

Effects of Working Memory on Structural Competition in  
Processing English Present Tense Morphology by L1 Thai  
Learners

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Mr. Sonthaya Rattanasak

จุฬาลงกรณ์มหาวิทยาลัย  
CHULALONGKORN UNIVERSITY

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ผลของหน่วยความจำขณะทำงานต่อการแข่งขันทางโครงสร้างในการประมวลผลหน่วยคำกาล  
ปัจจุบันในภาษาอังกฤษ โดยผู้เรียนที่มีภาษาไทยเป็นภาษาที่หนึ่ง



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต  
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Thesis Advisor	Associate Professor NATTAMA PONGPAIROJ, Ph.D.

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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 YOOTHANA CHUPPUNNARAT,  
Ph.D.)

DISSERTATION COMMITTEE

..... Chairman  
(Assistant Professor Sudaporn Luksaneeyanawin, Ph.D.)

..... Thesis Advisor  
(Associate Professor NATTAMA PONGPAIROJ, Ph.D.)

..... Examiner  
(Associate Professor Wirote Aroonmanakun, Ph.D.)

..... Examiner  
(Assistant Professor THEERAPORN RATITAMKUL, Ph.D.)

..... External Examiner  
(Associate Professor Supakorn Phoocharoensil, Ph.D.)



จุฬาลงกรณ์มหาวิทยาลัย  
CHULALONGKORN UNIVERSITY

สนธยา รัตนศักดิ์ : ผลของหน่วยความจำขณะทำงานต่อการแข่งขันทางโครงสร้างในการประมวลผลหน่วยคำกาลปัจจุบันในภาษาอังกฤษโดยผู้เรียนที่มีภาษาไทยเป็นภาษาที่หนึ่ง. ( Effects of Working Memory on Structural Competition in Processing English Present Tense Morphology by L1 Thai Learners) อ.ที่ปรึกษาหลัก : รศ. ดร.ณัฐมา พงศ์ไพโรจน์

ในการรับภาษาที่สอง การประมวลผลไวยากรณ์หน่วยคำแสดงความคล้อยตามของผู้เรียนภาษาที่สองมักปรากฏความแตกต่างจากเจ้าของภาษา และปัญหาของการประมวลผลหน่วยคำในภาษาที่สองมีสาเหตุมาจากปัจจัยหลายด้าน งานวิจัยด้านการประมวลผลหน่วยคำแสดงความคล้อยตามที่ผ่านมายังไม่สามารถหาข้อสรุปได้ว่า ระบบภาษาที่หนึ่งและระบบภาษาที่สองได้รับการกระตุ้นร่วมกันในขณะที่ประมวลผลหน่วยคำแสดงความคล้อยตามหรือไม่ งานวิจัยนี้จึงมุ่งศึกษาตัวแปรความแตกต่างระหว่างบุคคลด้านความจำขณะทำงานและความซับซ้อนด้านระยะห่างระหว่างประธานกับกริยาในการประมวลผลไวยากรณ์หน่วยคำแสดงความคล้อยตามในภาษาที่สอง

งานวิจัยนี้ประกอบด้วยการทดลอง จำนวน 2 แบบ ผู้เรียนชาวไทยที่เรียนภาษาอังกฤษเป็นภาษาที่สอง จำนวน 80 คน และเจ้าของภาษา จำนวน 80 คน เข้าร่วมการทดลองการอ่านที่ละคำแบบกำหนดเวลาด้วยตนเอง (self-paced reading) โดยประโยคที่ใช้ในการทดลองมีสองเงื่อนไขที่แตกต่างกันในด้านระยะห่างการพึ่งพาของหน่วยคำแสดงความคล้อยตาม โดยใช้โครงสร้างคูปานประโยคภาษาอังกฤษแบบสลับความหมายได้ในการสร้างระยะห่าง เช่น *\*The guy [that \_ knows the driver/that the driver knows \_] want to buy a new car.* ซึ่งสอดคล้องกับทฤษฎีการพึ่งพาที่มีลักษณะภายใน (the dependency locality theory) (Gibson, 1998, 2000) การออกแบบประโยคทดลองเป็นแบบ 2 x 2 โดยมีตัวแปรอธิบาย ได้แก่ ระยะห่างและความถูกต้องทางไวยากรณ์ของหน่วยคำแสดงความคล้อยตามทางพจน์ระหว่างประธานและกริยาของอนุประโยคหลัก ประโยคทดลองในการทดลองที่หนึ่งใช้ประธานเอกพจน์ ในขณะที่ในการทดลองที่สองใช้ประธานพหูพจน์ โดยแต่ละการทดลองประกอบด้วยประโยคทดลอง จำนวน 20 ประโยค โดยมีประโยคทดลองที่มีเงื่อนไขแบบถูกไวยากรณ์ จำนวน 10 ประโยค ประโยคทดลองที่มีเงื่อนไขแบบคิดไวยากรณ์ จำนวน 10 ประโยค และประโยคหลวม จำนวน 40 ประโยค โดยใช้โปรแกรม E-Prime 3.0 ในการออกแบบการทดลองการอ่านที่ละคำแบบกำหนดเวลาด้วยตนเอง นอกจากนี้ ยังใช้แบบอ่านวัดช่วงความจำขณะทำงาน (reading span task) เพื่อวัดขนาดของความจำขณะทำงานของกลุ่มตัวอย่าง โดยสมิทธิภาพภาษาอังกฤษของผู้เรียนชาวไทยอยู่ในระดับกลางสูงซึ่งวัดจากแบบวัด LexTALE

