 2015). In other words, the number of the non-critical items was three times greater than that of the critical ones. As a result, with 32 experimental items, the present study required 96 distractors, which was three times more than the number of the target sentences.

In sentence processing research, a distractor item refers to an unrelated item which is designed to include a specific linguistic form or structure in order to elicit a specific type of processing effects (Keating & Jegerski, 2015). This has been claimed to obscure the aims of the experimental items, that is, the test items of the present study examined the research participants' processing of the PRRC and RC structures and past participles with different salience degrees. The distractors incorporated three types of syntactic structures, i.e., Prepositional Phrase Ambiguity (PPA), Subject-

[41] Pseudorandomness refers to the random-looking organization of a group of items resulting from an ordering method which involves no randomness (Johnson, 2001).

Object Ambiguity (SOA), and Subject-Verb Agreement (SVA). Each of the three sentence structures involved one linguistic factor with two subfactors so that two versions could be made for each distractor. PPA sentences were related to two different targets of the prepositional phrases: a verb-modifying phrase or an object-modifying phrase. SOA items involved transitivity of the verb in the subordinate clauses: intransitive verbs and verbs which could be both transitive and intransitive. SVA sentences dealt with the number of the nouns: singular nouns and plural nouns. Thus, 2 versions per distractor (N = 96) led to 192 distractors in total.

According to Keating and Jegerski (2015), distractors should look superficially similar to the experimental items since they were anticipated to draw the subjects' attention away from the target items. The critical items and the distractors in the present study shared three similarities: the used words, the number of the items, and the comprehension questions which followed them. First, both the distractors and test items contained similar lexical words and phrases, which was to help reduce processing load for the research participants. All the noun phrases which were the subjects of the test items were included as part of the distractors in the three categories. Also, the researcher employed as many words as possible from the test items in composing the distractors. Second, the number of the distractors in each of the three groups was the same as that of the test items, i.e., 32 per group. The third similarity concerned the patterns of the comprehension questions. Each distractor was followed by a yes-no comprehension question. Like the questions for the experimental items, all the inquiries for the distractors were written in the past simple tense starting with *Did* and could be divided into two groups according to the subjects of the questions, i.e., a common noun, such as *the baby*, *the hunter*, and *the meeting*, or the indefinite pronoun *someone* or *something*. The questions with a common noun and those with an indefinite pronoun were counterbalanced for all the three groups of distractors across the two presentation lists.

All the distractors were segmented into five regions, as the experimental items were. Examples of the distractors, how they were split into regions, and yes-no comprehension questions are given in Table 32 (See all the sentences in the two presentation lists in Appendix C).

Types of Syntactic Structures	Subfactors	Examples	Comprehension Questions
Prepositional Phrase Ambiguity	Verb-modifying	The salesman / joined / the meeting / with / confidence.	Did the salesman lack confidence?
	Noun-modifying	The salesman / joined / the meeting / with / 120 attendees.	Did the meeting have many participants?
	Verb-modifying	The artist / visited / the art studio / with / enthusiasm.	Did someone enthusiastically visit the studio?
	Noun-modifying	The artist / visited / the art studio / with / a huge gate.	Did someone go to the studio which had a tiny gate?
Subject-Object Ambiguity	Intransitive	After / the waitress / walked, / the egg / started to burn.	Did the egg start to burn after the waitress walked away?
	Intransitive-Transitive	After / the waitress / fried, / the egg / started to burn.	Did the egg start to burn before the waitress fried it?
	Intransitive	As / the dancer / slept, / the show / started.	Did someone fall asleep when the show started?
	Intransitive-Transitive	As / the dancer / left, / the show / started.	Did someone leave before the show started?
Subject-Verb Agreement	Singular	The writer / in the apartment / was / writing / a textbook.	Did the writer write a textbook?
	Plural	The writers / in the apartment / were / writing / a textbook.	Did the writers read a textbook?
	Singular	The doctor / from the city / was / kind / to me.	Did someone from the city treat a person very well?
	Plural	The doctors / from the city / were / kind / to me.	Did someone from the city behave rudely towards a person?

Table 32: Examples of the three groups of distractors and comprehension questions

All regions of the overall 128 sentences in the SPRT were presented in Arial, size 26 font, in black letters against a white background. The sentences were centered between the top and the bottom of the computer screen, with each region presented in

succession from left to right across the screen. The 128 sentences in each presentation list were separated into 2 sets of 64 sentences. After they finished reading the first set, they took a 5-minute break in order to prevent the problem of exhaustion.

The procedure of the SPRT was that the participants pressed a key when they were ready to view each region in each sentence, thus determining their own reading speed. Once each new segment emerged, the previous region disappeared, thereby preventing the subjects from seeing the entire sentence on the screen. In this noncumulative centered presentation, the participants would not be aware of the length of the sentence and the number of words which followed. This helped encourage immediate processing. The SPRT was based on the assumption that a greater amount of reaction time a participant spent on reading a particular segment indicated that she had a difficulty processing and reading the region. Once the last region of each sentence disappeared, the participants were prompted to answer a yes-no question about the target sentence.

Since the SPRT was aimed to explore the L1 Thai subjects' processing of the PRRC and RC structures, it was important to make sure that the participants' reading times were not affected by vocabulary difficulties. Consequently, the native Thai speakers' knowledge of the words must be assessed first. Before taking the SPRT, the participants were asked to review a list of all words and word forms employed in the present study. The lists were in an alphabetical order, and the L1 Thai learners were encouraged to ask the researcher for the meaning of any words they were uncertain of. The participants were given different vocabulary lists depending on the sentence presentation list they took, namely the participants who were administered the List A SPRT received the vocabulary list A while those given the List B task got the vocabulary list B. The two vocabulary lists are provided in Appendix D.

Then, the instructions on the test-taking procedure and 5 practice items were given to the subjects prior to the test session in order to ensure that they got familiar with the procedure of the task. The participants were instructed to read the experimental sentences silently and as quickly and carefully as possible. They were told that they had to read the sentences one after the other, and they were to answer a yes-no question about each sentence.

The entire SPRT took participants about 40 minutes to complete. The amount of time spent on reading each region of the target sentences and answering the comprehension questions was recorded for further analyses.

3.1.3.2 The steps in using the SPRT

In connection with the steps in employing the SPRT for the present study, there are 12 steps as follows.

Step 1: The SPRT program was placed in a destination location in the used laptop. The program was opened by double-clicking the SPRT icon shown in Image 32.

Image 32: The SPRT Icon

Step 2: Next, the SPRT box (Image 33) showed up. The “Start” icon in the box was clicked in order to start the experiment.

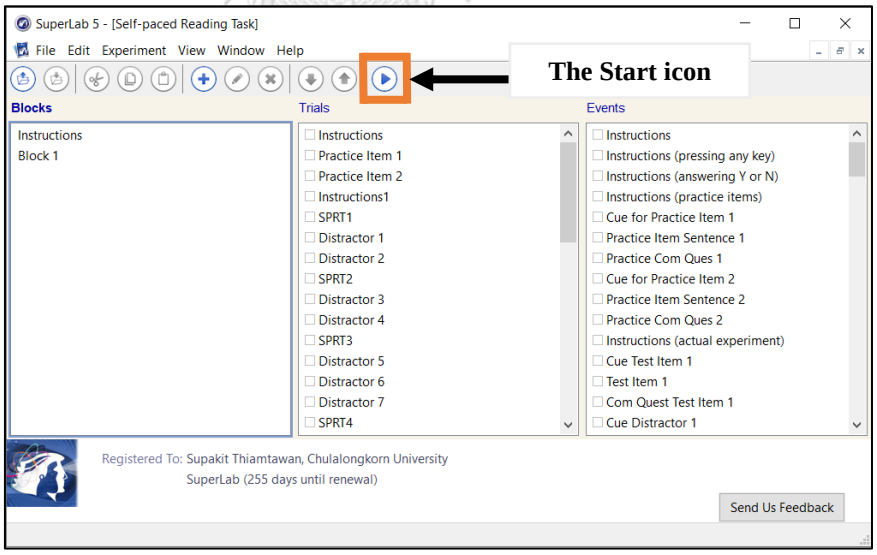


Image 33: The SPRT Box and the Start Icon

Step 3: When the “Start” icon was clicked, the “Run Experiment” box with two blanks (Image 34) appeared for the research participant to fill in information about her name and institution. Then, the “Run” button was clicked.

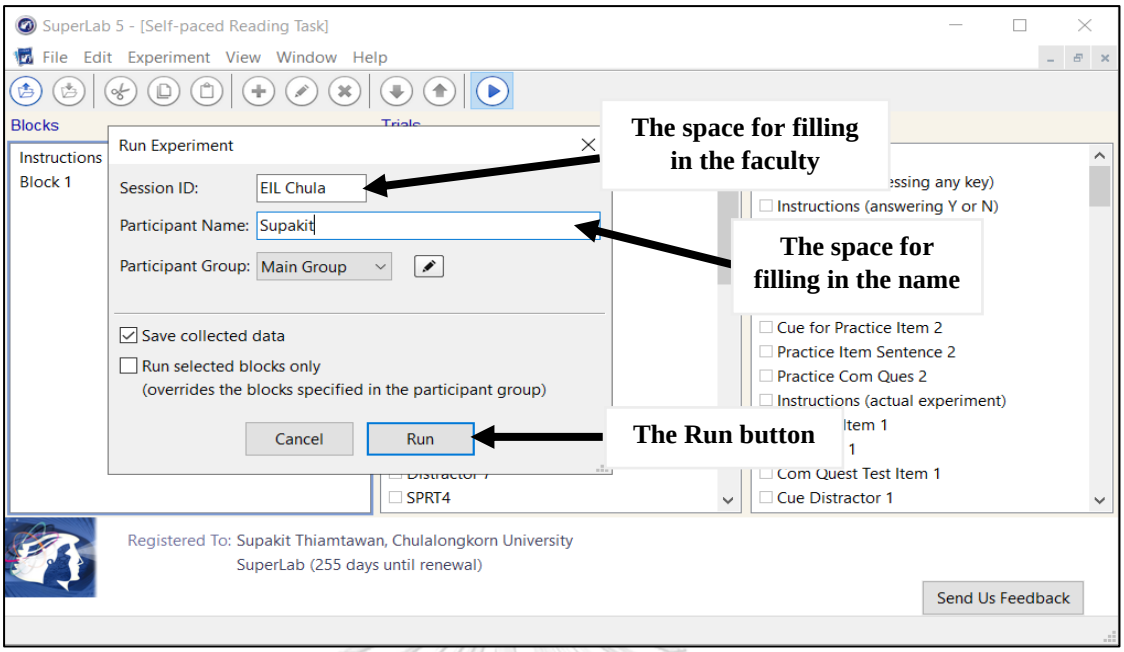


Image 34: The Run Experiment Box

Step 4: After that, the "Save the Collected Data File" box (Image 35) showed up so that the program created a text file which recorded the data about the amount of time the research participant spent on reading the sentences in the SPRT and answering the comprehension questions. The file was named by filling in the participant's name in the "File Name" blank. A location in which the text file would be saved was chosen. Then, the "Save" button was clicked.

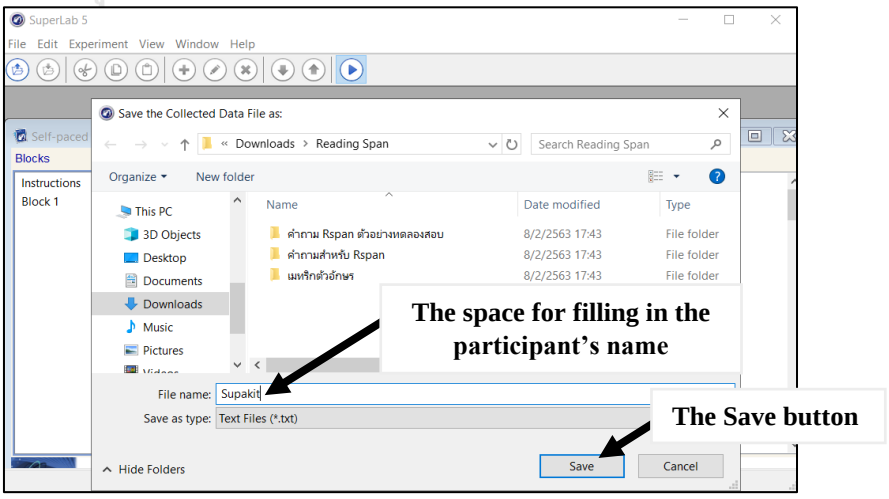


Image 35: The Save the Collected Data File Box

Step 5: Next, the “Welcome-to-the-SPRT” screen (Image 36) appeared.

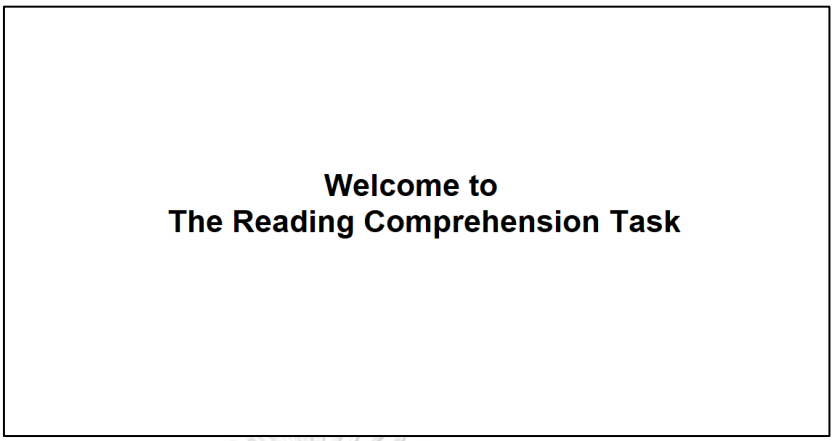


Image 36: The Welcome-to-the-SPRT Screen

Step 6: The window screens which followed showed the instructions on how to take the SPRT, as revealed in Image 37.

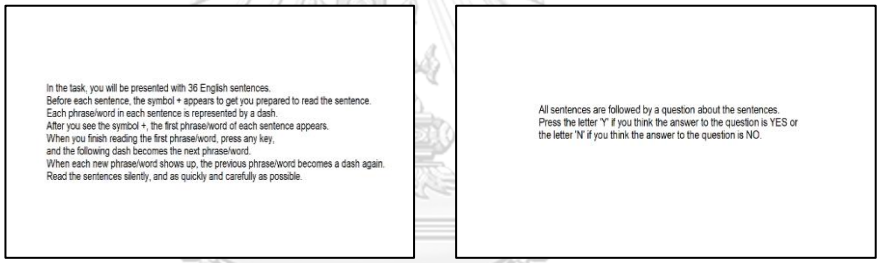


Image 37: The Window Screens on the Test-taking Instructions for the SPRT

Step 7: Then, the research participant was required to take part in a five-sentence trial in order to ensure her comprehension of the test-taking procedure. The participant’s performance on the trial was excluded from the data analyses. The window screen introducing the trial is manifested in Image 38.

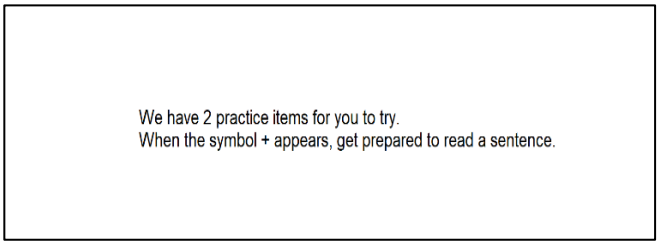


Image 38: The Window Screen Introducing the Test Trial

Step 8: After the research participant finished the trial, the actual experiment began. The test contained 128 unrelated English sentences. Before each sentence, the symbol + appeared at the center of the screen in order to cue the participant to get prepared for the sentence. The symbol + appeared for 1,500 milliseconds, and disappeared. Image 39 shows the window screen with the cue.

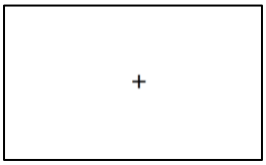


Image 39: The Window Screen with the Symbol +

Step 9: Each word or phrase in each item was represented by a dash. After the symbol + showed up and disappeared, the first word or phrase of each sentence appeared. When the research participant finished reading the first word or phrase, he/she was instructed to click the mouse, and the following dash became the next word or phrase. When each new word or phrase showed up, the previous word or phrase became a dash again. Image 40 reveals the window screens showing all the words and phrases in an SPRT item.

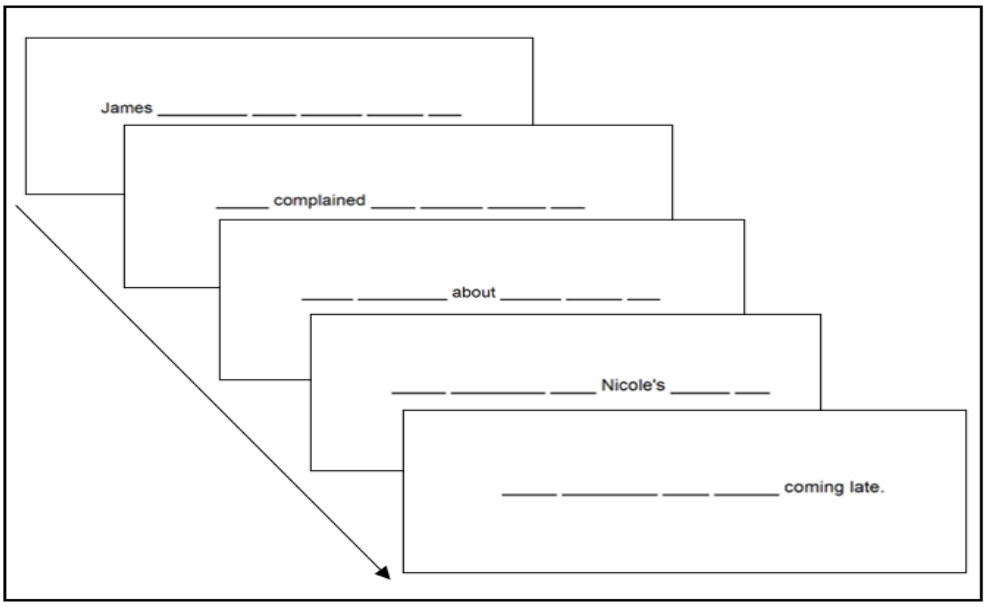


Image 40: The Window Screens Showing the Words and Phrases in an SPRT Item

Step 10: After the participant saw all the words and phrases in each SPRT item, the window screen with the sentence disappeared. Then, a yes-no comprehension question about the sentence she read appeared at the center of the screen. The participant was asked to press the letter ‘y’ if she considered the answer to the question was ‘yes’ or the letter ‘n’ if she thought the answer to the question was ‘no’. The window screen showing a comprehension question is provided in Image 41.

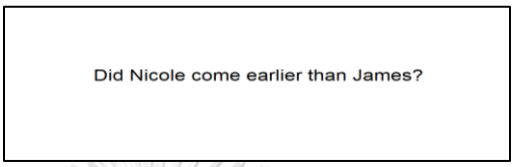


Image 41: The Window Screen Showing a Comprehension Question

Step 11: Then, the two window screens which followed showed the next sentence-question string. After the participant finished reading the first half of the task, that is, the 64th sentence-question string, the following window screen showed that he/she had to take a five-minute break before reading the rest of the items. Image 42 shows the break signaling screen of the SPRT.

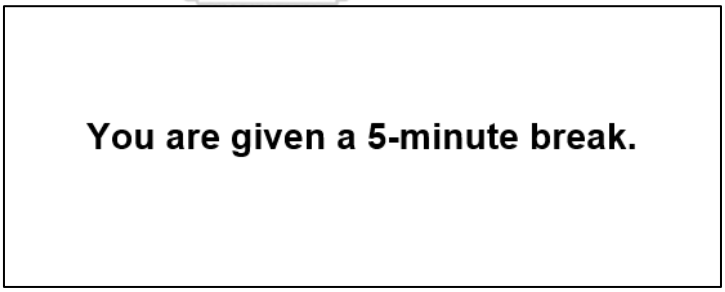


Image 42: The Break Signaling Window Screen of the SPRT

Step 12: After the participant saw and answered all the sentence-question strings in the task, the Thank You for Your Participation screen appeared. The window screen is shown in Image 43.

Image 43: The Thank You for Your Participation Screen

3.1.4 Validation of the salience hierarchy of the English irregular past participial verb forms and the research instruments

Prior to the application of the salience hierarchy of the past participial forms of English irregulars and the research instruments, they were validated.

The classification of English irregular verbs according to the salience of their past participial forms was validated by three native English experts who were English lecturers at Chulalongkorn University Language Institute. The index of Item-Objective Congruence (IOC), which was developed by Rovinelli and Hambleton (1976), was employed to evaluate the validity of the salience hierarchy, namely whether the verb classes were appropriate to the position they had been placed in the hierarchy. Each verb class in the hierarchy was rated as either +1 if the class was considered appropriate to the place it had been ranked, 0 when the experts did not think the verb class could be judged as either appropriate or inappropriate to the place it had been ranked, or -1 if the class was considered inappropriate to the place it had been ranked. For each verb class, the scores from the three experts were added and then divided by the number of the experts according to the formula shown below in (125).

(125) $$IOC = \frac{\sum R}{N}$$

$\sum R$ = the sum of the experts' scores

N = the number of the experts

Each verb class had to score higher than 0.5 to be considered appropriate to the position it had been ranked. All of the verb classes passed the IOC, scoring +1 on average. The IOC scores of the verb classes in the salience hierarchy are provided in Appendix E.

In connection with the working memory task, the RST in the present study was developed by Phinitkit (2015). He explored the content validity and the criterion-related validity of the task. Phinitkit had content validity of the sentences examined by three experts on neuroscience, evaluation and assessment, and cognitive science, and he got two comments from the experts. Firstly, the proper names of places should be changed to common nouns in order to prevent effects of geographical bias on the test-takers. For example, "ชายหาดบางแสน" (i.e., Bang Saen Beach, a beach in Chonburi Province on the eastern coast of Thailand) was changed to "ชายหาด" (i.e., a beach). Phinitkit was also recommended to exclude from the sentences the content addressing the violation of religious principles, for instance, "พระกำลังฉันอาหารเย็น" (i.e., A Buddhist monk is having dinner). In addition, Phinitkit assessed his RST's criterion-related validity compared to the standard program, namely the CSTs developed by Unsworth et al. (2005). To determine the developed program's criterion-related validity, the collected data were analyzed via basic statistics and Pearson's correlation coefficient. Phinitkit's developed program met the criterion-related validity with the standard program CSTs at a significant level of 0.01. The Pearson correlation coefficient of the data assessed by the RST was 0.83 ($p<.01$). This indicates that Phinitkit's RST assesses WM as well as the task in the standard program does.

Pertaining to the sentences in the SPRT, a norming study was conducted to select target sentences and distractors for the main experiment. According to Keating and Jegerski (2015), a norming study refers to an initial rating survey in language processing studies which is required when manipulation of the test items concerns a lexical, semantic, pragmatic or plausibility bias. This suggests that what the participants in the norming surveys are asked to rate varies, depending on the purposes of the studies. Carried out before the main experiment, such surveys are to

make sure the critical items created to sound plausible, slightly weird or unreasonable are considered as such by the participants (Featherstone et al., 2012).

Since the present research focused on processing of the PRRC and RC structures, the norming study here asked the participants to rate whether the events described by the experimental items sounded overall plausible when written in the two structures. This was to ensure that a participant's long reading times on an item did not occur because the event described by the item sounded unreasonable for her. The norming study consisted of two surveys: Survey 1 and Survey 2.

Survey 1 was carried out to choose experimental items. The survey comprised a total of 70 items, all of which involved different 70 noun phrases as the subject of the sentences. The researcher created two lists of sentences: List A and List B. Each of the 70 items had two versions: PRRC and RC. The two versions of the target items were pseudo-randomized and distributed across the two lists in a way in which each participant read only one version of each critical item, and two consecutive sentences of the same structure did not follow each other. The numbers of the PRRC items and the RC ones in the two lists were 35 each. The two lists of sentences in Survey 1 are shown in Appendix F.

Following the criterion for choosing participants for norming studies in Keating and Jegerski (2015), participants in the norming survey were recruited from the same population as the control group, i.e., 12 native English speakers who did not take part in the main experiment. The first six natives took List A, and the latter six took List B. The participants were instructed to read each sentence and rate plausibility of each item on a five-point rating scale from 1 ("Not very plausible") to 5 ("Very much plausible"). The researcher aimed to choose only the items whose described event was plausible when they were written in both the PRRC and RC structures. That is, the items whose plausibility score of both PRRC and RC structures was 2.55 or more than 2.55 were considered passing the norming test[42].

[42] Reaching the half of the full score, i.e., 2.5, might be claimed to pass the test because the number could be rounded up to 3. Such rounding follows the traditional rounding method, which states that all half-integers (e.g.1.5, 3.5, 4.5, and 5.5) are rounded up (Butcher et al., 2015). However, Wicklin (2019) claimed that the traditional rounding method could create a systematic bias, namely all half-integers

The results from Survey 1 showed that 51 sentences passed the criterion, and 4 sentences with the highest plausibility scores from each of the 8 past participles were selected, and thus 32 experimental items in total. The difference between the rating scores in both versions of each chosen target item did not exceed 1 (e.g., Havik et al., 2009). The plausibility scores of the experimental items are presented in Appendix G.

After the 32 critical items had been chosen from Survey 1, Survey 2 was conducted to select 192 distractors for the two presentation lists in the main experiment, namely 96 distractors per list. Unlike Survey 1 having two lists, Survey 2 contained only one version of sentences for the participants, i.e., all the 12 native English speakers who had taken part in the first survey. The words and phrases from the selected 32 critical items were employed to compose the distractors and their two versions. Survey 2 included the three groups of distractors with 90 items per group: Prepositional Phrase Ambiguity (PPA), Subject-Object Ambiguity (SOA), and Subject-Verb Agreement (SVA), accounting for a total of 270 items in the survey (See more details of the three types of distractors in Table 32).

The selection of distractors was comprised of two steps. Similar to the selection of the critical items, the first step was filtering out the sentences whose plausibility score was lower than 2.55. It was found that 251 items got 2.55 or more than 2.55, leaving 19 sentences omitted. The second step was choosing sentences from the 251 items. Thirty-two pairs of sentences were selected for each distractor type, accounting for 96 pairs in total. One criterion for the distractor selection was choosing the sentences with the 32 nouns in the critical items in equal quantity, i.e., 6 sentences for each noun. The 6 items made 3 sentence pairs, each of which was allocated for each of the three distractor types: PPA, SOA, and SVA. The sentences in each pair were distributed across the two lists of test items. The items in Survey 2 and their plausibility scores are provided in Appendix H.

---

were rounded up. In order to avoid such bias, the rounding method called *round-to-even* should be employed. According to the round-to-even method, rounding a half-integer depends on the last digit next to the target digit or the digit to be rounded (Blackstone, 2016: 1483). That is to say, in case the last digit is an odd number, namely 1, 3, 5, 7, or 9, the target digit increases by 1. On the contrary, the target digit is rounded down if the left digit is an even number, i.e., 0, 2, 4, 6, or 8. Following the round-to-even method, the numbers 2.5 and 2.55 are rounded to 2 and 2.6, respectively. In this study, 2.55, therefore, was used as the threshold for passing the norming test.

To summarize, 32 test items and 192 distractors were selected from Survey 1 and Survey 2, respectively. Table 33 encapsulates the information pertaining to the selected experimental sentences and distractors from the two surveys.

	Survey 1		**Survey 2**		**Total**
	The number of the presented items	**The number of the selected items**	**The number of the presented items**	**The number of the selected items**	
Target sentences	70	32			**32**
Distractors			270	192	**192**
The number of the selected experimental items and distractors					**224**

Table 33: The information about the number of the selected experimental sentences and distractors from Survey 1 and Survey 2

3.2 Research participants

Two groups of research participants were recruited: a native control group and a group of L1 Thai learners. All of them had normal or corrected-to-normal vision.

The native control group contained ten native English speakers among which there were nine faculty members and one graduate student at Chulalongkorn University, Thailand. The ten participants included four Americans, three British, two Australians, and one British American. They were from three institutes: Chulalongkorn University Language Institute (N = 6), Faculty of Arts (N = 3), and Faculty of Psychology (N = 1). As regards education, a master's degree and a bachelor's degree had been obtained by four participants each with the rest achieving a doctoral degree. Their ages ranged between 33 and 63, and the age mean was 41.2. They were to provide baseline data concerning the processing of irregular verbs in English PRRCs and RCs. Table 34 summarizes the information about the native controls.

Nationality	Occupation	Education	Age Range	Mean Age
American (4)	Lecturer (9)	Bachelor's degree (4)	33-63	41.2
British (3)		Master's degree (4)		
Australian (2)	Graduate student (1)	Doctoral degree (2)		
British American (1)				

Table 34: Information about the native control participants

The second group was the group of L1 Thai learners. Seventy L1 Thai undergraduate students from Chulalongkorn University took part in the present study. They were from nine faculties: Arts (N = 31), Psychology (N = 9), Medicine (N = 8), Engineering (N = 6), Commerce and Accountancy (N = 5), Communication Arts (N = 4), Political Science (N = 4), Law (N = 2), and Architecture (N = 1). Their ages ranged between 18 and 24, and the age mean was 20. All the undergraduates received formal instruction of English in their native country. The length of the instruction of English they were given ranged from 8 to 20 years, and the length mean was 15 years. Among the group, 44 students attended an Intensive English Program (IEP), an English Program (EP) or an international school where English was employed as a main medium of instruction. Regarding residence abroad, 46 learners lived in English-speaking countries, and the duration of residence ranged from 3 weeks to 3 months. The sample of the research was selected via purposive sampling. To put it simply, the participants were chosen based on the scores they got from one of the three English proficiency tests, i.e., IELTS, TOEFL iBT, and CU-TEP. This study included only the students in the 7.0-8.0 IELTS score range, the 95-120 TOEFL iBT score range, or the 99-120 CU-TEP score range, which is mapped to the C1 level of the Common European Framework of Reference for Languages (CEFR) (See details of the mapping between CU-TEP, IELTS, and TOEFL iBT scores and CEFR levels in Appendix A). With respect to the English proficiency tests, the majority of the participants, i.e., 44 people, took IELTS. Among the other 26 students, twenty-five took CU-TEP whereas another one took TOEFL iBT. The information about the L1 Thai subjects is encapsulated in Table 35.

Faculty	English Proficiency Test	Attendance at IEP, EP or International School	Residence Abroad	Length of Formal Instruction of English	Length of Formal Instruction of English Mean	Age Range	Mean Age
Arts (31)	IELTS (44)	Yes (44)	Yes (46)	8-20 years	15 years	18-24	20
Psychology (9)							
Medicine (8)							
Engineering (6)	CU-TEP (25)						
Commerce and Accountancy (5)							
Communication Arts (4)		No (26)	No (24)				
Political Science (4)	TOEFL iBT (1)						
Law (2)							
Architecture (1)							

Table 35: Information about the L1 Thai research participants

3.3 Data collection

Due to the spread of the COVID-19 pandemic, the experiments with the 3 groups of subjects were conducted online via ZOOM Cloud Meetings and a SuperLab feature called SuperLab Remote. SuperLab Remote was used to create a remote package, namely a zip file which incorporated an experiment file and the SuperLab Remote software allowing the research participants to join experiments everywhere as long as there was an internet connection and they had a Mac or Windows computer. Both the RST and SPRT were included in two remote packages. To carry out experiments with the participants, the remote packages and a ZOOM link were sent to them via email. In the ZOOM meeting, the participants were instructed on how to do the tasks, and were monitored to make sure they followed the task procedure. After they had finished doing the experiment tasks, the SuperLab Remote feature automatically created a file which recorded the data, i.e., the answers to the questions and the reading times, and they were asked to email the data file back to the researcher.

The data collection mentioned above was applied to both the native English speakers and L1 Thai learners, but the difference involved the number of the tasks given. The native controls took only the SPRT. They were instructed to read the sentences at their normal reading pace and to answer the comprehension questions. As aforementioned, the reading times on English PRRCs and RCs among the native English speakers were investigated in order to provide baseline data regarding the processing of irregular verbs in the two structures. Concerning the L1 Thai learners, both the RST and the SPRT were given to them. First, they completed the RST, which classified them into two groups according to WM level: the higher WM group and the lower WM group. Then, the learners took the SPRT so that their reading times on PRRCs and RCs could be recorded and examined. They were asked to read the sentences at their normal reading pace and to answer the comprehension.

3.4 Data analyses

In the RST, one point was given to a letter which was correctly recalled in serial order, and an L1 Thai research participant's reading span size was identified by counting the total number of the correctly recalled letters. In other words, even if a subject incorrectly judged the plausibility of a sentence, she got one point if she correctly recalled the letter appearing after the sentence in serial order. Because there were 75 letters in total, the possible maximum score was 75. After the completion of the RST, the participants are divided into groups according to their WM level: the higher WM group and the lower WM group. Following a standard procedure for classifying research participants by WM in previous studies using self-paced reading tasks (e.g., Havik et al., 2009; Dussias & Pinar, 2010; Zhou et al., 2017), the classification of the L1 Thai learners was carried out by calculating the median of their scores. The participants who scored higher than the median value were deemed to have higher WM whereas those scoring lower than the median were considered to have lower WM (e.g., Omaki, 2005; Hestvik et al., 2012).

With respect to the SPRT, data in relation to two aspects, namely accuracy of the answers to the comprehension questions and reading times on the target sentences, were explored.

First of all, the accuracy of the answers to the comprehension questions was statistically analyzed. Before the statistical analyses, a primary procedure in language processing research (e.g., Omaki, 2005; Keating & Jegerski, 2015) called data trimming was adopted. The procedure was to ensure that the data which were included in the analyses reflected the participants' careful attention given to reading the test items. In this case, the participants whose overall comprehension accuracy for the test items was lower than 80%, i.e., scoring up to 25 points out of 32, were eliminated.[43] After data trimming, the research participants' comprehension accuracy was statistically analyzed via two tests, namely a Kruskal-Wallis test and a Friedman test. While the Kruskal-Wallis test, which involved salience and structure as between-group variables, was used to figure out the test conditions in which the participant groups showed significantly different comprehension accuracy scores, the Friedman test, which included the two factors as within-group variables, examined differences between the test conditions among each participant group. Nemenyi post hoc tests were employed to identify the test condition pairs where the comprehension accuracy scores differed, and to investigate interaction between the three factors among the accuracy scores.

The reading times on English PRRCs and RCs were analyzed in order to explore two major topics: impact of structure, salience, and working memory and interaction between the three factors among the reading times for the two English constructions, namely PRRC and RC, and that for the irregular past participial forms with different salience levels, i.e., Groups 2 and 4.

The analyses of the online data focused on four regions in the experimental sentences, i.e., the *Past Participle* (*PP*), the *Modifier of the PP*, the *Main Verb* (*MV*), and the *Object*. For each PRRC test item, the *PP* region introduced the past participle of the sentence. The *Modifier of the PP* comprised three words that modified the past participle. The *MV* region showed the finite verb of the sentence which ensured that the past participle in the *PP* region was not the main verb. The *Object* region included a noun which functioned as the object of the main verb. Regarding the RC test items,

[43] Generally, language processing research do not include the participants who score lower than 70% or 80% since they might not have adequately focused on doing the task (Omaki, 2005: 71).

the past participle followed the subject and the phrase *who/which was*, which were excluded from the analyses. In (126) and (127), the *PP* region, the *Modifier of the PP* region, the *MV* region, and the *Object* region are represented by the numerical digits 1, 2, 3, and 4, respectively.

(126) PRRC: The tourist taken to that hotel planned a tour.

Sentence	The tourist	taken	to that hotel	planned	a tour.
Region		1	2	3	4

(127) RC: The monkey which was eaten in the forest passed a virus.

Sentence	The monkey which was	eaten	in the forest	passed	a virus.
Region		1	2	3	4

The reading times for the four regions were analyzed in two different ways in order to answer the research questions which involved two aspects, namely reading times on different structures (PRRCs and RCs) and effects of salience of the past participial forms of irregular verbs (past participles in Groups 2 and 4).

To examine the differences between how the research participants processed PRRCs and RCs, the reading times on the *PP* region and those on the *Modifier of the PP* region were combined as critical regions since they were structurally related as a participial phrase. The analyses also paid attention to the post-critical regions, i.e., the *MV* region and the *Object* region, as spillover regions in order to look into potential delayed processes which may spill over into the regions immediately following (Marsden, Thompson, & Plonsky, 2018). On the other hand, to investigate how salience of the past participle forms of irregulars influenced the participants' processing of PRRCs and RCs, the data analyses stressed the reading times on the *PP* region (the critical region) and those on the *Modifier of the PP* region (the spillover region). Although the *PP* region and the *Modifier of the PP* region were structurally related, they were separated from each other so that the effects of salience of the past participial forms of the irregulars on the processing of the rest of the participial phrases could be examined.

The reading times in milliseconds for all regions of all target sentences were recorded. The data were divided into correct responses (the participants correctly answered the comprehension questions) and incorrect responses (the participants incorrectly answered the comprehension questions). Following the standard procedure in this type of experiment in previous studies on the processing of PRRCs (e.g., MacDonald et al., 1992; Juffs, 1998), only the reading times for the correct responses were included in statistical analyses. The participants whose comprehension accuracy rates of the test items were below 80% were removed. Then, the reading times were screened for potential outliers via an outlier removal method called interquartile range (IQR). The procedure was aimed to cut off the reading times in which the participants lost concentration in the experiment.

The reading times on the four regions of interest were statistically analyzed via three-way analysis of variance (ANOVA) tests to probe into possible effects of three independent variables, i.e., 'group' (native English speakers, higher WM learners, and lower WM learners), 'structure' (PRRC and RC), and 'salience' (past participles in Salience Groups 2 and 4), on the dependent variable, namely the reading times. The analyses included 'group' as a between-group variable and 'structure' and 'salience' as within-group variables. As aforesaid, the investigation of the participants' processing of PRRCs and RCs and that of past participles from Salience Groups 2 and 4 considered different sets of regions in analyses. The analysis of the *Structure* data encompassed the reading times on all the four regions: *Past Participle* (*PP*), *Modifier of the PP*, *Main Verb* (*MV*), and *Object*, while that of the *Salience* data embraced the reading times spent on the regions *PP* and *Modifier of the PP*. Furthermore, two post-hoc tests, specifically the one-way ANOVA test and the pairwise t-test, were utilized for different purposes. First, post-hoc one-way ANOVA tests were conducted to identify whether salience and structure had a main effect on each other. To investigate salience effects on processing of the two structures, salience was deemed as a within-group variable. In the same vein, structure was included as a within-group variable to explore structure effects on processing of the participial forms. The second post-hoc test is pairwise t-tests used to scrutinize significant differences in reading times

among the three participant groups. The two post-hoc tests were employed for the data in both the *Structure* and *Salience* sections.

In describing significance level of the statistical data, *p*-adjusted values were used. Adjusted *p*-values are usually used to indicate the significance level for multiple comparisons in ANOVA, so it was appropriate for the present study where multiple comparisons were carried out, e.g., three pairs of participant groups were compared to investigate differences between them. If a regular *p*-value is used for multiple comparisons, error rates increase with each additional comparison.