ในการทดลองที่หนึ่ง ผลการวิเคราะห์โมเดลเชิงเส้นแบบผสมพบว่า เจ้าของภาษาและผู้เรียนชาวไทยมีความเร็วไวยากรณ์เมื่อประโยคประกอบด้วยการใช้หน่วยคำแสดงความคล้อยตามคิดไวยากรณ์ ทั้งในแบบระยะห่างการพึ่งพาของหน่วยคำแสดงความคล้อยตามแบบใกล้และแบบไกลผ่านระยะเวลาการอ่านที่ช้าลง อย่างไรก็ตาม ความสามารถในการแสดงความเร็วไวยากรณ์ได้รับอิทธิพลจากขนาดของความจำขณะทำงานและความซับซ้อนด้านระยะห่างระหว่างประธานและกริยา ในการทดลองที่สอง ผลการวิเคราะห์โมเดลเชิงเส้นแบบผสมพบว่า การประมวลผลของผู้เรียนชาวไทยแตกต่างจากการประมวลผลของเจ้าของภาษา ผู้เรียนชาวไทยใช้เวลาอ่านที่ช้าลงในประโยคแบบระยะห่างการพึ่งพาของหน่วยคำแสดงความคล้อยตามแบบใกล้เท่านั้นและมีความเร็วไวยากรณ์สัมพันธ์กับช่วงความจำขณะทำงานที่สูงขึ้น ในขณะที่เจ้าของภาษาสามารถแสดงความเร็วไวยากรณ์ทั้งในแบบระยะห่างการพึ่งพาของหน่วยคำแสดงความคล้อยตามแบบใกล้และแบบไกล

ผลการวิจัยเหล่านี้ชี้ให้เห็นว่า ความเร็วไวยากรณ์ที่แตกต่างจากเจ้าของภาษาในการประมวลผลไวยากรณ์หน่วยคำแสดงความคล้อยตามของผู้เรียนภาษาที่สองนั้นได้รับอิทธิพลจากความแตกต่างระหว่างบุคคลในแง่ของขนาดความจำขณะทำงาน และความซับซ้อนด้านระยะห่างระหว่างประธานและกริยา โดยเฉพาะการประมวลผลหน่วยคำแสดงความคล้อยตามที่ประกอบด้วยไวยากรณ์เฉพาะในภาษาที่สอง ได้แก่ หน่วยคำแสดงพหูพจน์และหน่วยคำแสดงความคล้อยตามในบุรุษที่สามเอกพจน์ในประโยคที่มีระยะห่างการพึ่งพาของหน่วยคำแบบไกล ข้อค้นพบในงานวิจัยนี้ชี้ให้เห็นว่า ภาษาที่หนึ่งและภาษาที่สองอาจได้รับการกระตุ้นร่วมกันแบบคู่ขนานและส่งผลการประมวลผลของผู้เรียนภาษาที่สอง โดยที่ความจำขณะทำงานอาจไม่เพียงพอต่อการประมวลผลหน่วยคำแสดงความคล้อยตาม ซึ่งเป็นผลมาจากการประมวลผลหน่วยคำที่อยู่ในประโยคที่มีระยะห่างการพึ่งพาของหน่วยคำแบบไกลและมีความซับซ้อนทางโครงสร้างภาษามากกว่า จึงส่งผลทำให้ความเร็วไวยากรณ์หน่วยคำแสดงความคล้อยตามที่คิดไวยากรณ์ในภาษาที่สองลดลง ทั้งนี้ปัญหาการประมวลผลหน่วยคำแสดงความคล้อยตามในผู้เรียนภาษาที่สองยังสอดคล้องกับสมมติฐานของการแข่งขันทางโครงสร้างระหว่างภาษาที่หนึ่งและภาษาที่สอง (the L1-L2 structural competition account) (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpiroj, 2013)