3.5 Implications of the pilot study

Prior to the main study, a pilot study was carried out for the following reasons: to measure the research instruments' practicality and to examine whether the data gained from the SPRT could answer the research questions.

Ten L1 Thai learners of L2 English took part in the pilot study. They had normal or corrected-to-normal vision. The age range among this participant group was between 19 and 36, and the mean age was 30.8. The research participants in the pilot were similar to those in the main study in one aspect, namely they were at the C1 level of English proficiency, which was determined by the scores they obtained from one of the three English proficiency tests, i.e., IELTS, TOEFL, and CU-TEP. All of them were paid for their participation.

The instruments employed in the pilot study contained the RST and the SPRT. The two tasks were administered to the participants in a quiet room to make sure that the participants could pay full attention to completing the tasks. The RST comprised 75 test items whereas the SPRT consisted of 12 test items and 24 distractors. Even though the RST had passed a validation check in Phinitkit's research, it was necessary to ensure that the task could categorize the participants in the present study into groups according to their WM level.

First, the participants individually took the RST, which classified them into two groups by WM level: the participants with higher WM and those with lower WM. The categorization of the learners was carried out by calculating their mean RST

score. The participants who scored higher than the mean score were considered having higher WM whereas those scoring lower than the mean score were deemed to have lower WM. The mean score was 62.6. Five learners scored higher than 62.6, while the other five scored lower than the mean score. Therefore, the pilot study comprised two groups of participants: a higher WM group and a lower WM group, with 5 people each. The mean scores of the higher WM group and the lower WM one were 66.25 and 58, respectively. After that, the ten learners were separately administered the SPRT in order to have the reading times they spent on the PRRCs and RCs recorded. They were instructed to use a mouse to proceed with reading the sentences, and to press the letter 'y' or 'n' on the keyboard when answering the comprehension questions. The data gained from the SPRT mainly involved the amount of time spent on reading two regions of the target sentences, i.e., the *PP* (e.g., *given*, *bitten*, and *thrown*) and the *Modifier of the PP* (e.g., *to the police*, *on the ankle*, and *on that table*). After the data were obtained, they were quantitatively analyzed for mean scores and standard deviations.

The RST and the SPRT met the two objectives of the pilot study. Regarding the first objective, the two research instruments were highly practical. The participants completed the tasks without any problems. The data from the RST could divide the participants into groups according to WM level while those from the SPRT showed the reading times in milliseconds of the subjects on all regions of the target sentences. In addition, the data obtained via the SPRT could answer the research questions. When it came to the structures, i.e., PRRCs and RCs, both groups of learners in the pilot spent more time reading the reduced RCs than reading the unreduced ones. Among the participants with lower WM, the reading times on PRRCs were similar to those on RCs. On the contrary, those with higher WM spent much more time reading PRRCs than RCs. Regarding the effects of the salience of the past participial forms of the irregulars, the reading times on the past participles in Group 2 among the learners with higher WM were higher than those on the past participial forms in Group 4. Among the lower WM participants, the reading times on the past participial forms in Group 2 were lower than those on the participles in Group 4. Table 36 and Table 37 show the reading times in relation to the structure-related

research question and those with respect to the salience-related research question, respectively.

Structure	Higher WM	Lower WM
PRRC	1312.366	1292.004
RC	1109.004	1173.606

Table 36: The reading times on the PP region and the Modifier of the PP region concerning the Structure-related research question

Salience Level	Higher WM	Lower WM
Group 2	1189.125	1302.253
Group 4	1178.5	1336.343

Table 37: The reading times on the PP region and the Modifier of the PP region concerning the Salience-related research question

In summary, carrying out the pilot study helped ensure that the research instruments, i.e., the RST and the SPRT, were practical. It also suggested that the data gained from the instruments could be further analyzed to answer the research questions.

3.6 Recruitment of research participants and compliance with research ethics for research involving human subjects

The two groups of research participants were recruited via two posters, one in Thai for L1 Thai learners and the other in English for native English speakers. The posters provided details of the tasks, the platform where the experiments were conducted (i.e., ZOOM Cloud Meeting), the duration of each data collection session, qualifications of the participants, contact information of the researcher, and the QR Code for accessing the online application form, which asked each participant to inform background information and contact information (See the application forms for participating in the present study in Appendix I). Only the application form for L1 Thai learners asked the participants to specify their CU-TEP score, length of formal instruction of English, experience of attending Intensive English Program (IEP) or English Program (EP), and experience of living or studying in an English-speaking country. Their CU-TEP scores indicated whether they were qualified for the research.

That is, the students whose CU-TEP scores ranged from 99 to 120 points were included in this study. The researcher reached the native speakers and the L1 Thai learners, who filled in the online application form, via phone, email or Facebook Messenger. The information sheet which provided information about the experiment was sent to them so that they could learn about the details of the tasks. Also, they were informed that they would electronically sign the consent form on the day in which they took part in the experiment. After they had agreed to do the tasks, the researcher made an appointment with them, created a ZOOM link, and sent the link and the task files to them via email. One-by-one, the participants joined the experiment. In the ZOOM meetings, the researcher instructed the participants on how to do the tasks, monitored them to make sure they followed the procedure of the tasks, and asked them to sign the consent form. As regards L1 Thai learners, the teachers at Chulalongkorn University Language Institute and Faculty of Arts, Chulalongkorn University, were asked to advertise the experiment by displaying the poster online, specifically on their Facebook and in their online classes. Concerning native speakers of English, the researcher asked the Office of International Affairs, Chulalongkorn University to advertise the experiment via their Facebook page. Also, the teachers at Chulalongkorn University Language Institute and Faculty of Arts, Chulalongkorn University, were asked to promote the experiment on their Facebook as well as in their online classes.

Before data collection, the present study and its procedure were approved by the Research Ethics Review Committee for Research Involving Human Subjects: the Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts, Chulalongkorn University (IRB Protocol No. 043/64). The L1 Thai learners and native English speakers were rewarded for their participation with 400 Baht and 300 Baht, respectively. The research participants' information was treated as confidential. No information in the report of the research findings could lead to identifying a research participant as an individual. The participants were informed that they had the right to withdraw from the research at any time without mentioning the reason, and that their withdrawal would not affect them, their study, and their work in the future.

3.7 Summary

This chapter gave information about the research methodology of this study. It began by describing the two research instruments, namely the reading span task and the self-paced reading task. The technical requirements for both tasks, the design and usage of the tasks, and the validation of the instruments were discussed. Then, the information about the qualifications of the research participants and the criteria for the participant selection was provided. This chapter also addressed how the data were collected from the participants, the statistical tools employed for analyzing the data, and the details and the implications of the pilot study. Finally, this chapter ended with the present study's recruitment of research participants as well as its compliance with ethical standards involving human participants.

The next chapter is the findings and discussion pertaining to the effects of working memory, salience, and structure on the research participants' processing of English RCs and PRRCs which included irregular verbs of different salience levels.

CHAPTER IV
RESULTS AND DISCUSSIONS

This chapter reports findings and discussions of the processing of English PRRCs and RCs among the three groups of research participants: the native control group and the two groups of L1 Thai learners with different levels of WM: the participants with higher WM and those with lower WM. Section 4.1 shows results and discussions of the findings of the present study. Section 4.2 provides a general discussion based on the findings. Section 4.3 presents a summary of the chapter.

4.1 Results and discussions of the findings of the study

This section consists of two subsections. Subsection 4.1.1 presents the findings of the RST with regard to the L1 Thai participants only, and Subsection 4.1.2 reports the SPRT results concerning the L1 Thai learners followed by those about the native English speakers as well as the discussions of the findings.

Before results and discussions, the hypotheses, which were presented in 1.4, are repeated here for convenience.

Hypothesis 1: The L1 Thai learners' WM levels and salience of the past participial forms of irregulars will affect the learners' processing of English RCs and PRRCs which contain past participles.

Hypothesis 2: The L1 Thai learners with higher WM will have a higher degree of accuracy in answering the comprehension questions than those with lower WM.

Hypothesis 3: The reading times the L1 Thai learners with higher WM spend on PRRCs will be significantly greater than those on RCs whereas the reading times the learners with lower WM spend on PRRCs will not be significantly greater than those on RCs.

Hypothesis 4: The reading times the L1 Thai learners with higher WM spend on less salient irregulars will be significantly greater than those on more salient

irregulars whereas the reading times the learners with lower WM spend on less salient irregulars will not be significantly greater than those on more salient irregulars.

4.1.1 Reading span task

Only the seventy L1 Thai learners had taken the RST before doing the SPRT. The RST scores ranged between 29 and 75. The classification of the L1 Thai subjects by WM span was carried out by dividing them into groups via the median split at 60. To be specific, the participants whose span was less than or equal to 60 were assigned to the lower span group whereas those with a more-than-60 score were considered as having higher WM span. With such classification, 37 participants were in the lower span group while 33 subjects belonged to the higher span group. The range of the scores among the higher WM group was from 62 to 75 whereas that among the lower WM group was from 29 to 60. The means of the RST scores among the higher WM L1 Thai subjects and those among the lower WM ones were 68.78 (SD = 3.70) and 50 (SD = 8.62), respectively. An independent t-test showed that the mean scores of the two WM groups were significantly different ($t(68) = -11.569$, $p < 0.05$). The RST scores of the research participants and the results of the independent t-test are presented in Appendix J and Appendix K, respectively.

4.1.2 Self-paced reading task

This subsection comprises 2 parts: 4.1.2.1 addresses the participants' comprehension accuracy whereas 4.1.2.2 deals with the reading times spent on the test items.

4.1.2.1 Comprehension accuracy

This part contains 2 segments, namely 4.1.2.1.1 and 4.1.2.1.2, which provide the results and discussions of the findings about comprehension accuracy, respectively.

4.1.2.1.1 Results: comprehension accuracy

In connection with the L1 Thai learners, prior to further analyses, the participants whose overall comprehension accuracy for the test items was lower than 80%, i.e., scoring up to 25 points out of 32, were excluded[44]. With this criterion, 11 people and 7 people were excluded from the lower span group and the higher span one, respectively. Therefore, 26 people from each group passed the criterion, accounting for a total of 52 participants to be analyzed. The comprehension accuracy scores of the L1 Thai research participants from the two WM groups are reported in Appendix L.

The remaining data were then divided according to span group: higher WM and lower WM. After that, the overall mean comprehension accuracy for the four target conditions among the two L1 Thai groups was calculated. The mean comprehension accuracy values of the learners with higher WM were as follows: 95.19% (SD = 0.70) for the PRRC/Salience 2, 94.71% (SD = 0.76) for the RC/Salience 2, 87.02% (SD = 0.82) for the PRRC/Salience 4, and 89.90% (SD = 1.02) for the RC/Salience 4. The mean comprehension accuracy values of the lower WM participants were 93.27% (SD = 0.71) for the PRRC/Salience 2, 91.35% (SD = 0.84) for the RC/Salience 2, 84.62% (SD = 1.03) for the PRRC/Salience 4, and 86.06% (SD = 1.11) for the RC/Salience 4.

Among the native speakers of English, the overall mean comprehension accuracy for the four target conditions was as follows: 85% (SD = 0.79) for the PRRC/Salience 2, 91.25% (SD = 0.67) for the RC/Salience 2, 91.25% (SD = 1.06) for the PRRC/Salience 4, and 95% (SD = 0.70) for the RC/Salience 4. No data trimming was required since all the subjects in the group achieved comprehension accuracy higher than 80%. The comprehension accuracy scores of the native speakers of English are provided in Appendix M.

The data about the mean comprehension accuracy among the three groups of research participants are graphically presented in Figure 9 and Table 38.

---

[44] Omaki (2005) claimed that, in language processing research, the participants who score lower than 70% or 80% are usually excluded since they might not have paid sufficient attention to the task.

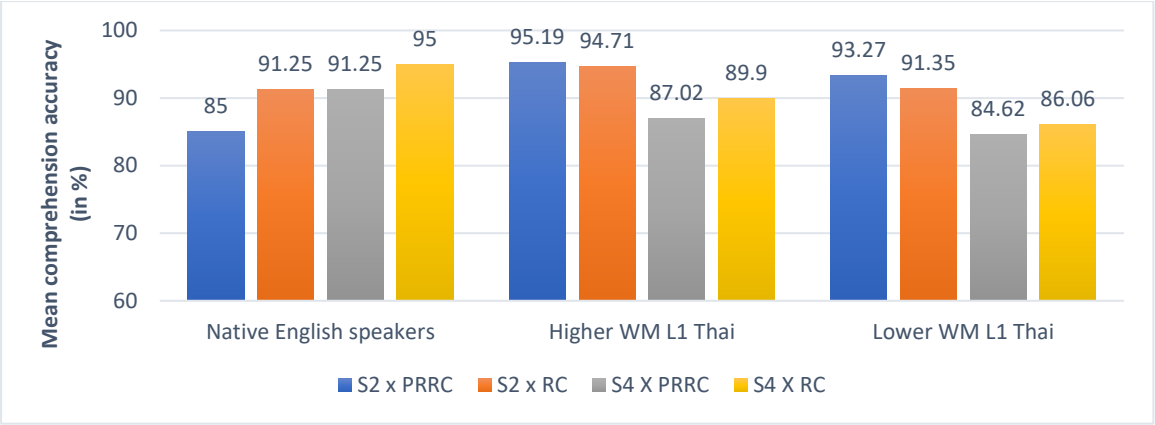


Figure 9: Mean comprehension accuracy in the four target conditions by the three groups of participants

Test Condition	Participants					
	L1 TH Higher WM		L1 TH Lower WM		L1 EN	
	Mean (ratio)	SD	Mean (ratio)	SD	Mean (ratio)	SD
PRRC/Salience 2	95.19%	0.70	93.27%	0.71	85.00%	0.79
RC/Salience 2	94.71%	0.76	91.35%	0.84	91.25%	0.67
PRRC/Salience 4	87.02%	0.82	84.62%	1.03	91.25%	1.06
RC/Salience 4	89.90%	1.02	86.06%	1.11	95.00%	0.70

Table 38: Mean comprehension accuracy in the four target conditions by the three groups of participants

According to Figure 9 and Table 38, the comprehension accuracy of all the three participant groups was quite high. They scored higher than 80% across all the four test conditions.

4.1.2.1.2 Discussions: comprehension accuracy

With respect to the participants' comprehension accuracy, two non-parametric statistical tests, i.e., Kruskal-Wallis test and Friedman test, were employed since the data were not normally distributed.[45] The two tests were aimed to analyze the comprehension accuracy data in relation to three aspects: WM's impact, effects of

[45] Kruskal-Wallis test and Friedman test are non-parametric statistical tests; that is, they do not assume normality or normal distribution of data, but they assume that data are not normally distributed (e.g., Hecke, 2010; Smalheiser, 2017). According to Sun (2020), non-parametric tests, including Kruskal-Wallis tests and Friedman tests, are usually used when the collected data are abnormally distributed. The difference between a Kruskal-Wallis test and a Friedman test is that the former compares many groups that are not arranged in pairs whereas the latter compares repeated measures, i.e., one subject group that is measured on several occasions (Cleophas & Zwinderman, 2016).

salience and structure, and interaction between the two factors, which are addressed in 4.1.2.1.2.1, 4.1.2.1.2.2, and 4.1.2.1.2.3, respectively.

4.1.2.1.2.1 Working memory's effects on the L1 Thai learners' comprehension accuracy

The first issue involved effects of WM on the L1 Thai learners' comprehension accuracy. The L1 Thai subjects were divided by the RST into two groups according to their WM level: higher WM and lower WM groups. The participants with higher WM were hypothesized to have higher comprehension accuracy than those with lower WM did. Table 39 presents the mean comprehension accuracy scores measured by percentage of the two L1 Thai groups for the four test conditions.

Test Condition	Participants			
	L1 TH Higher WM		L1 TH Lower WM	
	Mean (ratio)	SD	Mean (ratio)	SD
PRRC/Salience 2	95.19%	0.70	93.27%	0.71
RC/Salience 2	94.71%	0.76	91.35%	0.84
PRRC/Salience 4	87.02%	0.82	84.62%	1.03
RC/Salience 4	89.90%	1.02	86.06%	1.11

Table 39: Mean comprehension accuracy in the four target conditions by the two L1 Thai participant groups

According to the between-group comparison in Table 39, the mean comprehension accuracy of the L1 Thai subjects with higher WM was greater than that of the participants with lower WM across all the four test conditions. A Kruskal-Wallis test was then conducted to identify the test conditions in which there were significant differences between the subject groups in terms of comprehension accuracy score. However, the statistical analysis manifested no significant differences between the L1 Thai learners with higher WM and those with lower WM as regards comprehension accuracy score for every test condition. This suggested that WM had no impact on the L1 Thai learners' offline processing. Consequently, the lack of WM effects rejected Hypothesis 2, which stated that the learners with higher WM would have a higher degree of comprehension accuracy than those with lower WM.

The absence of WM effects may be attributable to the low level of resource demands of the research instrument in the present study, i.e., the self-paced reading task (SPRT). In the literature of language processing and individual differences, the presence of WM impact has been found to depend on the employed task's cognitive burden. Just and Carpenter (1992) explained that cognitive differences, including working memory capacity, could affect individuals' processing performance when the cognitive demands of the given research instrument exceeded their available resources. In other words, when the used task consumed less cognitive capacity, differences in performance among individuals with different WM levels were smaller and harder to notice; however, the distinctions tended to be more striking when they took a more capacity demanding task.

In connection with the present study, the SPRT asked the participants to read sentences and answer a yes-no question about each sentence. The task simply tested whether the research participants understood the meaning conveyed by the sentences, specifically the modified nouns' thematic role assigned by the past participle, which imposed a low cognitive burden for them. The low degree of resource demands together with the L2 learners' advanced English proficiency probably resulted in the lack of WM effects on the participants' offline performance. This was in line with the findings of numerous previous studies (e.g., Havik et al., 2009; Hopp, 2015; Zhou et al., 2017). For instance, Zhou et al. (2017) looked into L1 Chinese learners' processing of English wh-extractions by administering the participants two tasks: a grammaticality judgment task (GJT) and a translation task. WM was found to affect the participants' offline processing in only the translation task which was more demanding than the GJT. In the GJT, the accuracy scores of the L1 Chinese learners with different WM levels did not significantly differ.

To summarize, WM had no significant impact on the L1 Thai participants' comprehension accuracy due to the low cognitive demand of the SPRT used in the present study.

4.1.2.1.2.2 Effects of salience and structure on the L1 Thai learners' comprehension accuracy

The second issue to be examined was the extent to which salience and structure affected the comprehension accuracy of the L1 Thai research participants. The four test conditions were paired with each other, making a total of four pairs investigating effects of the two factors, as illustrated in Table 40.

Paired test conditions	Investigated factor
1) PRRC/Salience 2 vs PRRC/Salience 4	*Salience*
2) RC/Salience 2 vs RC/Salience 4	
3) PRRC/Salience 2 vs RC/Salience 2	*Structure*
4) PRRC/Salience 4 vs RC/Salience 4	

Table 40: Four test condition pairs and their investigated factors

According to Table 40, the PRRC/Salience 2 vs PRRC/Salience 4 pair and the RC/Salience 2 vs RC/Salience 4 pair examined impacts of salience whereas the PRRC/Salience 2 vs RC/Salience 2 pair and the PRRC/Salience 4 vs RC/Salience 4 pair looked into effects of structure.

Table 41 reveals the mean comprehension accuracy data in relation to *Salience.*

Participant group	Pair 1		Pair 2	
	PRRC/Salience 2	PRRC/Salience 4	RC/Salience 2	RC/Salience 4
L1 TH Higher WM	95.19%	87.02%	94.71%	89.90%
L1 TH Lower WM	93.27%	84.62%	91.35%	86.06%

Table 41: Mean comprehension accuracy in relation to Salience

As for *Salience*, the two L1 Thai groups performed better with the past participles from Salience Group 2 than with those from Salience Group 4 in both the PRRC/Salience 2 vs PRRC/Salience 4 pair and the RC/Salience 2 vs RC/Salience 4 pair.

Table 42 shows the mean comprehension accuracy data in relation to *Structure*.

Participant group	**Pair 1**		**Pair 2**	
	PRRC/Salience 2	**RC/Salience 2**	**PRRC/Salience 4**	**RC/Salience 4**
L1 TH Higher WM	95.19%	94.71%	87.02%	89.90%
L1 TH Lower WM	93.27%	91.35%	84.62%	86.06%

Table 42: Mean comprehension accuracy in relation to Structure

Pertaining to *Structure*, the L1 Thai participants showed higher accuracy for PRRCs than for RCs in the PRRC/Salience 2 vs RC/Salience 2 pair, but revealed lower accuracy for the reduced RCs than for the unreduced RCs for the PRRC/Salience 4 vs RC/Salience 4 pair.

Statistical analyses of the data were carried out to investigate effects of salience and structure. A Friedman test was conducted in order to see if there were statistically significant differences between the test conditions among each participant group. Significant differences were found in both the L1 Thai learners with higher WM ($df = 3$, $W = 0.225$, $\chi^2 = 15.733^{**}$, $p < 0.01$) and those with lower WM ($df = 3$, $W = 0.278$, $\chi^2 = 11.145^{*}$, $p < 0.05$). The statistical results from the Friedman test are given in Appendix N.

After that, Nemenyi post hoc tests were performed to identify the test condition pairs in which the comprehension accuracy scores were significantly different. The tests revealed a significant difference among the higher WM L1 Thai participants by the two condition pairs: 1) PRRC/Salience 2 vs RC/Salience 2 ($p < 0.05$), and 2) RC/Salience 2 vs PRRC/Salience 4 ($p < 0.05$). Among the lower WM L1 Thai participants, the differences between their mean comprehension accuracy

scores in the conditions PRRC/Salience 2 and RC/Salience 2 were barely significant, i.e., 0.065. The statistical results from the Nemenyi post hoc tests are provided in Appendix O.

Effects of salience and structure were investigated by taking into account the data from the Nemenyi post hoc tests.

With regard to salience, the researcher considered the comprehension accuracy scores in the two pairs of conditions: 1) RC/Salience 2 vs RC/Salience 4, and 2) PRRC/Salience 2 vs PRRC/Salience 4. No significant differences were observed among the two groups of L1 Thai participants. As a result, salience had no impact on the L1 Thai learners' offline processing.

To examine the effects of structure, the comprehension accuracy scores in the two condition pairs, i.e., PRRC/Salience 2 vs RC/Salience 2 and PRRC/Salience 4 vs RC/Salience 4, were taken into consideration. The findings revealed significant differences between the mean comprehension accuracy for the PRRC/Salience 2 and that for the RC/Salience 2 condition among the L1 Thai learners with higher WM. Moreover, the differences between the lower WM L1 Thai participants' mean comprehension accuracy scores in these two conditions were barely significant. The two groups of L1 Thai subjects were more accurate when reading PRRCs than when reading RCs. Regarding the PRRC/Salience 4 vs RC/Salience 4 pair, no significant difference was observed among the L1 Thai learners. It can be concluded that structure had effects on the comprehension accuracy of the two L1 Thai groups with different WM levels only when they dealt with past participles in Salience Group 2.

Table 43 summarizes the data concerning the statistically significant differences between the mean comprehension accuracy scores among the two L1 Thai groups in relation to *Salience* and *Structure*.

Investigated factor	Condition pair	Significantly different statistical data	
		L1 TH Higher WM	L1 TH Lower WM
Salience	RC/Salience 2 vs RC/Salience 4	–	–
	PRRC/Salience 2 vs PRRC/Salience 4	–	–
Structure	PRRC/Salience 2 vs RC/Salience 2	+	–
	PRRC/Salience 4 vs RC/Salience 4	–	–

Table 43: The statistically significant differences between the mean comprehension accuracy among the L1 Thai participant groups in relation to Salience and Structure

4.1.2.1.2.2.1 Structure effect on comprehension accuracy

As mentioned above, structure had some effects on the L1 Thai learners' comprehension accuracy when they dealt with the past participles from Salience Group 2. Significant differences were observed between the mean comprehension accuracy scores for the PRRC/Salience 2 condition and those for the RC/Salience 2 condition among the higher WM L1 Thai participants. Furthermore, the accuracy scores between the two condition pairs among the lower WM participants bordered on significance. The two groups of L1 Thai learners were more accurate when reading PRRCs than when reading RCs.

The L2 learners' significantly higher comprehension accuracy for PRRCs than for RCs was possibly attributed to the following three reasons: the PRRCs' increasing frequency in English texts, consumption of lower cognitive resources in processing the reduced RCs than those in processing the unreduced ones, and the participants' high English proficiency.

First of all, the L1 Thai learners showed a higher rate of comprehension accuracy for PRRCs than that for non-reduced RCs as a result of the reduced RCs' highly frequent occurrence in English written texts. Non-finite participle clauses, which include reduced relative clauses, have been reported to predominantly appear in a variety of writing genres, such as narratives, textbooks, and articles (e.g., Beaman, 1984; Granger, 1997; Biber & Gray, 2010; Biber, Gray, & Poonpon, 2011; Hundt, et

al., 2012; Rafajlovičová, 2012). According to Granger (1997), the reduced RCs occur in various writing genres so often that the clauses have been regarded as a common component of English texts. It was thus assumed that L2 English learners have received a high exposure to the PRRC structure. It was therefore possible that the frequent occurrence of the PRRCs in English written texts made the L1 Thai subjects get used to the structure and its meaning in relation to the voice and the role of the modified nouns. The increasing frequency of the reduced RCs led the learners to achieve a higher comprehension accuracy for PRRCs than for RCs although the former structure is more structurally complex than the latter one. This is in agreement with the findings of Thiamtawan and Pongpairoj (2013). They looked into the production of English PRRCs and RCs among L1 Thai intermediate learners of L2 English, and expected the subjects to produce more unreduced RCs than the reduced ones because of the non-existence of the latter construction in Thai, their native language. The results, however, indicated the reverse, showing that the participants produced a higher number of the reduced RCs than that of the unreduced ones. Thiamtawan and Pongpairoj attributed the L2 learners' production of the PRRCs to their familiarity with the structure, which was associated with the high frequency of their occurrence in English texts.

The next reason why the comprehension accuracy for RCs was lower than that for PRRCs involves the demand for higher cognitive resources in processing the former than that for processing the latter. In other words, the unreduced RCs might be more complicated to process and comprehend than the reduced ones. It is possible that L2 learners need to consider three factors when they process the unreduced RCs: the verb's agreement with the subject and tense, English tenses and aspects, and relative pronouns.

Firstly, processing an RC tackles the verb's agreement with the subject and tense of the subordinate clause. English verbs vary in form in order to agree with the subject and tense of the given sentence. First of all, the RC processing seems to be related to subject-verb agreement, namely the state in which a subject and a finite verb in the same clause agree with each other in number and person (e.g., Johansson, 2018; Pettersson, 2019). When the subject is a singular noun, the verb must match the

subject by being singular. In a similar vein, the verb must reflect plurality when a plural noun is the subject. Moreover, the verb form varies according to countability of the given noun. According to Molin (2020), uncountable nouns occur with only the singular verb form while the verbs used with a countable noun could be either singular or plural, depending on the number of the noun. As to person agreement, Estling Vannestål (2015) claimed that, in the present tense, the third person singular nouns require a verb with the inflectional morpheme -s, whereas the verbs which are employed with the third person plural subjects and the first or second person noun phrases do not take any morpheme. It is also necessary for readers to take into account the correlation between the verb forms and the tense of the sentences. Such agreement involves two issues: the inflectional morphemes attached to the finite verb in the RC as well as the changes in the form of the auxiliary verbs. The first point concerns the inflectional morphemes affixed to the finite verbs. In an RC, an inflectional morpheme is attached to the main verb in the subordinate clause, and different morphemes are used with different English tenses. For instance, the morphemes '-s,' '-ed,' and '-ing' are employed with the present tense, past or perfect tense, and progressive tense, respectively. Thus, the readers have to determine whether or not the used morpheme agrees with the tense of the given sentence. Second, the variations of the forms of the auxiliaries might impose a cognitive difficulty for L2 learners. The auxiliary verbs vary according to the tense of the sentence and the number of the subject. The auxiliaries include *be*, *have,* and *do*. *Be* becomes *is*, *am,* or *are* for the present tense, and *was* or *were* for the past tense. *Have* turns to *has* or *have* for the present tense, and *had* for the past tense. *Do* changes into *does* and *do* for the present tense, and *did* for the past tense. The second issue that has to be given some consideration when RCs are processed concerns a variety of tenses and aspects in English. On experiencing an RC, readers need to allocate part of their cognitive capacity for considering the time at which an action happens through the finite verb of the subordinate clause. Furthermore, the RC processing might be overloaded with different grammatical components required by different tenses, such as present perfect (*have* or *has* + a past participle), present perfect continuous (*have* or *has* + *been* + a present participle), past perfect (*had* + a past participle), past perfect continuous (*had* + *been* + a present participle), future perfect (*will* + *have* + a past participle), and

future perfect continuous (*will* + *have* + *been* + a present participle). Other than subject-verb agreement and tenses, the correlation between relative pronouns and the nouns they follow could make the processing of RCs more cognitive demanding. Different relative pronouns are used to refer to nouns with different animacy statuses, i.e., 'who' and 'whom' for human nouns, 'which' for non-human antecedents, and 'that' for both human and non-human nouns (Endley, 2010). In processing an unreduced RC, readers might have to determine whether or not the pronoun agrees with its antecedent.

In stark contrast, processing a PRRC seems to consume fewer cognitive resources in light of its simpler form. Compared to an RC, the reduced RC construction is comprised of fewer elements, specifically a noun phrase and a past participle. This means the L2 learners in the present study did not have to devote attention to the three issues mentioned above while processing PRRCs, leaving them adequate cognitive capacity to successfully deal with the comprehension questions which followed the construction.

To summarize, agreement between the verb and subject and tense, various tenses and aspects, and relative pronouns appeared to be additional cognitive burdens for the L2 learners when they processed the full RCs, and thus, impeding the offline processing of the structures. This was not the case for processing the PRRC structure. The greater cognitive demand required for processing RCs than that for processing PRRCs was likely to yield the comprehension accuracy scores for the former, which were significantly lower than those for the latter.

Lastly, the higher comprehension accuracy rate for PRRCs than that for RCs might be related to the fact that all the L1 Thai subjects had high English proficiency. As aforementioned, all the L1 Thai learners in the present study possessed a high degree of English proficiency determined by one of the three English proficiency tests, namely IELTS, TOEFL iBT, and CU-TEP. Coupled with the high frequency of the PRRCs, which led them to be familiar with the structure, the research participants had a strong tendency to have developed a full understanding of the concept of the reduced RCs and mastered how to use it. The association between individuals' L2 proficiency and their offline performance is consistent with Rah and Adone (2010),

who found that the L1 German learners with advanced English proficiency were highly accurate in judging the grammaticality of the PRRC structure in their offline processing.

To recapitulate, the comprehension accuracy for the participial reduced relative clauses among the L1 Thai subjects was higher than that for the full relative clauses probably due to the reduced RCs' highly frequent occurrence in English written texts, a requirement of fewer cognitive resources for processing the PRRCs than those for processing the RCs, and advanced English proficiency of the L2 learners themselves.

4.1.2.1.2.2.2 Salience effect on comprehension accuracy

Pertaining to salience, no significant differences were observed between the mean comprehension accuracy scores for both the RC/Salience 2 vs RC/Salience 4 pair (e.g., 'The squirrel which was given to the painter climbed a tree.' and 'The panther which was seen in the valley seized a fox.', respectively) and the PRRC/Salience 2 vs PRRC/Salience 4 pair (e.g., 'The beggar shaken from the coldness wanted a jacket.' and 'The model drawn on the billboard earned an award.', respectively). To be specific, the comprehension accuracy scores for the past participles from Salience Group 2 (e.g., *shaken* and *given*) and those for the PPs from Salience Group 4 (e.g., *seen* and *known*) did not significantly differ regardless of the structure. This suggested that salience exerted no effects on the L1 Thai subjects' offline processing.

The lack of salience effects might be accounted for by three factors: similarities between the past participles with different salience levels, the occurrence of the verbs from the two salience groups in the same structures, and the L1 Thai participants' sensitivity to thematic information.

First, the absence of salience impact could be due to similarities between the past participles from the two salience groups. Although the past participial forms from Salience Group 2 are more perceptually salient than those from Group 4, they are remarkably similar in two aspects: number of syllables and meaning with regard to passive voice. The first resemblance addresses the number of syllables of the used

past participles. As mentioned in Section 3.1.3.1, to control the length effects, the present study encompassed past participial forms which have either one or two syllables, such as *blown*, *drawn*, *eaten*, and *taken*. All the past participles included in the current research are also alike in that they indicate passive meaning. English past participles are usually employed to form two types of constructions: perfect and passive (Huddleston & Pullum, 2002). Since the present study aimed to examine the processing of MV-RR ambiguities, the used past participial forms have transitive meaning and involve the passive usage only; that is, the modified nouns receive impacts from an action. In spite of their different salience degrees, the past participles in the present study bear close similarities in number of syllables and passive meaning. The two similarities tended to make the degrees of cognitive processing loads of the target sentences similar, leading to the insignificantly different rates of answering the comprehension questions for the past participles from the two salience groups.

The second factor which explains why salience did not significantly affect the participants' offline processing is that the two groups of past participles were placed in the same constructions within a condition pair. The past participial forms with different salience degrees in the RC/Salience 2 vs RC/Salience 4 pair and those in the PRRC/Salience 2 vs PRRC/Salience 4 pair appeared in the unreduced RCs and the reduced RCs, respectively. The identical structures in each pair apparently comprise the same structural components to be processed. To be specific, the RCs in the present study contain the relative pronoun *who* or *which*, the verb *was*, and a past participle whereas the PRRCs have only a past participle. Despite including the past participles with different salience levels, the same structures in each condition pair were apt to have similar degrees of structural complexity, bringing about the insignificantly different rates of correctly answering the comprehension questions in the RC/Salience 2 vs RC/Salience 4 pair and those in the PRRC/Salience 2 vs PRRC/Salience 4 pair.

Lastly, salience had no effects on the L1 Thai subjects' offline processing probably because of their great sensitivity to information regarding thematic roles. As stated by Rahmah (2018), thematic roles or thematic relations involve semantic identification of the role a particular noun phrase plays in relation to a given situation.

There are a number of thematic roles, among which are agent, namely the doer of the action, and theme or patient, i.e., the recipient of the action. As an example, in the sentence 'The man opened the window', the subject 'The man' performs the action of opening, and thus, plays the role of agent. However, the object 'the window', which is affected by the action, is a theme or patient. L2 learners' sensitivity to thematic roles is strongly bolstered by the Shallow Structure Hypothesis or SSH (Clahsen & Felser, 2006). The SSH proposes that L2 learners heavily depend on semantic, not syntactic, information in processing L2 sentences, and that the semantic processing cues the learners tend to be sensitive to include argument structure, plausibility, and thematic relations. L2 learners' heavy use of thematic information and other types of semantic processing cues has been attested in numerous studies, e.g., Juffs and Harrington (1995), Frenck-Mestre and Pynte (1997), Williams et al. (2001), Papadopoulou and Clahsen (2003), Felser and Roberts (2004), and Juffs (2004). In case of the present study, the thematic role of the modified nouns concerns the role of the subjects, which is an important part of the target sentences (e.g., '*The student* known for her brilliance kissed her boyfriend.') whereas the information about salience, namely the phonological differences between the past tense and past participial forms of the verbs, does not directly deal with the meaning of the sentences. Therefore, the more important role of thematic information in determining the meaning of the sentences was assumed to be kept available in the participants' memory, and to minimize effects of salience on their offline processing. Given that the comprehension questions in the offline task primarily asked the participants about the modified nouns' thematic role, i.e., whether the nouns were an agent (e.g., Did the postman take someone to the drugstore?) or a theme or patient (e.g., Did someone give the squirrel to the painter?), they should be able to use the activated thematic information in answering the questions. For this reason, the subjects might be more sensitive to the thematic role of the modified nouns than the salience degrees of the verbs, and thus, resorting to the information about the semantic roles in processing the target sentences offline.

Briefly, salience appeared to have no influence over the L1 Thai subjects as a result of similarities between the past participles in the present study, the occurrence of the past participial forms from the two salience groups in the identical grammatical

constructions, and the L2 learners' sensitivity to information concerning thematic roles.

4.1.2.1.2.3 Interaction between structure and salience among the L1 Thai learners' comprehension accuracy

Apart from WM's impact and effects of salience and structure, interaction between the two factors was given consideration. The data from the Nemenyi post hoc tests were examined further in order to find interaction between effects of salience and structure.

An interaction between the two factors involved a contradiction between two test condition pairs in terms of statistically significant differences. That is, the statistical difference between the mean comprehension accuracy scores in a condition pair must be significant whereas that in another pair must not, or vice versa.

There were two types of interaction: salience's dependence on structure and structure's dependence on salience. Salience's dependence on structure refers to how the two structures, i.e. RCs and PRRCs, affected the degree to which the comprehension accuracy scores for the past participles from Salience Group 2 (e.g., *given* and *shaken*) and those from Salience Group 4 (e.g., *known* and *blown*) statistically differed from each other. On the other hand, structure's dependence on salience involves how the past participles from the two salience groups influenced the extent to which the comprehension accuracy scores for the RCs and those for the PRRCs were statistically different from each other. Salience's dependence on structure was explored by considering the RC/Salience 2 vs RC/Salience 4 pair (e.g., 'The squirrel which was given to the painter climbed a tree.' and 'The panther which was seen in the valley seized a fox.', respectively) and the PRRC/Salience 2 vs PRRC/Salience 4 pair (e.g., 'The beggar shaken from the coldness wanted a jacket.' and 'The model drawn on the billboard earned an award.', respectively). Structure's dependence on salience was examined by taking into account the PRRC/Salience 2 vs RC/Salience 2 pair and the PRRC/Salience 4 vs RC/Salience 4 pair.

As aforesaid, an interaction between the two factors concerned a contrast between two test condition pairs in terms of statistically significant differences. In other words, the statistical difference between the mean comprehension accuracy scores in a condition pair must be significant whereas that in another pair must not, or vice versa. Structure's dependence on salience was observed among the higher WM L1 Thai participants. The comprehension accuracy scores for PRRC/Salience 2 and those for RC/Salience 2 significantly differed while the comprehension accuracy scores for PRRC/Salience 4 and those for RC/Salience 4 were not significantly different. This suggested that the effect of structure was dependent on salience. When the L1 Thai learners with higher WM encountered the past participles from Salience Group 2, the effect of structure was more obvious. On the contrary, structure's impact was weaker when they experienced the past participles from Salience Group 4. Table 44 summarizes the data about the interaction between the effects of salience and structure among the two L1 Thai groups with different WM levels.

Factor	**Condition pair**	**Significantly different statistical data**	
		L1 TH Higher WM	**L1 TH Lower WM**
Salience's dependence on Structure	RC/Salience 2 RC/Salience 4	-	-
	PRRC/Salience 2 PRRC/Salience 4	-	-
Structure's dependence on Salience	PRRC/Salience 2 RC/Salience 2	+	-
	PRRC/Salience 4 RC/Salience 4	-	-

Table 44: The data about the interaction between the effects of salience and structure among the L1 Thai participant groups' comprehension accuracy

The mean comprehension accuracy scores for the PRRC/Salience 2 pair and those for the RC/Salience 2 pair significantly differed, but no differences were observed between the PRRC/Salience 4 pair and the RC/Salience 4 pair. Such result indicated that significant differences were found only when the L1 Thai learners dealt with the irregular verbs from Salience Group 2.