สาขาวิชา ภาษาอังกฤษเป็นภาษานานาชาติ  
ปีการศึกษา 2564

ลายมือชื่อนิติศ .....  
ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

# # 6087800820 : MAJOR ENGLISH AS AN INTERNATIONAL LANGUAGE

KEYWORD: agreement processing, crosslinguistic influence, distance, second language acquisition,  
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Sonthaya Rattanasak : Effects of Working Memory on Structural Competition in Processing English Present Tense Morphology by L1 Thai Learners. Advisor: Assoc. Prof. NATTAMA PONGPAIROJ, Ph.D.

In the course of second language (L2) acquisition, L2 grammatical processing is often found to be dissimilar to that of native speakers, and nonnative processing difficulties have been attributed to various sources. In the realms of agreement processing, whether both first language (L1) and L2 linguistic systems are co-activated simultaneously within a bilingual mind during grammatical processing remains an active question in language sciences. This study examined individual differences in terms of working memory capacity and distance-based complexity in L2 agreement processing.

In two word-by-word self-paced reading experiments, a total of 80 agreement-lacking Thai learners of L2 English and 80 native speakers of English read sentences involving English subject-verb agreement dependencies in two distance conditions. Distance was manipulated based on the dependency locality theory (Gibson, 1998, 2000), using semantically reversible English relative clauses (e.g., *\*The guy [that \_ knows the driver/that the driver knows \_] want to buy a new car*). Two explanatory variables were crossed in a 2 x 2 design: distance (short-distance subject-extracted relative clause (SRC) vs. long-distance object-extracted relative clause (ORC)) and grammaticality of the subject-verb agreement (grammatical vs. ungrammatical). Stimuli in Experiment 1 involved singular subjects while those in Experiment 2 contained plural subjects; each consisted of 20 sentences, half grammatical and half ungrammatical, along with 40 distractors. The self-paced reading experiments were designed using the E-Prime 3.0 software package. A complex reading span task was used as a measure of working memory capacity. LexTALE scores showed L2 English proficiency to be upper-intermediate.

In Experiment 1, linear mixed-effects modeling revealed that the native speakers and L2 learners were sensitive to agreement violation in both short-distance SRC ungrammatical and long-distance ORC ungrammatical conditions, shown by reading slowdowns. Their ability to show and maintain their sensitivity was, however, modulated as a function of working memory capacity and distance-based complexity. In Experiment 2, linear mixed-effects modeling showed that unlike the native speakers, who were able to show and maintain their sensitivity in both distance conditions, higher-span L2 learners showed longer reading times which were observed only in the short-distance SRC ungrammatical condition.

These findings indicated that nonnative sensitivity to L2 agreement violation tended to be modulated by individual differences in terms of working memory capacity and distance-based linguistic complexity, particularly in agreement processing that involved multiple unique-to-L2 features, i.e., plural and third-person singular morphology, in long-distance agreement dependencies. To account for L2 learners' agreement processing difficulties, the findings suggested that L2 learners may labor under parallel activation, whereby working memory capacity is insufficient to resolve long-distance agreement dependencies, where the linguistic environment was more complex, thus resulting in reduced sensitivity to L2 agreement violation. The research findings were congruent with the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongparoj, 2013).