The relationship between salience and significant differences in comprehension accuracy for the two structures was closely linked to the classification of the English irregulars according to their salience level proposed in the present study. According to the division, the verbs from different salience groups have different degrees of salience, which could make the success in identifying the past participle in PRRCs vary. The more salient an irregular is, the more likely L2 learners are to successfully distinguish the past participial form from the past simple one. The current research encompassed verbs from two salience groups: Group 2 and Group 4. The irregulars from Group 2 were expected to be more salient than those from Group 4, and thus, being more apt to be successfully processed than the verbs in the latter group.

The notion of salience could explain the presence and absence of significant differences in the PRRC/Salience 2 vs RC/Salience 2 pair and the PRRC/Salience 4 pair vs RC/Salience 4 pair, respectively. That is to say, the comprehension accuracy scores for the PRRC/Salience 2 condition were significantly higher than those for the RC/Salience 2 condition in light of great processing advantage provided by the irregular verbs from Salience Group 2. The advantage was related to phonological differences between the past simple and past participial forms of the irregulars in Group 2. The two forms of the verbs strikingly differ in the number of syllables and the internal vowels, such as *took-taken, shook-shaken*, and *took-taken*; consequently, it does not require a lot of cognitive resources to identify the form in the PRRCs. Once the processing of the irregulars was not much cognitive demanding, the L1 Thai subjects had sufficient cognitive resources for taking the grammatical structures into consideration. As aforementioned, the PRRCs have been increasingly frequent in English written texts, and carry lower processing burdens than the RCs, so the target sentences for the PRRC/Salience 2 condition should be simpler to comprehend than those for the RC/Salience 2 condition, making the L1 Thai participants answer the comprehension questions for the former condition more accurately than those for the latter condition. All the reasons mentioned led to the significantly higher comprehension accuracy rate for the PRRC/Salience 2 condition than that for the RC/Salience 2 condition.

Compared to the verbs in Group 2, the irregular verbs in Salience Group 4 have a lower salience degree since the differences between their past participial and past simple forms are subtle. The past participial and past simple forms of the less salient verbs slightly differ in the internal vowels and the presence of the affix *n*, such as *drew-drawn*, *knew-known*, and *blew-blown*. Therefore, the L2 learners might find it cognitive taxing to determine the given past participles in the PRRCs and RCs. Much attention which was drawn to identifying the given forms might lessen the effects of different degrees of processing burdens posed by the two structures themselves. This brought about the insignificantly different comprehension accuracy rates observed in the PRRC/Salience 4 vs RC/Salience 4 pair. 8

The mean comprehension accuracy scores for the PRRC/Salience 2 condition and those for the RC/Salience 2 condition were significantly different; however, no significant differences were found between the PRRC/Salience 4 condition and the RC/Salience 4 condition. This indicated impact of salience on the L2 learners' language processing. Previous studies have lent support to salience effects on second language processing (e.g., Goldschneider & DeKeyser, 2001; Ellis, 2006; Ellis & Sagarra, 2011; Cintrón-Valentín & Ellis, 2016[46]). Unlike the current study, where salience is referred to as phonological differences between the past tense and past participial forms of English irregulars, the previous research defines salience as the degree to which a particular grammatical item, such as lexical words and morphemes, stood out, compared to other items. Yet, all these studies were in agreement that the components which attracted more attention were more salient than those which drew less attention, and that the more perceptually prominent elements were more likely to be processed successfully than the less salient ones.

46 As an example, Cintrón-Valentín and Ellis (2016) conducted an eye-tracking experiment in order to explore how L1 Chinese learners processed two grammatical elements with different salience degrees in Latin: the more salient adverbial lexical words and the less prominent inflectional morphemes. The subjects were asked to read Latin sentences which included the adverbs and morphemes, and to make a judgment about temporal reference of the sentences. The learners were found to rely more on the lexical words in processing the temporal reference than on the morphemes. Their greater sensitivity to the adverbs than that to the morphemes was linked to the former's higher degree of salience than the latter's. In other words, the more prominent components seemed to help L2 learners process sentences better than the less salient ones did.

4.1.2.2 Reading times

This section encompasses 2 subsections: 4.1.2.2.1 and 4.1.2.2.2, which involve the results and discussions of the findings with respect to reading times, respectively.

4.1.2.2.1 Results: reading times

The analyses of the reading time data consisted of three steps: data trimming, calculation of the mean and standard deviation values of the reading times, and statistical analyses.

The first step was data trimming conducted to cut off two types of data: data involving the incorrect answers and outliers. Firstly, the reading time data from the test items for which the subjects incorrectly answered the comprehension questions were excluded from further analyses. Secondly, outliers were excluded through an outlier removal method called interquartile range (IQR). The outlier removal led to a deletion of 10.35% and 11.44% of the data on *Structure* and those on *Salience*, respectively.

Pertaining to the outlier removal approaches, it should be noted that a common method of removing outliers in previous PRRC processing studies was trimming the reading times which were beyond 2 or 3 standard deviations (SDs) from the mean of each analyzed region (e.g., Juffs, 1998; Rah & Adone, 2010). However, one limitation of the SD method was that it could effectively remove outliers only when the data were normally distributed (Dhadse, 2021). In case of the data which were abnormally or asymmetrically distributed, some data points greatly exceeded the mean; therefore, the mean and SD of the data were elevated, and the use of the SD method could prevent many potential outliers from being eliminated. The outlier removal method called Interquartile Range (IQR) was then chosen. Within the IQR method, a set of data was divided into quartiles and arranged in ascending order (Maini, 2020). Then, the data were cut into four equal parts through three values, namely Quartile 1 (Q1), Quartile 2 (Q2), and Quartile 3 (Q3), which represented the 25^{th}, 50^{th}, and 75^{th} percentile of the data, respectively. IQR referred to the range between the lower and upper limits, i.e., Q1 – (1.5 x IQR) and Q3 + (1.5 x IQR), respectively. As stated by

Maini (2020), the data points which fell below the lower limit or above the upper one were considered outliers. Dhadse (2021) claimed that the IQR method was preferred when the asymmetrically distributed data were tackled because it could cut off more outliers and led the data to be normally distributed. The data in the present study were asymmetrically distributed, and included some extreme outliers. As a result, the IQR approach was employed for eliminating the outliers in the study.

The following step was the calculation of the mean and standard deviation values of the reading times among each participant group. This step directly concerned four regions, i.e., *PP*, *Modifier of the PP*, *MV*, and *Object*. Examples of each region are demonstrated in Table 45.

N/A	**PP**	**Modifier of the PP**	**MV**	**Object**
The student	known	for her brilliance	kissed	her boyfriend

Table 45: Examples of the four regions: PP, Modifier of the PP, MV, and Object

The reading times from the four regions were analyzed in two different ways to explore effects of the two variables: *Salience* and *Structure*. In connection with *Salience*, the reading times from the *PP* region and those from the *Modifier of the PP* region were considered the critical and spillover regions, respectively. Pertaining to *Structure*, the *PP* and the *Modifier of the PP* regions were combined as the critical region, and the *MV* region, together with the *Object* region, accounted for the spillover region.

After that, the mean reading times on the critical and spillover regions for each test condition by the three groups of research participants were submitted to a three-way ANOVA. The three-way ANOVA was performed with *group* as a between-subject variable and *salience* and *structure* as within-subject variables to find if the three participant groups significantly differed and if salience and structure had effects on the participants' processing, respectively. The data concerning *Structure* and those regarding *Salience* were separately analyzed in order to examine the participants' processing of PRRCs and RCs, and their processing of past participles from Salience Group 2 and those from Salience Group 4, respectively. Accordingly, this subsection

includes 2 segments: 4.1.2.2.1.1 and 4.1.2.2.1.2, which involve the results regarding *Structure* and *Salience*, respectively.

4.1.2.2.1.1 Results: Structure

As aforementioned, in the *Structure* section, the *PP* and the *Modifier of the PP* regions were combined as the critical region, and the *MV* region, together with the *Object* region, accounted for the spillover region. Following the outlier removing process, the reading times were analyzed employing descriptive statistical analyses to calculate the mean reading times and standard deviation. The reading times in the critical and spillover regions concerning *Structure* among the three participant groups are tabulated in Table 46.

Test Condition		**Participants**					
		L1 TH Higher WM		**L1 TH Lower WM**		**L1 EN**	
		Mean (ms)	**SD**	**Mean (ms)**	**SD**	**Mean (ms)**	**SD**
PRRC/Salience 2	Critical	1665.59	375.33	1814.64	426.55	1465.42	306.42
	Spillover	1975.47	484.78	1819.26	379.28	2229.60	609.91
RC/Salience 2	Critical	1601.31	357.42	1789.08	426.44	1389.03	153.43
	Spillover	1828.70	483.39	1750.63	390.55	1908.71	351.97
PRRC/Salience 4	Critical	1598.00	430.69	1687.63	426.68	1318.73	223.89
	Spillover	1768.61	430.85	1955.61	445.49	1797.61	398.39
RC/Salience 4	Critical	1664.08	349.27	1831.88	409.50	1552.63	329.95
	Spillover	1814.04	460.58	1717.94	319.70	2012.80	436.79

Table 46: Mean reading times in the four target conditions by the three groups of participants concerning Structure

The data of the mean reading times in connection with *Structure* among the L1 Thai learners with higher WM, the L1 Thai learners with lower WM, and the native English controls are illustrated in Figures 10, 11, and 12, respectively.

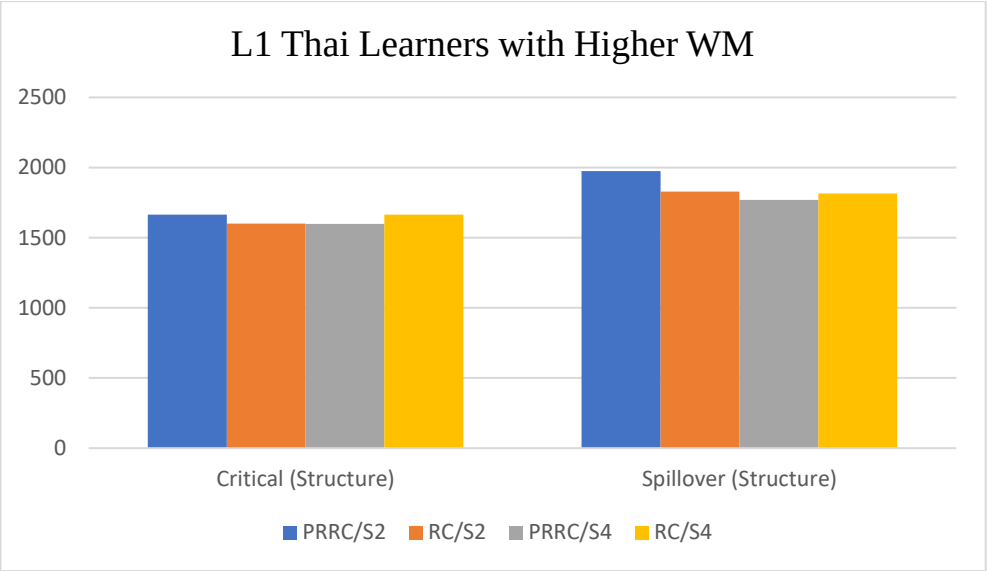


Figure 10: Mean reading times in the four target conditions by the L1 Thai learners with higher WM (Structure)

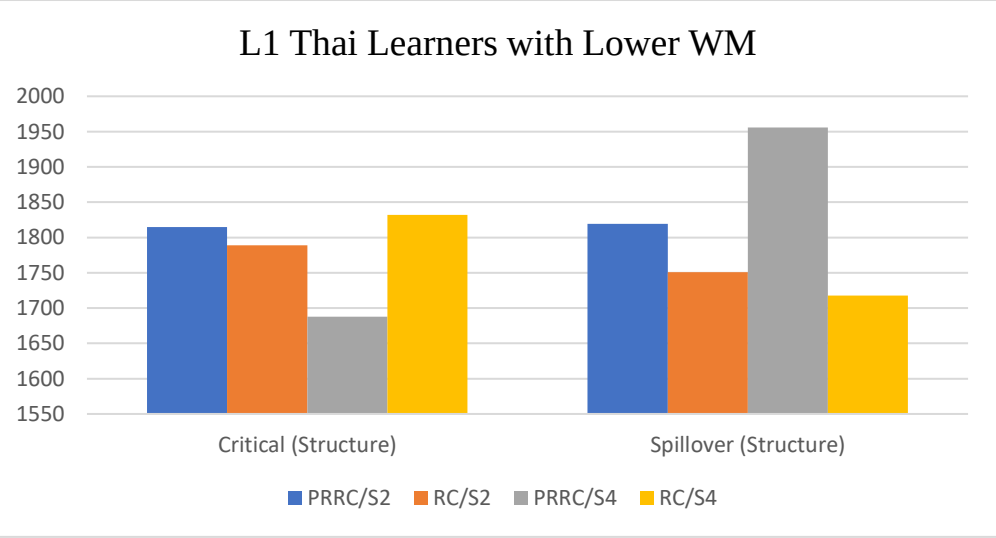


Figure 11: Mean reading times in the four target conditions by the L1 Thai learners with lower WM (Structure)

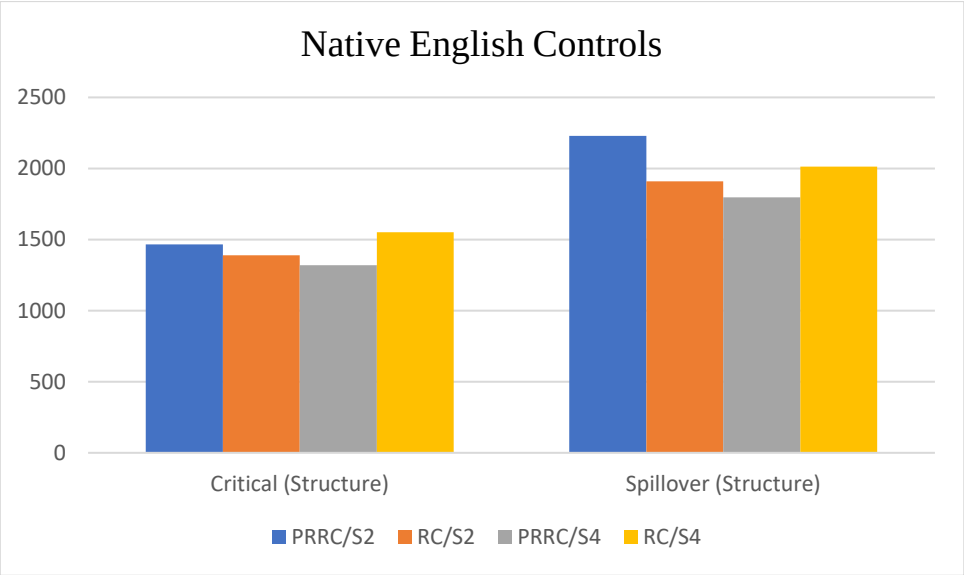


Figure 12: Mean reading times in the four target conditions by the native English controls (Structure)

Comparisons between the reading times of the three participant groups in relation to *Structure* at the critical region and the spillover region are presented in Figure 13 and Figure 14, respectively.

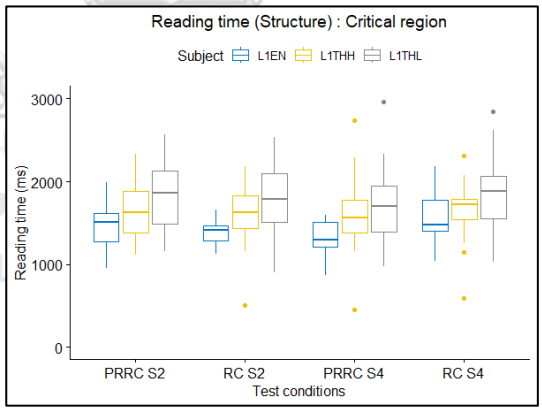


Figure 13: Comparison of reading time (Structure) of each group of participants by test conditions at the critical region

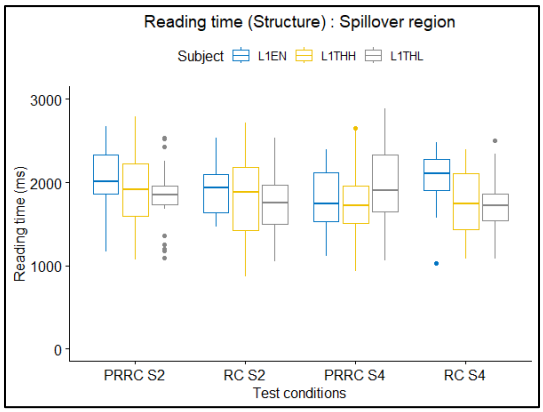


Figure 14: Comparison of reading time (Structure) of each group of participants by test conditions at the spillover region

A three-way ANOVA test was employed to examine effects of the variables on the reading times of the native and non-native participants. Table 47 shows the statistical results from the three-way ANOVA concerning *Structure*.

Regions	Factors	*df*	Effect size (η^2)	F-statistics
Critical	Group	2,59	0.096	4.214*
	Salience	1,59	0.000212	0.176
	Structure	1,59	0.003	2.940
	Group: Salience	2,59	0.000817	0.339
	Group: Structure	2,59	0.002	0.864
	Salience: Structure	1,59	0.015	7.283**
	Group: Salience: Structure	2,59	0.002	0.407
Spillover	Group	2,59	0.020	0.854
	Salience	1,59	0.006	5.408*
	Structure	1,59	0.008	6.313*
	Group: Salience	2,59	0.011	4.770*
	Group: Structure	2,59	0.004	1.328
	Salience: Structure	1,59	0.010	4.157*
	Group: Salience: Structure	2,59	0.022	4.708*

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 47: The statistical results from the three-way ANOVA concerning Structure

As regards the critical region, there was a main effect of group, $F(2,59) = 4.214$, $p < 0.05$, $\eta^2 = 0.096$. In addition, a significant interaction between salience and structure was found, $F(1,59) = 7.283$, $p < 0.01$, $\eta^2 = 0.015$. No other interactions were observed. In connection with the spillover region, there were significant main effects of salience and structure, but no main effect of group was found. Significant interactions were evident in all the two-way comparisons and the three-way

comparison. The data were divided into two parts according to regions: the critical region and the spillover region in 4.1.2.2.1.1.1 and 4.1.2.2.1.1.2, respectively.

4.1.2.2.1.1.1 Effects of factors at the critical region regarding Structure

In connection with the effect of group, a post-hoc pairwise t-test was conducted to identify the pairs of participant groups in which reading times significantly differed. The post-hoc test yielded significant differences in reading time at the critical region among one pair of participant groups: the native controls – the lower WM L1 Thai learners for the RC + Salience 2 condition ($p < 0.05$). Meanwhile, there was no significant difference in reading time at the spillover region. The statistical results from the post-hoc test for the critical region in the four test conditions among the three participant groups are shown in Table 48.

No	Condition	Pair of participant groups	*p*	*p*-adjusted (Bonferroni)[47]
1	PRRC/S2	L1 EN vs Higher WM L1 Th	0.172	0.515
2	PRRC/S2	L1 EN vs Lower WM L1 Th	0.0189*	0.0567
3	PRRC/S2	Higher WM vs Lower WM	0.172	0.516
4	PRRC/S4	L1 EN vs Higher WM L1 Th	0.0683	0.205
5	PRRC/S4	L1 EN vs Lower WM L1 Th	0.0172*	0.0515
6	PRRC/S4	Higher WM vs Lower WM	0.427	1
7	RC/S2	L1 EN vs Higher WM L1 Th	0.126	0.377
8	RC/S2	L1 EN vs Lower WM L1 Th	0.00483**	0.0145*
9	RC/S2	Higher WM vs Lower WM	0.0702	0.211
10	RC/S4	L1 EN vs Higher WM L1 Th	0.426	1
11	RC/S4	L1 EN vs Lower WM L1 Th	0.049*	0.147
12	RC/S4	Higher WM vs Lower WM	0.11	0.331

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 48: The statistical results from the post-hoc pairwise t-test for the critical region (Structure)

According to Table 48, the post-hoc pairwise t-test showed significant differences between the lower WM L1 Thai learners and the native controls for the RC/Salience 2 condition (No. 8, $p < 0.05$). The natives also took less time than the lower WM learners for the two test conditions: 1) PRRC/Salience 2 (No. 2, 0.0567),

[47] The adjusted P-value represents the minimum level of significance for multiple comparisons, at which a particular comparison can be deemed statistically significant (Chen et al., 2017).

2) PRRC/Salience 4 (No. 5, 0.0515), although the differences in the two conditions were marginally significant[48]. There was only the RC/Salience 4 condition (No. 11) in which the differences between the two participant groups were not significant (0.147).

Moreover, a significant interaction between salience and structure was yielded, $F(1,59) = 7.283$, $p < .01$, $\eta^2 = 0.015$. Then, a post-hoc one-way ANOVA test was conducted to identify whether the two factors had a main effect on each other. The statistical results from the post-hoc test for the critical region among the three participant groups are displayed in Table 49.

Participant group	**Salience group**	***p*-adjusted (Bonferroni)**
L1 EN	Group 2	0.417
L1 EN	Group 4	0.037*
Higher WM L1 Th	Group 2	0.274
Higher WM L1 Th	Group 4	0.292
Lower WM L1 Th	Group 2	0.741
Lower WM L1 Th	Group 4	0.043*

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 49: The statistical results from the post-hoc one-way ANOVA for the critical region (Structure)

The post-hoc test revealed that structure had a main effect on the reading times of the natives ($p < 0.05$) and the lower WM learners ($p < 0.05$) when they encountered the sentences with the Salience Group 4 forms. No significant effect was observed among the higher WM L1 Thai learners when they read the Salience Group 4 sentences.

Structure had a main effect on the processing of PRRCs and RCs among the native controls and the lower WM L1 Thai learners when they read the sentences with the Salience Group 4 irregulars. When they encountered the Group 4 forms, the reading times the two participant groups spent for PRRCs and RCs significantly differed. Both the natives and the lower WM learners read the critical regions in the reduced RCs faster than those in the unreduced ones. In contrast, when they

[48] According to Pritschet et al. (2016), the percentage of *p*-values between .05 and .10 is described as "marginally significant".

experienced the Group 2 participial forms, the reading times the two groups took for the two constructions did not significantly differ.

4.1.2.2.1.1.2 Effects of factors at the spillover region regarding Structure

Concerning the spillover region, significant main effects of salience and structure were found, but there was no main effect of subject. Significant interactions were observed in all the two-way comparisons and the three-way comparison; however, only the interaction between salience and structure was discussed in this section because it covered all the interactions. Moreover, the significant interaction between subject and salience was not taken into account because it was irrelevant to the research questions of the present study.

As mentioned, there was a significant interaction between structure and salience at the spillover region, $F(1,59) = 4.157$, $p < 0.05$, $\eta^2 = 0.010$. The post-hoc tests yielded two significant interactions between structure and salience: 1) structure effects on processing of the participial forms from Salience Group 4 among the lower WM L1 Thai group and 2) salience effects on processing of the reduced RCs among the native control and the higher WM L1 Thai groups.

First, structure had a main effect on the lower WM L1 Thai learners' processing of the Salience Group 4 participial forms. The statistical results from the post-hoc test for the structure effects on processing of the participial forms from Salience Groups 2 and 4 at the spillover region among the three participant groups are shown in Table 50.

Participant group	**Salience group**	***p*-adjusted (Bonferroni)**
L1 EN	Group 2	0.156
L1 EN	Group 4	0.069
Higher WM L1 Th	Group 2	0.096
Higher WM L1 Th	Group 4	0.519
Lower WM L1 Th	Group 2	0.395
Lower WM L1 Th	Group 4	0.001**

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 50: The statistical results from the post-hoc one-way ANOVA for structure effects on processing of Salience Groups 2 and 4 at the spillover region (Structure)

According to Table 50, structure had a main effect on the processing of the Salience Group 4 irregulars among the lower WM L1 Thai learners ($p < 0.01$). The structure effect at the spillover region was similar to that at the critical region in that the differences between the reading times the lower WM group took for PRRCs and RCs with the Salience Group 4 forms reached significance while those for the two structures with the Group 2 irregulars did not.

The next interaction at the spillover region in the *Structure* data is that salience had a main effect on the processing of PRRCs among the higher WM L1 Thai learners and the native controls. The statistical results from the post-hoc test for salience effects on processing of the two constructions at the spillover region among the three participant groups are shown in Table 51.

Participant group	**Structure**	***p*-adjusted (Bonferroni)**
L1 EN	PRRC	0.043*
L1 EN	RC	0.439
Higher WM L1 Th	PRRC	0.006**
Higher WM L1 Th	RC	0.857
Lower WM L1 Th	PRRC	0.066
Lower WM L1 Th	RC	0.667

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 51: The statistical results from the post-hoc one-way ANOVA for salience effects on processing of PRRCs and RCs at the spillover region (Structure)

Salience had a main effect on processing of the processing of PRRCs among the higher WM L1 Thai learners ($p < 0.01$) and the native controls ($p < 0.05$). When they encountered the reduced RCs, the reading times they took for the spillover regions in the Salience Group 2 sentences and Group 4 sentences significantly differed. Both groups read the spillover regions in the Salience Group 4 sentences faster than those in the Salience Group 2 sentences. On the other hand, when they read the unreduced RCs, the reading times the two groups spent for the spillover regions in the Salience Group 2 sentences and Group 4 sentences were not significantly different.

In summary, at the critical region of the *Structure* data, two findings were observed: 1) a main effect of group, i.e., significant differences between the native controls and the lower WM L1 Thai learners, and 2) a significant interaction between structure and salience among the native controls and the lower WM L1 Thai learners. At the spillover region, the post-hoc test showed two significant interactions: 1) structure effects on processing of the participial forms from Salience Group 4 among the lower WM L1 Thai group and 2) salience effects on processing of the reduced RCs among the native control and the higher WM L1 Thai groups. Table 52 encapsulates the statistical results from the three-way ANOVA (Structure).

Regions	**Results**	**Participant groups**	**Details of the results**
Critical (PP + Modifier of the PP)	1. Effect of group	The native controls vs The lower WM learners	The native controls were faster than the lower WM learners in all the conditions.
	2. Interaction	1.2.1 The native controls 1.2.2 The lower WM learners (Structure effect on processing of the participial forms from Salience Groups 2 and 4)	Salience 2: The reading times the two groups took for the two constructions did not significantly differ.
			Salience 4: The reading times the two groups took for the two constructions significantly differed. Both groups read the critical regions in PRRCs faster than those in RCs.
Spillover (Main verb + Object)	1. Interaction	The lower WM learners (Structure effects on processing of the participial forms from Salience Group 4)	Salience 2: The reading times the learners took for the two constructions did not significantly differ.
			Salience 4: The reading times the learners took for the two constructions did significantly differ. They read the spillover regions in PRRCs more slowly than those in RCs.
		1.1.1 The native controls 1.1.2 The higher WM learners (Salience effects on processing of the PRRCs)	PRRC: The reading times the two participant groups took for the Group 2 and Group 4 sentences significantly differed. Both groups read the spillover regions in the Group 4 sentences faster than those in the Group 2 sentences.
			RC: The reading times the two participant groups took for the Group 2 and Group 4 sentences did not significantly differ.

Table 52: Summary of the statistical results from the three-way ANOVA (Structure)

4.1.2.2.1.2 Results: Salience

In the *Salience* section, the *PP* region and the *Modifier of the PP* region were considered the critical region and the spillover region, respectively. The data of the mean reading times and standard deviation among the three participant groups pertaining to *Salience* are provided in Table 53.

Test condition		**Participants**					
		L1 TH High WM		**L1 TH Low WM**		**L1 EN**	
		Mean (ms)	**SD**	**Mean (ms)**	**SD**	**Mean (ms)**	**SD**
PRRC/Salience 2	Critical	638.27	155.24	694.95	174.26	595.84	107.82
	Spillover	948.41	204.11	1047.52	243.08	828.28	206.26
RC/Salience 2	Critical	666.79	173.35	680.02	114.76	605.44	63.77
	Spillover	877.57	210.52	1016.77	297.40	770.26	108.60
PRRC/Salience 4	Critical	633.78	189.17	616.08	135.36	560.35	86.17
	Spillover	945.76	240.20	1021.47	303.33	725.17	176.48
RC/Salience 4	Critical	667.01	150.46	702.95	149.24	604.54	94.64
	Spillover	950.65	248.46	1075.18	278.03	867.56	229.76

Table 53: Mean reading times in the four target conditions by the three groups of participants concerning Salience

The visual data of the mean reading times with respect to *Salience* among the higher WM L1 Thai learners, the lower WM L1 Thai learners, and the native English controls are provided in Figures 15, 16, and 17, respectively.

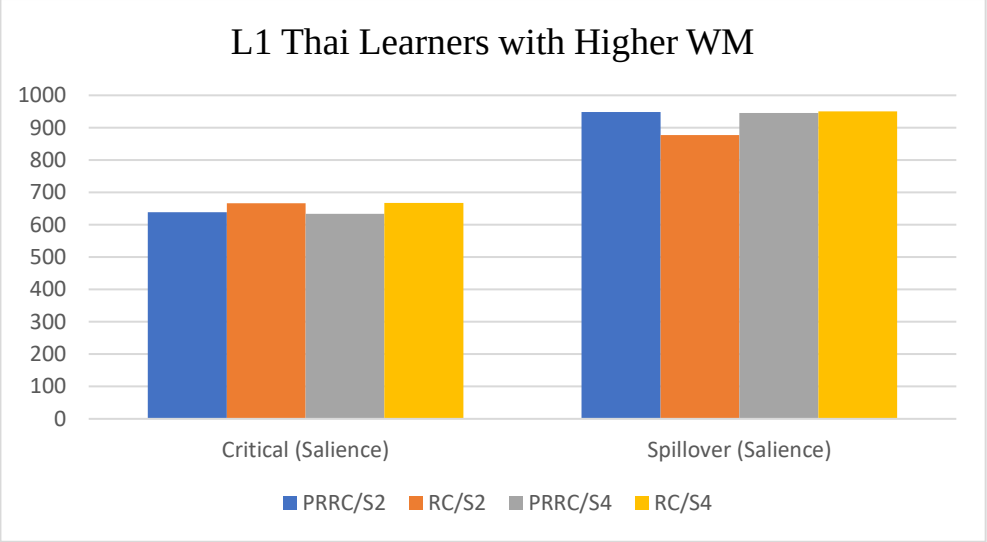


Figure 15: Mean reading times in the four target conditions by the L1 Thai learners with higher WM (Salience)

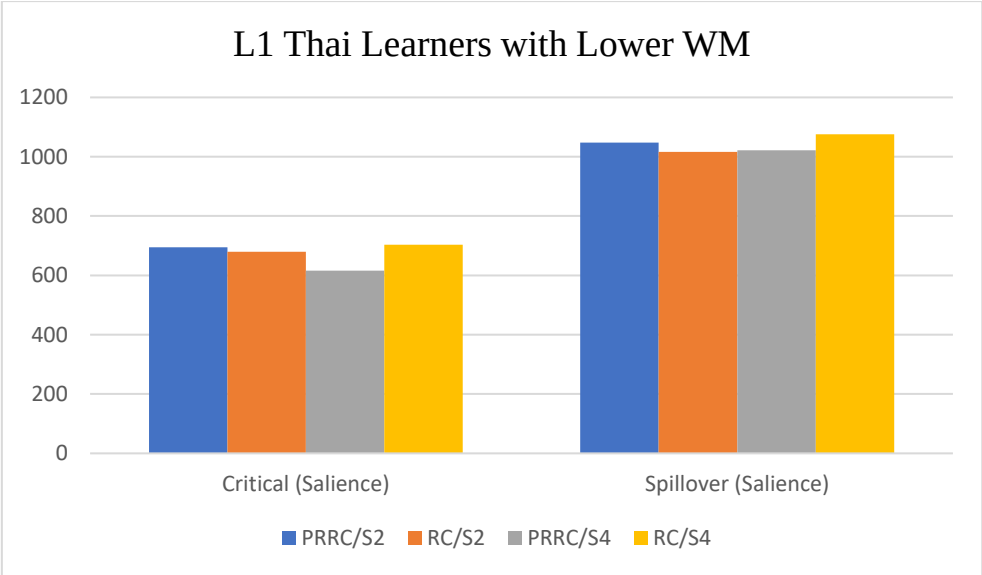


Figure 16: Mean reading times in the four target conditions by the L1 Thai learners with lower WM (Salience)

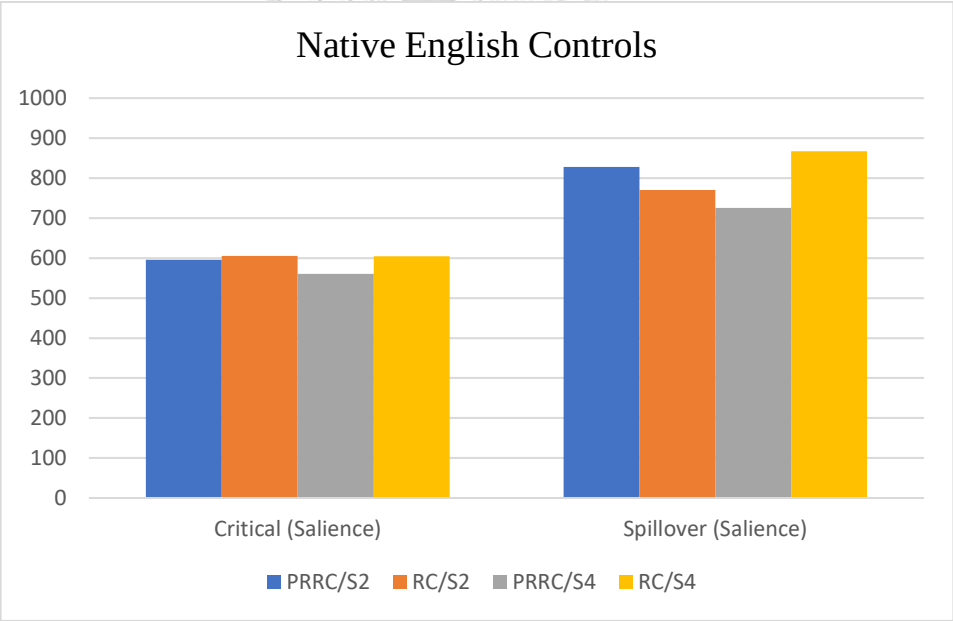


Figure 17: Mean reading times in the four target conditions by the native English controls (Salience)

Comparisons between the reading times of the three participant groups in relation to Salience at the critical region and the spillover region are illustrated in Figure 18 and Figure 19, respectively.

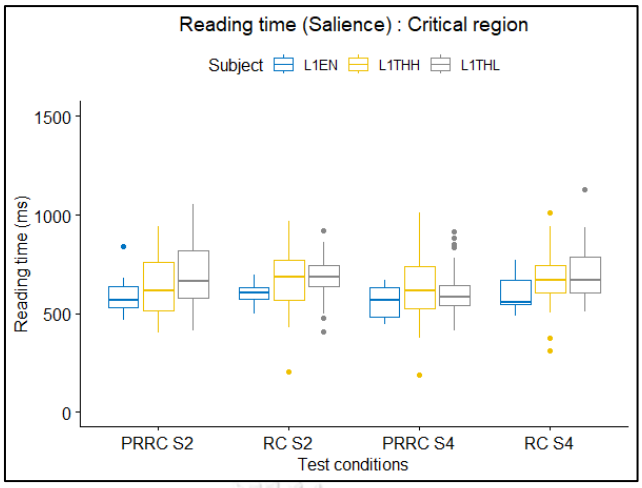


Figure 18: Comparison of reading time (Salience) of each group of participants by test conditions at the critical region

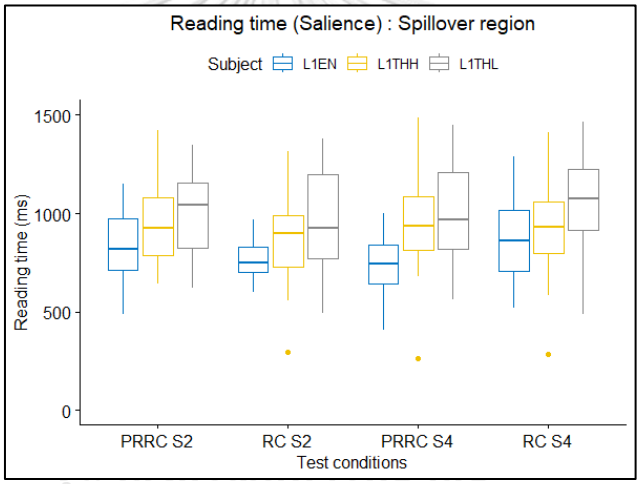


Figure 19: Comparison of reading time (Salience) of each group of participants by test conditions at the spillover region

Effects of each variable on the reading times of the three groups of participants were estimated using a three-way ANOVA test. Table 54 provides the statistical results from the three-way ANOVA concerning *Salience*.

Regions	**Factors**	***df***	**Effect size (η^2)**	**F-statistics**
Critical	Group	2,59	0.036	1.645
	Salience	1,59	0.003	1.885
	Structure	1,59	0.009	7.615**
	Group: Salience	2,59	0.002	0.626
	Group: Structure	2,59	0.000134	0.053
	Salience: Structure	1,59	0.005	1.787
	Group: Salience: Structure	2,59	0.006	0.996

Spillover	Group	2,59	0.112	5.506**
	Salience	1,59	0.000928	0.482
	Structure	1,59	0.000169	0.132
	Group: Salience	2,59	0.000808	0.210
	Group: Structure	2,59	0.003	1.339
	Salience: Structure	1,59	0.013	5.664*
	Group: Salience: Structure	2,59	0.002	0.472

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 54: The statistical results from the three-way ANOVA concerning Salience

Regarding the critical region, structure was found to be a main effect, $F(1,59) = 7.615$, $p < 0.01$, $\eta^2 = 0.009$. No other main effect and significant interaction was observed at the critical region. In respect of the spillover region, there was a significant effect of group, $F(2,59) = 5.506$, $p < 0.01$, $\eta^2 = 0.112$. Salience and structure alone did not affect the reading times. Furthermore, a significant interaction between salience and structure was found, $F(1,59) = 5.664$, $p < 0.05$, $\eta^2 = 0.013$. The data were separated into two parts by regions: the critical region and the spillover region in 4.1.2.2.1.2.1 and 4.1.2.2.1.2.2, respectively.

4.1.2.2.1.2.1 Effects of factors at the critical region regarding Salience

The three-way ANOVA test revealed a main effect of structure at the critical region, $F(1,59) = 7.615$, $p < 0.01$, $\eta^2 = 0.009$. Statistical results from the post-hoc one-way ANOVA test for the critical region among the three participant groups are shown in Table 55.

Participant group	Salience group	*p*-adjusted (Bonferroni)
L1 EN	Group 2	0.776
L1 EN	Group 4	0.31
Higher WM L1 Th	Group 2	0.297
Higher WM L1 Th	Group 4	0.23
Lower WM L1 Th	Group 2	0.658
Lower WM L1 Th	Group 4	0.015*

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 55: The statistical results from the post-hoc one-way ANOVA for the critical region (Salience)

According to Table 55, a significant effect of structure was observed among only the lower WM L1 Thai learners' processing of the irregular past participial forms from Salience Group 4 ($p < 0.05$). The reading times the learners took for the PRRCs and RCs significantly differed when they read the Group 4 participial forms. They spent less time reading the past participles in the reduced RCs than those in the full ones. Nevertheless, the reading times the learners spent for the two constructions did not significantly differ when they read the Group 2 forms.

4.1.2.2.1.2.2 Effects of factors at the spillover region regarding Salience

A main effect of group was observed at the spillover region, $F(2,59) = 5.506$, $p < 0.01$, $\eta^2 = 0.112$. A post-hoc pairwise t-test demonstrated significant differences in reading time among one pair of participant groups: the native controls – the lower WM L1 Thai learners. The statistical results from the post-hoc test for the spillover region in the *Salience* data are shown in Table 56.

No	Condition	Pair of participant groups	*p*	*p*-adjusted (Bonferroni)
1	PRRC/Salience 2	L1 EN vs Higher WM L1 Thai	0.151	0.452
2	PRRC/Salience 2	L1 EN vs Lower WM L1 Thai	0.0101*	0.0304*
3	PRRC/Salience 2	Higher WM vs Lower WM	0.112	0.337
4	PRRC/Salience 4	L1 EN vs Higher WM L1 Thai	0.0269*	0.0806
5	PRRC/Salience 4	L1 EN vs Lower WM L1 Thai	0.00343**	0.0103*
6	PRRC/Salience 4	Higher WM vs Lower WM	0.3	0.9
7	RC/Salience 2	L1 EN vs Higher WM L1 Thai	0.236	0.708
8	RC/Salience 2	L1 EN vs Lower WM L1 Thai	0.00791**	0.0237*

9	RC/Salience 2	Higher WM vs Lower WM	0.0416*	0.125
10	RC/Salience 4	L1 EN vs Higher WM L1 Thai	0.392	1
11	RC/Salience 4	L1 EN vs Lower WM L1 Thai	0.0352*	0.105
12	RC/Salience 4	Higher WM vs Lower WM	0.0879	0.264

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 56: The statistical results from the post-hoc pairwise t-test for the spillover region (Salience)

Table 56 reveals that the natives, compared to the lower WM L1 Thai learners, spent significantly shorter time reading the *Modifier of the PP* regions of the three conditions: 1) RC/Salience 2 (No. 8, $p < 0.05$), 2) PRRC/Salience 2 (No. 2, $p < 0.05$), and 3) PRRC/Salience 4 (No. 5, $p < 0.05$). Similar to the finding of the *Structure* data, the differences between the natives and the lower WM learners in the RC/Salience 4 condition did not reach significance (No. 11, 0.105).

The three-way ANOVA test also revealed a significant interaction between salience and structure at the spillover region, $F(1,59) = 5.664$, $p < 0.05$, $\eta^2 = 0.013$. The statistical results from the post-hoc test for salience effects on processing of PRRCs and RCs at the spillover region among the three participant groups are shown in Table 57.

Participant group	**Structure**	***p*-adjusted (Bonferroni)**
L1 EN	PRRC	0.477
L1 EN	RC	0.976
Higher WM L1 Th	PRRC	0.875
Higher WM L1 Th	RC	0.994
Lower WM L1 Th	PRRC	0.028*
Lower WM L1 Th	RC	0.444

Significance level: * p < 0.05, ** p < 0.01, *** p < 0.001

Table 57: The statistical results from the post-hoc one-way ANOVA for salience effects on processing of PRRCs and RCs at the spillover region (Salience)

The statistical data in Table 57 demonstrates that salience had a main effect on processing of the PRRCs among the lower WM L1 Thai learners ($p < 0.05$). When they read the reduced RCs, the reading times they took for the spillover regions in the Salience Group 2 sentences (e.g., The lawyer taken to the airport) and for those in the Group 4 sentences (e.g., The lawyer seen at the airport) significantly differed. The lower WM learners read the *Modifier of the PP* regions in the Group 4 sentences faster than those in the Group 2 sentences. On the contrary, no significant difference was observed between the reading times for the Group 2 sentences and those for the Group 4 sentences when the learners read the unreduced RCs.

In conclusion, at the critical region, a post-hoc test yielded a main effect of structure on the lower WM L1 Thai learners' processing. When it comes to the spillover region, two findings were found: 1) a main effect of group, namely significant differences between the native controls and the lower WM L1 Thai learners, and 2) a significant interaction between salience and structure among the lower WM learners. Table 58 recapitulates the statistical results from the three-way ANOVA (Salience).

Regions	**Results**	**Participant groups**	**Details of the results**
Critical (PP)	1. Structure effect on processing of the participial forms from Salience Groups 2 and 4	The lower WM learners	Salience 2: The reading times the participants took for the two constructions did not significantly differ.
			Salience 4: The reading times they took for the two constructions did significantly differ. They read the critical regions in PRRCs faster than those in RCs.
Spillover (Modifier of the PP)	1. Effect of group	The native controls vs The lower WM learners	The native controls were faster than the lower WM learners in all the conditions.
	2. Interaction	The lower WM learners (Salience effect on processing of the PRRCs)	PRRC: The reading times the participants took for the Group 2 and Group 4 sentences significantly differed. They read the spillover regions in the Group 4 sentences faster than those in the Group 2 sentences.

			RC: The reading times the two participant groups took for the Group 2 and Group 4 sentences did not significantly differ.

Table 58: Summary of the statistical results from the three-way ANOVA (Salience)

The following subsection, namely 4.1.2.2.2, presents the discussions of the research findings regarding the reading times of the present study.

4.1.2.2.2 Discussions: reading times

There are two parts under this subsection: 4.1.2.2.2.1 and 4.1.2.2.2.2, which deal with the discussions of the findings with respect to *Structure* and *Salience*, respectively.

4.1.2.2.2.1 Discussions: Structure

The *Structure* data were discussed in relation to two issues: differences in reading times between the three participant groups and effects of structure and salience on the reading times for the two structures in 4.1.2.2.2.1.1 and 4.1.2.2.2.1.2, respectively.

4.1.2.2.2.1.1 Discussions: Differences between the participant groups as regards Structure

The first issue to be discussed is the differences in reading times between the participant groups. Two findings are worth being mentioned: 1) significant differences between the lower WM learners and the natives at the critical region and 2) the relationship between the higher WM L1 Thai learners and the other two participant groups.

As mentioned in 4.1.2.2.1.1.1, a post-hoc pairwise t-test yielded significant differences at the critical region between the lower WM L1 Thai learners and the native controls for the RC/Salience 2 condition. The natives also took less time than the learners for the two test conditions: 1) PRRC/Salience 2, 2) PRRC/Salience 4, although the differences in the two conditions were marginally significant. There was

only the RC/Salience 4 condition in which the differences between the natives and the lower WM learners were not significant.

The natives were significantly faster than the lower WM learners in processing the critical regions probably because of two reasons: lower automaticity degree of L2 processing and L1 transfer.

The first reason which could contribute to the L1 Thai learners' slower speed of online processing of the critical regions is associated with the distinctions between the level of automaticity in processing the L1 and that in comprehending an L2. Native language processing has been assumed to be more automatic than L2 processing. The lower degree of automaticity in L2 processing could be supported by two accounts with respect to resource-limitation and cerebral activation.

The first account involves non-native speakers' inadequate processing resources. L2 learners usually have fewer cognitive resources than L1 speakers (Ito & Pickering, 2021). More specifically, McDonald (2006) claimed that L2 learners are likely to have lower memory span, lexical decoding and accessing capability, and processing speed for the L2 compared to those for their native language. Such resources are required for accessing and recognizing L2 words, combining each word with the preceding structure, and predicting the upcoming information, all of which could result in efficient language processing. Therefore, the L2 learners who are deficient in the cognitive capacity tend to have more difficulties in processing the L2 and require more time and resources. This leads them to be less automatic and slower processors than the native speakers. Less automaticity of L2 processing has also been substantiated by neuroimaging evidence or images of the activity of the cerebral areas and the nervous system. The volume of activation in a human's brain can reflect the degree of processing difficulties a learner has. According to Hasegawa et al. (2002), the higher volume of activation a learner shows during her processing of a sentence, the more resources and efforts she requires for comprehending it. Hasegawa and associates investigated L1 Japanese participants' cortical activation during their processing of sentences in Japanese and English, and they found that the participants' activation was greater for the English sentences than for the Japanese ones. Such a result indicated that L2 processing was more resource-demanding than L1 processing.

L1 processing's higher degree of automaticity than L2 processing's has been well-attested by a vast body of the L2 processing literature (e.g., Sharifian, 2002; Mueller, 2005; Stowe & Sabourin, 2005; Jin, 2007; Segalowitz & Hulstijn, 2009; Alptekin & Erçetin, 2010; Rah & Adone, 2010; Saur et al., 2009; Meisel, 2011; Trenkic et al., 2014; Tang, 2015; Reichle et al., 2016). Moreover, several previous studies observed that even highly proficient learners took significantly slower reading time for processing some L2 grammar domains than native speakers (e.g., English *wh*-movement in White & Genesee, 1996; English reduced RC ambiguities in Juffs, 1998; Dutch subject-object ambiguities in Havik et al., 2009; English *wh*-extractions in Dussias & Piñar, 2010; English reflexive pronouns in Felser & Cunnings, 2012).

Apart from lower automaticity degree of L2 processing, the L2 learners' reading could be impeded and slowed down by Thai-English differences as to the two structures in the test items: RC and PRRC.

Pertaining to relative clauses, Thai differs from English in two types of components: the element which exists in Thai and those which do not. The former includes relative pronouns while the latter involves S-V agreement and tense.

The first distinction concerns relative pronouns, pronouns which precede subordinate clauses in RCs. Relative pronouns in the two languages differ in the dependence of the relativizer selection on animacy of the head nouns. That is, the selection of relativizers in English depends on animacy of the modified noun while that in Thai does not. As Endley (2010) stated, the relative pronouns in English are usually chosen according to the animacy of the head noun, that is, 'who' for antecedents which are human or human-like animals, 'which' for human collectives and animate or inanimate nouns, and 'that' for human, animate or inanimate antecedents (See details of the English relative pronouns in Subsection 2.2.1 of Chapter II). Unlike the English relative pronouns, the use of the three main relative pronouns in Thai, i.e., '/tʰîː/,' '/sûŋ/,' and '/ʔan/', is not affected by animacy of the antecedents; consequently, they can be interchangeably used to modify the same noun

in several circumstances (Sornhiran, 1978)[49]. To conclude, English establishes agreement between the selected relative pronouns and animacy of the head nouns while Thai does not. In case of the present study, the English-Thai difference could directly affect the processing of the L1 Thai participants since the experimental sentences included either *who* or *which*, which were used with human nouns and animal nouns, respectively. Samples of the experimental RC sentences with the two relative pronouns are *The salesman who was taken to the prison cheated her boss* and *The monkey which was eaten in the forest passed a virus*, respectively.

In addition to relative pronouns, the L1 Thai learners might have to take into account two RC grammatical components which are non-existent in their L1: S-V agreement and tenses (See detailed discussions of the processing burdens of English RCs in Subsection 4.1.2.1.2.2.1). The heavy processing burdens of the phrase "who was" or "which was" in a relative clause could consume the L2 learners' cognitive resources, and leave the learners inadequate capacity. Thus, they could have difficulties reading the following critical region which required them to do a task, i.e., identifying the thematic role of the subject. This led them to read the region slower than the native controls who had enough resources for their L1 processing.

Moreover, the distinctions between reduced RCs in Thai and English might underlie the lower WM learners' longer reading times than the native controls' in the PRRC/Salience 2 and PRRC/Salience 4 conditions. The constructions in the two languages differ in two aspects: existence of the PRRC itself and how an RC is shortened.

First of all, the English PRRC has no direct Thai equivalent. As stated in Subsection 2.2.2 of Chapter II, the nearest Thai counterpart is the reduced relative clause or the RC which lacks a relative pronoun (Yaowapat & Prasithrathsint, 2006; Rungrojsuwan, 2015). Also, Thai is an isolating language, i.e., a type of language which does not have inflectional morphemes, including the past participial suffixes, a main component of English PRRCs. English inflectional morphemes have been found

[49] Among the three relativizers, '/ʔan/' is the least common. It is usually employed in formal speech and literary texts (Iwasaki & Ingkaphirom, 2005: 243, 246).

to pose problems for learners whose native language lacks such morphemes. Since inflection does not exist in Thai, L1 Thai learners tend to have problems acquiring them (Yordchim & Gibbs, 2014). L1 Thai learners' difficulty in acquiring English inflectional morphemes has been reported in a large number of studies (e.g., Pojprasat, 2007; Kongthai, 2015; Rungrojsuwan, 2015; Chumkamon, 2017). In all the research, the learners' problem was attributed to non-existence of the morphemes in their native language.

Secondly, although Thai RCs can be curtailed, the way of reducing RCs in Thai is different from that in English in two aspects. The first difference is associated with the contexts in which the relative pronoun omission is allowed. In most cases, the English relative pronouns are optional irrespective of the role the pronouns play in relation to the verbs in the RCs: subject or object (Azar, 1999). In contrast, the Thai relative pronouns can be omitted only when they refer to the subject of the clause (Iwasaki & Ingkaphirom, 2005). Iwasaki and Ingkaphirom (2005) further explained that not all subject relative clauses in Thai could be reduced. Instead, a Thai relativizer in an RC can be deleted in two cases: A) when the RC provides broad information regarding the modified noun, and B) when the head noun can be considered a definable category of people. The second distinction in relation to the reduced RCs is about the simplicity degree of how RCs in the two languages are shortened. Thai has a simpler way of reducing RCs than English does. As for the reduction of Thai RCs, only the omission of the subordinate clause markers is sufficient. However, in English, the reduction of some RCs needs only the deletion of the relative pronouns while that of others necessitates both relative pronoun omission and other alterations, i.e., omitting the verb *be* or adding the *–ing* suffix to the verb in the clauses, depending on the grammatical elements which come after the relative pronoun. Consequently, compared to English, Thai has fewer contexts where the relative pronouns can be omitted and the simpler RC reduction which needs the relative pronoun deletion only (See details of the differences between English PRRCs and Thai reduced relative clauses and examples of the two constructions in Subsection 2.2 of Chapter II).

In addition of the differences between the lower WM learners and the native controls, the comparison of the reading times of the three participant groups in Figures 13 and 14 revealed that the higher WM L1 Thai learners did not significantly differ from the other two participant groups in the amount of time they took for processing both the critical and spillover regions in the *Structure* data. The SPRT data also showed that the natives were significantly faster than only the lower WM learners, not the higher WM ones. The higher WM readers read faster than their lower WM counterparts, and were more similar in reading times to the native English speakers. Such result might be associated with the difference in WM span between the two L1 Thai groups. An individual's cognitive capacity size has been claimed to be correlated with the time course of her processing. The larger capacity a reader has, the more quickly she can read and process sentences (Just & Carpenter, 1992). The findings were related to Hypothesis 1, which was that the L1 Thai learners' WM levels and salience of the PP forms would affect their processing of RCs and PRRCs. The data indicated that the WM capacity level could play a role in the L1 Thai learners' processing. Hypothesis 1 was therefore born out.

4.1.2.2.2.1.2 Discussions: Effects of structure and salience and interaction between the two factors as regards Structure

The second issue is the effects of structure and salience on the participants' processing of PRRCs and RCs, and interaction between the two factors. The data were divided into two parts according to regions: the critical region and the spillover region in 4.1.2.2.2.1.2.1 and 4.1.2.2.2.1.2.2, respectively.

4.1.2.2.2.1.2.1 Effects of factors at the critical region regarding Structure

In respect of the critical region, a post-hoc one-way ANOVA test showed that structure had a main effect on the processing of PRRCs and RCs among the native controls and the lower WM L1 Thai learners when they experienced the target sentences with the Salience Group 4 irregulars. Specifically, when they encountered the less salient PPs, the reading times the two groups took for PRRCs and RCs significantly differed. Both the natives and the lower WM learners spent shorter time reading the critical regions in the reduced RCs than reading those in the unreduced

ones. On the other hand, when they read the more salient PPs, the differences between their reading times for the two constructions did not reach significance.

The finding was related to Hypothesis 1 and Hypothesis 3 of the present study. Hypothesis 1 was that the L1 Thai learners' WM and salience of the past participial forms would modulate their processing of English RCs and PRRCs. The data in this part showed that the PP forms from Salience Group 4 allowed the learners to distinguish between PRRCs and RCs whereas those from Group 2 did not. It was evident that a less salience degree brought about effects on the lower WM learners' processing of the two structures, substantiating Hypothesis 1.

Hypothesis 3 was that the reading times the higher WM learners spent on PRRCs would be significantly longer than those on RCs while the reading times the lower WM learners took for PRRCs would not be significantly higher than for those on RCs. The finding in this part was associated with the lower WM learners. It showed that, when the learners encountered the Group 2 verbs, their reading times on PRRCs were not significantly different from those on RCs. As seen from the mean reading times of the *Structure* data in Table 46, the lower WM learners spent more time on the critical regions in PRRCs than on those in RCs, but the differences did not reach significance. On the contrary, their reading times on PRRCs and RCs were significantly different when the participants were given the Group 4 forms. Simply put, non-significant differences between the reading times on PRRCs and those on RCs among the lower WM learners were related to their processing of the target sentences with the more salient irregulars. Therefore, Hypothesis 3 was partially supported.

The finding might be due to the difference between the irregulars from Salience Groups 2 and 4 concerning processing loads related to the degree of phonological alterations. In the present study, the salience degree of a verb is determined by the extent to which the past tense and past participial forms of the verb phonologically differ from each other. The greater the changes of the verb are, the more salient it is assumed to be. The verbs from Group 2 need an internal vowel change and an addition of the syllabic [ən] morpheme. For instance, the past tense form *took* inflects to the past participial form *taken* by changing its vowel from [ʊ] to

[eɪ] and attaching the syllabic [ən] morpheme to its end. As for the Group 4 verbs, the past tense form becomes the past participial form by changing the internal vowel and affixing an *n* to the end. As an example, in order to become the past participial form *drawn*, the past tense form *drew* changes its vowel from [uː] to [ɔː] and an *n* segment is attached to it. According to Bayley (1994), the phonological alterations which concern an addition of a syllable are considered more perceptually salient than the segment-related changes. Based on Bayley's statement, the Group 2 verbs are more prominent than the Group 4 verbs. The salience level of a past participle might play a role in L2 learners' processing in that the past tense and past participial forms of the more salient irregulars should be easier to distinguish than those of the less prominent verbs. Therefore, it was hypothesized that the research participants should find processing the Group 2 irregulars less problematic than processing the Group 4 verbs.

However, it was found that the reading times the two participant groups took for PRRCs and RCs significantly differed when they encountered the Group 4 irregulars. This indicated an opposite direction of salience effects. Because the past tense and past participial forms of the Group 4 irregulars are more phonologically similar, they might find it simpler and less cognitive demanding to identify the given form. This left them adequate cognitive capacity for considering distinct structural complexity levels of PRRCs and RCs, leading them to spend significantly different amounts of reading times for the two constructions. On the contrary, the irregular verbs from Group 2 necessitate more perceptually prominent phonological alterations. The past tense and past participial forms of the Group 2 irregulars are more markedly different, so it could be more capacity taxing for the participants to figure out the past tense form to which the past participial form is related. As a result, the participants might need more cognitive resources in identifying the participial forms of the Salience Group 2 verbs. So, they had inadequate capacity, and did not consider information about the two structures. This could account for why their reading times for the PRRCs and RCs in the Salience Group 2 sentences did not significantly differ. The finding suggested that a high level of phonological similarities between the past tense form and past participial form of an irregular verb helped the participants distinguish the two forms and allocate some of their cognitive resources for exploiting

other information processing cues, i.e., structural complexity levels of PRRC and RC in this case.

Pertaining to the different reading times for the two structures in the Salience Group 4 sentences, both the native control and the lower WM L1 Thai groups spent more time reading the critical regions in RCs than reading those in PRRCs. Their longer reading times for the RCs might be related to processing burdens of the construction itself. To be specific, the unreduced RCs demanded the participants' larger cognitive capacity for processing the subject-verb agreement, tense, and relative pronoun in the subordinate clauses (See detailed discussions of the processing burdens of English RCs in Subsection 4.1.2.1.2.2.1). The additional difficulties caused by the phrase 'who was' or 'which was' in RCs could consume a lot of their cognitive capacity and slow down the participants' processing of the following critical regions. In contrast, in processing PRRCs, they did not have to consider the cognitive burdens, as in their processing of RCs; consequently, they had enough cognitive resources which made them read the following past participles and prepositional phrases in the reduced RCs faster than those in the RCs.

4.1.2.2.2.1.2.2 Effects of factors at the spillover region regarding Structure

For the spillover region, the post-hoc test yielded two significant interactions between structure and salience: 1) structure effects on processing of the PPs from Salience Group 4 among the lower WM L1 Thai learners and 2) salience effects on processing of the PRRCs among the native controls and the higher WM L1 Thai learners.

First of all, structure had a main effect on the processing of the Salience Group 4 PPs among the lower WM L1 Thai learners. The structure effect at the spillover region was similar to that at the critical region in that the differences between the reading times the lower WM group took for PRRCs and RCs with the less salient forms were significant while those for the two structures with the more salient forms were not.

The finding was associated with Hypothesis 3. Non-significant differences between the reading times for PRRCs and those for RCs among the lower WM

learners were observed only when they read the target sentences with the Salience Group 2 verbs. The mean reading times of the *Structure* data in Table 46 revealed that the lower WM learners took longer time on the spillover regions in PRRCs than on those in RCs, and the difference was not significant. In contrast, the learners' reading times on the two constructions significantly differed when they read the sentences with the Group 4 irregulars. As a result, Hypothesis 3 was partially confirmed.

In agreement with the structure effect at the critical region, the main effect of structure at the spillover region was attributable to different amounts of cognitive capacity required for identifying the given participial forms from the two salience groups: Group 2 and Group 4 (See details of the difference between the two salience groups regarding processing burdens in Subsection 4.1.2.2.2.1.2.1).

Although structure had a main effect on the lower WM learners' processing of the Salience Group 4 irregulars in both the critical and spillover regions, the relationship between the reading times for the two structures at the spillover regions was opposite to that at the critical regions. Specifically, they read the *MV + Object* regions in the PRRCs more slowly than those in the RCs; however, their reading times for the *PP + Modifier of the PP* regions in the reduced RCs were shorter than those in the full RCs. The opposite relationship between the reading times for PRRCs and RCs at the critical and those at the spillover regions might be explained by different levels of processing difficulties of the two regions in the two structures. The critical regions in RCs seemed more capacity-taxing than those in PRRCs while the spillover regions in PRRCs tended to consume more processing resources than those in RCs.

Regarding the critical regions, PRRCs required a smaller quantity of processing resources than RCs for two reasons. First, the reduced RCs contained fewer words than the full RCs. In the unreduced RCs, the number of the words preceding the past participial forms was 4 while the past participles in the reduced adjective clauses followed a 2-word noun phrase. A PRRC which consisted of fewer words was apt to carry fewer cognitive burdens than an RC with more words. Second, when reading a PRRC, the learners did not have to consider the S-V agreement, tense, and relative pronoun issues, as they did when processing the phrase "who was" or

"which was" in an RC. To summarize, the fewer cognitive loads of the PRRCs left the learners sufficient processing resources which allowed the lower WM learners to read the critical regions in the reduced RCs faster than those in the unreduced RCs.

As to the spillover regions, the learners with lower WM spent longer time for PRRCs. This was probably because of the greater demand of cognitive capacity in processing the structure's spillover region, i.e., the participants' delayed assignment of the thematic role of the subjects. The fact that the *Subject* regions in the PRRC sentences contained only a two-word NP, namely the definite article *the* + a disyllabic NP, such as 'the writer,' 'the doctor' or 'the poet', could provide the participants with a greater range of possible elements which appeared after the subjects. This gave the readers unclear hints about the grammatical parts which followed the NP, and could influence the speed at which the participants determined the subject's thematic role, i.e., the agent or the doer of an action and theme or the recipient of an action. During the processing of the critical regions in a PRRC, they might not immediately assign the thematic role of the modified noun since they needed to figure out what a reduced form of an RC referred to. The identification of the PRRC structure might postpone the assignment of the thematic role of the modified noun until the spillover region. Therefore, the delayed thematic role assignment coupled with the processing of the finite verb and the object altogether could lead the participants to spend much time reading the spillover region. Contrarily, the *Subject* region of an RC encompassed the relative pronoun-copula string 'who was' or 'which was', which facilitated the participants' identification of the thematic role. The readers tended to connect the past participle in the critical region to the relative pronoun-copula string as an RC and quickly assign the thematic role 'patient' for the modified noun. When the readers entered the spillover region, they did not have to allocate part of their cognitive resources for considering the thematic role of the NP, and thus, were able to utilize the resources for processing the *MV* and *Object* regions. Accordingly, the participants took less time reading the spillover regions in the unreduced RCs than those in the reduced ones.

The second interaction at the spillover region in the *Structure* section was that **s**alience had a main effect on processing of the processing of the reduced RCs among the higher WM L1 Thai group and the native control group. When the two participant groups read the PRRCs, the reading times they took for the spillover regions in the sentences with the more salient PPs (e.g., The doctor taken to the airport loved the woman) and those with the less salient PPs (e.g., The doctor seen at the airport loved the woman) were significantly different. The spillover regions in the Salience Group 4 sentences were read faster than those in the Salience Group 2 sentences. On the contrary, when they read the RCs, the reading times the two groups spent for the spillover regions in the Salience Group 2 sentences and Group 4 sentences did not significantly differ.

The research finding as regards the higher WM L1 Thai learners was related to Hypothesis 1 and Hypothesis 4 of the present study. Hypothesis 1 was that the L1 Thai learners' WM and salience of the PP forms would affect their processing of English RCs and PRRCs. The finding here revealed that, when the higher WM learners read the PRRCs, they processed the spillover regions in the Salience Group 4 sentences significantly faster than those in the Group 2 sentences, indicating salience effects on the learners' processing. This supported Hypothesis 1.

Hypothesis 4 was that the reading times the higher WM learners spent on the Salience Group 4 irregulars would be significantly longer than those on the Salience Group 2 forms whereas the reading times the lower WM learners took for the Group 4 irregular verbs would not be significantly higher than those for the Group 2 verbs. The result in this part was relevant to the learners with more WM capacity. The data revealed that the higher WM learners read the spillover regions in the Salience Group 4 sentences significantly faster than those in the Salience Group 2 sentences, which rejected Hypothesis 4.

When they read the unreduced RCs, the reading times the higher WM L1 Thai learners and the native controls spent for the *Main Verb + Object* regions in the Salience Group 2 sentences and Group 4 sentences did not significantly differ. Only the result related to the L1 Thai learners is discussed here. Three reasons account for the absence of different reading times for the spillover regions in the Salience Group 2

and Group 4 sentences which included an RC. First, in processing an RC, the higher WM learners had to employ much cognitive capacity for considering the S-V agreement, tense, and relative pronoun in the subordinate clause. Moreover, a higher number of words in the RC, i.e., 4 words compared to 2 words of a PRRC, could add cognitive burdens for them. Thus, they might have insufficient resources for distinguishing between the more salient irregulars and the less salient ones. Furthermore, RCs contain the phrase 'who was' or 'which was' as the indicator of the given past participial form. Because the spillover regions, namely the *Main Verb + Object* regions, involved the readers' solution of the main verb/reduced relative ambiguity, readers had to identify the form appearing after the subject. However, the phrase 'who was' or 'which was" in an RC, regardless of the salience group included in the subordinate clause, could make it clear for the learners that the form which followed the phrase was not a finite verb, so they could anticipate a main verb in the following region for both the Salience Group 2 and Group 4 sentences.

By contrast, as they read PRRCs, the reading times the higher WM L1 Thai learners spent for the spillover regions in the Salience Group 2 sentences and Group 4 sentences significantly differed. This might be because the PRRC processing required fewer cognitive resources, leading the learners to have sufficient capacity for considering the salience level of the irregular verbs.

In relation to the verbs from the two salience groups, the past tense and past participial forms of the Group 4 irregulars, compared to those of the Group 2 verbs, are more phonologically similar, requiring less capacity for the L1 Thai learners to identify the given forms in the reduced clauses. The simpler identification of the less salient irregular verbs left the learners more cognitive resources which made them process the *Main Verb + Object* regions in the Group 4 sentences faster than those in the Group 2 sentences.

The next subsection, i.e., 4.1.2.2.2.2, discusses the research findings as regard *Salience*.

4.1.2.2.2.2 Discussions: Salience

This subsection contains two parts: 4.1.2.2.2.2.1 and 4.1.2.2.2.2.2, which provide the discussions of differences in reading times between the three participant groups and effects of structure and salience on the reading times on the past participles, respectively.

4.1.2.2.2.2.1 Discussions: Differences between the participant groups as regards Salience

Similar to the discussions of the *Structure* data, differences in reading times between the participant groups are first investigated. Two findings are discussed: 1) significant differences between the lower WM learners and the natives at the spillover region and 2) the relationship between the higher WM L1 Thai learners and the other two participant groups.

The native controls spent significantly shorter time reading the spillover regions, specifically the *Modifier of the PP* regions, of the three conditions: 1) RC/Salience 2, 2) PRRC/Salience 2, and 3) PRRC/Salience 4, than the lower WM learners. Also, the natives were faster in reading the RC/Salience 4 condition than the learners, but their differences were not significant. The three conditions in which the differences between the two participant groups reached significance are discussed first.

The significant differences in the reading times of the two groups for the three test conditions can be linked to lower automaticity degree of L2 processing. L2 processing has been claimed to be less automatic, yet more resource-demanding than L1 processing (e.g., Rah & Adone, 2010; Saur et al., 2009; Meisel, 2011; Trenkic et al., 2014; Tang, 2015; Reichle et al., 2016). The concept of the less automatic L2 processing applied to the processing of the prepositional phrases in the RC and PRRC structures. In connection with an unreduced RC, once the native English speakers experienced the past participle, they should be faster than the L1 Thai learners in figuring out that they were reading a passive RC, and thus, manage to make a faster prediction about the following grammatical elements. The ability to predict the upcoming information at a faster rate tended to make them realize earlier than the L2

learners that the past participle could be followed by a prepositional phrase. This allowed the native controls to take shorter time reading the prepositional phrases in the RCs than the learners. When reading the more complex PRRCs, the L1 English participants' larger number of cognitive resources could make them faster in identifying the forms which followed the subjects of the sentences as past participles. The capability to realize the given forms earlier could lead them to make faster predictions about the following prepositional phrases than the L2 learners. The more automatic processing of the native controls accounted for their shorter reading times on the spillover regions than the L1 Thai learners'.

When the statistical results regarding the differences between the participant groups in the *Structure* and *Salience* sections were considered together, one interesting aspect as to the RC/Salience 4 condition was observed. The differences between the natives and the lower WM learners in the reading times for this test condition in both sections (i.e., the critical regions and spillover regions in the *Structure* and *Salience* sections, respectively) did not reach significance. The reason which accounted for the non-significant differences between the two participant groups in the reading times for the RC/S4 condition might be processing burdens of the RC structure.

The processing of the RC/Salience 4 items of both the lower WM L1 Thai learners and native controls could be hindered by processing burdens of the RC structure itself. The construction seemed to cause difficulties for the participants in light of two reasons: L1 transfer for the L1 Thai learners and a high number of the words preceding the *PP* and *Modifier of the PP* regions for both the native controls and the learners.

Firstly, L1 transfer, namely Thai-English differences regarding RC, could impede the L1 Thai learners' processing (See detailed discussions of the effects of L1 transfer on the L1 Thai learners' processing in Subsection 4.1.2.2.2.1.1).

The second reason was the number of the words which preceded the past participles. To discuss the reason, the reading times on the RCs should be considered in comparison with those on the PRRCs. The lower WM learners and the native

controls spent longer time reading the *PP* and *Modifier of the PP* regions in the RCs than those in the PRRCs. The mean reading times of the PRRC/S4 and RC/S4 conditions for the critical regions of *Structure* and the spillover regions of *Salience* are provided in Tables 59 and 60, respectively.

Critical region	**L1 TH Low WM**		**L1 EN**	
	PRRC/S4	**RC/S4**	**PRRC/S4**	**RC/S4**
Mean (ms)	1687.63	1831.88	1318.73	1552.63
p	0.043*		0.037*	

Table 59: The reading times for the PRRC/S4 and RC/S4 conditions of the lower WM L1 Thai learners and native controls for critical regions (Structure)

Spillover region	**L1 TH Low WM**		**L1 EN**	
	PRRC/S4	**RC/S4**	**PRRC/S4**	**RC/S4**
Mean (ms)	1021.47	1075.18	725.17	867.56
p	0.262		0.107	

Table 60: The reading times for the PRRC/S4 and RC/S4 conditions of the lower WM L1 Thai learners and native controls for spillover regions (Salience)

The paired t-test yielded significant differences between the reading times for the PRRC/Salience 4 condition and those for the RC/Salience 4 condition among the native controls and the lower WM L1 Thai learners at the critical region in the *Structure* section. The statistical results suggested that the given construction could affect the amount of time the participants took for processing it.

The significant differences between the reading times for the PRRC/S4 condition and those for the RC/S4 condition were ascribed to the difference between PRRC and RC in connection with the number of the words which appeared before the past participles. In the unreduced RCs, the number of the words preceding the past participial forms was 4, including the definite article *the*, a noun, the relative pronoun *who* or *which*, and the copula *was*. Samples of the words placed before the past participles in the RCs are *the merchant who was seen*, *the artist who was known*, and *the duckling which was eaten*. Yet, the past participles in the reduced RCs followed a noun phrase which comprised fewer words: the definite article *the* and a noun, e.g., *the dancer taken*, *the beggar shaken*, and *the sportsman drawn*. The unequal numbers

of the words which were placed before the past participles in the two structures might give rise to different degrees of cognitive loads. The RCs which comprised more words seemed to carry more cognitive burdens than the PRRCs with fewer words. The correlation between the number of the preceding words and their processing difficulty degree could be supported by a processing phenomenon called word length effect or the extent to which the processing of a word is affected by the number of the letters in the word (Barton et al., 2014). One kind of variables which has been commonly employed to explore the word length effect is the temporal measurements, including reading times. The amount of time spent on reading a word has been claimed to correlate to the quantity of the letters in the word. The longer a word is, the higher processing difficulty it tends to have, and thus, readers are likely to take more time reading the longer words than the shorter ones. Many research studies observed that participants spent more time processing longer words than reading shorter words, indicating that they had more problems with the former than with the latter (e.g., racially diverse students' processing of pseudowords in Callahan, 2011; native European Portuguese speakers' processing of Portuguese infinitives in Vanderschueren & Diependaele, 2013; L1 Persian learners' processing of English words in Fotovatnia et al., 2019; L1 English speakers' and L1 Chinese learners' processing of English words in Tan & Foltz, 2020; Spanish-English bilinguals' processing of code-switched sentences in Salig, 2021; L1 English processing in Lõo et al., 2022). The concept of word length effect was relevant to the words preceding the past participial forms in the RCs and PRRCs in the present study in that the two constructions contained different numbers of words, and hence different numbers of letters. Compared to the PRRCs, the RCs included more preceding words, which meant a higher number of letters. Accordingly, it could be assumed that the preceding words in the unreduced RCs taxed more cognitive resources of the native controls and the lower WM L1 Thai learners than those in the reduced RCs did, and left them less capacity making them spend more similar amounts of time processing the past participles.

However, it should be noted that different amounts of reading times on the PRRCs and the RCs were not linked to different numbers of the words in the two constructions. As mentioned in Chapter III: Methodology, both PRRC and RCs were

chunked into critical regions and spillover regions with the same number of words. For the RCs, the phrases ‘who was’ and ‘which was’ were grouped with the subjects because they were not included in the data analyses. Although the occurrence of the phrases ‘who was’ and ‘which was’ and the past participles in different regions of the RCs contradicted syntactic chunking, grouping the words this way was necessary in light of a methodological reason. That is, the number of the words involving the critical regions must be kept identical across all the test items regardless of the structure in order to prevent length effects on the participants’ processing. Such segmentation of the sentences was consistent with some previous studies on RC-PRRC processing which divided the RC structures by separating the relative pronouns and copulas from the past participles (e.g., MacDonald et al., 1992; Yang & Shih, 2013). In the present study, only the reading times on the words in the critical and spillover regions of both structures were analyzed. Because the critical and spillover regions in both RCs and PRRCs contained the same number of words, the longer reading times on the regions in the former were not attributable to the higher number of words in the structure per se. Instead, the accumulating cognitive burdens of the phrases ‘who was/which was’ could have effects on processing of the following regions.

The second finding as regards the differences between the participant groups was that the L1 Thai learners with higher WM did not significantly differ from the other two participant groups in the reading times, as illustrated in Figures 18 and 19. Although the higher WM learners’ reading times on the spillover regions were closer to the native controls’ times in the RC/Salience 2 condition, and to their lower WM counterparts in the PRRC/Salience 4 condition, the differences did not reach significance.

Consistent with the data on the differences between the participant groups in the *Structure* section, the finding here demonstrated that the native controls read significantly faster than only the lower WM learners, not the higher WM ones. It was also found that the higher WM readers read faster than the lower WM ones, and were closer to the native English speakers in reading times. The findings suggested WM’s effects on the L1 Thai learners’ processing in that a sufficient pool of cognitive

capacity allows L2 readers to process L2 sentences faster and to perform more similarly to L1 readers. Therefore, the findings substantiated Hypothesis 1, which stated that working memory capacity would influence the L1 Thai learners' processing of the two constructions.

4.1.2.2.2.2.2 Discussions: Effects of structure and salience and interaction between the two factors as regards Salience

This subsection deals with the effects of structure and salience on the participants' processing of the Salience Group 2 PPs and the Group 4 ones, and interaction between the variables. Under this subsection, there are two parts: 4.1.2.2.2.2.2.1 and 4.1.2.2.2.2.2.2, which tackle the critical region and the spillover region, respectively.

4.1.2.2.2.2.2.1 Effects of factors at the critical region regarding Salience

A post-hoc one-way ANOVA test demonstrated that structure had a main effect on the processing of the irregulars from Salience Groups 4 among the lower WM L1 Thai learners. That is, the reading times the learners took for the PRRCs and RCs significantly differed when they read the Group 4 participial forms. They spent less time reading the past participles in the PRRCs than those in the RCs. Nevertheless, no significant difference between the reading times for the two constructions was observed when they read the Group 2 forms. Again, the finding was associated with different amounts of cognitive capacity required for identifying the given participial forms from the two salience groups: Group 2 and Group 4, as mentioned in the discussion of the critical region of the *Structure* data. That is, the L2 learners might need more cognitive resources in distinguishing between the past tense and past participial forms of Salience Group 2 which were more markedly different; consequently, they had inadequate cognitive capacity, and failed to exploit structural information in their processing. Conversely, the Salience Group 4 forms whose two forms were more phonologically similar might leave the learners sufficient resources for considering information about the two structures. When dealing with the Group 4 irregulars, the lower WM learners took more reading times for the past participles in RCs possibly because the structure required more cognitive capacity from them in

processing the S-V agreement, tense, and relative pronoun in the subordinate clauses (See detailed discussions of the processing burdens of English RCs in Subsection 4.1.2.1.2.2.1).