Field of Study:	English as an International Language	Student's Signature .....
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## LIST OF ABBREVIATIONS

3S	third-person singular
CM	Competition Model
DLT	Dependency Locality Theory
ERC	English relative clause
G	grammatical
L1	first language
L2	second language
L2A	second language acquisition
LexTALE	Lexical Test for Advanced Learners of English
LMEs	Linear-mixed effects
ms	millisecond
MV	main verb, matrix verb
N	noun
NNS	nonnative speaker
NP	noun phrase
NS	native speaker
ORC	object-extracted relative clause
Q	question
RC	relative clause
RSPAN	reading span
RT	reading time
SD	standard deviation
SG	singular
SPR	self-paced reading
SRC	subject-extracted relative clause
UG	ungrammatical
V	verb
WM	working memory

# CHAPTER I

## INTRODUCTION

### 1.1 Background of the study

In the course of second language (L2) development, L2 learners are often assumed to hold two linguistic systems in their mind, presumably with their first language (L1) more firmly established (Austin et al., 2015; Jegerski, 2018; Kaan et al., 2015; Kroll et al., 2015; Sharwood Smith, 2019; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013). Thus, whether and to what extent the two linguistic systems are recruited to incrementally use morphosyntactic information during online L2 sentence processing remains an active question in the language sciences. Given that language processing in L2 is usually deemed more complex, compared to that in L1, examining the roles of both linguistic variables and variables concerning individual differences involved in sentence processing would offer better understanding of how L2 linguistic knowledge is used during real-time or online processing.

Particularly in the realm of L2 morphosyntactic processing inquiry, describing whether or not and to what extent L2 learners' or nonnative speakers' (NNSs) sensitivity to agreement violations during online comprehension differs from that of native speakers (NSs) has been in a long-standing debate in the field of L2 or bilingual<sup>1</sup> sentence processing (Bock & Cutting, 1992; Bock & Miller, 1991; Brehm et al., 2019; Cunnings, 2017; Foote, 2011; Keating, 2009, 2010; Lim & Christianson, 2015; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012; Shibuya & Wakabayashi, 2008; Siriwittayakorn & Miyamoto, 2019; Wagers et al.,

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<sup>1</sup> The term “bilingual” is used in this study in a broad sense of proficiency in another language other than L1 and is not meant to imply a particular level of L2 proficiency.

2009, among others). In recent years, a prolific body of research has been generated to examine the sources of difficulties and attempt to account for why establishing novel L2 linguistic representations and processing in L2 grammatical learning has been more effortful (Ellis, 2015). Empirical research findings to date have sufficiently provided convincing evidence that L2 morphosyntactic processing is influenced by both linguistic properties involved in the processing (Brehm et al., 2019; Keating, 2009, 2010; Shibuya & Wakabayashi, 2008; Siriwittayakorn & Miyamoto, 2019) and that the L2 learners' individual differences in terms of L2 proficiency and cognitive resources necessary for morphosyntactic computations play a crucial role (e.g., Coughlin & Tremblay, 2013; Hopp, 2010, 2017; Kaan et al., 2015; Keating, 2010; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012; Trenkic et al., 2014).

Some previous studies, however, demonstrated that L2 learners were insensitive to morphosyntactic violation in that morphological knowledge is not an integral part of L2 competence. On this theoretical ground, L2 linguistic knowledge in real-time processing may be less automatic and thus usually slower compared to the native language processing, even among highly proficient L2 learners (e.g., Jiang, 2004, 2007; Sato & Felser, 2010). Furthermore, Clahsen and Felser's (2006, 2018) Shallow Structure Hypothesis was proposed to explain differences between L1 and L2 sentence parsing. It posited that L2 grammatical processing was assumed to be less detailed, and thus non-native shallow parsing was guided mainly by lexical-semantic and pragmatic information rather than syntactic information, as compared to L1 processing. Therefore, unlike in native language processing, using syntactic information to parse sentences in L2 processing may not be fully operated. Based on this view, morphosyntactic computations in L2 would be restricted merely to local

domains, such as in closely adjacent agreement dependencies. Meanwhile, other studies have indicated that L2 learners are not necessarily insensitive to morphosyntactic violations (e.g. Coughlin et al., 2019; Hopp, 2010; Lim & Christianson, 2015; Sagarra & Herschensohn, 2012; Shibuya & Wakabayashi, 2008; Siriwittayakorn & Miyamoto, 2019), thus attributing variable sensitivity during L2 sentence processing to a range of sources, such as crosslinguistic influence (Chen et al., 2007; Hopp, 2010; Sagarra, 2021), long-distance agreement dependencies (e.g., Coughlin & Tremblay, 2013; Foote, 2011; Keating, 2009, 2010; Ocampo, 2013), limited cognitive resources, and L2 proficiency (Coughlin & Tremblay, 2013; Hopp, 2010; Kaan et al., 2015; Keating, 2010; McDonough & Trofimovich, 2016; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012).