The result in this part was linked to Hypothesis 1 as well as Hypothesis 3. When experiencing the Salience Group 4 forms, the learners with lower WM spent significantly different amounts of reading time for the full RCs and for the reduced ones, but vice versa when they encountered the Group 2 verbs. The significant differences which were localized to the less salient PP forms demonstrated salience effects on their processing of the two constructions, substantiating Hypothesis 1. Additionally, it was shown that the lower WM learners' reading times on the PRRCs were not significantly different from those on the RCs only when they encountered the Group 2 irregulars. As seen from the mean reading times of the *Structure* data in Table 47, the lower WM learners spent more time on the spillover regions in PRRCs than on those in RCs, but the differences were not significant. Yet, their reading times on PRRCs and RCs were significantly different when the participants were given the Group 4 forms. Apparently, the non-significant differences between the reading times for the two structures were found with their processing of the more salient PP forms, not the less salient ones. So, Hypothesis 3 was partially confirmed.

4.1.2.2.2.2.2.2 Effects of factors at the spillover region regarding Salience

The post-hoc test revealed that salience had a main effect on processing of the PRRCs among the L1 Thai learners with lower WM capacity. The reading times they spent for the spillover regions in the Salience Group 2 sentences (e.g., The lawyer taken <u>to the airport</u>) and Group 4 sentences (e.g., The lawyer seen <u>at the airport</u>) were not significantly different when they read the RCs; however, when they experienced the reduced RCs, a significant difference was observed between the reading times they took for the spillover regions in the Salience Group 2 sentences and those in the Group 4 sentences. According to Table 53, the lower WM learners read the spillover regions in the sentences with the less salient PPs faster than those in the sentences with the more salient PPs.

The finding was related to a part of Hypothesis 4, which stated that the reading times the lower WM learners spent on the Group 4 forms would not be significantly longer than those on the Group 2 forms. According to the SPRT data, a non-significant difference between the reading times for the Group 2 and Group 4 forms was found only when the learners processed the RCs. Their reading times on the less salient forms were longer than those on the more salient ones, but the difference was not significant. Conversely, their reading times on the PPs with different salience levels were significantly different as they processed the PRRCs. Therefore, Hypothesis 4 was partially supported.

Again, the significant difference between the reading times for the PPs from the two salience groups which was limited to the PRRC sentences could be linked to the distinction between RC and PRRC regarding the number of the words preceding the spillover regions in the two constructions. In the RCs, the spillover regions followed 5 words, namely a definite article, an NP, a relative pronoun, a copula, and a past participle (e.g., The lawyer who was seen at the airport), which could add cognitive burdens related to S-V agreement, tense, and relative pronoun in the subordinate clauses. After processing the RCs, the learners had insufficient resources for taking into account the salience level of the given forms, and thus, tended not to distinguish between the PPs from the two salience groups. In the PRRCs, the spillover regions, however, were preceded by 3 words: a definite article, an NP, and a past participle (e.g., The lawyer seen at the airport); therefore, the participants did not have to consider the additional burdens, as imposed by the RCs. So, the less cognitive demanding PRRCs might leave the participants with adequate capacity for processing the irregulars from the two salience groups.

In connection with the PPs from the two salience groups, the lower WM learners read the *Modifier of the PP* regions in the Salience Group 4 sentences significantly faster than those in the Group 2 sentences. The finding could be supported by the distinction between the two groups regarding the level of phonological changes the irregulars required for their inflection from the past tense form to the past participial one. The phonological differences between the past tense and participial forms of the Group 2 irregular verbs were more marked than those of

the Group 4 verbs, so the lower WM learners might necessitate more cognitive resources in identifying the Group 2 forms than figuring out the Group 4 ones. This could lead the learners to have fewer resources left for processing the *Modifier of the PP* regions in the Group 2 sentences than for those in the Group 4 sentences, explaining why they were slower when processing the prepositional phrases following the Group 2 participles.

As shown in the findings in both the *Structure* and *Salience* data, the native controls' L1 processing tended to be affected by salience and structure.[50]

The results and discussions regarding the reading times in the *Structure* and *Salience* data are encapsulated in Table 61.

[50] Native speakers' sensitivity to information cues has been evidenced by a group of language processing studies (e.g., use of animacy information in solving MV/RR ambiguities in Just & Carpenter, 1992; use of plausibility information in processing English *wh*-questions in Williams, 2006; use of plausibility information in processing English long-distance *wh*-extraction in Dussias & Piñar, 2010). Among the studies, Just and Carpenter (1992) examined native English speakers' use of animacy information in solving MV/RR ambiguities of English PRRCs, and they found that several participants showed longer fixation times on the disambiguating region in reduced RCs with animate nouns than in those with inanimate nouns. The finding suggested the participants' use of animacy information in processing ambiguous sentences. Although the research of Just and Carpenter is different from the present study in terms of the factors investigated, the results of both studies showed that native speakers' processing could be influenced by information cues as well.

	Regions	Results	Participant groups	Details of the results	Discussions
Structure	Critical (PP + Modifier of the PP)	1. Effect of Subject	The native controls vs The lower WM learners	The native controls were faster than the lower WM learners in all the conditions.	The lower WM learners' longer reading times were due to two factors: lower automaticity degree of L2 processing and L1 negative transfer related to RCs and reduced RCs.
		2. Interaction	1.2.1 The native controls 1.2.2 lower WM learners (Structure effect on processing of the participial forms from Salience Groups 2 and 4)	Salience 2: The reading times the two groups took for the two constructions did not significantly differ.	Salience 2 needs more cognitive resources in identifying the participial forms since their past tense and past participial forms are markedly different. The learners then had inadequate capacity left for considering structural information.
				Salience 4: The reading times the two groups took for the two constructions significantly differed. Both groups read the critical regions in PRRCs faster than those in RCs.	Salience 4 requires fewer cognitive resources in identifying the participial forms because their past tense and past participial forms are more phonologically similar. The participants took more reading times for the critical regions in RCs probably because they might need to process the S-V agreement, tense, and relative pronoun in the subordinate clauses.
	Spillover (Main verb + Object)	1. Interaction	The lower WM learners (Structure effects on processing of the participial	Salience 2: The reading times the learners took for the two constructions did not significantly differ.	Salience 2 needs more cognitive resources in identifying the participial forms. So, the learners had inadequate capacity left for considering structural information.
				Salience 4: The reading times the learners took for the two	Salience 4 requires fewer cognitive resources in identifying the participial

			forms from Salience Group 4)	constructions did significantly differ. They read the spillover regions in PRRCs more slowly than those in RCs.	forms. They spent more time reading the spillover regions in PRRCs because of their delayed identification of the thematic role of the subjects in the construction.
			1.1.1 The native controls 1.1.2 Higher WM learners (Salience effects on processing of the PRRCs)	PRRC: The reading times the two participant groups took for the Group 2 and Group 4 sentences significantly differed. Both groups read the spillover regions in the Group 4 sentences faster than those in the Group 2 sentences.	Processing of PRRCs might require fewer cognitive resources, leading the participants to have sufficient capacity for considering the salience level of the irregular verbs. Compared to the Group 2 forms, the past tense and PP forms of the Group 4 verbs are more phonologically similar, requiring less capacity for the learners to identify the given forms in the reduced clauses. The identification of the Group 4 forms left the participants more cognitive resources which made them process the MV + Object regions faster.
				RC: The reading times the two participant groups took for the Group 2 and Group 4 sentences did not significantly differ.	RCs require more cognitive capacity for processing the S-V agreement, tense, and relative pronoun. The construction also contains a higher number of words which could add cognitive burdens for the participants. They might have insufficient resources for considering the salience level of the past participial forms.
	Critical (PP)	1. Structure effect on processing of the	The lower WM learners	Salience 2: The reading times the participants took for the two constructions did not significantly differ.	Salience 2 needs more cognitive resources in identifying the participial forms. The learners then had inadequate capacity left for considering structural information.

Salience		participial forms from Salience Groups 2 and 4		Salience 4: The reading times they took for the two constructions did significantly differ. They read the critical regions in PRRCs faster than those in RCs.	Salience 4 requires fewer cognitive resources in identifying the participial forms. The lower WM learners took more reading times for the PPs in RCs because the structure required more cognitive capacity for processing the S-V agreement, tense, and relative pronoun in the subordinate clause.
	Spillover (Modifier of the PP)	1. Effect of Subject	The native controls vs The lower WM learners	The native controls were faster than the lower WM learners in all the conditions.	The lower WM learners' longer reading times were due to two reasons: lower automaticity degree of L2 processing.
		2. Interaction	The lower WM learners (Salience effect on processing of the PRRCs)	PRRC: The reading times the participants took for the Group 2 and Group 4 sentences significantly differed. They read the spillover regions in the Group 4 sentences faster than those in the Group 2 sentences.	Processing of PRRCs might require fewer cognitive resources, leading the participants to have sufficient capacity for considering the salience level of the irregular verbs. Compared to the Group 2 forms, the past tense and PP forms of the Group 4 verbs are more phonologically similar, requiring less capacity for identifying the given forms in the PRRCs. The identification of the Group 4 forms left the participants more cognitive resources which made them process the spillover regions faster than when they experienced the Group 2 forms.
				RC: The reading times the two participant groups took for the Group 2 and Group 4 sentences did not significantly differ.	RCs require more cognitive capacity for processing the S-V agreement, tense, and relative pronoun. The construction also contains a higher number of words. They

					might have insufficient resources for considering the salience level of the past participial forms.

Table 61**: Summary of the results and discussions regarding the reading times in Structure and Salience**

4.2 General discussion

In this section, two issues concerning the major findings are discussed: the effects of working memory capacity (4.2.1) and the impact of structure and salience (4.2.2).

4.2.1 Effects of working memory

The first issue concerns the effects of WM on the L1 Thai learners' processing of English RCs and PRRCs. Two main findings in connection with the WM effects are discussed: the WM impact localized to the subjects' online processing and the higher WM participants' shorter reading times than the lower WM ones'.

First of all, the effects of WM were likely to be observed in only the online processing of the L1 Thai participants, not the offline one. The reading times of the two L1 Thai groups with different WM degrees significantly differed while the differences between their comprehension accuracy scores were not significant. This was probably associated with the concept of different degrees of cognitive burdens demanded by the two processing task types (Just & Carpenter, 1992). The notion proposes that distinctions between readers with different cognitive capacity levels are more likely to occur in the more demanding tasks than in the less difficult ones. The online task of the present study asked the participants to read the target sentences as fast as they could; however, in the offline task, they simply answered yes-no questions based on the sentences. Clearly, the online part was more demanding than the offline one, so the WM impact was more likely to be observed in the former than the latter.

Second, in both the *Structure* and *Salience* data, the L1 Thai learners with higher WM read the target sentences faster than those with lower WM, and took similar amounts of reading time to those of the native English speakers. The result can be explained by the difference between the two L1 Thai groups in cognitive capacity level. Readers' cognitive capacity level has been assumed to affect the amount of time they spend on their sentence processing. As Just and Carpenter (1992) claimed, the greater capacity a reader possesses, the more quickly she can process sentences. Higher WM readers have a larger capacity size helping them combine the upcoming

information with the preceding one faster than the lower span ones, leading the former to take shorter reading times than the latter.

4.2.2 Effects of structure and salience

The second issue is related to the influences of the two variables, i.e., structure and salience. The effects of the two factors are separately discussed.

Pertaining to the impact of structure, one finding is worth being mentioned: the L1 Thai learners' longer reading times on the RCs than those on the PRRCs. The two L1 Thai groups with different levels of memory span took longer time reading the RCs than the PRRCs. The finding resulted probably because the number of words occurring before the past participles in the unreduced RCs was greater than that in the reduced ones. Compared to the PRRCs, the RCs included two more words: a relative pronoun and a copula, which required the readers to deal with the concord between the selected relative pronouns and the head nouns as well as the correlation between the copulas and the preceding nouns and tense of the clauses. Consequently, the RCs imposed heavier cognitive burdens than the PRRCs did. It can be concluded that structure had effects on both the L1 Thai groups due to the difference in number of words between RCs and PRRCs. The distinction probably posed different levels of processing burdens which could account for the participants' significantly different amounts of reading times for the two constructions.

As regards the salience effect, the higher span learners took longer time reading the spillover regions in the target sentences with the Group 2 past participles than those in the sentences with the Group 4 participles. The finding could be related to the differences between the past participles from the two salience groups: the level of phonological alterations and the syllabic number. The first difference involves the degree of the phonological changes required by the irregulars from the two salience classes. In the present study, salience of a verb refers to the extent to which the past tense and past participial forms of the verb phonologically differ from each other. The verbs which undergo bigger changes are assumed to be more salient. Thus, the Group 2 participles, which include more prominent alterations, i.e., an internal vowel change and an addition of the syllabic [ən] morpheme, tend to be more salient than the Group

4 verbs with less obvious changes: an internal vowel change and an affixation of n. Examples of the Group 2 participles and the Group 4 ones are *shook-shaken* of *shake* and *knew-known* of *know*, respectively. According to the research findings, the more distinct the differences between the two forms were, the greater processing difficulties the learners tended to have. The two forms of the Group 2 irregulars are more markedly different than those of the Group 4 ones; therefore, it could be more capacity taxing for the participants to distinguish the two forms of the more salient irregulars. As a result, the research participants might need a greater amount of reading time for identifying the Group 2 participles.

4.3 Summary

This chapter presented the results of the research experiment and discussion of the findings. Due to the outlier removal issue, the participant inclusion criteria with respect to the findings of the two tasks were explained first. Then, the chapter revealed the remaining data about the participants' comprehension accuracy scores and reading times. Concerning the online experiment, the two groups of data, namely the *Structure* data and the *Salience* data, were separately shown. Then, the chapter discussed the findings in relation to the differences between the three participant groups and the effects of structure and salience and interaction between the two factors among the participant groups. This chapter ended by providing a general discussion regarding effects of WM, structure, and salience on the participants' processing.

The following chapter provides a summary of the findings, implications, limitations of this study, and recommendations for future research.

CHAPTER V
CONCLUSIONS

This chapter comprises three sections. Section 5.1 presents the summary of the findings based on the findings in Chapter IV. Section 5.2 describes implications of this study in relation to theoretical and pedagogical aspects. Section 5.3 discusses limitations of this study and recommendations for future research.

5.1 Summary of the findings

This section is about whether the research findings confirmed the four hypotheses of the present study. The research aimed to explore effects of working memory (WM) on L1 Thai learners' processing of English RCs and PRRCs with the following research objectives addressed in Chapter I:

1) To investigate the extent to which the L1 Thai learners' WM levels and salience of the past participial forms of irregulars will affect the learners' processing of English RCs and PRRCs which contain past participles.

2) To examine how the L1 Thai learners with different WM degrees, i.e., higher and lower WM, differ in the level of comprehension accuracy.

3) To look into how the L1 Thai learners with different WM levels, i.e., higher and lower WM, differ in the amount of time they spend on processing English RCs and PRRCs with past participles.

4) To explore how the classification of English irregular verbs according to the salience of their past participial forms affects the processing of English RCs and PRRCs among the L1 Thai learners with different WM levels, i.e., higher and lower WM.

In parallel with all the objectives above, the following hypotheses were constructed and tested:

Hypothesis 1: The L1 Thai learners' WM levels and salience of the past participial forms of irregulars will affect the learners' processing of English RCs and PRRCs which contain past participles.

The research findings showed that WM and salience affected only the L1 Thai learners' online processing. Regarding salience effects, the higher WM and lower WM learners spent different amounts of reading times for the spillover regions in Group 2 and Group 4 sentences in the *Structure* and *Salience* data, respectively. Pertaining to working memory, the data in both *Structure* and *Salience* sections revealed that the native controls were significantly different from only the lower WM learners, not the higher WM ones. Furthermore, the learners who had more WM capacity read the target sentences faster than those with less cognitive capacity. The findings suggested a pivotal role of WM on the learners' online processing. Yet, the effects of the two factors were absent in the participants' offline processing. Therefore, Hypothesis 1 was partially supported by the research findings.

Hypothesis 2: The L1 Thai learners with higher WM will have a higher degree of accuracy in answering the comprehension questions than those with lower WM.

The result of the offline experiment demonstrated that the difference between the comprehension accuracy rates of the two L1 Thai groups did not reach significance. Thus, Hypothesis 2 was rejected.

Hypothesis 3: The reading times the L1 Thai learners with higher WM spend on PRRCs will be significantly greater than those on RCs whereas the reading times the learners with lower WM spend on PRRCs will not be significantly greater than those on RCs.

In connection with the higher WM learners, the findings in both the *Structure* and *Salience* data showed that the reading times they took for the PRRCs and RCs did not significantly differ, contradicting the part of the hypothesis which was related to the higher WM group. Pertaining to the lower WM learners, as shown in the findings of the *Structure* (critical and spillover regions) and *Salience* (critical region) sections, when the learners read the less salient irregular verbs, the reading times they took for

the two constructions significantly differed. However, when they experienced the more salient forms, their reading times for the PRRCs were longer than those for the RCs, but the difference was not significant. The non-significant difference between the reading times for the two structures which was localized to their processing of the Salience Group 2 verbs was in partial support of the part of the hypothesis associated with the lower WM group. Given the data on the two groups of L1 Thai learners, Hypothesis 3 was partly confirmed.

Hypothesis 4: The reading times the L1 Thai learners with higher WM spend on less salient irregulars will be significantly greater than those on more salient irregulars whereas the reading times the learners with lower WM spend on less salient irregulars will not be significantly greater than those on more salient irregulars.

An SPRT finding in the *Structure* section (spillover region) showed that, when the higher WM learners encountered the items which included a PRRC, they took more time reading the spillover regions in the Salience Group 2 sentences than those in the Salience Group 4 sentences. This did not bear out the hypothesis part regarding the higher span group. However, the part related to the lower span group was partly supported because the finding in the *Salience* section (spillover region) revealed that the reading times the lower WM learners took for the Group 4 sentences were not significantly longer than those for the Group 2 sentences only when they read the RC items. In contrast, when given the PRRC items, they spent significantly different amounts of time for the Group 2 and Group 4 sentences. As a result, Hypothesis 4 was partially confirmed.

The research findings therefore partially supported the first, third, and fourth hypotheses whereas the second hypothesis was rejected.

5.2 Implications

The implications of the current study are discussed in relation to theoretical and pedagogical aspects.

The research findings had one theoretical implication concerning L2 processing. A sufficient pool of cognitive resources could make it more possible for

L2 readers to process L2 sentences as similarly as native speakers do. The statistical data demonstrated that only the lower WM learners' reading times were significantly different from the native controls'. This meant that the readers with more cognitive resources were faster in reading the target sentences than the lower WM ones, and thus, the former were closer to the native speakers in the amount of time spent on processing the sentences online.

One pedagogical implication could also be provided. The implication was linked to the lower WM learners' online processing with respect to *Structure*. The learners spent more time reading the spillover regions in the PRRCs than those in the RCs. The finding might result from the postponed assignment of the thematic role of the subjects in the PRRCs. The result might be related to the fact that the reduced RCs lacked such clear indicators as the phrases 'who was' and 'which was' as the RCs had. Thus, the learners might find it more problematic to identify the thematic role of the subjects in the reduced RCs. In the present study, the PRRCs included the irregular verbs whose past tense and past participial forms were clearly different, e.g., *chose* and *chosen.* The identification of the thematic role of a subject then directly involved the verb form which followed the subject. Consequently, the pedagogical implication is that L2 English learners should notice the verb form which follows the subject. If the subject precedes a past participial form, they are encountering a PRRC, and the subject plays the thematic role of patient or theme. In case a past tense form follows the subject, they are reading the predicate of the sentence. The thematic role of the subject is agent. The more quickly the given form is recognized, the faster they tend to realize the thematic role. L2 learners' capability to identify the thematic roles faster could result from their familiarity with the past tense and past participial forms of irregular verbs. The learners could familiarize themselves with both forms by being highly exposed to the forms in authentic contexts. Teachers could therefore provide their students with authentic texts where the two forms are prevalent, and have them practice identifying whether the subjects of the given forms perform or receive the actions in the clauses. Simply put, a high input frequency enables the learners to be more familiar with the past tense and past participial forms in use, leading them to determine the thematic role of the subjects faster.

5.3 Limitations of the study and recommendations for future research

Three recommendations are suggested for future research. First of all, further research might look into more irregular past participial classes in the salience hierarchy. The current study included two classes, i.e., an internal vowel change plus an addition of the syllabic [ən] morpheme and an internal vowel change plus an affixation of *n*. Taking more past participial classes into account could achieve a clearer picture of influence of salience on the processing of PRRCs and RCs. In addition, further studies might explore how salience and individual differences in cognitive capacity affect the processing of the two constructions among L2 learners from various L1s which are different in the level of similarity between the shortened adjective clauses in the languages and the English PRRCs. Lastly, future studies could measure native English speakers' working memory and compare effects of WM and salience on L1 processing of PRRCs and RCs with those on L2 processing.

REFERENCES

Akande, A. T. (2003). "Acquisition of Inflectional Morphemes by Nigerian Learners of English Language." Nordic Journal of African Studies **12**: 310-326.

Al-Momani, M. M. A.-A. (2019). "A study on the function of the English participial phrases." US-China Foreign Language **17**(2): 67-73.

Allan, D. (2004). Oxford Placement Test, Oxford University Press.

Alotaibi, A. M. (2016). "Examining the learnability of English relative clauses: Evidence from Kuwaiti EFL learners." English Language Teaching **9**(2): 57-65.

Alptekin, C. and G. Erçetin (2010). "The role of L1 and L2 working memory in literal and inferential comprehension in L2 reading." Journal of Research in Reading **33**(2): 206-219.

Alroudhan, H. E. (2016). "The acquisition of English restrictive relative clauses by Arab adult EFL learners." Advances in Language and Literary Studies **7**(1): 33-53.

Anderson, J. (1978). Order of difficulty in adult second language acquisition. Second Language Research: Issues and implications. W. Ritchie. New York, Academic Press**:** 91-108.

Atkinson, R. C. and R. M. Shiffrin (1968). Human memory: A proposed system and its control processes. The Psychology of Learning and Motivation. K. Spence and J. T. Spence. New York, Academic Press. **2:** 89-195.

Austin, G., et al. (2015). "Structural competition in second language production: Towards a constraint-satisfaction model." Language Learning **65**(3): 689–722.

Azar, B. S. (1999). Understanding and Using English Grammar. New York, Longman.

Baars, B. J. and N. M. Gage (2013). Fundamentals of Cognitive Neuroscience: A Beginner's Guide. San Diego, CA, US, Elsevier Academic Press.

Baddeley, A. D. (1996a). "Exploring the central executive." The Quarterly Journal of Experimental Psychology **49**(1): 5-28.

Baddeley, A. D. (1996b). "The fractionation of working memory." Proceedings of the National Academy of Sciences of the United States of America **93**(24): 13468–13472.

Baddeley, A. D. (2000). "The episodic buffer: A new component of working memory?" Trends in Cognitive Sciences **4**(11): 417-423.

Baddeley, A. D. (2003). "Working memory and language: An overview." Journal of Communication Disorders **36**(3): 189-208.

Baddeley, A. D. (2012). "Working memory: Theories, models, and controversies." Annual Review of Psychology **63**: 1-29.

Baddeley, A. D. and G. Hitch (1974). Working Memory. The Psychology of Learning and Motivation: Advances in Research and Theory. G. Bower. New York, Academic Press**:** 47-89.

Bailey, R. (2016, November 15). "Divisions of the Brain: Forebrain, Midbrain, Hindbrain." from https://www.thoughtco.com/divisions-of-the-brain-4032899.

Ballard, K. (2001). The Frameworks of English. Basingstoke, Palgrave.

Bandini, H. H. M., et al. (2013). "Levels of phonological awareness, working memory, and lexical knowledge in elementary school children." Paidéia **23**(56): 329-337.

Barclay, T. (2019). "Brain: Human Brain Diagrams and Detailed Information." from https://www.innerbody.com/image/nerv02.html.

Bayley, R. (1994). Interlanguage variation and the quantitative paradigm: Past tense marking in Chinese-English. Research Methodology in Second-Language Acquisition. E. E. Tarone, S. M. Gass and A. D. Cohen. Hillsdale, NJ, Lawrence Erlbaum**:** 157-181.

Beaman, K. (1984). Coordination and Subordination Revisited: Syntactic Complexity in Spoken and Written Narrative Discourse. Coherence in Spoken and Written Discourse. D. Tannen. Norwood, Ablex**:** 45-80.

Beare, K. (2019, May 23). "Reduced Relative Clauses." from https://www.thoughtco.com/reduced-relative-clauses-1211107.

Behney, J., et al. (2017). The L2 acquisition of Italian tense: The role of salience. Salience in Second Language Acquisition. S. M. Gass, P. Spinner and J. Behney. New York, Routledge**:** 89-106.

Behrens, B. (1998). Contrastive discourse: An interlingual approach to the interpretation and translation of free ING-participial adjuncts, University of Oslo, Norway.

Bel, A., et al. (2016). "Transfer and proficiency effects in L2 processing of subject anaphora." Lingua **184**: 134-159.

Besner, D. (1987). "Phonology, lexical access in reading, and articulatory suppression: A critical review." Quarterly Journal of Experimental Psychology **39**: 467–478.

Besner, D., et al. (1981). "Reading for meaning: The effects of concurrent articulation." Quarterly Journal of Experimental Psychology **33**: 415-437.

Biber, D. and B. Gray (2010). "Challenging stereotypes about academic writing: complexity, elaboration, explicitness." Journal of English for Academic Purposes **9**: 2-20.

Biber, D., et al. (2011). "Should we use characteristics of conversation to measure grammatical complexity in L2 writing development?" TESOL QUARTERLY **45**(1): 5–35.

Biber, D., et al. (1999). Longman grammar of spoken and written English. Pearson

Education Limited, Harlow, Essex.

Blackstone, E. H. (2016). "Rounding numbers." The Journal of Thoracic and Cardiovascular Surgery **152**(6): 1481-1483.

Blackwood, D. H. and W. J. Muir (1990). "Cognitive brain potentials and their application." British Journal of Psychiatry Supplements **9**: 96-101.

Blumenthal-Dramé, A., et al. (2017). "Editorial: Perceptual Linguistic Salience: Modeling Causes and Consequences." Frontiers in Psychology **7**: 411.

Boonmaton, M. (2000). Relationships between Verbal Working Memory, English Listening, and Reading Comprehension Abilities of Mathayon Suksa Five Students, Bangkok Metropolis, Chulalongkorn University, Bangkok, Thailand.

Bordalo, P., et al. (2012). "Salience theory of choice under risk." Quarterly Journal of Economics **127**(3): 1243-1285.

Bordalo, P., et al. (2013). "Salience and consumer choice." Journal of Political Economy **121**: 803-843.

Boudewyn, M. A., et al. (2013). "Effects of working memory span on processing of lexical associations and congruence in spoken discourse." Frontiers in Psychology **4**: 1-16.

Brown, R. (1973). A First Language: The Early Stages. Cambridge, MA, Harvard University Press.

Bulut, T., et al. (2013). "Processing asymmetry between subject and object relative clauses in English as a second language." DİLBİLİM DERGİSİ **29**(1): 45-68.

Burgess, L. (2018, February 26). "Left brain vs. right brain: Fact and fiction." from https://www.medicalnewstoday.com/articles/321037.php.

Burke, G. (2016, December 23). "Ever wonder what's going on in your kid's developing brain?". from https://medium.com/@galynburke/child-development-post-1-ever-wonder-whats-going-on-in-your-kid-s-developing-brain-3b57395a10ca.

Burt, J. S., et al. (1993). "Associative priming in perceptual identification: Effects of prime-processing requirements." Memory & Cognition **21**(1): 125-137.

Callahan, M. D. (2011). Orthographic Learning Through Self-Teaching: Effects of Decoding Accuracy, Decoding Speed, Word Length, Morphology, and Individual Differences. Berkeley, California, University of California.

Cao, Y. (2013). "An empirical study on English participle acquisition of the Chinese arts majors." Theory and Practice in Language Studies **3**(1): 116-123.

Carneiro, M. M. (2017). "Investigating bilinguals' sensitivity to English regular past morphology: A self-paced reading experiment with Brazilian learners." Revista Brasileira de Linguística Aplicada **17**(3): 483-507.

Carroll, D. W. (2008). Psychology of Language. Belmont, CA, Wadsworth-Thomson Learning.

Cedrus Corporation (2014). SuperLab 6.0. San Pedro, CA.

Charunrochana, J. (2009). Fundamental Linguistics. Bangkok, Thailand, Kasetsart University Press.

Chen, L., et al. (2007). "ERP signatures of subject–verb agreement in L2 learning." Bilingualism: Language and Cognition **10**(2): 161-174.

Chen, S.-Y., et al. (2017). "A general introduction to adjustment for multiple comparisons." Journal of Thoracic Disease **9**(6): 1725-1729.

Cheyette, S. J. and D. C. Plaut (2017). "Modeling the N400 ERP component as transient semantic over-activation within a neural network model of word comprehension." Cognition **162**: 153–166.

Chiarcos, C., et al. (2011). Salience: Multidisciplinary Perspectives on its Function in Discourse. Berlin, Walter de Gruyter.

Chumkamon, S. (2017). Use of English Grammatical Morphemes among L1-Thai Learners, Thammasat University, Bangkok, Thailand.

Cintrón-Valentín, M. C. and N. C. Ellis (2016). "Salience in second language acquisition: Physical form, learner attention, and instructional focus." Frontiers in Psychology **7**: article 1284.

Clahsen, H. and C. Felser (2006a). "Continuity and shallow structures in language processing." Applied Psycholinguistics **27**(1): 107-126.

Clark, A. (2013). "Whatever next? Predictive brains, situated agents, and the future of cognitive science." Behavioral and Brain Sciences **36**(3): 181-204.

Cleophas, T. J. and A. H. Zwinderman (2016). Clinical Data Analysis on a Pocket Calculator: Understanding the Scientific Methods of Statistical Reasoning and Hypothesis Testing. Cham, Switzerland, Springer International Publishing.

Cohen-Mimran, R., et al. (2013). "The effect of morphological complexity on verbal working memory: Results from Arabic speaking children." Journal of Psycholinguistic Research **42**(3): 239-253.

Conrad, R. (1964). "Acoustic confusion in immediate memory." British Journal of Psychology **55**(1): 75-84.

Conway, A. R. A., et al. (2001). "The cocktail party phenomenon revisited: The importance of working memory capacity." Psychonomic Bulletin & Review **8**: 331–335.

Coughlin, C. E. and A. Tremblay (2013). "Proficiency and working memory based explanations for nonnative speakers' sensitivity to agreement in sentence processing." Applied Psycholinguistics **34**: 615–646.

Daneman, M. and I. Green (1986). "Individual differences in comprehending and producing words in context." Journal of Memory and Language **25**(1): 1-18.

De Renzi, E. (1982). Disorders of Space Exploration and Cognition. New York, NY,

John Wiley & Sons.

DeCapua, A. (2017). Grammar for Teachers: A Guide to American English for Native and Non-native Speakers. New York, NY, Springer.

Dhadse, A. (2021). "Removing Outliers. Understanding How and What behind the Magic.". Retrieved October 10, 2021, from https://medium.com/analytics-vidhya/removing-outliers-understanding-how-and-what-behind-the-magic-18a78ab480ff.

Difalcis, M., et al. (2020). "Syllabic length effect in Spanish: Evidence from adult readers." Ocnos **19**(3): 19-28.

Dussias, P. E. and P. Piñar (2010). "Effects of reading span and plausibility in the reanalysis of wh-gaps by Chinese-English second language speakers." Second Language Research **26**(4): 443-472.

Eastwick, E. C. and C. Phillips (1999). Variability in semantic cue effectiveness on syntactic ambiguity resolution: Inducing low-span performance in high-span readers. The AMLaP 99. University of Edinburgh, UK.

Ellis, N. C. (2006). "Selective attention and transfer phenomena in SLA: Contingency, cue competition, salience, interference, overshadowing, blocking, and perceptual learning." Applied Linguistics **27**: 1–31.

Ellis, N. C. and N. Sagarra (2011). "Learned attention in adult language acquisition: A replication and generalization study and meta-analysis." Studies in Second Language Acquisition **33**: 589–624.

Ellis, N. C. and S. G. Sinclair (1996). "Working memory in the acquisition of vocabulary and syntax: Putting language in good order." The Quarterly Journal of Experimental Psychology **49**: 234-250.

Ellis, R. (1987). "Interlanguage variability in narrative discourse: Style shifting in the use of the past tense." Studies in Second Language Acquisition **9**(1): 1-20.

Endley, M. J. (2010). Linguistic Perspectives on English Grammar: A Guide for EFL Teachers. Charlotte, NC, Information Age Pub.

Engle, R. W., et al. (1990). "Word knowledge and working memory capacity." Journal of Educational Psychology **82**: 799-804.

Estling Vannestål, M. (2015). University Grammar of English with a Swedish Perspective. Lund, Studentlitteratur.

Etzioni, A. (2016). "The salience of salience in international relations." The Brown Journal of World Affairs **23**(2): 237-250.

Featherstone, C. R., et al. (2012). "Norming the odd: Creation, norming, and validation of a stimulus set for the study of incongruities across music and language." Behavior Research Methods **44**(1): 81-94.

Felser, C. and I. Cunnings (2012). "Processing reflexives in English as a second language: The role of structural and discourse-level constraints." Applied

Psycholinguistics **33**: 571–603.

Felser, C., et al. (2003). "Children's processing of ambiguous sentences: A study of relative clause attachment." Language Acquisition **11**(5): 127-163.

Felser, C. and L. Roberts (2004). Plausibility and recovery from garden paths in second language sentence processing. AMLaP. Aix-en-Provence.

Ferreira, F. and C. Clifton (1986). "The independence of syntactic processing." Journal of Memory and Language **25**(3): 348-368.

Ferreiro, E. and A. Teberosky (1999). Psicogênese da língua escrita. Porto Alegre, Artmed.

Fitzsimmons, G. and D. Drieghe (2011). "The influence of number of syllables on word skipping during reading." Psychonomic Bulletin & Review **18**: 736–741.

Foley, M. and D. Hall (2004). Longman Advanced Learners' Grammar: A self-study reference & practice book with answers. Harlow, Longman.

Foong, E. (2013, February). "Split-brain." from http://psychapprentice.weebly.com/psychology-lexicon/split-brain.

Foote, R. (2011). "Integrated knowledge of agreement in early and late English-Spanish bilinguals." Applied Psycholinguistics **32**(1): 187-220.

Franceschina, F. (2001). "Morphological or syntactic deficits in near-native speakers? An assessment of some current proposals." Second Language Research **17**(3): 213-247.

Frenck-Mestre, C. and J. Pynte (1997). "Syntactic ambiguity resolution while reading in second and native languages." The Quarterly Journal of Experimental Psychology **50A**: 119–148.

Gass, S. M. and J. Lee (2011). "Working memory capacity, inhibitory control, and proficiency in a second language." Studies in Bilingualism **43**: 59-84.

Gathercole, S. E. (2008). "Working memory." Learning and Memory: A Comprehensive Reference **2**: 33-51.

Gathercole, S. E. and A. D. Baddeley (1993). Working memory and language. Hillsdale, NJ, Lawrence Erlbaum.

George, A. and C. Williams (2017). How your brain works: Inside the most complicated object in the known universe. London, JohnMurray Learning.

Ghilzai, S. A. (2014). "The role of L1 transfer in the processing of L2 English possessive constructions: Evidence from German." European Academic Research **2**(6): 7454-7481.

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

Gibson, E. (2000). The dependency locality theory: a distance-based theory of linguistic complexity. Image, language, brain: Papers from the first mind articulation project

symposium. A. Marantz, Y. Miyashita and W. O'Neil. Cambridge, MA, MIT Press**:** 95–126.

Gibson, E., et al. (1996). "Cross-linguistic attachment preferences: Evidence from English and Spanish." Cognition **59**: 23-59.

Gilboy, E., et al. (1995). "Argument structure and association preferences in Spanish and English compound NPs." Cognition **54**(2): 131-167.

Gillon Dowens, M., et al. (2010). "Morphosyntactic processing in late second-language learners." Journal of Cognitive Neuroscience **22**(8): 1870–1887.

Gindri, G., et al. (2007). "Memória de trabalho, consciência fonológica e hipótese de escrita." Pró-Fono Revista de Atualizacao Científica **19**(3): 313-322.

Goad, H., et al. (2003). Missing surface inflection in L2 acquisition: A prosodic account. Proceedings of the 27th Annual Boston University Conference on Language Development, Somerville, MA, Cascadilla.

Goldschneider, J. M. and R. M. DeKeyser (2001). "Explaining the "natural order of L2 morpheme acquisition" in English: A meta-analysis of multiple determinants." Language Learning **51**(1): 1-50.

Gove, P. B. (1965). ""Gerund/ Noun" and "Participle/ Adjective"." American Speech **40**(1): 40-46.

Granger, S. (1997). On identifying the syntactic and discourse features of participle clauses in academic English: Native and non-native writers compared. Studies in English Language and Teaching: In honor of FlorAarts. F. Aarts, J. Aarts, I. d. Monnink and H. Wekke. Amsterdam & Atlanta, Rodopi**:** 185-198.

Greenbaum, S. and G. Nelson (2002). An Introduction to English Grammar London, Pearson Education Limited.

Greenbaum, S. and G. Nelson (2009). An Introduction to English Grammar. London, Longman.

Grice, T. and J. Greenan (2009). Oxford English for Careers: Nursing 2 (Student's Book). Oxford, Oxford University Press.

Han, J. and D. B. Wackman (2017). "Partisan self-stereotyping: Testing the salience hypothesis in a prediction of political polarization." International Journal of Communication **11**: 603-625.

Harley, T. (2001). The Psychology of Language: From Data to Theory. New York, NY, Psychology Press.

Hasegawa, M., et al. (2002). "An fMRI study of bilingual sentence comprehension and workload." Neuroimage **15**(3): 647–660.

Havik, E., et al. (2009). "Processing subject-object ambiguities in L2 Dutch: A self-paced reading study with German L2 learners of Dutch." Language Learning **59**(1): 73-112.

Hawkins, R. and C. Y. Chan (1997). "The partial availability of universal acquisition: The 'failed functional features hypothesis'." Second Language Research **13**: 187-226.

Hawkins, R. and S. A. Liszka (2003). Locating the source of defective past tense marking in advanced L2 English speakers. The Lexicon-Syntax Interface in Second Language Acquisition. R. van Hout, A. Hulk, F. Kuiken and R. J. Towell. Amsterdam, John Benjamins**:** 21-44.

Haznedar, B. and B. D. Schwartz (1997). Are there optional infinitives in child L2 acquisition? Proceedings of the 21st Annual Boston University Conference on Language Development, Somerville, MA, Cascadilla.

He, S., et al. (2016). Exemplar-driven top-down saliency detection via deep association. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, Las Vegas, NV, USA.

Hecke, T. V. (2010). "Power study of anova versus Kruskal-Wallis test." Journal of Statistics and Management Systems **15**(2): 241-247.

Hestvik, A., et al. (2012). "Working memory effects of gap-predictions in normal adults: An event-related potentials study." Journal of Psycholinguistic Research **41**(6): 425-438.

Hewings, M. (2000). Advanced grammar in use: A self-study reference and practice book for advanced learners of English: With answers. Cambridge, Cambridge University Press.

Hofmann, W., et al. (2008). "Working memory capacity and self-regulatory behavior: Toward an individual differences perspective on behavior determination by automatic versus controlled processes." Journal of Personality and Social Psychology **95**(4): 962-977.

Hogg, R. (2002). An Introduction to Old English. Edinburgh, Edinburgh University Press.

Hopp, H. (2015). "Individual differences in the second language processing of object-subject ambiguities." Applied Psycholinguistics **36**(2): 129–173.

Housen, A. (2002). The development of Tense-Aspect in English as a second language and the variable influence of inherent aspect. The L2 Acquisition of Tense-Aspect Morphology. R. Salaberry and Y. Shirai. Philadelphia, Benjamins**:** 155-197.

Huddleston, R. and G. K. Pullum (2002). The Cambridge Grammar of the English Language. Cambridge, Cambridge University Press.

Huddleston, R. and G. K. Pullum (2005). A Student's Introduction to English Grammar. Cambridge, Cambridge University Press.

Hundt, M., et al. (2012). "Relative complexity in scientific discourse." English Language and Linguistics **16**(Special Issue 02): 209 – 240.

Ismail, M. (2016). "Inflectional morphemes." IJSRSET **2**(2): 142-152.

Ito, A. and M. J. Pickering (2021). Automaticity and prediction in non-native language

comprehension. Prediction in Second Language Processing and Learning. E. Kaan and T. Grüter. Amsterdam, John Benjamins Publishing**:** 26–46.

Iwasaki, S. and P. Ingkaphirom (2005). A Reference Grammar of Thai. Cambridge, Cambridge University Press.

Janssen, N., et al. (2008). "A tale of two frequencies: Determining the speed of lexical access for Mandarin Chinese and English compounds." Language and Cognitive Processes **23**: 1191–1223.

Jegerski, J., et al. (2011). "Cross-linguistic variation and the acquisition of pronominal reference in L2 Spanish." Second Language Research **27**: 481–507.

Jia, G. and A. Fuse (2007). "Acquisition of English grammatical morphology by native Mandarin-speaking children and adolescents: Age-related differences." Journal of Speech, Language, and Hearing Research **50**: 1280-1299.

Jin, F. (2007). Second Language Acquisition and Processing of Norwegian DP Internal Agreement. Norway, Norwegian University of Science and Technology.

Jingling, L. and L. Zhaoping (2008). "Change detection is easier at texture border bars when they are parallel to the border: Evidence for V1 mechanisms of bottom-up salience." Perception **37**: 197–206.

Johansen, N. B. (2008). New Research on Short-Term Memory. New York, Nova Biomedical Books.

Johansson, E. (2018). Subject-Verb Agreement in L2 Learner Language: A Study of Compulsory School English in a Swedish Context, The University of Gothenburg.

Johnson, G. (2001). Connoisseurs of Chaos Offer a Valuable Product: Randomness. New York Times**:** 1.

Juffs, A. (1998). "Main verb versus reduced relative clause ambiguity resolution in L2 sentence processing." Language Learning **48**(1): 107-147.

Juffs, A. (2004). "Representation, processing and working memory in a second language." Transactions of the Philological Society **102**(2): 199–225.

Juffs, A. and M. Harrington (1995). "Parsing effects in second language sentence processing: Subject and object asymmetries in wh- extraction." Studies in Second Language Acquisition **17**: 483–516.

Juffs, A. and M. Harrington (1996). "Garden-path sentences and error data in second language processing research." Language Learning **46**: 286–324.

Just, M. A. and P. A. Carpenter (1992). "A capacity theory of comprehension: Individual differences in working memory." Psychological Review **99**(1): 122-149.

Kane, M. J., et al. (2001). "A controlled-attention view of working memory capacity." Journal of Experimental Psychology: General **130**(2): 169-183.

Kane, M. J., et al. (2004). "The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning." Journal of

Experimental Psychology: General **133**(2): 189-217.

Kaushanskaya, M. and J. Yoo (2013). "Phonological short-term and working memory in bilinguals' native and second language." Applied Psycholinguistics **34**(5): 1005-1037.

Keating, G. D. and J. Jegerski (2015). "Experimental designs in sentence processing research." Studies in Second Language Acquisition **37**(1): 1-32.

Keller, T. A., et al. (2003). "Brain imaging of tongue-twister sentence comprehension: Twisting the tongue and the brain." Brain and Language **84**(2): 189-203.

Khumdee, M. and N. Pongpairoj (2014). "Variable production of English past tense marking by L1 Thai learners: An application of the failed functional features hypothesis (FFFH)." Thoughts **1**: 126-144.

Kim, J. H. and K. Christianson (2017). "Working memory effects on L1 and L2 processing of ambiguous relative clauses by Korean L2 learners of English." Second Language Research **33**(3): 365-388.

Kimppa, K., et al. (2019). "Acquisition of L2 morphology by adult language learners." Cortex **116**: 74-90.

King, J. and M. A. Just (1991). "Individual differences in syntactic processing: The role of working memory." Journal of Memory and Language **30**: 580-602.

Kiss, I., et al. (2007). "Control processes in verbal working memory: An event-related potential study." Brain Research **1172**: 67–81.

Klein, E. C., et al. (2004). Past tense affixation in L2 English: The effects of lexical aspect and perceptual salience. The 28th Annual Boston University Conference on Language Development. USA.

Klein, W., et al. (1995). Conclusions. The Acquisition of Temporality in a Second Language. R. Dietrich, W. Klein and C. Noyau. Philadelphia, PA, John Benjamins**:** 261-280.

Kongthai, K. (2015). "The influence of native language in the production of English tenses by Thai and Spanish learners." Journal of Graduate Study in Humanities and Social Sciences, Khon Kaen University **4**(2): 127-145.

LaBerge, D. and S. J. Samuels (1974). "Toward a theory of automatic information processing in reading." Cognitive Psychology **6**(2): 293-323.

Lafford, B. A. (1996). The development of tense/aspect relations in L2 Spanish narratives: Evidence to test competing theories. The Second Language Research Forum 96. Tucson, AZ.

Langacker, R. W. (1987). Foundations of Cognitive Grammar, Volume I, Theoretical Prerequisites. Stanford, California, Stanford University Press.

Lardiere, D. (1998). "Case and tense in the 'fossilized' steady state." Second Language Research **14**(1): 1-26.

Laskova, V. (2007). "Verbal participles and the prenominal position in English." Rivista di Grammatica Generativa **32**: 125-140.

Lázaro, M., et al. (2020). "Perceptual salience of derivational suffixes in visual word recognition." Scandinavian Journal of Psychology **61**(3): 348-360.

Lee, L. S., et al. (1991). "An efficient natural language processing system specially designed for the Chinese language." Computational Linguistics **17**(4): 312-319.

Lee, S. A. (2007). "Ing forms and the progressive puzzle: A construction-based approach to English progressives." Journal of Linguistics **43**(1): 153-195.

Lekawatana, P., et al. (1969). A Contrastive Study of English and Thai. Ann Arbor, The University of Michigan.

Leppänen, V. (2019). Ablaut and the Latin Verb: Aspects of Morphophonological Change, Ludwig Maximilian University of Munich, Munich.

Letourneau, M. S. (2001). English Grammar. Fort Worth, TX, Harcourt College Publishers.

Lezak, M. D., et al. (2004). Neuropsychological assessment Oxford University Press.

Li, Y. and C. Brantmeier (2021). "The effects of working memory capacity on reading comprehension and strategy use with chinese EFL university students." The Reading Matrix: An International Online Journal **21**(1): 1-26.

Lin, C. J. C. (2018). "Subject prominence and processing dependencies in prenominal relative clauses: The comprehension of possessive relative clauses and adjunct relative clauses in Mandarin Chinese." Language **94**(4): 758-797.

Loberger, G. and K. Shoup (2009). Webster's New World English Grammar Handbook. Hoboken, NJ, Wiley Publishing, Inc.

Logie, R. H. (1995). Visuo-spatial Working Memory. Hove, United Kingdom, Erlbaum.

Logie, R. H. and C. Marchetti (1991). Visuo-spatial working memory: Visual, spatial or central executive? Mental Images in Human Cognition. R. H. Logie and M. Denis. Oxford, England, North-Holland**:** 105-115.

Lõo, K., et al. (2022). "Morphological processing is gradient not discrete in L1 and L2 English masked priming." The Mental Lexicon **17**(1): 76 – 103.

MacDonald, M. C., et al. (1992). "Working memory constraints on the processing of syntactic ambiguity." Cognitive Psychology **24**(1): 56-98.

Maini, E. (2020). "Interquartile Range to Detect Outliers in Data." Retrieved October 10, 2021, from https://www.geeksforgeeks.org/interquartile-range-to-detect-outliers-in-data/.

Maluf, M. R. and S. D. Barrera (1997). "Consciência fonológica e linguagem escrita em pré- escolares." Psicologia Reflexão e Crítica **10**(1): 125-145.

Mansbridge, M. and K. Tamaoka (2018). "The (In)Sensitivity of Plural -S by Japanese

Learners of English." Open Journal of Modern Linguistics **8**: 176-198.

Marsden, E., et al. (2018). "A methodological synthesis of self-paced reading in second language research." Applied Psycholinguistics **39**(5): 861-904.

Marvin, T. (2002). Past participles in reduced relatives. Proceedings of ConSOLE IX. M. V. Koppen, E. Thrift, E. J. van der Torre and M. Zimmermann**:** 141-156.

McDonald, J. (2006). "Beyond the critical period: Processing-based explanations for poor grammaticality judgment performance by late second language learners." Journl of Memory and Language **55**: 381–401.

Mcdonough, K. and P. Trofimovich (2016). "The role of statistical learning and working memory in L2 speakers' pattern learning." The Modern Language Journal **100**(2): 428-445.

McKoon, G. and R. Ratcliff (2003). "Meaning through syntax: Language comprehension and the reduced relative clause construction." Psychological Review **110**(3): 490-525.

Medeiros, V. P. D., et al. (2013). "Expressive vocabulary and analyze the variables in a regional sample of students in Maceió." Audiology - Communication Research **18**(2): 71-77.

Meisel, J. M. (2011). First and Second Language Acquisition: Parallels and Differences. Cambridge, Cambridge University Press.

Meltzer-Asscher, A. (2010). "Present participles: Categorial classification and derivation." Lingua **120**(9): 2211-2239.

Meniado, J. C. (2019). "Evaluating the English proficiency of faculty members of a higher education institution: Using results to develop responsive professional development program." International Journal of English Linguistics **9**(2): 52-64.

Milwidsky, C. (2008). Working Memory and Phonological Awareness, University of Witwatersrand, Johannesburg.

Minow, V. (2010). Variation in the Grammar of Black South African English. Frankfurt, Peter Lang.

Mittwoch, A. (1988). "Aspects of English aspect: On the interaction of perfect, progressive and durational phrases." Linguistics and Philosophy **11**(2): 203-254.

Miyake, A., et al. (1994). "Working memory constraints on the resolution of lexical ambiguity: Maintaining multiple interpretations in neutral contexts." Journal of Memory and Language **33**(2): 175–202.

Mohammadi, R. R., et al. (2014). "Syllabic length effect in visual word recognition by SLA learners." International Journal of Applied Linguistics & English Literature **3**(4): 29-37.

Molin, V. (2020). An Error Analysis of Subject-Verb Agreement by Swedish Learners of English: A Corpus-Based Study of the Difficulties Surrounding Subject-Verb

Agreement for Swedish Students, University of Gävle.

Mueller, J. L. (2005). "Electrophysiological correlates of second language processing." Second Language Research **21**(2): 152-174.

Murakami, A. and T. Alexopoulou (2016). "L1 interference on the acquisition order of English grammatical morphemes: A learner corpus study." Studies in Second Language Acquisition **38**(3): 365-401.

Murphy, R. (2004). English Grammar in Use: A Self-study Reference and Practice Book for Intermediate Learners of English. Cambridge, Cambridge University Press.

Næss, Å. (2011). Case on the margins: Pragmatics and argument marking in Vaeakau-Taumako and beyond. Case, Animacy and Semantic Roles. S. Kittilä, K. Västi and J. Ylikoski, John Benjamins Publishing Company**:** 305-328.

Nakamura, C., et al. (2020). "An extra cue is beneficial for native speakers but can be disruptive for second language learners: Integration of prosody and visual context in syntactic ambiguity resolution." Frontiers in Psychology **10**.

Naksakul, K. (2002). Rabopsiengphasathai (The Sound System of Thai). Bangkok, Faculty of Arts Publications Project, Chulalongkorn University.

Newell, A. (1973). Production systems: Models of control structures. Visual Information Processing. W. G. Chase. San Diego, CA, Academic Press**:** 463-526.

Nickels, L., et al. (1997). "Fractionating the articulatory loop: Dissociations and associations in phonological recoding in aphasia." Brain and Language **56**(2): 161–182.

Nielsen, J. A., et al. (2013). "An evaluation of the left-brain vs. right-brain hypothesis with resting state functional connectivity magnetic resonance imaging." PLoS ONE **8**(8): e71275.

Nilsson, M. (2006). Processing Dependencies: Working Memory Load in Sentence Parsing, Uppsala University, Uppsala.

O'Reilly, J. (2018). Processing and Production of Unique and Non-unique-to-L2 syntactic Structures: The Case of English Articles and Tense-aspect, University of York, the United Kingdom.

Oakhill, J. and F. E. Kyle (2000). "The relation between phonological awareness and working memory." Journal of Experimental Child Psychology **75**(2): 152-164.

Odlin, T. (1989). Language Transfer. New York, Cambridge University Press.

Omaki, A. (2005). Working Memory and Relative Clause Attachment in First and Second Language Processing. Department of Second Language Studies, University of Hawaii, the United States.

Papadopoulou, D. and H. Clahsen (2003). "Parsing strategies in L1 and L2 sentence processing: A study of relative clause attachment in Greek." Studies in Second Language Acquisition **24**: 501–528.

Parkinson, J. and J. Musgrave (2014). "Development of noun phrase complexity in the writing of English for Academic Purposes students." Journal of English for Academic Purposes **14**: 48-59.

Parrott, M. (2000). Grammar for English Language Teachers. Cambridge, Cambridge University Press.

Pettersson, H. (2019). Subject-Verb Agreement in ESL Texts: A Corpus-based Study of Swedish ESL Students' Written Production, Mid Sweden University.

Pfenninger, S. E. (2011). "Age effects on the acquisition of nominal and verbal inflections in an instructed setting." Studies in Second Language Learning and Teaching **1**(3): 401-420.

Phinitkit, S. (2015). Development Computer Program for Phonological Working Memory Capacity Assessment of Upper Secondary School Students, Burapha University, Chonburi, Thailand.

Pickering, S. J., et al. (2001). "Development of memory for pattern and path: Further evidence for the fractionation of visuo-spatial memory." The Quarterly Journal of Experimental Psychology **54**(2): 397-420.

Pinker, S. and M. T. Ullman (2002). "The past and future of the past tense." Trends in Cognitive Sciences **6**(11): 456–463.

Pinmanee, S. (2015). Kan plae khansung [Advanced translation], Chulalongkorn University Press.

Plunkett, K. and V. Marchman (1991). "U-shaped learning and frequency effects in a multi-layered perceptron: Implications for child language acquisition." Cognition **38**(1): 43-102.

Pojprasat, S. (2007). An analysis of translation errors made by Mattayomsuksa 6 students, Srinakharinwirot University, Thailand.

Pongpairoj, N. (2015). "Asymmetries in L2 English Article Omissions with First and Second Mention Definite Referents by L1 Thai Learners." Pasaa Paritat Journal **30**: 27–64.

Pongpairoj, N., & Mallikamas, P. (2004). "Itthiphon khong phasa angkrit nai bot plae phasa thai [Influence of the English language on Thai translations]." Journal of Letters **33**(1): 69-110.

Popa, S. (2016). Language transfer in second language acquisition. Some effects of L1 instruction (Romanian) on L2/L3 learning (Catalan/Spanish), Universitat de Lleida, Lleida, Spain.

Prapobaratanakul, C. and N. Pongpairoj (2016). "Variable production of English past tense morphology: A case study of a Thai-speaking learner of English." PASAA **51**: 71-96.

Prasithrathsint, A. (2006). Development of thùuk passive marker in Thai. Passivization and typology: Form and function. W. Abraham and L. Leisiö. Amsterdam, John

Benjamins**:** 115-131.

Prévost, P. and L. White (2000). "Missing Surface Inflection or Impairment in second language acquisition? Evidence from tense and agreement." Second Language Research **16**(2): 103-133.

Pritschet, L., et al. (2016). "Marginally Significant Effects as Evidence for Hypotheses: Changing Attitudes Over Four Decades." Psychological Science **27**(7): 1036–1042.

Quirk, R., et al. (1985). A Comprehensive Grammar of the English Language. London & New York, Longman.

Rácz, P. (2012). "Operationalising salience: Definite article reduction in the North of England." English Language and Linguistics **16**(1): 57–79.

Rafajlovičová, R. (2012). The distribution and role of relative clauses in different text types. English Matters III: A collection of papers by the Institute of English and American Studies Faculty. A. Kačmárová. Prešov, SR, Prešovská univerzita v Prešove**:** 11-24.

Rah, A. and D. Adone (2010). "Processing of the reduced relative clause versus main verb ambiguity in L2 learners at different proficiency levels." Studies in Second Language Acquisition **32**(1): 79-109.

Rahmah, F. (2018). A Thematic Roles Analysis Of Webtoon Orange Marmalade In English And Indonesian Version, Universitas Muhammadiyah Surakarta.

Ranganath, C. and G. Rainer (2003). "Neural mechanisms for detecting and remembering novel events." Nature Reviews Neuroscience **4**(3): 193–202.

Rattanasak, S., et al. (2022). "Effects of working memory capacity and distance-based complexity on agreement processing: a crosslinguistic competition account." Applied Linguistics Review.

Reichle, R. V., et al. (2016). "Working memory capacity in L2 processing." Probus: International Journal of Latin and Romance Linguistics **28**(1): 29-55.

Roberts, L., et al. (2007). "Antecedent priming at trace positions in children's sentence processing." Journal of Psycholinguistic Research **36**(2): 175-188.

Robinson, P. (2012). Abilities to learn: Cognitive abilities. Encyclopedia of the Sciences of Learning. N. Seel. New York, NY, Springer Academic**:** 17-20.

Rodríguez, G. A. (2008). Second Language Sentence Processing: Is It Fundamentally Different?, University of Pittsburgh, Pittsburgh, the United States.

Rohl, M. and C. Pratt (1995). "Phonological awareness, verbal working memory and the acquisition of literacy." Reading and Writing: An Interdisciplinary Journal **7**: 327-360.

Romano, F. (2015). "Salience and proficiency as determinants in the acquisition of L2 morphology." Italian Journal of Linguistics **27**(2): 75-110.

Rovinelli, R. J. and R. K. Hambleton (1976). "On the use of content specialists in the assessment of criterion-referenced test item validity." Dutch Journal of Educational Research **2**: 49-60.

Rungrojsuwan, S. (2015). "Morphological processing difficulty of Thai learners of English with different levels of English proficiency." MANUSYA: Journal of Humanities **18**(1): 73-92.

Sagarra, N. and J. Herschensohn (2010). "Proficiency and animacy effects on L2 gender agreement processes during comprehension." Language Learning **61**(1): 80-116.

Salaberry, R. (2000). Spanish Past Tense Aspect: L2 Development in a Tutored Setting. Amsterdam, John Benjamins.

Salaberry, R. (2008). Marking Past Tense in Second Language Acquisition: A Theoretical Model. London, Continuum.

Salig, L. K. (2021). The role of cognitive control in bilingual code-switch comprehension. College Park, The Graduate School, University of Maryland.

Santiago, J., et al. (2000). "Sequential activation processes in producing words and syllables: Evidence from picture naming." Language and Cognitive Processes **15**: 1–44.

Sarkissian, J. and J. Behney (2017). Salience of noun-adjective agreement in L2 Latin. Salience in Second Language Acquisition. S. M. Gass, P. Spinner and J. Behney. New York, Routledge**:** 223-243.

Saur, D., et al. (2009). "Word order processing in the bilingual brain." Neuropsychologia **47**: 158–168.

Schachter, P. (1985). Parts-of-speech systems. Language Typology and Syntactic Description. T. Shopen, Cambridge University Press. **1:** 3-61.

Segalowitz, N. and J. H. Hulstijn (2009). Automaticity in bilingualism and second language learning. Handbook of bilingualism: Psycholinguistic approaches. J. F. Kroll and A. M. B. d. Groot, Oxford University Press**:** 371-388.

Service, E. (1992). "Phonology, working memory, and foreign-language learning." The Quarterly Journal of Experimental Psychology **45**(1): 21-50.

Service, E. and S. Maury (2015). "Differential recall of derived and inflected word forms in working memory: Examining the role of morphological information in simple and complex working memory tasks." Frontiers in Human Neuroscience **8**(1064): 1-16.

Service, E., et al. (2002). "Bilingual working memory span is affected by language skill." European Journal of Cognitive Psychology **14**: 383–407.

Shanshan, G. and W. Tongshun (2007). "Study on the relationship between working memory and EFL listening comprehension." CELEA Journal **30**(6): 46-56.

Sharifian, F. (2002). "Processing hyponymy in L1 and L2." Journal of Psycholinguistic

Research **31**(4): 421-436.

Sherman, C. (2019, August 2). "Right Brain, Left Brain: A Misnomer." from https://dana.org/article/right-brain-left-brain-really/.

Shin, J., et al. (2019). "The interplay between working memory and background knowledge in L2 reading comprehension." TESOL QUARTERLY **53**(2): 320-347.

Shin, M. K. (2015). "The resetting of the head direction parameter." Foreign Language Education Research **18**: 17-35.

Siewierska, A. (2005). Passive construction. The World Atlas of Language Structures M. Haspelmath, M. S. Dryer, D. Gil and B. Comrie. Oxford, Oxford University Press**:** 434-437.

Simoens, H., et al. (2017). The effect of perceptual salience on processing L2 inflectional morphology. Salience in Second Language Acquisition. S. M. Gass, P. Spinner and J. Behney. New York, Routledge**:** 107-130.

Sleeman, P. (2008). "Prenominal and postnominal reduced relative clauses: Arguments against unitary analyses." Bucharest Working Papers in Linguistics **9**(1): 5-16.

Sleeman, P. (2017). Participial relative clauses. Oxford Research Encyclopedia of Linguistics. M. Aronoff, Oxford University Press**:** 185.

Smalheiser, N. R. (2017). Data Literacy: How to Make your Experiments Robust and Reproducible. Cambridge, MA, Academic Press.

Solt, S., et al. (2003). L2 perception and production of the English regular past: Evidence of phonological effects. Proceedings of the 28th Annual Boston University Conference on Language Development, Somerville MA, Cascadilla Press.

Sornhiran, P. (1978). A transformational study of relative clauses in Thai. Ann Arbor, Michigan, The University of Texas at Austin.

Stanton, T. (2011). "The reduced relative clause: A misnomer?" Début: The Undergraduate Journal of Languages, Linguistics and Area Studies **2**(2): 55–65.

Steer, J. M. and K. A. Carlisi (1998). The Advanced Grammar Book. Boston, MA, Heinle & Heinle.

Stenneken, P., et al. (2007). "Processing of syllables in production and recognition tasks." Journal of Psycholinguistic Research **36**(1): 65-78.

Stowe, L. A. and L. Sabourin (2005). "Imaging the processing of a second language: Effects of maturation and proficiency on the neural processes involved." International Review of Applied Linguistics **43**: 329–353.

Suda, K. (2015). "The influences of proficiency levels and working memory capacities on sentence comprehension by Japanese learners of English." EUROSLA Yearbook **15**: 143–163.

Suktrakul, S. (1975). A contrastive analysis of relative clauses in Thai-English. Ann Arbor, Michigan, Rutgers, The State University of New Jersey.

Sun, J. (2020). Progress in Molecular Biology and Translational Science, Elsevier.

Surprenant, A. M., et al. (1999). "Irrelevant speech, phonological similarity, and presentation modality." Memory **7**(4): 405-420.

Swaab, T. Y., et al. (2011). ERPs and language processing. Oxford Handbook of Event-related Potential Components. S. J. Luck and E. S. Kappenman. New York, Oxford University Press**:** 397–439.

Tajika, H. (1999). Variable patterns of tense/aspect marking in interlanguage, University of Minnesota, Minneapolis, the United States.

Takeda, K. (1999). Multiple Headed Structures, University of California, Irvine, the United States.

Tallerman, M. (2015). Understanding Syntax, Routledge.

Tan, M. and A. Foltz (2020). "Task sensitivity in L2 English speakers' syntactic processing: Evidence for good-enough processing in self-paced reading." Frontiers in Psychology **11**.

Tanaka, M. N., et al. (2011). The production of head-initial and head-final languages. Processing and Producing Head-final Structures. H. Yamashita, Y. Hirose and J. L. Packard. Dordrecht, Springer**:** 113–129.

Tang, C. (2015). "Applications of stalling mechanisms in Chinese-English bilinguals' L1 and L2 spoken discourse." International Journal of Bilingualism **19**(1): 92-114.

Thiamtawan, S. (2012). Avoidance behavior among L1 Thai learners: The case of the English adjectival phrase with present participle. Bangkok, Thailand, Chulalongkorn University.

Thiamtawan, S. and N. Pongpairoj (2013). "Avoidance of the use of English participial reduced relative clauses among L1 Thai learners." Language Education and Acquisition Research Network Journal **6**(2): 12-34.

Tokowicz, N. and B. MacWhinney (2005). "Implicit and explicit measures of sensitivity to violations in second language grammar: An Event-Related Potential Investigation." Studies in Second Language Acquisition **27**: 173–204.

Transue, J. E. (2007). "Identity salience, identity acceptance, and racial policy attitudes: American national identity as a uniting force." American Journal of Political Science **51**(1): 78-91.

Trenkic, D., et al. (2014). "Real-time grammar processing by native and non-native speakers: Constructions unique to the second language." Bilingualism: Language and Cognition **17**(2): 237–257.

Trenkic, D. and N. Pongpairoj (2013). "Referent salience affects second language article use." Bilingualism: Language and Cognition **16**(1): 152–166.

Trueswell, J. C., et al. (1994). "Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution." Journal of Memory and Language **33**:

285-318.

Tunmer, W. E. and M. Rohl (1991). Phonological awareness and reading acquisition. Phonological Awareness in Reading: The Evolution of Current Perspectives. D. Sawyer and B. Fox. New York, Springer Verlag**:** 1-30.

Uludağ, O. (2020). "Transfer of L1 processing strategies to the interpretation of sentence-level L2 input: A cross-linguistic comparison on the resolution of relative clause attachment ambiguities." Eurasian Journal of Applied Linguistics **6**(2): 155–188.

Unsworth, N., et al. (2004). "Working memory capacity and the antisaccade task: Individual differences in voluntary saccade control." Journal of Experimental Psychology: Learning, Memory, and Cognition **30**(6): 1302–1321.

Unsworth, N., et al. (2005). "An automated version of the operation span task." Behavior Research Methods **37**(3): 498-505.

Van den Noort, M., et al. (2006). "Foreign language proficiency and working memory capacity." European Psychologist **11**: 289-296.

Van der Stigchel, S., et al. (2009). "The limits of top-down control of visual attention." Acta Psychologica **132**(3): 201–212.

Van Petten, C., et al. (1997). "Working memory capacity dissociates lexical and sentential context effects." Psychological Science **8**(3): 238-242.

Vanderschueren, C. and K. Diependaele (2013). "The Portuguese inflected infinitive: An empirical approach." Corpus Linguistics and Linguistic Theory **9**(1): 161-186.

White, L. (2003). Second Language Acquisition and Universal Grammar. New York, Cambridge University Press.

White, L. and F. Genesee (1996). "How native is near-native? The issue of ultimate attainment in adult second language acquisition." Second Language Research **11**: 233-265.

Wicklin, R. (2019, November 11). "Round to Even." from https://blogs.sas.com/content/iml/2019/11/11/round-to-even.html.

Wilding, J. and W. White (1985). "Impairment of rhyme judgments by silent and overt articulatory suppression." The Quarterly Journal of Experimental Psychology **37**(1): 95-107.

Wilhelm, O., et al. (2013). "What is working memory capacity, and how can we measure it?" Frontiers in Psychology **4**(433): 1-22.

Williams, J., et al. (2001). "Native and non-native processing of English wh- questions: Parsing strategies and plausibility constraints." Applied Psycholinguistics **22**: 509–540.

Williams, J. N. (2006). "Incremental interpretation in second language sentence processing." Bilingualism: Language and Cognition **9**(1): 71-88.

Witzel, J., et al. (2012). "Deeper than shallow: Evidence for structure-based parsing biases in second-language sentence processing." Applied Psycholinguistics **33**: 419-456.

Wolfram, W. (1985). "Variability in tense marking: A case for the obvious." Language Learning **35**(2): 229-253.

Wolfram, W. and D. Hatfield (1984). Tense Marking in Second Language Learning: Patterns of Spoken and Written English in a Vietnamese Community. Washington DC, Center for Applied Linguistics.

Wudthayagorn, J. (2018). "Mapping the CU-TEP to the Common European Framework of Reference (CEFR)." LEARN Journal **11**(2): 163-180.

Xu, F. and S. Pinker (1995). "Weird past tense forms." Journal of Child Language **22**(3): 531–556.

Yang, P. and S. Shih (2013). "A reading-time study of the main verb versus reduced relative clause ambiguity resolution by English learners in Taiwan." Applied Psycholinguistics **34**(6): 1109-1133.

Yaowapat, N. and A. Prasithrathsint (2006). Reduced relative clauses in Thai and Vietnamese. SEALS XVI: Papers from the Sixteenth Annual Meeting of the Southeast Asian Linguistics Society. P. Sidwell and U. Tadmor. Canberra, Pacific Linguistics**:** 143-159.

Yordchim, S. and T. J. Gibbs (2014). "Error analysis of English inflection among Thai university students." International Scholarly and Scientific Research & Innovation **8**(7): 2140-2143.

Young, D. J. (1984). Introducing English Grammar. London, Hutchinson.

Zarcone, A., et al. (2016). "Salience and attention in surprisal-based accounts of language processing." Frontiers in Psychology **7**: 844.

Zhang, B. and Z. Jiang (2008). "On grammatical differences between daily British and American English." Asian Social Science **4**(6): 69-73.

Zhang, Y. and I. Widyastuti (2010). "Acquisition of L2 English morphology: A family case study." Australian Review of Applied Linguistics **33**(3): 1-17.

Zhou, H., et al. (2017). "Effects of working memory capacity and tasks in processing L2 complex sentence: Evidence from Chinese-English bilinguals." Frontiers in Psychology **8**: Article ID 595.

Zirk-Sadowski, J., et al. (2013). "Content-specificity in verbal recall: A randomized controlled study." PLoS ONE **8**: e79528.

APPENDICES

Appendix A

The CU-TEP, IELTS, and TOEFL iBT score ranges mapped to the CEFR levels

CU-TEP cut-off score ranges (max. 120 points)	CEFR levels
14-34	A2
35-69	B1
70-98	B2
99-120	C1

(Wudthayagorn, 2018: 174)

Common European Framework (CEFR)	IELTS (0-9.0)	TOEFL iBT (0-120)
C2	8.5-9.0	n/a
C1	7.0-8.0	95
B2	5.5-6.5	72
B1	4.0-5.0	42
A2	n/a	n/a
A1	n/a	n/a

(Meniado, 2019: 57)

Appendix B

The list of sentences in Phinitkit's (2015) RST

1. Test items (75 items)

1.1 Three-sentence sets

Set	Number of item	Sentence	Answer
1	1	แม่กำลังตำน้ำพริกสำหรับแกงส้มในห้องนอน	ไม่ใช่
	2	แม่ใช้มีดปังตอสับหมูทำต้มจืด	ใช่
	3	ฉันเห็นนกกระจอกเทศกำลังบินอยู่บนท้องฟ้า	ไม่ใช่
2	1	ลุงกำลังพายเรืออยู่ในทะเลทราย	ไม่ใช่
	2	รถทุกคันต้องชะลอความเร็วเมื่อเห็นสัญญาณไฟจราจรสีเหลือง	ใช่
	3	ตำรวจจราจรเป่านกหวีดอยู่กลางสี่แยกไฟแดง	ใช่
3	1	สมหมายไปเรียนว่ายน้ำในสวนสาธารณะ	ไม่ใช่
	2	ลุงแย้มเห็นพระกำลังจำวัดในกุฏิ	ใช่
	3	แม่เล่านิทานอีสปเรื่องปลาบู่ทองให้ฟังก่อนนอน	ไม่ใช่

1.2 Four-sentence sets

Set	Number of item	Sentence	Answer
1	1	สุนีย์รับประทานข้าวขาหมูทุกวันเพื่อลดความอ้วน	ไม่ใช่
	2	ยายแย้มไปดูโขนเรื่องรามเกียรติ์	ใช่
	3	วินัยนำสุกรไปไถนาเตรียมปลูกข้าว	ไม่ใช่
	4	กุ๊กไก่ดื่มกาแฟแก้ง่วงนอน	ใช่
2	1	สมพงษ์กำลังเล่นฟุตบอลในสระน้ำหลังบ้าน	ไม่ใช่
	2	สุเทพกำลังทำโจทย์สมการกำลังสองวิชาคณิตศาสตร์	ใช่
	3	มาลีเห็นปลาโลมากำลังว่ายน้ำอยู่บนก้อนเมฆ	ไม่ใช่
	4	สมานถ่ายรูปดอกไม้ด้วยแปรงสีฟัน	ไม่ใช่
3	1	มนัสเป็นเด็กที่สูงมากเพราะดื่มนมทุกวัน	ใช่
	2	ดวงใจกราบแม่ด้วยดอกมะลิในวันแม่	ใช่
	3	ยุพินแปรงฟันด้วยโทรศัพท์มือถือ	ไม่ใช่
	4	อุดมชวนเพื่อนไปเล่นฟุตบอลที่สนามหน้าโรงเรียน	ใช่

1.3 Five-sentence sets

Set	Number of item	Sentence	Answer
1	1	ปิยะรินน้ำใส่แก้วให้แม่ดื่ม	ใช่
	2	มาลัยขี่จักรยานอยู่บนทางรถไฟ	ใช่
	3	วสันชัยแห่ขันหมากไปสู่ขอสมจิตรรอบโบสถ์	ไม่ใช่
	4	ประเทืองสวมหมวกนิรภัยทุกครั้งที่ขับรถจักรยานยนต์	ใช่
	5	สุรัตน์กำลังว่ายน้ำในสระน้ำหลังบ้าน	ใช่
2	1	เบิร์ดหยอดเหรียญบาทในโทรศัพท์มือถือเพื่อเติมเงิน	ไม่ใช่
	2	อาทิตย์ปลูกผักคะน้าในสวนหลังบ้าน	ใช่
	3	ตำรวจนำตัวผู้ร้ายไปกักขังที่วัดก่อนส่งขึ้นศาล	ไม่ใช่
	4	วีระพลหุงข้าวในตู้เย็น	ไม่ใช่
	5	น้องธีเตรียมตัวไปโรงเรียนในวันจักรี	ไม่ใช่
3	1	สุพจน์ก่อไฟเผาปลาในครัวหลังบ้าน	ใช่
	2	อิทธิพลอ่านหนังสือเตรียมสอบขณะกำลังว่ายน้ำ	ไม่ใช่
	3	วันชัยวิ่งออกกำลังกายบนท้องฟ้า	ไม่ใช่
	4	พ่อเร่งเครื่องรถเมื่อเห็นสัญญาณไฟแดงที่สี่แยก	ไม่ใช่
	5	จุรีพรแต่งตัวไปประกวดนางนพมาศคืนวันลอยกระทง	ใช่

1.4 Six-sentence sets

Set	Number of item	Sentence	Answer
1	1	สมเกียรติเก็บกับข้าวไว้ในตู้เย็นไม่ให้เสีย	ใช่
	2	ปนัดดารีดผ้าด้วยกระติกน้ำร้อน	ไม่ใช่
	3	องอาจใช้กรรไกรตัดกระดาษเป็นรูปดอกไม้	ใช่
	4	โอภาสกำลังปีนต้นพริกอยู่	ไม่ใช่
	5	มนัสนั่งดูพระอาทิตย์ลับขอบฟ้าตอนเที่ยงคืน	ไม่ใช่
	6	มาลัยขับรถอยู่บนทางด่วน	ใช่
2	1	วิโรจน์ไปเก็บดอกไม้ที่สวนหลังบ้าน	ใช่
	2	ลุงแช่มเปิดเพลงหมอลำหลังจากพระสวดอภิธรรมจบ	ไม่ใช่
	3	พี่ชายกำลังตกปลาด้วยขวาน	ไม่ใช่
	4	พี่อ้วนพาแม่ไปตรวจสุขภาพประจำปีที่โรงพยาบาล	ใช่

	5	คุณยายพายเรือข้ามคลองไปรับคุณตา	ใช่
	6	สมรักษ์กำลังชกมวยกับสมจิตในสระว่ายน้ำ	ไม่ใช่
3	1	แมรีบซักผ้าตั้งแต่เช้าเพราะแดดกำลังแรง	ใช่
	2	สมภพรีบตื่นแต่เช้าเพื่อไปดูดาวบนท้องฟ้า	ไม่ใช่
	3	ยุทธนากำลังหุงข้าวด้วยเตารีด	ไม่ใช่
	4	ศาลตัดสินให้นิรันดร์ติดคุก 10 ปีเพราะจำหน่ายยาบ้า	ใช่
	5	ต้องตาดีใจมากเมื่อสุนัขตัวโปรดถูกรถชนตาย	ใช่
	6	สมพงษ์ถวายสังฆทานไปให้บรรพบุรุษที่ล่วงลับไปแล้ว	ใช่