Integral to research in second language acquisition (L2A) is the prominent role of L1. An increasing amount of recent research has been conducted to tackle the central question in L2A of whether bilinguals' two linguistic systems are activated selectively or in parallel during real-time processing in production (Austin et al., 2015; Trenkic & Pongpairoj, 2013) as well as in comprehension (Hopp, 2010, 2017; Jiang, 2004, 2007; Kaan et al., 2015; Rankin et al., 2019; Sagarra, 2021; Trenkic et al., 2014). One of the ramifications of crosslinguistic influence on L2 grammatical processing is that processing routines from the L1 may simultaneously interfere with those in the L2. It has been further suggested that, regardless of which language is being currently used, the learners' two linguistic systems may not be kept fully apart, especially in cognitively demanding language processes (Austin et al., 2015; Hopp, 2017; Jegerski, 2018; Kroll et al., 2015; Sharwood Smith, 2019; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013). Simply put, L1 and L2 grammars are believed to be

competing for selection as a result of parallel activation of the two relevant linguistic features of both languages (McManus, 2022). Although the prominent role of L1 has been well acknowledged in L2 sentence processing, its relationship with cognitive variables such as working memory (WM) capacity (Baddeley, 2010, 2012, 2015; Baddeley & Hitch, 1974; Wen & Jackson, 2022), which is assumed to come into play in complex linguistic computations, seems less clear.

Recent literature on L2A has exhibited evidence of language processing difficulties in relation to WM (e.g., Coughlin & Tremblay, 2013, for sensitivity to number agreement; Dussias & Piñar, 2010, for sentences with filler-gap dependency; Kim & Christianson, 2017, for relative clause attachment). In this study, WM refers to a combination of temporary storage of information and its manipulation, which is postulated to be active, to retain, process, and use the received information during ongoing mental processes in order to execute cognitive tasks, including L2 sentence processing (Baddeley, 2010, 2012, 2015; Baddeley & Hitch, 1974; Just & Carpenter, 1992; Wen & Jackson, 2022). Past evidence regarding L2 agreement processing showed mixed research results. Some studies showed an indication that WM capacity played an important role in NNSs' ability to show sensitivity to morphosyntactic violation (e.g., Coughlin & Tremblay, 2013; Keating, 2010; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010), while others did not (e.g., Foote, 2011).

As regards the influence from the linguistic variables in relation to WM capacity in agreement processing, *distance* between the agreement controllers and agreeing elements has been found to affect the ability to show sensitivity to agreement

violation both in NSs and NNSs (e.g., Foote, 2011; Keating, 2010). This type of non-adjacent agreement processing has usually been employed to investigate L2 agreement dependencies, and the notion of distance was often based on the number of words and prepositional phrases, as shown by previous literature on agreement processing (e.g., Jiang, 2004; Keating, 2010; Siriwittayakorn & Miyamoto, 2019). To reveal novel insights in the L2 agreement research arena, the notion of distance was manipulated based on the number of new discourse referents between the gap and filler within semantically reversible English relative clauses (ERCs). That is, the agreement dependencies were considered short-distance in the subject-extracted relative clause (SRC) and long-distance in the object-extracted relative clause (ORC) constructions. Keeping track of agreement processing while incrementally processing the two types of intervening materials for comprehension was assumed to differently influence WM load during online processing. The concept of distance-based complexity was consistent with the dependency locality theory (DLT), proposed by Gibson (1998, 2000).

Even though the acquisition problems with the English subject-verb number agreement have been reported in offline studies (Phoocharoensil et al., 2016; Pongpairoj, 2002; Thapthimhin & Pongpairoj, 2015; Timyam, 2018, among others), little online processing research on L2 agreement in L1 Thai learners of L2 English has been conducted (Siriwittayakorn & Miyamoto, 2019). Moreover, much of the previous research placed an emphasis on the learners' L2 English proficiency (see Hopp, 2017; Kahoul, 2014; Shibuya & Wakabayashi, 2008; Siriwittayakorn & Miyamoto, 2019; Yao & Chen, 2017). Specifically in the context of L1 Thai learners of L2 English, very few past studies were conducted to investigate L2 English

agreement processing in association with WM capacity (see Rungrojsuwan, 2007; 2015, for English morphological processing by L1 Thai learners in relation to memory systems and L2 English proficiency). In addition, none of the past empirical studies relevant to the processing of English present tense morphology in the Thai learners' context have been found to include the measurement of WM capacity to reflect individual differences in terms of cognitive capacity (see Siriwittayakorn & Miyamoto, 2019, for agreement attraction effects). With respect to the linguistic complexity based on distance, since most past studies (e.g., Keating, 2010) manipulated agreement dependency lengths by increasing the number of intervening phrases and words, it would be useful to reveal the effects of the underlying processes of distance while being able to control for uses of lexical items in the intervening materials to avoid unnecessary processing loads when comparing short-distance and long-distance dependencies.