1.5 Seven-sentence sets

Set	Number of item	Sentence	Answer
1	1	วันนี้พ่อขับรถเร็วมากเพราะหมอกกำลังลงจัด	ไม่ใช่
	2	แม่ทำต้มข่าไก่เป็นอาหารช่วงเทศกาลกินเจ	ไม่ใช่
	3	ประเพณีก่อพระทรายจัดขึ้นในช่วงเทศกาลสงกรานต์	ใช่
	4	ลูกเห็บตกใส่ศีรษะเดชาจนแตกขณะที่แดดออกแรงมาก	ไม่ใช่
	5	ปรีชากำลังโกนผมเพราะจะบวชเป็นพระ	ใช่
	6	บรรจงกำลังเตรียมสารเคมีสำหรับสอนวิทยาศาสตร์	ใช่
	7	แม่อุ้มน้องเดินเล่นในสนามฟุตบอลตอนเที่ยง	ไม่ใช่
2	1	ไพลินมองดูฝูงค้างคาวกำลังบินออกหากินในตอนเช้า	ไม่ใช่
	2	สมจิตพาฝูงวัวไปกินหญ้าที่เชิงเขาหลังบ้าน	ใช่
	3	ป้านิดกำลังแปรงฟันด้วยผงซักฟอก	ไม่ใช่
	4	สมคิดดื่มกาแฟก่อนขับรถแก้ง่วงนอน	ใช่
	5	การสู้วัวกระทิงเป็นกีฬาประจำชาติไทย	ไม่ใช่
	6	พ่อขุดหลุมเตรียมปลูกต้นกล้วยหลังบ้าน	ใช่
	7	ปิยะกำลังเดินเล่นบนแม่น้ำ	ไม่ใช่
3	1	อุบลท่องคำศัพท์ภาษาอังกฤษเพื่อเตรียมสอบวิชารำวง	ไม่ใช่
	2	คุณยายเปิดวิทยุเพื่อดูละครช่อง 7	ไม่ใช่
	3	กนกเดินออกกำลังกายในสวนสุขภาพทุกเช้า	ใช่
	4	บรรเจิดเลี้ยงปาท่องโก๋ไว้ในตู้ปลา	ไม่ใช่
	5	พ่อพาไปดูช้างที่สวนสัตว์	ใช่

	6	ยุทธนาไปซ่อมรถยนต์ที่อู่หน้าหมู่บ้าน	ใช่
	7	สุชาติอ่านหนังสือพิมพ์อยู่ในห้องสมุด	ใช่

2. Trial items (10 items)

Set	Number of item	Sentence	Answer
1	1	คุณยายนำอาหารไปทำบุญที่วัดในวันพระ	ใช่
	2	ณเดชตกจากต้นไม้ทำให้แขนหัก	ใช่
2	1	ปรีชาเข้าแถวเคารพธงชาติในเวลา 15.30 น.	ไม่ใช่
	2	ชินกรเติมน้ำตาลลงในก๋วยเตี๋ยวช่วยเพิ่มความเค็ม	ไม่ใช่
3	1	บังอรซื้อเสื้อกันหนาวใส่ในเดือนเมษายน	ไม่ใช่
	2	สมพงษ์เลี้ยงวัวสำหรับรับประทานไข่	ไม่ใช่
4	1	สมบัติขับรถยนต์บนน้ำทะเล	ไม่ใช่
	2	เบิร์ดหยอดเหรียญบาทในโทรศัพท์มือถือเพื่อเติมเงิน	ไม่ใช่
5	1	แม่ถือร่มไปตลาดเพราะฝนกำลังจะตก	ใช่
	2	สุนีย์ไปเวียนเทียนที่วัดในวันวิสาขบูชา	ใช่

Appendix C

The two presentation lists of sentences in the SPRT

List A	List B
1. The baby given to that couple loved the toy.	1. The baby who was given to that couple loved the toy.
2. The writer admired the actor with long hair.	2. The writer admired the actor with deep respect.
3. After the robber disappeared, the merchant fell down.	3. After the robber pushed, the merchant fell down.
4. The student who was known for her brilliance kissed her boyfriend.	4. The student known for her brilliance kissed her boyfriend.
5. The hunter hunted the monkey with a gun.	5. The hunter hunted the monkey with black hair.
6. The kitten of my sister was scratching my sofa.	6. The kittens of my sister were scratching my sofa.
7. As the model posed, the journalist photographed her.	7. As the model read, the journalist photographed her.
8. The beggar on the street was allergic to seafood.	8. The beggars on the street were allergic to seafood.
9. The dancer taken to this clinic dated a tailor.	9. The dancer who was taken to this clinic dated a tailor.
10. The workman attacked the thief with intensity.	10. The workman attacked the thief with a mole.
11. The bakers of the restaurant were sensitive to comments.	11. The baker of the restaurant was sensitive to comments.
12. As the gecko climbed, the snake bit it.	12. As the gecko crawled, the snake bit it.
13. The writer who was seen near the river raised a dog.	13. The writer seen near the river raised a dog.
14. Before the sportsman dived, his girlfriend drank coffee.	14. Before the sportsman kissed, his girlfriend drank coffee.
15. The roofer tasted the noodles with pepper.	15. The roofer tasted the noodles with a fork.
16. When the turtle swam, the workman grabbed it.	16. When the turtle bit, the workman grabbed it.
17. The merchants in the room were signing a contract.	17. The merchant in the room was signing a contract.
18. The duckling eaten in the village caused a disease.	18. The duckling which was eaten in the village caused a disease.
19. My boyfriend raised the rooster with care.	19. My boyfriend raised the rooster with a sharp beak.
20. The pupils in the class were doing their homework.	20. The pupil in the class was doing her homework.
21. The driver pushed the car with huge wheels.	21. The driver pushed the car with force.
22. The model who was drawn on the billboard earned an award.	22. The model drawn on the billboard earned an award.
23. The waitresses in the kitchen were	23. The waitress in the kitchen was using

	using their cellphones.		her cellphone.
24.	Before the duckling walked, the vet monitored it.	24.	Before the duckling ate, the vet monitored it.
25.	The workman blown off the scooter bruised his arm.	25.	The workman who was blown off the scooter bruised his arm.
26.	The hunters in the forest were shooting the monkeys.	26.	The hunter in the forest was shooting the monkeys.
27.	The trainer trained the sportsman with strong muscles.	27.	The trainer trained the sportsman with a dumbbell.
28.	After the rooster attacked, my grandpa got a wound.	28.	After the rooster leaped, my grandpa got a wound.
29.	The squirrel which was given to the painter climbed a tree.	29.	The squirrel given to the painter climbed a tree.
30.	The postman with a big bag was calling a man.	30.	The postmen with a big bag were calling a man.
31.	The baby looked at the toy with curiosity.	31.	The baby looked at the toy with a price tag.
32.	The panther seen in the valley seized a fox.	32.	The panther which was seen in the valley seized a fox.
33.	After the artist drew, the comic sold well.	33.	After the artist died, the comic sold well.
34.	The boxer passed the driving test with ease.	34.	The boxer passed the driving test with 10 questions.
35.	The tourist from China was crazy about a movie.	35.	The tourists from China were crazy about a movie.
36.	The salesman joined the meeting with confidence.	36.	The salesman joined the meeting with 120 attendees.
37.	The pupil who was known for his brightness passed a test.	37.	The pupil known for his brightness passed a test.
38.	As the dancer slept, the show started.	38.	As the dancer left, the show started.
39.	The poets in the village were famous for their writings.	39.	The poet in the village was famous for her writings.
40.	The beggar shaken from the coldness wanted a jacket.	40.	The beggar who was shaken from the coldness wanted a jacket.
41.	Before the patient complained, the doctor missed his flight.	41.	Before the patient explained, the doctor missed his flight.
42.	The oyster on the dish was good for our health.	42.	The oysters on the dish were good for our health.
43.	The skater destroyed the cellphone with a blue mobile case.	43.	The skater destroyed the cellphone with a hammer.
44.	The postman who was taken to the drugstore called his mother.	44.	The postman taken to the drugstore called his mother.
45.	After the writer wrote, the child cried.	45.	After the writer slept, the child cried.
46.	The hero helped the boy with blonde hair.	46.	The hero helped the boy with courage.
47.	The models from Paris were joining a fashion show.	47.	The model from Paris was joining a fashion show.
48.	Before the squirrel escaped, the cage door was open.	48.	Before the squirrel ran, the cage door was open.
49.	The monkey eaten in the forest	49.	The monkey which was eaten in the

	passed a virus.		forest passed a virus.
50.	The panther in the zoo was eating some meat.	50.	The panthers in the zoo were eating some meat.
51.	Before the tutor taught, the students talked.	51.	Before the tutor arrived, the students talked.
52.	The waiter grabbed the gecko with brown spots.	52.	The waiter grabbed the gecko with fear.
53.	The artist from the studio was painting the wall.	53.	The artists from the studio were painting the wall.
54.	The sportsman who was drawn on the paper coached his nephew.	54.	The sportsman drawn on the paper coached his nephew.
55.	The beggar watched the dog with black spots.	55.	The beggar watched the dog with curiosity.
56.	Before the builder washed, his feet were muddy.	56.	Before the builder exercised, his feet were muddy.
57.	The kitten scratched a fish with its claws.	57.	The kitten scratched a fish with black spots.
58.	The baker shaken from the thunder closed the door.	58.	The baker who was shaken from the thunder closed the door.
59.	The drivers in the garage were afraid of thunder.	59.	The driver in the garage was afraid of thunder.
60.	Before the salesman agreed, his colleague was upset.	60.	Before the salesman drank, his colleague was upset.
61.	The roofer who was blown off the rooftop cracked his head.	61.	The roofer blown off the rooftop cracked his head.
62.	The duckling in the village was spreading a disease.	62.	The ducklings in the village were spreading a disease.
63.	As the baby played, the toy became dirty.	63.	As the baby crawled, the toy became dirty.
64.	The dancer admired the police with deep respect.	64.	The dancer admired the police with a knife.
65.	After the teacher helped, the pupil finished her homework.	65.	After the teacher sighed, the pupil finished her homework.
66.	The waitress seen in the kitchen fried an egg.	66.	The waitress who was seen in the kitchen fried an egg.
67.	The boxers in the gym were hiring a trainer.	67.	The boxer in the gym was hiring a trainer.
68.	The doctor touched the wound with care.	68.	The doctor touched the wound with pus.
69.	The tourist who was taken to that hotel planned a tour.	69.	The tourist taken to that hotel planned a tour.
70.	The skater in the stadium was coaching my nephew.	70.	The skaters in the stadium were coaching my nephew.
71.	The chef cleaned the oysters with cold water.	71.	The chef cleaned the oysters with brown shells.
72.	The squirrel of the diver was chewing a nut.	72.	The squirrels of the diver were chewing a nut.
73.	When the panther approached, its prey ran away.	73.	When the panther growled, its prey ran away.
74.	The artist known for his talent painted the wall.	74.	The artist who was known for his talent painted the wall.

75.	Before the hero came, the kid almost died.	75.	Before the hero helped, the kid almost died.
76.	The student disappointed the teacher with a test score.	76.	The student disappointed the teacher with short hair.
77.	Just as the baker arrived, the bakery closed.	77.	Just as the baker cooked, the bakery closed.
78.	The kitten which was given to my sister scratched my sofa.	78.	The kitten given to my sister scratched my sofa.
79.	The roofer on the roof was jealous of a colleague.	79.	The roofers on the roof were jealous of a colleague.
80.	The robber killed a postman with a scar.	80.	The robber killed a postman with anger.
81.	After the waitress fried, the egg started to burn.	81.	After the waitress walked, the egg started to burn.
82.	The doctors from the city were kind to me.	82.	The doctor from the city was kind to me.
83.	The poet drawn on the textbook coined a term.	83.	The poet who was drawn on the textbook coined a term.
84.	The tourist visited the temple with great joy.	84.	The tourist visited the temple with many visitors.
85.	The workman in the car was going to a theater.	85.	The workmen in the car were going to a theater.
86.	The gecko which was eaten in the backyard scared my girlfriend.	86.	The gecko eaten in the backyard scared my girlfriend.
87.	The builder used the notebook with a red cover.	87.	The builder used the notebook with much care.
88.	Before the chef cooked, the oysters were raw.	88.	Before the chef smiled, the oysters were raw.
89.	The doctor known for his kindness saved my life.	89.	The doctor who was known for his kindness saved my life.
90.	The duckling stared at the cat with fear.	90.	The duckling stared at the cat with white fur.
91.	The sportsman at the airport was having curry.	91.	The sportsmen at the airport were having curry.
92.	Whenever the beggar sang, his daughter woke up.	92.	Whenever the beggar snored, his daughter woke up.
93.	The writer in the apartment was writing a textbook.	93.	The writers in the apartment were writing a textbook.
94.	The boxer who was shaken from the battle needed a drug.	94.	The boxer shaken from the battle needed a drug.
95.	After the kitten died, its owner was sad.	95.	After the kitten scratched, its owner was sad.
96.	The model joined a fashion show with 300 participants.	96.	The model joined a fashion show with confidence.
97.	After the hunter shot, the monkey died.	97.	After the hunter laughed, the monkey died.
98.	The salesman taken to the prison cheated her boss.	98.	The salesman who was taken to the prison cheated her boss.
99.	The insect annoyed the poet with a buzz.	99.	The insect annoyed the poet with a big belly.
100.	The baby in the stroller was	100.	The babies in the strollers were

dependent on her parents.	dependent on their parents.
101. Before the driver shouted, the kids were noisy.	101. Before the driver approached, the kids were noisy.
102. The merchant who was seen in the office owned a mansion.	102. The merchant seen in the office owned a mansion.
103. The dancers from the ballet school were receiving an award.	103. The dancer from the ballet school was receiving an award.
104. The pupil passed the exam with 40 questions.	104. The pupil passed the exam with ease.
105. The rooster given to my grandpa joined a cockfight.	105. The rooster which was given to my grandpa joined a cockfight.
106. The students in the class were taking a test.	106. The student in the class was taking a test.
107. Before the postman called, the receiver was busy.	107. Before the postman arrived, the receiver was busy.
108. The waitress burned the paper with a cigarette lighter.	108. The waitress burned the paper with a black stain.
109. When the tourist booked, the tickets were available.	109. When the tourist worked, the tickets were available.
110. The skater who was blown off a skateboard twisted his ankle.	110. The skater blown off a skateboard twisted his ankle.
111. The geckos in the backyard were scaring my girlfriend.	111. The gecko in the backyard was scaring my girlfriend.
112. The panther killed the deer with its sharp claws.	112. The panther killed the deer with a short tail.
113. When the roofer coughed, my brother went out.	113. When the roofer sang, my brother went out.
114. The florist loved the squirrel with black spots.	114. The florist loved the squirrel with all his heart.
115. The hero drawn on the laptop helped a kid.	115. The hero who was drawn on the laptop helped a kid.
116. The builders in the room were carrying bricks.	116. The builder in the room was carrying bricks.
117. The artist visited the art studio with a huge gate.	117. The artist visited the art studio with enthusiasm.
118. The oyster which was eaten in the party boosted my health.	118. The oyster eaten in the party boosted my health.
119. The rooster of my grandpa was joining the cockfight.	119. The roosters of my grandpa were joining the cockfight.
120. Before the skater appeared, his wife left.	120. Before the skater showered, his wife left.
121. The baker answered the customer with an expensive pen.	121. The baker answered the customer with high speed.
122. The builder blown off the ladder sprained his elbow.	122. The builder who was blown off the ladder sprained his elbow.
123. After the boxer laughed, his girlfriend hit him.	123. After the boxer attacked, his girlfriend hit him.
124. The salesmen from the company were kind to their customers.	124. The salesman from the company was kind to his customers.
125. The driver who was shaken from the earthquake parked his car.	125. The driver shaken from the earthquake parked his car.

126. Before the poet smiled, his textbook earned an award.	126. Before the poet wrote, his textbook earned an award.
127. The merchant cleaned the scissors with dull blades.	127. The merchant cleaned the scissors with water.
128. The heroes in the clip were helping a kid.	128. The hero in the clip was helping a kid.

Appendix D

The two vocabulary lists given to the participants before the SPRT experiments

ก่อนทำการทดลอง ขอให้ท่านอ่านสารบัญคำศัพท์ด้านล่าง หากท่านไม่เข้าใจความหมายของคำศัพท์คำใด ขอให้ท่านแจ้งผู้ทำการวิจัยเพื่อจะได้อธิบายความหมายของคำศัพท์ดังกล่าวให้ท่าน

List A	List B
1. Brilliance = ความฉลาด หรือทักษะที่ยอดเยี่ยม	**1.** Brilliance = ความฉลาด หรือทักษะที่ยอดเยี่ยม
2. Allergic = มีอาการแพ้	**2.** Allergic = มีอาการแพ้
3. Intensity = ความรุนแรง	**3.** Mole = ไฝ
4. Gecko = ตุ๊กแก	**4.** Crawl = คลาน
5. Raise = เลี้ยงดู	**5.** Gecko = ตุ๊กแก
6. Roofer = ช่างทำหลังคา	**6.** Raise = เลี้ยงดู
7. Duckling = ลูกเป็ด	**7.** Roofer = ช่างทำหลังคา
8. Rooster = ไก่ตัวผู้	**8.** Beak = จะงอยปาก
9. Billboard = ป้ายบิลบอร์ด	**9.** Duckling = ลูกเป็ด
10. Bruise = ทำให้เกิดแผลฟกช้ำ	**10.** Rooster = ไก่ตัวผู้
11. Curiosity = ความอยากรู้อยากเห็น	**11.** Billboard = ป้ายบิลบอร์ด
12. Valley = หุบเขา	**12.** Bruise = ทำให้เกิดแผลฟกช้ำ
13. Seize = ตะครุบ, จับ	**13.** Leap = กระโดด
14. Brightness = ความฉลาด	**14.** Belly = พุง, ท้อง
15. Poet = นักกวี, ผู้ประพันธ์บทกวี	**15.** Ease = ความง่ายดาย
16. Miss = พลาด, ไปไม่ทัน	**16.** Stain = รอยเปื้อน
17. Oyster = หอยนางรม	**17.** Enthusiasm = ความกระตือรือร้น
18. Skater = นักสเก็ตบอร์ด	**18.** Curiosity = ความอยากรู้อยากเห็น
19. Muddy = เปื้อนโคลน	**19.** Price tag = ป้ายราคา
20. Scratch = ข่วน	**20.** Hammer = ค้อน
21. Claw = กรงเล็บ	**21.** Courage = ความกล้าหาญ
22. Crack = ทำให้แตก	**22.** Pus = น้ำหนอง
23. Prey = เหยื่อ	**23.** Growl = คำราม
24. Scar = แผลเป็น	**24.** Valley = หุบเขา
25. Coin = สร้างคำใหม่	**25.** Seize = ตะครุบ, จับ
26. Backyard = สนามหลังบ้าน	**26.** Brightness = ความฉลาด
27. Twist = ทำให้บาดเจ็บ	**27.** Poet = นักกวี, ผู้ประพันธ์บทกวี
28. Buzz = เสียงหึ่ง ๆ	**28.** Miss = พลาด, ไปไม่ทัน
29. Stroller = รถเข็นเด็ก	**29.** Oyster = หอยนางรม
30. Cockfight = การชนไก่	**30.** Skater = นักสเก็ตบอร์ด

31. Scare = ทำให้กลัว	**31.** Muddy = เปื้อนโคลน
32. Cigarette lighter = ไฟแช็ก	**32.** Crack = ทำให้แตก
33. Boost = ปรับปรุง	**33.** Coin = สร้างคำใหม่
34. Sprain = ทำให้เจ็บปวด	**34.** Backyard = สนามหลังบ้าน
35. Dull = ที่อ	**35.** Twist = ทำให้บาดเจ็บ
36. Elbow = ข้อศอก	**36.** Cockfight = การชนไก่
	37. Scare = ทำให้กลัว
	38. Boost = ปรับปรุง
	39. Sprain = ทำให้เจ็บปวด
	40. Elbow = ข้อศอก

Appendix E

The Item-objective Congruence (IOC) scores of the verb classes in the classification of English irregular verbs according to phonological differences between their past participle and past tense forms

Verb class no.	Expert 1	Expert 2	Expert 3	Average
1	1	1	1	1.00
2	1	1	1	1.00
3	1	1	1	1.00
4	1	1	1	1.00
5	1	1	1	1.00
6	1	1	1	1.00
7	1	1	1	1.00
Average				1.00

Appendix F

The two lists of sentences for Norming Survey 1

Set A

Directions: Read each sentence and rate the plausibility of the situation (how likely the situation can occur) by putting a tick (✓) in a box.

Sentences	Plausibility				
	1 Not very plausible	2 Not plausible	3 Plausible	4 Very plausible	5 Very much plausible
1) The tourist who was taken to that hotel planned a tour.					
2) The turtle eaten near the river killed a fish.					
3) The builder who was blown off the ladder sprained his elbow.					
4) The boxer shaken from the battle needed a drug.					
5) The housewife who was given to the surgeon cooked the curry.					
6) The tiger seen in the grassland knocked its prey.					
7) The lawyer who was known for her justice blamed a gangster.					
8) The kitten given to my sister scratched my sofa.					
9) The oyster which was eaten in the party boosted my health.					
10) The pilot blown off the mountain treated his backache.					
11) The model who was drawn on the billboard earned an award.					
12) The baker shaken from the thunder closed the door.					
13) The panther which was seen in the valley seized a fox.					
14) The parrot given to the farmer chased a worm.					
15) The plumber who was blown off a drawer started the fight.					
16) The gecko eaten in the backyard scared my girlfriend.					
17) The doctor who was known for his kindness saved my life.					
18) The postman taken to the drugstore called his mother.					
19) The rabbit which was given to his daughter played a ball.					
20) The idol drawn on the notebook banned an airline.					
21) The spider which was eaten on the cupboard harmed a chef.					
22) The writer seen near the river raised a dog.					
23) The cashier who was shaken from the robber feared the thief.					
24) The actress known for her beauty					

bored her husband.					
25) The climber who was blown off the mountain gained a wound.					
26) The victim eaten in the jungle caused a terror.					
27) The dentist who was taken to the museum missed his flight.					
28) The patient shaken from the needle pushed the nurse.					
29) The wrestler who was drawn on the teacup signed a contract.					
30) The lizard given to her husband hunted a rat.					
31) The squirrel which was given to the painter climbed a tree.					
32) The teacher blown off the ferry needed some help.					
33) The artist who was known for his talent painted the wall.					
34) The athlete drawn on the worksheet hired a trainer.					
35) The painter who was seen in the theater rented a house.					
36) The salesman taken to the prison cheated her boss.					
37) The monkey which was eaten in the forest passed a virus.					
38) The hamster given to the diver chewed an apple.					
39) The roofer who was blown off the rooftop cracked his head.					
40) The duckling eaten in the village caused a disease.					
41) The beggar who was shaken from the coldness wanted a jacket.					
42) The soldier known for his courage joined a war.					
43) The rooster which was given to my grandpa joined a cockfight.					
44) The burglar seen in the garage burned a store.					
45) The sailor who was eaten in the ocean shocked his brother.					
46) The workman blown off the scooter bruised his arm.					
47) The poet who was drawn on the textbook coined a term.					
48) The pigeon eaten in the farmland spoiled the farm.					
49) The waitress who was seen in the kitchen fried an egg.					
50) The singer taken to the stadium formed a band.					
51) The woman who was shaken from a cockroach crushed the creature.					
52) The baby given to that couple loved the toy.					
53) The witness who was shaken from the killer watched the murder.					
54) The gangster known for his					

madness fired his gun.					
55) The hero who was drawn on the laptop helped a kid.					
56) The climber eaten in the valley scared his grandma.					
57) The student who was known for her brilliance kissed her boyfriend.					
58) The diver seen in the island tested his snorkel.					
59) The actor who was taken to the airport liked a movie.					
60) The driver shaken from the earthquake parked his car.					
61) The robber who was given to the police robbed a barber.					
62) The sportsman drawn on the paper coached his nephew.					
63) The insect which was eaten in the meadow caused a nuisance.					
64) The pupil known for his brightness passed a test.					
65) The puppy which was given to the florist ruined her crop.					
66) The dancer taken to this clinic dated a tailor.					
67) The hunter who was eaten in the forest haunted his cousin.					
68) The skater blown off a skateboard twisted his ankle.					
69) The merchant who was seen in the office owned a mansion.					
70) The servant given to the princess cleaned her palace.					

Set B

Directions: Read each sentence and rate the plausibility of the situation (how likely the situation can occur) by putting a tick (✓) in a box.

Sentences	Plausibility				
	1 Not very plausible	2 Not plausible	3 Plausible	4 Very plausible	5 Very much plausible
1) The tourist taken to that hotel planned a tour.					
2) The turtle which was eaten near the river killed a fish.					
3) The builder blown off the ladder sprained his elbow.					
4) The boxer who was shaken from the battle needed a drug.					
5) The housewife given to the surgeon cooked the curry.					
6) The tiger which was seen in the grassland knocked its prey.					
7) The lawyer known for her justice blamed a gangster.					
8) The kitten which was given to my sister scratched my sofa.					

9) The oyster eaten in the party boosted my health.					
10) The pilot who was blown off the mountain treated his backache.					
11) The model drawn on the billboard earned an award.					
12) The baker who was shaken from the thunder closed the door.					
13) The panther seen in the valley seized a fox.					
14) The parrot which was given to the farmer chased a worm.					
15) The plumber blown off a drawer started the fight.					
16) The gecko which was eaten in the backyard scared my girlfriend.					
17) The doctor known for his kindness saved my life.					
18) The postman who was taken to the drugstore called his mother.					
19) The rabbit given to his daughter played a ball.					
20) The idol who was drawn on the notebook banned an airline.					
21) The spider eaten on the cupboard harmed a chef.					
22) The writer who was seen near the river raised a dog.					
23) The cashier shaken from the robber feared the thief.					
24) The actress who was known for her beauty bored her husband.					
25) The climber blown off the mountain gained a wound.					
26) The victim who was eaten in the jungle caused a terror.					
27) The dentist taken to the museum missed his flight.					
28) The patient who was shaken from the needle pushed the nurse.					
29) The wrestler drawn on the teacup signed a contract.					
30) The lizard which was given to her husband hunted a rat.					
31) The squirrel given to the painter climbed a tree.					
32) The teacher who was blown off the ferry needed some help.					
33) The artist known for his talent painted the wall.					
34) The athlete who was drawn on the worksheet hired a trainer.					
35) The painter seen in the theater rented a house.					
36) The salesman who was taken to the prison cheated her boss.					
37) The monkey eaten in the forest passed a virus.					
38) The hamster which was given to the diver chewed an apple.					
39) The roofer blown off the rooftop cracked his head.					

40) The duckling which was eaten in the village caused a disease.					
41) The beggar shaken from the coldness wanted a jacket.					
42) The soldier who was known for his courage joined a war.					
43) The rooster given to my grandpa joined a cockfight.					
44) The burglar who was seen in the garage burned a store.					
45) The sailor eaten in the ocean shocked his brother.					
46) The workman who was blown off the scooter bruised his arm.					
47) The poet drawn on the textbook coined a term.					
48) The pigeon which was eaten in the farmland spoiled the farm.					
49) The waitress seen in the kitchen fried an egg.					
50) The singer who was taken to the stadium formed a band.					
51) The woman shaken from a cockroach crushed the creature.					
52) The baby who was given to that couple loved the toy.					
53) The witness shaken from the killer watched the murder.					
54) The gangster who was known for his madness fired his gun.					
55) The hero drawn on the laptop helped a kid.					
56) The climber who was eaten in the valley scared his grandma.					
57) The student known for her brilliance kissed her boyfriend.					
58) The diver who was seen in the island tested his snorkel.					
59) The actor taken to the airport liked a movie.					
60) The driver who was shaken from the earthquake parked his car.					
61) The robber given to the police robbed a barber.					
62) The sportsman who was drawn on the paper coached his nephew.					
63) The insect eaten in the meadow caused a nuisance.					
64) The pupil who was known for his brightness passed a test.					
65) The puppy given to the florist ruined her crop.					
66) The dancer who was taken to this clinic dated a tailor.					
67) The hunter eaten in the forest haunted his cousin.					
68) The skater who was blown off a skateboard twisted his ankle.					
69) The merchant seen in the office owned a mansion.					
70) The servant who was given to the princess cleaned her palace.					

Appendix G

The plausibility scores of the experimental items in Norming Survey 1

	Set A						Set B					
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
Given												
**1. The baby given to that couple loved the toy.	3	2	5	3	5	3	5	2	2	4	4	5
	PRRC (3.5)						RC (4.25)					
**2. The kitten given to my sister scratched my sofa.	5	4	5	5	5	5	5	4	4	2	3	5
	PRRC (4.83)						RC (3.83)					
**3. The squirrel given to the painter climbed a tree.	3	1	3	4	3	5	4	3	5	4	5	2
	RC (3.16)						PRRC (3.83)					
**4. The rooster given to my grandpa joined a cockfight.	1	3	3	3	1	5	4	3	5	3	4	2
	RC (2.66)						PRRC (3.5)					
5. The rabbit given to his daughter played a ball.	1	4	1	1	1	1	3	1	1	2	1	1
	RC (1.5)						PRRC (1.5)					
6. The puppy given to the florist ruined her crop.	2	3	1	3	2	5	3	3	5	2	3	1
	RC (2.67)						PRRC (2.83)					
7. The robber given to the police robbed a barber.	1	1	2	3	1	5	4	4	5	2	3	1
	RC (2.17)						PRRC (3.17)					
8. The parrot given to the farmer chased a worm.	4	4	5	2	4	1	2	1	4	1	1	5
	PRRC (3.33)						RC (2.33)					
9. The housewife given to the surgeon cooked the curry.	1	1	1	2	1	5	1	1	1	1	2	1
	RC (1.83)						PRRC (1.17)					
10. The lizard given to her husband hunted a rat.	4	3	3	3	4	1	3	2	3	2	1	5
	PRRC (3)						RC (2.67)					
11. The hamster given to	4	3	5	3	3	1	3	2	1	3	2	5

the diver chewed an apple.												
	PRRC (3.17)						RC (2.67)					
12. The servant given to the princess cleaned her palace.	3	2	5	3	3	4	2	3	4	1	2	5
	PRRC (3.33)						RC (2.83)					
Taken												
**13. The postman taken to the drugstore called his mother.	4	3	5	3	4	2	3	3	3	1	3	5
	PRRC (3.5)						RC (3)					
**14. The salesman taken to the prison cheated her boss.	5	4	5	4	4	3	3	3	4	3	3	5
	PRRC (4.16)						RC (3.5)					
**15. The tourist taken to that hotel planned a tour.	1	5	5	3	5	5	5	2	5	4	4	2
	RC (4)						PRRC (3.66)					
**16. The dancer taken to this clinic dated a tailor.	5	3	5	3	5	2	3	2	5	3	3	5
	PRRC (3.83)						RC (3.5)					
17. The dentist taken to the museum missed his flight.	3	2	3	1	2	5	3	3	5	2	5	3
	RC (2.67)						PRRC (3.5)					
18. The singer taken to the stadium formed a band.	5	3	1	2	4	2	3	2	4	3	2	5
	PRRC (2.83)						RC (3.17)					
19. The actor taken to the airport liked a movie.	3	2	3	1	4	5	5	3	5	3	4	1
	RC (3)						PRRC (3.5)					
Eaten												
**20. The oyster eaten in the party boosted my health.	3	2	2	3	2	5	4	2	5	2	4	3
	RC (2.83)						PRRC (3.33)					
**21. The duckling eaten in the village caused a disease.	4	2	5	4	4	2	3	2	2	3	3	5
	PRRC (3.5)						RC (3)					
**22. The monkey eaten in the forest passed a virus.	2	2	2	3	4	5	5	4	1	5	4	1
	RC (3)						PRRC (3.33)					
**23. The gecko eaten in the backyard scared my	4	4	3	1	4	3	2	4	5	3	1	5

girlfriend.												
	PRRC (3.17)						RC (3.33)					
24. The climber eaten in the valley scared his grandma.	1	1	1	1	2	1	1	2	1	1	1	5
	PRRC (1.17)						RC (1.83)					
25. The spider eaten on the cupboard harmed a chef.	1	1	1	3	1	5	2	1	2	1	3	1
	RC (2)						PRRC (1.67)					
26. The sailor eaten in the ocean shocked his brother.	1	1	1	2	1	5	3	1	1	1	4	1
	RC (1.83)						PRRC (1.83)					
27. The hunter eaten in the forest haunted his cousin.	2	1	2	1	1	5	1	4	1	1	5	3
	RC (2)						PRRC (2.5)					
28. The turtle eaten near the river killed a fish.	3	3	5	2	3	1	2	1	1	1	2	5
	PRRC (2.83)						RC (2)					
29. The victim eaten in the jungle caused a terror.	3	1	2	2	3	2	2	1	1	1	1	5
	PRRC (2.17)						RC (1.83)					
30. The insect eaten in the meadow caused a nuisance.	1	3	1	1	2	5	4	2	1	2	3	1
	RC (2.17)						PRRC (2.17)					
31. The pigeon eaten in the farmland spoiled the farm.	2	1	2	1	4	1	1	1	1	1	1	5
	PRRC (1.83)						RC (1.67)					
Shaken												
**32. The baker shaken from the thunder closed the door.	4	4	5	2	5	2	4	2	2	3	4	5
	PRRC (3.66)						RC (3.33)					
**33. The driver shaken from the earthquake parked his car.	5	3	5	4	2	2	4	3	3	3	3	5
	PRRC (3.5)						RC (3.5)					
**34. The beggar shaken from the coldness wanted a jacket.	2	5	1	3	3	5	4	2	5	3	4	4
	RC (3.16)						PRRC (3.66)					
**35. The boxer shaken from the battle needed a drug.	2	2	4	4	5	3	3	4	2	3	3	5

	PRRC (3.33)						RC (3.33)					
36. The witness shaken from the killer watched the murder.	1	2	1	4	2	5	3	2	4	2	2	2
	RC (2.5)						PRRC (2.5)					
37. The patient shaken from the needle pushed the nurse.	3	1	5	2	4	2	3	3	1	4	3	5
	PRRC (2.83)						RC (3.17)					
38. The woman shaken from a cockroach crushed the creature.	3	4	1	3	1	5	1	3	1	4	3	3
	RC (2.83)						PRRC (2.5)					
39. The cashier shaken from the robber feared the thief.	3	5	1	1	1	5	2	2	4	3	4	4
	RC (2.67)						PRRC (3.17)					
Known												
**40. The student known for her brilliance kissed her boyfriend.	4	4	5	4	4	5	5	4	5	5	5	3
	RC (4.33)						PRRC (4.5)					
**41. The artist known for his talent painted the wall.	4	5	3	4	4	5	5	4	5	5	5	5
	RC (4.16)						PRRC (4.83)					
**42. The pupil known for his brightness passed a test.	5	5	5	5	5	5	5	5	2	5	5	5
	PRRC (5)						RC (4.5)					
**43. The doctor known for his kindness saved my life.	5	5	4	4	3	5	5	4	5	5	4	4
	RC (4.33)						PRRC (4.5)					
44. The gangster known for his madness fired his gun.	5	5	5	2	5	4	4	3	3	5	3	5
	PRRC (4.33)						RC (3.83)					
45. The soldier known for his courage joined a war.	5	3	5	5	5	4	2	5	5	3	4	5
	PRRC (4.5)						RC (4)					
46. The lawyer known for her justice blamed a gangster.	1	4	4	3	3	5	5	3	5	4	2	2
	RC (3.33)						PRRC (3.5)					
47. The actress known for her beauty bored her husband.	5	3	5	4	3	3	4	4	4	3	3	5

	PRRC (3.83)						RC (3.83)					
Seen												
**48. The waitress seen in the kitchen fried an egg.	2	2	5	3	5	5	5	3	5	5	5	2
	RC (3.66)						PRRC (4.16)					
**49. The merchant seen in the office owned a mansion.	4	3	5	4	3	5	5	4	5	5	5	3
	RC (4)						PRRC (4.5)					
**50. The writer seen near the river raised a dog.	5	3	5	4	4	2	3	2	5	4	3	5
	PRRC (3.83)						RC (3.66)					
**51. The panther seen in the valley seized a fox.	5	3	5	3	1	5	1	4	5	4	4	3
	RC (3.66)						PRRC (3.5)					
52. The painter seen in the theater rented a house.	3	1	3	3	3	5	5	5	3	2	5	1
	RC (3)						PRRC (3.5)					
53. The tiger seen in the grassland knocked its prey.	5	2	5	2	4	2	5	3	1	4	1	5
	PRRC (3.33)						RC (3.17)					
54. The diver seen in the island tested his snorkel.	5	2	5	1	2	3	3	2	4	5	2	4
	PRRC (3)						RC (3.33)					
55. The burglar seen in the garage burned a store.	4	3	5	3	3	1	3	4	5	2	1	5
	PRRC (3.17)						RC (3.33)					
Blown												
**56. The roofer blown off the rooftop cracked his head.	5	4	5	5	5	3	3	5	4	3	4	4
	RC (4.5)						PRRC (3.83)					
**57. The workman blown off the scooter bruised his arm.	3	5	3	3	4	5	5	2	5	2	5	3
	PRRC (3.83)						RC (3.66)					
**58. The skater blown off a skateboard twisted his ankle.	2	4	4	3	4	4	5	4	5	2	5	3
	PRRC (3.5)						RC (4)					
**59. The builder blown off the ladder sprained his	5	4	5	5	5	3	4	4	4	3	5	4

elbow.												
	RC (4.5)						PRRC (4)					
60. The teacher blown off the ferry needed some help.	2	3	5	2	3	3	4	2	3	4	1	4
	PRRC (3)						RC (3)					
61. The climber blown off the mountain gained a wound.	2	2	3	5	3	4	4	3	2	3	3	5
	RC (3.17)						PRRC (3.33)					
62. The plumber blown off a drawer started the fight.	1	3	2	1	2	2	2	1	2	2	2	3
	RC (1.83)						PRRC (2)					
63. The pilot blown off the mountain treated his backache.	1	3	3	2	1	2	3	1	1	1	1	3
	PRRC (2)						RC (1.67)					
Drawn												
**64. The model drawn on the billboard earned an award.	1	3	1	4	3	5	4	2	5	2	4	3
	RC (2.83)						PRRC (3.33)					
**65. The sportsman drawn on the paper coached his nephew.	4	2	5	4	3	1	2	3	2	3	3	5
	PRRC (3.16)						RC (3)					
**66. The hero drawn on the laptop helped a kid.	3	1	2	3	2	5	4	2	5	4	4	2
	RC (2.66)						PRRC (3.5)					
**67. The poet drawn on the textbook coined a term.	3	3	3	3	1	5	5	2	5	3	2	4
	RC (3)						PRRC (3.5)					
68. The idol drawn on the notebook banned an airline.	2	1	1	1	1	1	1	1	1	1	1	5
	PRRC (1.17)						RC (1.67)					
69. The wrestler drawn on the teacup signed a contract.	1	1	1	5	1	5	3	3	5	1	4	1
	RC (2.33)						PRRC (2.83)					
70. The athlete drawn on the worksheet hired a trainer.	4	3	5	4	2	1	3	1	1	1	2	5
	PRRC (3.17)						RC (2.17)					