To the best of my knowledge, little specific research has been conducted to reveal the interplay among WM capacity (Coughlin & Tremblay, 2013; Sagarra & Herschensohn, 2010, 2012), distance-based complexity (Foote, 2011; Gibson, 1998, 2000; Keating, 2010; Ocampo, 2013), and crosslinguistic influence (Hopp, 2010, 2017; Sagarra, 2021), as predicted by the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013) in the processing of L2 English present tense morphology, i.e., the English third-person singular (3S) morpheme *-s*.

The present investigation added to this line of research by examining the extent to which 1) WM capacity, and 2) linear distance between an agreement

controller and an agreement target verb influenced L2 agreement processing by upper-intermediate L1 Thai learners of L2 English, whose L1 lacks agreement morphology, as compared to the NSs of English, in two self-paced reading (SPR) experiments. This research predicted that agreement processing at the matrix verbs would, therefore, add additional WM load during processing. This may lead to a decline in sensitivity to agreement violations, which would be indicated by a lack of reading slowdown at an ungrammaticality. The results were discussed in light of the L1-L2 structural competition account, which posits that variable processing performance may arise when grammatical patterns licensed by the learners' L1 compete with those licensed by L2 for selection, particularly in cognitively more demanding linguistic contexts (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpaiboj, 2013).

## **1.2 Objectives of the study**

There were two research objectives in the present study:

- 1) To examine the extent to which working memory affects the processing of the English third-person singular inflectional agreement morphology by L1 Thai learners of L2 English, and
- 2) To probe whether the L1-L2 structural competition account can be accounted for in the processing of the English third-person singular inflectional agreement morphology by L1 Thai learners of L2 English.

## **1.3 Research questions**

This present research attempted to answer two research questions, which are as follows:



1) To what extent does working memory affect the processing of the English third-person singular inflectional agreement morphology by L1 Thai learners of L2 English?

2) Can the L1-L2 structural competition account be accounted for in the processing of the English third-person singular inflectional agreement morphology by L1 Thai learners of L2 English?

#### **1.4 Statements of hypotheses**

Two research hypotheses in correspondence to the research questions were formulated.

Hypothesis 1: Working memory will affect L1 Thai learners' processing of L2 English third-person singular inflectional agreement morphology based on the different degrees of distance-based complexity.

1.1. L1 Thai learners of L2 English with higher working memory capacity will be more likely to maintain sensitivity to the agreement morphology in both less distant subject-extracted relative clause conditions and more distant object-extracted relative clause conditions. They will show greater sensitivity to the morphological agreement violations, and thus longer reading times are expected when agreement violations are detected. Since the object-extracted relative clauses are syntactically more complex than the subject-extracted relative clauses, with higher cognitive resources available, the learners with higher working memory capacity will show greater grammatical sensitivity by taking longer to read the matrix verb regions with agreement violations.

1.2. L1 Thai learners of L2 English with lower working memory capacity will

be less likely to maintain sensitivity to the agreement violation in both less distant subject-extracted relative clause conditions and more distant object-extracted relative clause conditions. They will show less sensitivity to the agreement violations, and thus shorter reading times are expected when they read sentences with agreement violations. Since the object-extracted relative clauses are more complex than the subject-extracted relative clauses, with fewer cognitive resources available, the learners with lower working memory capacity will show less grammatical sensitivity by taking a shorter time to read the verbs with agreement violations.

1.3. Native English speakers will show sensitivity to the morphological agreement violations in their sentence processing through longer reading times when compared with the reading times taken to read sentences which are well-formed with morphological agreement. They will take longer to process the verbs in the object-extracted relative clause conditions than in the subject-extracted relative clause conditions. The processing patterns from the learners with higher working memory capacity will be more convergent with those of the native speakers, whereas those from the learners with low working memory capacity will be less convergent.

Hypothesis 2: The L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013) can be accounted for in the processing of the English third-person singular inflectional agreement morphology by L1 Thai learners of L2 English.

The L1-L2 structural competition account can be accounted for when the effects of working memory during the online processing are modulated by different degrees of distance-based complexity. L1 Thai learners of L2 English will find the

processing of the English third-person singular inflectional agreement morphology in sentences with object-extracted relative clause constructions more complex and difficult to process than the agreement processing in the subject-extracted relative clause constructions. The L1-appropriate bare form of the verb, which is considered better established in the learners' L1 system, will be resorted to more in the more distant object-extracted relative clause condition than in the less distant subject-extracted relative clause condition. On the contrary, the target L2 English agreement morphology will be employed more in the less distant subject-extracted relative clauses than in the more distant object-extracted relative clauses, where allocation of cognitive resources is more available.

### **1.5 Scope of the study**

This research focused on native and nonnative morphosyntactic processing during reading for comprehension. It aimed at exploring how L1 Thai learners of L2 English, as compared to the NSs, processed English subject-verb number agreement morphology. Both individual variables and linguistic variables were taken into consideration in the investigation. The scope of this study was therefore constrained by the psychological construct of an individual variable, i.e., WM capacity, which was assumed to influence the processing of the inflectional agreement morphology in syntactically complex sentence structures. The primary cognitive variable, WM capacity as measured by a reading span (RSPAN) task in the participants' L1, was examined to identify the extent to which it played a role in real-time processing of the non-adjacent L2 agreement dependencies. Therefore, WM capacity was regarded as a prospective crucial determinant contributing, as computational resources, to the crosslinguistic competition in L2 agreement processing in the present study. To

address this central concern of how L2 English inflectional agreement morphology was processed and acquired, the processing patterns of the English 3S morpheme in the matrix verb regions were investigated in two distance conditions, i.e., short-distance agreement dependencies and long-distance agreement dependencies, using semantically reversible ERCs. The findings were expected to reveal and provide understanding of how L1 Thai learners of L2 English processed agreement morphology in real-time in the target language, English, in comparison with the native language processing done by the NSs.

### **1.6 Definition of terms**

Operational definitions related to the present research are explained in this section for clarity and particularity of the terms used throughout this research.

#### **a. Working memory**

Working memory (WM) is a term in cognitive psychology referring to a mechanism in a human mind consisting of temporary storage of information and its processing, which is necessary for learning to take place. It is postulated to be active while various complex tasks, such as L2 sentence processing, are carried out. In the field of L2 processing and L2A inquiry, WM is generally understood to have multiple components with limited storage facility and limited duration, thus retaining information temporarily in the online language processing (Baddeley, 2010, 2012).

#### **b. Working memory capacity**

Working memory capacity can be broadly defined as the ability to successfully retain a certain amount of information in one's mind at one time while processing a cognitive task (Cowan, 2016). WM capacity is limited (Baddeley &

Hitch, 1974; Cowan, 1999). The present study follows Baddeley and Hitch's (1974) WM model and its subsequent revised model (Baddeley, 2000, 2012) as it allows for the traceability of its subsystems relative to L2 verbal information processing, i.e., the phonological loop and central executive, responsible for its verbal working memory storage and manipulations, respectively.

### **c. L1-L2 structural competition**

L1-L2 structural competition refers to an L2 processing phenomenon emerging in an attempt to comprehend or produce target language functional categories differently licensed by both the learners' L1 and L2 systems. Variable performance, in this regard, may be considered attributable to the two linguistic forms competing for selection in the attempt to produce or comprehend the target language in real-time processing, which probably relies on sufficient cognitive resources for computations in complex linguistic contexts (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpaibroj, 2013). The term crosslinguistic competition may be used interchangeably with L1-L2 structural competition to refer to this notion.

### **d. L2 Processing**

L2 processing refers to the mental processes, computations, or cognitive operations which are involved in both receptive and productive aspects of an L2 (Jiang, 2018). In this study, the focus is on L2 English subject-verb number agreement processing presented in syntactically complex sentence structures. Such L2 agreement processing is expected to take place at a point of time at which an L2 learner utilizes their computational and linguistic resources to interact with the linguistic variables demanded by the comprehension task.