**** The selected experimental items**

Appendix H

The list of sentences for Norming Survey 2 and their plausibility scores

Sentences	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Average
1) **The workmen in the car were going to a theater.	5	3	4	5	5	4	3	2	5	5	4	5	4.17
2) **Before the sportsman kissed, his girlfriend drank coffee.	3	2	3	2	4	4	2	3	2	3	3	5	3
3) The builder used the notebook with a blue stain.	3	4	3	4	4	3	4	2	2	4	3	5	3.42
4) **The salesman from the company was kind to his customers.	5	5	5	5	4	4	5	5	5	5	4	5	4.73
5) **The artist visited the art studio with enthusiasm.	5	3	4	3	4	4	4	3	5	4	4	5	4
6) The squirrels of the diver were sleeping on a branch.	2	3	3	1	2	2	2	5	3	3	4	5	2.92
7) **Before the skater showered, his wife left.	4	3	5	4	3	4	4	3	4	5	3	5	3.92
8) **The doctor from the city was kind to me.	5	5	5	5	5	5	5	5	5	5	5	5	5
9) **After the boxer attacked, his girlfriend hit him.	2	5	4	2	2	4	3	4	3	2	2	5	3.17
10) **The robber killed a postman with a scar.	4	3	5	4	2	5	4	3	3	3	4	5	3.75
11) **The roosters of my grandpa were joining the cockfight.	4	2	4	3	3	3	4	2	1	2	2	5	2.92
12) When the tourist slept, the tickets were available.	2	1	2	2	4	2	3	4	2	2	3	2	2.42
13) **The oysters on the dish were good for our health.	4	1	5	4	2	3	1	3	1	3	3	5	2.92
14) The doctor touched the wound with much blood.	5	3	2	3	4	3	3	3	4	1	3	5	3.25
15) Just as the baker wrote, the bakery closed.	1	4	2	4	3	1	2	3	4	2	2	5	2.75

16)	The roofer on the street was thinking about a colleague.	4	3	4	5	4	5	5	4	3	5	3	5	4.17
17)	**As the model read, the journalist photographed her.	4	2	3	4	3	4	3	4	4	5	4	5	3.75
18)	**The skater destroyed the cellphone with a hammer.	3	3	4	5	4	2	5	3	1	4	2	4	3.33
19)	**As the baby crawled, the toy became dirty.	2	1	2	3	3	2	3	2	3	4	2	5	2.67
20)	**The gecko in the backyard was scaring my girlfriend.	5	5	5	5	5	5	5	5	3	4	5	5	4.75
21)	The merchant cleaned the scissors with vinegar.	3	5	4	4	2	1	4	3	2	5	4	5	3.5
22)	**After the hunter laughed, the monkey died.	2	4	1	3	1	5	3	5	2	4	3	5	3.17
23)	**The driver pushed the car with force.	1	2	3	2	4	3	2	4	3	4	2	5	2.92
24)	The sportsmen at the coffee shop were meeting their friends.	4	5	4	5	4	5	4	4	5	5	4	5	4.5
25)	**The writer admired the actor with long hair.	3	4	5	4	5	3	5	4	4	5	2	5	4.08
26)	The builders in the garden were wheeling a cart.	4	3	5	4	5	4	5	5	4	5	4	5	4.42
27)	**After the waitress fried, the egg started to burn.	5	2	5	4	2	1	2	4	1	4	3	5	3.17
28)	**The panthers in the zoo were eating some meat.	4	5	5	5	5	5	4	5	4	5	4	5	4.67
29)	**The beggar watched the dog with curiosity.	3	4	4	3	5	3	5	2	4	1	4	5	3.58
30)	The squirrel of the diver was sleeping on a branch.	3	1	3	2	2	4	3	4	4	3	2	5	3
31)	**After the teacher sighed, the pupil finished her homework.	3	2	4	3	2	4	3	2	3	2	2	5	2.92
32)	**The skater in the stadium was coaching my nephew.	5	5	5	4	5	3	5	5	4	4	5	5	4.58

33)	The waiter grabbed the gecko with fun.	2	1	2	3	1	2	3	3	1	2	3	2	2.08
34)	After the waitress ran, the egg started to burn.	4	3	1	3	4	3	4	3	2	3	2	5	3.08
35)	**The merchant in the room was signing a contract.	5	5	5	5	5	5	5	5	4	4	5	5	4.83
36)	**As the dancer left, the show started.	5	3	4	2	4	3	5	4	3	4	4	5	3.83
37)	**The salesman joined the meeting with confidence.	3	5	5	5	3	4	2	4	3	4	5	5	4
38)	**The postmen with a big bag were calling a man.	4	5	5	4	4	5	5	4	3	4	4	5	4.33
39)	Before the chef hiccupped, the oysters were raw.	2	4	2	3	2	1	4	2	3	1	2	4	2.5
40)	**The drivers in the garage were afraid of thunder.	5	3	5	4	5	3	4	4	5	1	3	5	3.92
41)	**The model joined a fashion show with 300 participants.	3	5	5	5	5	5	4	5	5	1	4	5	4.33
42)	**Before the duckling ate, the vet monitored it.	2	3	3	2	2	3	1	2	3	2	3	5	2.58
43)	**The builder used the notebook with much care.	5	5	2	4	5	3	4	4	3	4	4	5	4
44)	**The workman in the car was going to a theater.	5	5	4	5	5	5	3	2	5	4	4	5	4.33
45)	**The baker answered the customer with an expensive pen.	3	4	3	3	2	3	4	2	2	3	2	5	3
46)	**After the artist drew, the comic sold well.	5	2	4	4	3	1	2	1	2	1	1	5	2.58
47)	**The student disappointed the teacher with short hair.	2	4	5	4	3	4	4	5	2	4	3	5	3.75
48)	**The babies in the strollers were dependent on their parents.	5	5	4	5	5	5	5	5	5	4	5	5	4.83
49)	After the writer screamed, the child cried.	3	1	2	1	3	4	3	4	3	3	4	5	3
50)	The boxer passed the driving test with a lot of	4	3	2	3	4	4	2	3	3	3	4	5	3.33

	pages.													
51)	**After the robber pushed, the merchant fell down.	4	4	3	5	4	4	4	5	4	4	2	5	4
52)	**The hunter in the forest was shooting the monkeys.	5	5	5	4	5	5	5	5	5	4	5	5	4.83
53)	**The trainer trained the sportsman with a dumbbell.	3	1	2	3	4	3	4	3	4	2	2	5	3
54)	**Before the poet wrote, his textbook earned an award.	2	3	3	2	3	1	3	4	3	2	3	5	2.83
55)	**The tourists from China were crazy about a movie.	4	5	5	4	5	5	5	5	5	5	5	5	4.83
56)	Before the squirrel slept, the cage door was open.	2	4	2	1	3	2	4	3	3	4	4	5	3.08
57)	**The pupil passed the exam with 40 questions.	5	3	5	4	3	5	3	5	3	3	3	5	3.92
58)	Whenever the beggar cried, his daughter woke up.	1	4	2	3	2	2	3	2	4	2	4	5	2.83
59)	The builder in the garden was wheeling a cart.	5	4	5	4	4	3	5	4	3	5	5	5	4.33
60)	**When the panther approached, its prey ran away.	5	4	5	5	5	5	4	5	5	4	5	5	4.75
61)	**The kitten scratched a fish with its claws.	3	3	4	3	3	4	4	4	3	4	2	5	3.5
62)	**Before the duckling walked, the vet monitored it.	5	3	5	3	5	3	4	3	2	3	3	5	3.67
63)	**The oyster on the dish was good for our health.	5	2	5	4	4	4	2	3	1	3	2	5	3.33
64)	**The dancer admired the police with a knife.	4	5	4	3	5	4	3	5	4	3	2	5	3.92
65)	**The student in the class was taking a test.	4	5	5	5	5	5	4	5	5	4	5	5	4.75
66)	**After the rooster leaped, my grandpa got a wound.	1	2	4	3	1	3	3	2	3	2	3	5	2.67
67)	The driver	2	1	4	3	2	3	3	2	4	1	3	5	2.75

	pushed the car with attempts.													
68)	**When the roofer coughed, my brother went out.	5	5	5	4	5	4	4	5	4	5	5	5	4.67
69)	The workmen in the car were living in the building.	3	3	3	4	5	4	3	5	4	2	4	5	3.75
70)	Just as the model screamed, the journalist photographed her.	3	2	4	2	2	4	1	3	2	3	2	5	2.75
71)	**The baby looked at the toy with curiosity.	5	5	5	5	5	5	1	5	5	3	5	5	4.5
72)	**When the tourist booked, the tickets were available.	5	4	5	5	5	3	4	5	3	1	3	5	4
73)	**The poet in the village was famous for her writings.	4	4	5	3	5	5	4	4	3	5	4	5	4.25
74)	**Just as the baker arrived, the bakery closed.	5	2	5	2	4	4	4	5	5	3	1	5	3.75
75)	**The salesman joined the meeting with 120 attendees.	2	5	5	4	5	3	4	5	4	4	5	5	4.25
76)	**The artist from the studio was painting the wall.	5	3	5	4	5	4	4	5	5	3	4	5	4.33
77)	Before the postman worked, the receiver was busy.	3	4	3	1	3	5	2	3	4	2	1	4	2.92
78)	**The waitress in the kitchen was using her cellphone.	5	5	5	5	5	4	5	5	5	5	5	5	4.92
79)	**After the teacher helped, the pupil finished her homework.	5	5	4	5	5	4	4	4	5	4	4	5	4.5
80)	**The merchant cleaned the scissors with water.	4	5	5	4	4	3	4	4	3	4	5	5	4.17
81)	**Before the hero helped, the kid almost died.	5	5	5	3	5	4	4	3	4	3	1	5	3.92
82)	The sportsman at the coffee shop was meeting his friends.	4	5	5	3	5	5	5	4	5	4	3	5	4.42
83)	**Whenever the beggar sang, his daughter woke up.	4	2	4	5	3	4	5	4	3	4	3	5	3.83

84)	My boyfriend raised the rooster with colorful hair.	2	2	4	1	3	3	2	4	3	2	3	5	2.83
85)	The hunters in the forest were curing the monkeys.	3	4	5	4	4	3	1	3	4	5	4	5	3.75
86)	**After the kitten scratched, its owner was sad.	1	3	2	4	4	1	4	2	4	3	3	5	3
87)	The dancer admired the police with attempts.	5	4	4	2	3	3	2	5	4	2	2	5	3.42
88)	When the turtle ate, the workman grabbed it.	2	2	4	1	3	4	2	4	1	3	2	5	2.75
89)	**The skaters in the stadium were coaching my nephew.	4	5	3	4	5	5	5	5	4	3	3	5	4.25
90)	After the boxer jumped, his girlfriend hit him.	2	4	2	3	4	3	2	4	2	2	1	5	2.83
91)	**The doctor touched the wound with pus.	4	2	2	3	3	5	4	5	3	1	4	5	3.42
92)	**The builders in the room were carrying bricks.	5	4	5	4	5	5	4	5	4	4	5	5	4.58
93)	The panther killed the deer with big eyes.	4	3	1	4	3	5	2	2	4	1	2	5	3
94)	**The duckling in the village was spreading a disease.	4	4	5	3	5	4	5	4	4	3	5	5	4.25
95)	**The driver pushed the car with huge wheels.	4	5	5	2	4	2	3	2	4	1	3	5	3.33
96)	**Before the tutor arrived, the students talked.	4	3	5	5	3	4	3	4	4	3	3	5	3.83
97)	**The tourist from China was crazy about a movie.	5	4	5	4	4	4	3	5	5	4	5	5	4.42
98)	The model joined a fashion show with boredom.	2	4	3	3	1	3	2	4	3	4	4	5	3.17
99)	**Before the chef smiled, the oysters were raw.	1	3	5	3	1	4	2	3	4	3	2	5	3
100)	**The geckos in the backyard were scaring my girlfriend.	5	5	5	5	5	5	5	5	5	4	3	5	4.75
101)	After the artist appeared, the comic sold well.	1	3	2	1	2	1	2	2	1	2	2	2	1.75

102) The baby looked at the toy with a nice design.	2	4	2	3	3	4	2	4	2	4	3	5	3.17
103) **The dancer from the ballet school was receiving an award.	5	5	5	5	5	5	5	5	5	4	5	5	4.92
104) **The hero helped the boy with blonde hair.	5	3	5	5	4	4	3	4	3	4	4	5	4.08
105) The postman with many parcels was riding a bike.	5	4	5	4	5	5	4	5	4	4	5	5	4.58
106) Before the salesman approached, his colleague was upset.	1	2	4	3	3	2	1	2	2	1	2	4	2.25
107) **The insect annoyed the poet with a buzz.	4	4	5	2	4	3	2	3	4	3	2	5	3.42
108) After the teacher laughed, the pupil finished her homework.	3	2	2	3	3	2	4	3	2	3	3	4	2.83
109) **The panther in the zoo was eating some meat.	5	5	4	5	5	4	4	5	4	5	4	5	4.58
110) The baker answered the customer with reluctance.	5	3	4	2	3	2	1	3	4	4	4	5	3.33
111) **As the dancer slept, the show started.	4	2	3	5	2	2	3	4	3	4	2	5	3.25
112) **The beggar on the street was allergic to seafood.	5	5	5	3	5	2	4	3	5	3	3	5	4
113) **Before the builder exercised, his feet were muddy.	4	3	5	4	4	3	5	4	3	4	4	5	4
114) The workman attacked the thief with a lot of money.	4	4	3	3	2	3	4	4	3	3	2	5	3.33
115) After the robber came, the merchant fell down.	1	1	1	1	2	1	1	2	1	2	1	5	1.58
116) **The kitten scratched a fish with black spots.	4	5	5	5	4	3	4	5	4	4	3	5	4.25
117) **The hunters in the forest were shooting the monkeys.	5	5	5	5	4	5	5	5	5	5	5	5	4.92
118) **The roofer	4	4	4	4	3	5	4	3	3	5	4	5	4

tasted the noodles with pepper.													
119) **Before the sportsman dived, his girlfriend drank coffee.	5	3	5	2	4	2	4	3	5	3	5	5	3.83
120) **The skater destroyed the cellphone with a blue mobile case.	1	3	2	1	2	2	3	4	2	4	3	5	2.67
121) The salesman from the company was advertising a car.	3	4	5	5	5	4	5	4	5	5	4	5	4.5
122) After the hunter walked, the monkey died.	1	3	2	1	3	2	3	1	3	2	2	4	2.25
123) The robber killed a postman with hatred.	3	2	3	4	4	2	3	2	3	3	2	5	3
124) **After the boxer laughed, his girlfriend hit him.	3	4	4	5	3	4	4	3	2	2	3	5	3.5
125) **The waiter grabbed the gecko with fear.	5	4	4	3	2	1	4	3	4	3	4	5	3.5
126) Before the patient screamed, the doctor missed his flight.	2	3	4	3	4	3	2	3	3	1	1	5	2.83
127) The artist visited the art studio with boredom.	4	5	4	3	3	4	2	4	3	3	4	5	3.67
128) **The heroes in the clip were helping a kid.	5	4	5	4	4	5	4	4	5	3	3	5	4.25
129) Before the builder crawled, his feet were muddy.	2	4	2	3	2	4	2	3	4	2	3	5	3
130) **The chef cleaned the oysters with brown shells.	2	1	2	1	3	4	4	3	4	4	3	5	3
131) After the rooster ran, my grandpa got a wound.	3	1	3	2	2	4	1	3	2	3	1	4	2.42
132) **The pupils in the class were doing their homework.	5	5	5	5	5	5	5	5	5	4	5	5	4.92
133) **The waitress burned the paper with a cigarette lighter.	5	5	5	3	5	5	5	3	5	4	4	5	4.5
134) **The baby in the stroller was dependent on her parents.	5	5	5	5	5	4	5	5	5	5	5	5	4.92
135) Before the squirrel ate, the	1	3	2	3	3	3	1	2	1	3	3	5	2.5

cage door was open.													
136) The chef cleaned the oysters with pearls.	1	1	2	1	3	1	3	2	3	2	1	3	1.92
137) **When the roofer sang, my brother went out.	4	3	3	4	3	4	4	3	3	4	2	5	3.5
138) **The models from Paris were joining a fashion show.	5	4	5	4	5	5	5	4	4	5	5	5	4.67
139) Before the duckling bit, the vet monitored it.	3	1	2	2	2	3	1	2	3	1	3	4	2.25
140) **The baker of the restaurant was sensitive to comments.	5	4	5	3	3	3	4	2	4	2	3	5	3.58
141) **The student disappointed the teacher with a test score.	5	4	5	5	3	3	3	5	4	4	4	5	4.17
142) **The poets in the village were famous for their writings.	5	4	5	4	5	3	3	4	5	4	4	5	4.25
143) **The beggar watched the dog with black spots.	5	5	5	4	4	2	3	4	5	3	3	5	4
144) **After the writer wrote, the child cried.	1	3	3	2	4	2	4	5	3	4	2	5	3.17
145) **The kitten of my sister was scratching my sofa.	5	5	5	4	5	4	3	5	2	4	3	5	4.17
146) **The tourist visited the temple with many visitors.	3	4	4	4	5	3	4	5	4	3	5	5	4.08
147) **After the rooster attacked, my grandpa got a wound.	5	3	5	2	4	2	2	4	1	4	3	5	3.33
148) The salesmen from the company were advertising a car.	4	5	4	5	5	3	5	4	5	4	3	5	4.33
149) Before the driver arrived, the kids were noisy.	2	3	4	2	4	3	4	3	1	3	2	5	3
150) **The duckling stared at the cat with fear.	1	4	3	3	1	4	3	4	3	2	4	5	3.08
151) **After the hunter shot, the monkey died.	5	4	4	2	5	2	4	2	3	3	4	5	3.58
152) **The waiter grabbed the gecko with brown spots.	3	2	4	5	2	4	3	5	4	4	4	5	3.75

153) **Just as the baker cooked, the bakery closed.	3	3	4	3	3	2	2	3	2	3	4	5	3.08
154) **The beggars on the street were allergic to seafood.	3	3	4	3	4	3	4	3	3	4	3	5	3.5
155) **The boxer passed the driving test with 10 questions.	3	2	4	4	2	3	4	5	4	2	3	5	3.42
156) **Before the patient explained, the doctor missed his flight.	4	2	2	3	4	4	3	4	2	3	4	5	3.33
157) **The waitresses in the kitchen were using their cellphones.	5	5	5	5	5	5	5	4	5	3	4	5	4.67
158) The student disappointed the teacher with a beautiful car.	3	2	1	2	3	4	3	4	3	3	4	5	3.08
159) **After the artist died, the comic sold well.	2	1	1	2	3	2	3	4	3	2	3	5	2.58
160) The pupil passed the exam with determination.	5	3	3	4	1	3	4	2	3	3	2	5	3.17
161) The roofers on the street were thinking about a colleague.	5	4	3	4	5	5	4	3	4	4	4	5	4.17
162) **The merchant cleaned the scissors with dull blades.	4	5	4	5	5	4	4	5	3	5	4	5	4.42
163) **After the writer slept, the child cried.	4	2	3	5	4	3	3	2	2	4	2	5	3.25
164) **The panther killed the deer with its sharp claws.	5	5	2	4	3	4	3	4	4	3	5	5	3.92
165) Before the poet cooked, his textbook earned an award.	1	3	2	2	4	1	2	1	2	3	4	5	2.5
166) **The workman attacked the thief with intensity.	4	3	3	4	5	2	2	3	2	5	4	5	3.5
167) **As the model posed, the journalist photographed her.	5	5	5	5	5	5	4	5	5	3	5	5	4.75
168) **The sportsman at the airport was having curry.	5	5	5	5	4	5	5	5	5	4	5	5	4.83
169) **The baby looked at the toy with a price tag.	3	5	3	5	4	3	4	4	3	3	2	5	3.67
170) **The rooster of	5	2	5	3	3	2	3	2	1	3	1	5	2.92

my grandpa was joining the cockfight.													
171) **The florist loved the squirrel with black spots.	5	4	5	5	2	5	4	3	4	3	4	5	4.08
172) **After the kitten died, its owner was sad.	3	5	4	4	5	5	5	3	4	5	4	5	4.33
173) **The salesmen from the company were kind to their customers.	4	5	4	5	3	4	5	4	5	5	4	5	4.42
174) **When the tourist worked, the tickets were available.	3	4	3	3	2	3	3	2	4	3	4	4	3.17
175) **The robber killed a postman with anger.	3	5	2	1	4	3	2	4	5	3	1	5	3.17
176) **The ducklings in the village were spreading a disease.	5	5	5	5	5	4	3	3	4	3	3	5	4.17
177) As the dancer cancelled, the show started.	3	2	3	3	2	2	4	1	3	2	3	4	2.67
178) **The chef cleaned the oysters with cold water.	5	5	5	5	5	5	4	5	5	3	4	5	4.67
179) As the gecko ate, the snake bit it.	2	2	4	2	3	3	1	2	1	3	3	5	2.58
180) **The bakers of the restaurant were sensitive to comments.	5	5	5	2	5	3	4	3	2	4	4	5	3.91
181) **The hunter hunted the monkey with black hair.	3	5	1	4	1	5	4	2	4	3	2	5	3.25
182) The boxer in the office was looking for a trainer.	5	5	5	3	5	4	5	4	5	5	5	5	4.67
183) The beggar watched the dog with a telescope.	1	1	1	2	1	1	3	1	3	3	2	3	1.83
184) **The driver in the garage was afraid of thunder.	4	3	4	5	5	3	4	3	4	2	3	5	3.75
185) **Before the tutor taught, the students talked.	5	3	5	5	5	2	3	5	3	5	4	5	4.17
186) **The artist visited the art studio with a huge gate.	5	3	5	4	4	4	3	4	3	3	3	5	3.83
187) **The doctors from the city were kind to me.	5	5	5	5	5	5	5	5	5	5	5	5	5

188)	**The waitress burned the paper with a black stain.	3	3	5	3	2	4	3	4	2	3	4	5	3.42
189)	**Before the skater appeared, his wife left.	4	5	4	4	4	2	3	4	4	4	4	5	3.92
190)	The roofer tasted the noodles with pork sausages.	3	2	4	4	3	4	3	3	2	4	4	5	3.42
191)	**The writer in the apartment was writing a textbook.	5	5	5	2	5	3	4	4	4	4	4	5	4.17
192)	**When the turtle bit, the workman grabbed it.	4	4	3	2	3	2	2	4	3	2	3	4	3
193)	**The builder used the notebook with a red cover.	4	4	5	4	5	5	4	5	2	4	5	5	4.33
194)	**Before the hero came, the kid almost died.	4	5	5	4	5	4	4	3	5	4	4	5	4.33
195)	**The sportsmen at the airport were having curry.	5	5	5	5	4	5	5	5	5	5	5	5	4.92
196)	The insect annoyed the poet with a big house.	1	3	2	2	1	3	2	3	3	1	3	5	2.42
197)	The model from Paris was posing for a photographer.	4	5	4	5	4	5	4	3	5	4	4	5	4.33
198)	The kitten scratched a fish with its paws.	3	4	3	3	2	3	3	2	3	2	2	5	2.92
199)	**Before the squirrel ran, the cage door was open.	3	5	1	3	5	4	2	4	2	3	1	5	3.17
200)	The postmen with many parcels were riding a bike.	5	4	3	5	3	5	4	3	4	5	4	5	4.17
201)	**Before the chef cooked, the oysters were raw.	5	3	5	3	4	4	4	5	2	4	5	5	4.08
202)	The hunter hunted the monkey with a small nose.	1	3	1	2	3	1	2	2	1	3	3	3	2.08
203)	**The writers in the apartment were writing a textbook.	4	3	4	3	5	5	4	5	3	4	4	5	4.08
204)	**The doctor touched the wound with care.	5	5	4	5	5	4	4	5	4	4	4	5	4.5
205)	The skaters in the playground were	3	3	5	3	5	3	3	4	5	3	4	5	3.83

blaming my nephew.													
206) **As the gecko crawled, the snake bit it.	4	3	3	3	2	3	3	4	4	2	3	5	3.25
207) **The artists from the studio were painting the wall.	5	5	5	4	5	5	4	5	4	5	5	5	4.75
208) **The duckling stared at the cat with white fur.	4	3	4	3	3	4	4	3	2	2	3	5	3.33
209) **As the baby played, the toy became dirty.	5	2	2	3	2	2	1	4	2	1	2	5	2.58
210) The boxers in the office were looking for a trainer.	4	3	4	5	4	5	5	5	4	5	4	5	4.42
211) **My boyfriend raised the rooster with a sharp beak.	4	1	3	2	4	4	3	5	3	1	4	5	3.25
212) **The pupil in the class was doing her homework.	4	5	3	4	5	5	4	5	5	4	5	5	4.5
213) **Whenever the beggar snored, his daughter woke up.	3	4	2	4	2	3	1	5	3	3	2	5	3.08
214) **The roofer tasted the noodles with a fork.	4	5	3	4	5	4	2	3	4	3	3	5	3.75
215) The models from Paris were posing for a photographer.	4	5	4	5	4	5	5	4	4	5	4	5	4.5
216) **When the turtle swam, the workman grabbed it.	4	5	4	5	5	4	4	3	4	3	3	5	4.08
217) **The boxer passed the driving test with ease.	5	5	5	4	5	4	5	3	5	4	3	5	4.42
218) **The merchants in the room were signing a contract.	5	5	5	5	4	5	5	5	3	3	5	5	4.58
219) **Before the salesman agreed, his colleague was upset.	5	2	5	3	4	4	4	3	5	1	3	5	3.67
220) The skater in the playground was blaming my nephew.	5	3	4	3	4	4	5	4	3	5	4	5	4.08
221) **The hunter hunted the monkey with a gun.	4	5	5	2	5	4	5	5	3	4	2	5	4.08

222)	**The dancers from the ballet school were receiving an award.	5	5	5	5	5	5	5	5	5	5	5	5	5
223)	**Before the driver approached, the kids were noisy.	3	4	3	4	3	4	2	4	1	4	3	5	3.33
224)	The panthers in the zoo were climbing a tree.	5	5	4	5	4	5	4	3	4	5	5	5	4.5
225)	**The dancer admired the police with deep respect.	5	3	5	4	5	4	4	2	4	3	3	5	3.92
226)	**The squirrel of the diver was chewing a nut.	3	5	2	4	3	4	4	3	2	4	3	5	3.5
227)	The duckling stared at the cat with curiosity.	2	3	2	2	2	4	3	1	1	2	3	4	2.42
228)	**After the waitress walked, the egg started to burn.	4	3	3	5	3	4	2	4	1	3	3	5	3.33
229)	**The insect annoyed the poet with a big belly.	1	3	2	4	3	2	1	4	2	3	2	5	2.67
230)	The merchants in the room were arguing with their friends.	4	5	4	3	5	4	5	4	5	5	5	5	4.5
231)	**Before the patient complained, the doctor missed his flight.	5	2	3	3	4	1	3	3	2	2	2	5	2.92
232)	**The model joined a fashion show with confidence.	4	2	4	4	3	5	4	5	5	3	5	5	4.08
233)	**The roofers on the roof were jealous of a colleague.	5	5	5	4	5	4	5	4	3	4	4	5	4.42
234)	**As the gecko climbed, the snake bit it.	2	4	3	2	4	3	1	4	2	2	3	5	2.92
235)	**The hero in the clip was helping a kid.	5	5	4	4	5	4	5	3	4	3	3	5	4.17
236)	**The tourist visited the temple with great joy.	5	3	5	5	5	4	3	5	5	3	4	5	4.33
237)	The workman in the car was living in the building.	2	5	4	3	4	5	3	2	3	4	2	5	3.5
238)	**Before the poet smiled, his textbook earned an award.	4	2	3	3	2	2	2	3	3	1	2	5	2.67
239)	**The pupil	4	3	5	3	4	4	3	5	3	4	4	5	3.92

passed the exam with ease.													
240) The panther in the zoo was climbing a tree.	4	3	4	4	4	5	5	4	3	4	5	5	4.17
241) **Before the postman called, the receiver was busy.	5	1	5	2	3	4	3	2	5	1	3	5	3.25
242) **The squirrels of the diver were chewing a nut.	2	5	2	4	3	4	3	3	2	2	3	5	3.12
243) **The baker answered the customer with high speed.	5	4	4	3	4	4	2	5	3	2	5	5	3.83
244) **Before the salesman drank, his colleague was upset.	3	1	3	4	2	4	2	3	3	2	3	5	2.92
245) **The boxer in the gym was hiring a trainer.	5	5	5	5	5	5	5	4	5	5	5	5	4.92
246) **Before the driver shouted, the kids were noisy.	2	4	2	4	3	5	3	3	4	4	2	5	3.42
247) The skater destroyed the cellphone with a crack.	3	3	2	1	3	1	2	2	3	1	2	5	2.33
248) **The kittens of my sister were scratching my sofa.	3	5	5	2	4	3	5	5	3	4	5	5	4.08
249) **The writer admired the actor with deep respect.	5	3	5	4	3	4	3	4	4	4	3	5	3.92
250) **The roofer on the roof was jealous of a colleague.	5	4	4	5	5	4	5	5	4	3	4	5	4.42
251) **My boyfriend raised the rooster with care.	4	3	4	4	4	5	4	5	3	4	4	5	4.08
252) **Before the builder washed, his feet were muddy.	3	1	3	4	5	3	5	4	2	1	4	5	3.33
253) **The hero helped the boy with courage.	5	5	4	5	4	3	4	3	5	5	4	5	4.33
254) The merchant in the room was arguing with his friends.	4	5	4	4	5	5	5	4	4	5	4	5	4.5
255) **The panther killed the deer with a short tail.	4	5	3	5	4	2	3	1	3	4	2	5	3.42
256) **The students in the class were taking a test.	5	5	5	5	5	5	5	5	5	4	4	5	4.83

257) **The workman attacked the thief with a mole.	5	3	3	1	4	3	4	5	4	3	4	5	3.67
258) The hunter in the forest was curing the monkeys.	4	4	3	4	4	4	1	2	3	4	5	5	3.58
259) **Before the squirrel escaped, the cage door was open.	3	4	4	3	4	4	3	1	3	2	2	5	3.17
260) **The model from Paris was joining a fashion show.	5	4	5	4	5	5	4	4	5	4	4	5	4.5
261) **The trainer trained the sportsman with strong muscles.	3	3	3	4	4	2	4	1	4	4	3	5	3.33
262) **Before the postman arrived, the receiver was busy.	4	2	4	4	2	3	4	3	3	3	4	5	3.42
263) **The builder in the room was carrying bricks.	5	4	4	4	5	5	4	5	3	4	4	5	4.33
264) Before the skater sat, his wife left.	2	4	2	2	4	1	3	2	1	2	3	2	2.33
265) The trainer trained the sportsman with a pair of eyeglasses.	2	1	1	3	1	2	3	3	1	4	3	5	2.42
266) **After the robber disappeared, the merchant fell down.	2	2	3	2	3	2	2	3	2	3	3	5	2.67
267) **The boxers in the gym were hiring a trainer.	5	5	4	5	5	5	4	5	5	5	3	5	4.67
268) **When the panther growled, its prey ran away.	4	4	2	3	5	2	4	2	5	4	4	5	3.67
269) **The florist loved the squirrel with all his heart.	5	2	4	5	5	3	4	4	5	4	5	5	4.25
270) **The postman with a big bag was calling a man.	5	5	5	5	5	4	4	5	5	4	4	5	4.67

**** The selected experimental items**

Appendix I

The application forms for participating in the present study

Participation in Supakit Thiamtawan's research

This experiment is part of the dissertation of Mr. Supakit Thiamtawan, a graduate student at the Doctor of Philosophy program in English as an International Language (Interdisciplinary program), Graduate School, Chulalongkorn University.

The researcher would like you to read English sentences and answer yes-no comprehension questions based on the sentences. It will take approximately 50 minutes to complete the reading task. There are 128 sentences with 5 practice sentences in the task. You will read the sentences on a computer screen.

The experiment will be conducted online at your convenience. You need either a Mac or Windows computer to join the experiment.

You will be paid 300 Baht for your participation in the study.

1. First Name-Last Name
2. Age
3. Gender
    - o Male
    - o Female
    - o Prefer not to say
4. Your nationality
5. Your profession
    - o an undergraduate student
    - o a graduate student
    - o a faculty member
6. Your education
    - o A high school diploma
    - o A bachelor's degree
    - o A master's degree
    - o A doctoral degree
7. The faculty where you are studying or working at
8. The operating system of your computer
    - o Mac
    - o Windows
9. Your contact information (e.g., mobile phone number, Line, Facebook, etc.)

แบบฟอร์มสมัครเข้าร่วมงานวิจัยของนายศุภกิตติ์ เทียมตะวัน

งานวิจัยนี้ เป็นส่วนหนึ่งของวิทยานิพนธ์ดุษฎีบัณฑิตของนายศุภกิตติ์ เทียมตะวัน นิสิตบัณฑิตวิทยาลัย สาขาภาษาอังกฤษเป็นภาษานานาชาติ จุฬาลงกรณ์มหาวิทยาลัย

การทดลองประกอบด้วยแบบทดสอบออนไลน์จำนวน 2 ชุด

แบบทดสอบชุดที่ 1 เป็นกิจกรรมทดสอบความจำ นิสิตต้องอ่านประโยคภาษาไทยจำนวน 75 ประโยค ตอบคำถามเกี่ยวกับประโยค และจดจำตัวอักษรไทยที่ปรากฏหลังประโยค

แบบทดสอบชุดที่ 2 เป็นแบบทดสอบการอ่านประโยคภาษาอังกฤษจำนวน 128 ประโยค นิสิตต้องอ่านประโยคภาษาอังกฤษ และตอบคำถามเกี่ยวกับประโยค

ผู้เข้าร่วมวิจัยจะเข้าร่วมการทดลองแบบออนไลน์ ผ่านคอมพิวเตอร์ระบบปฏิบัติการ Mac หรือ Windows ของผู้เข้าร่วมวิจัย

การทดลองทั้งหมดจะใช้เวลาทั้งสิ้นประมาณหนึ่งชั่วโมง

ผู้เข้าร่วมวิจัยจะได้รับค่าตอบแทน เป็นจำนวนเงิน 400 บาท

1) ชื่อ-นามสกุล

2) อายุ

3) เพศ

- o ชาย
- o หญิง
- o ไม่ต้องการระบุ

4) เป็นนิสิตจากคณะใด

5) เรียนวิชาภาษาอังกฤษมาเป็นเวลากี่ปี

6) เคยศึกษาในหลักสูตร English Program หรือในโรงเรียนนานาชาติหรือไม่

- o เคย
- o ไม่เคย

7) เคยไปศึกษาต่อหรือใช้ชีวิตในประเทศที่ใช้ภาษาอังกฤษเป็นภาษาหลักในการสื่อสารหรือไม่

- o เคย
- o ไม่เคย

8) จากข้อ 7 หากท่านตอบ "เคย" เป็นระยะเวลาเท่าใด

9) คะแนน CU-TEP ของนิสิต

10) ระบบปฏิบัติการของคอมพิวเตอร์ของนิสิต

- o Mac
- o Windows

11) ช่องทางติดต่อ (เบอร์โทรศัพท์, Line, Facebook, Email)

Appendix J

The reading span task scores of the L1 Thai participants

Participant number	Score	Participant number	Score
1	**70**	36	**60**
2	**72**	37	**51**
3	**62**	38	**72**
4	**41**	39	**29**
5	**50**	40	**47**
6	**56**	41	**69**
7	**72**	42	**66**
8	**58**	43	**49**
9	**55**	44	**57**
10	**68**	45	**64**
11	**64**	46	**72**
12	**73**	47	**70**
13	**60**	48	**45**
14	**53**	49	**68**
15	**73**	50	**45**
16	**56**	51	**73**
17	**59**	52	**72**
18	**63**	53	**63**
19	**67**	54	**62**
20	**39**	55	**45**
21	**74**	56	**60**
22	**35**	57	**60**
23	**52**	58	**49**
24	**70**	59	**66**
25	**67**	60	**60**
26	**43**	61	**67**
27	**70**	62	**39**
28	**69**	63	**56**
29	**37**	64	**59**
30	**32**	65	**53**
31	**74**	66	**67**
32	**75**	67	**68**
33	**54**	68	**47**
34	**55**	69	**58**
35	**68**	70	**46**

Appendix K

The results of the independent t-test with respect to the differences between the L1 Thai groups with different WM levels

Group statistics

Group	N	Mean	Std. Deviation	Std. Error Mean
Lower WM	37	50.0000	8.62490	1.41792
Higher WM	33	68.7879	3.70606	.64514

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
				t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence interval of the Difference	
		F	Sig.						Lower	Upper
Score										
-	Equal variances assumed	21.257	.000	-11.589	68	.000	-18.78788	1.62122	-22.02297	-15.55279
-	Equal variances not assumed			-12.061	50.036	.000	-18.78788	1.55779	-21.91674	-15.65902

Appendix L

The comprehension accuracy scores of the two L1 Thai groups with different WM levels

Scores of the higher WM participants	Scores of the lower WM participants
*24	*25
27	*20
30	29
29	30
31	*25
*15	*25
29	26
27	26
32	30
31	29
*23	27
28	26
*15	27
30	*25
30	29
28	32
26	*24
29	26
31	32
30	27
*24	29
29	27
31	*25
32	*22
28	30
*25	*25
26	26
*23	28
30	*25
30	*24
30	29
30	30
30	29
	26
	32
	30
	26

***The excluded participants whose comprehension accuracy score was lower than 80%**

Appendix M

The comprehension accuracy scores of the native controls

Participant number	Score
1	**32**
2	**30**
3	**30**
4	**26**
5	**26**
6	**28**
7	**26**
8	**31**
9	**32**
10	**29**

Appendix N

The statistical results from the Friedman Test

Participants	*df*	Effect size (Kendall's *W*)	χ^2
L1 TH High WM	3	0.225	15.733**
L1 TH Low WM	3	0.278	11.145*
L1 EN	3	0.980	7.839*

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix O

The statistical results from the Nemenyi Tests

Post-hoc test on L1 TH High WM (Nemenyi test)

p-adjusted (bonferroni)	Salience 2 PRRC	Salience 4 PRRC	Salience 2 RC
Salience 4 PRRC	1	-	-
Salience 2 RC	0.027*	0.027*	-
Salience 4 RC	0.435	0.435	0.570

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Post-hoc test on L1 TH Low WM (Nemenyi test)

p-adjusted (bonferroni)	Salience 2 PRRC	Salience 4 PRRC	Salience 2 RC
Salience 4 PRRC	0.852	-	-
Salience 2 RC	0.065	0.342	-
Salience 4 RC	0.096	0.435	0.999

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Post-hoc test on L1 EN (Nemenyi test)

p-adjusted (bonferroni)	Salience 2 PRRC	Salience 4 PRRC	Salience 2 RC
Salience 4 PRRC	0.036*	-	-
Salience 2 RC	< 0.001***	0.313	-
Salience 4 RC	< 0.001***	0.001**	0.173

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

VITA

NAME	Supakit Thiamtawan
DATE OF BIRTH	30 July 1987
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Faculty of Liberal Arts, Mahidol University (BA) Faculty of Arts, Chulalongkorn University (MA) Graduate School, Chulalongkorn University (Ph.D.)
HOME ADDRESS	159, Moo 9, Soi Sukhaphiban 2, Buddhamonthon Sai 4 Rd., Kratumban, Omnoi, Samutsakhon, 74130
PUBLICATION	1. Pongpairoj, N., & Thiamtawan, S. (2019). A Study of L2 English Inversion Structures by L1 Thai Learners. The International Journal of Communication and Linguistic Studies, 17(1), 11-22. 2. Thiamtawan, S., & Pongpairoj, N. (2013). Avoidance of the Use of English Participial Reduced Relative Clauses among L1 Thai Learners. LEARN Journal, 1(2), 12-34.