### **e. English present tense morphology**

English present tense morphology refers to the English third-person singular inflectional morpheme *-s* at the matrix verb position of a sentence with a center-embedded subject-extracted relative clause and object-extracted relative clause in this study. The term English present tense morphology, third-person singular (3S) morpheme *-s*, and agreement morphology may be used interchangeably in this study (Larsen-Freeman & Celce-Murcia, 2015).

### **f. Distance**

The term *distance* is used to refer to the manipulations of non-adjacent or long-distance agreement dependencies of the experimental linguistic stimuli. Based on the dependency locality theory (Gibson, 1998, 2000), two types of distance, determined by the number of new discourse referents between the filler and gap in center-embedded English relative clause constructions, were employed to create linear distance between the agreement controllers and the agreeing matrix verbs. In the short-distance agreement dependencies, an English subject-extracted relative clause is adopted (e.g., \*The guy *that* \_ *knows the driver* want to buy a new car.), whereas in the long-distance agreement dependencies, an English object-extracted relative clause is used (e.g., \*The guy *that the driver knows* \_ want to buy a new car.).

### **g. Native speakers of English**

In this study, native speakers of English are the participants whose native language is American English, residing in the US during the time of data collection. They were from various study disciplines either at an undergraduate or graduate level at a US public university, University of Illinois at Urbana-Champaign.

#### **h. L1 Thai learners of L2 English**

In the present study, L1 Thai learners of L2 English are native Thai speakers residing in Thailand, studying at an undergraduate level, and learning English as an L2 primarily by means of formal classroom instruction with relatively limited exposure to L2 English outside classrooms. Their L2 English proficiency is at an upper-intermediate level as determined by the Lexical Test for Advanced Learners of English or LexTALE (Lemhöfer & Broersma, 2012). They had no extensive experience in an English-speaking country and were required to not be proficient in languages other than their L1 Thai and L2 English. When comparing with the native speakers of English (NSs), the term nonnative speakers (NNSs) may be used interchangeably to refer to this group of participants.

#### **i. Lexical Test for Advanced Learners of English (LexTALE)**

The Lexical Test for Advanced Learners of English, or LexTALE, is a measure of L2 English proficiency. The test is based on lexical decisions and has been widely adopted in psycholinguistic and L2A research due to its practical use and a high correlation with other placement tests, such as the Quick Placement Test (Lemhöfer & Broersma, 2012). According to Lemhöfer and Broersma (2012), LexTALE can be used to discriminate between lower-intermediate (or lower), upper-intermediate, and advanced learners of English, and provide an approximate estimate of L2 English proficiency. In this study, LexTALE was administered to both the native speakers of English and the L1 Thai learners of L2 English.

#### **j. Reading span task**

A reading span (RSPAN) task is a measure of the participants' cognitive

resources, or WM capacity. The task measures two main components of WM: the processing and the temporary storage. An automated version of the task, which was developed by Redick et al. (2012), Unsworth et al. (2005), and Unsworth et al. (2009), was employed in the present study. In each trial, the participants read a sentence on a computer screen and determined whether it was semantically plausible. The participants were then instructed to memorize a letter recall stimulus in lists of different lengths ranging from three to seven sentences. The RSPAN task was in the participants' L1, and it was administered to both the native speakers of English and the L1 Thai learners of L2 English.

#### **k. Self-paced reading task**

In this study, a non-cumulative word-by-word moving-window self-paced reading (SPR) task was used to investigate L2 agreement processing. Both the native speakers of English and L1 Thai learners of English silently read sentences which appeared on a computer screen, word by word and at their own pace. In this task, they were instructed to advance their reading by pressing the spacebar key. Each time a participant pressed the spacebar key, each word of the sentence appeared to the right of the screen one at a time. The appearing region replaced a set of dashes equivalent to the total number of masked characters and word boundaries. At the end of each trial, there was a statement verification subtask to probe the participants' comprehension.

### **1.7 Significance of the study**

In psycholinguistic inquiry relative to L2A, fundamental understanding of L2 learners' cognitive processes and the underlying mechanisms involved in the



processing of L2 sentences is a matter of focal concern. Hence, the contributions of the present research were mainly concerned with demonstrating how L2 learners used their L2 linguistic information to process the language in their mind. More specifically, it extended the knowledge of how allocation of cognitive resources contributed to L2 processing and acquisition of L2 inflectional agreement morphology.

Insightful L2 sentence processing phenomena relevant to native and nonnative speakers' ability to resolve long-distance agreement dependencies were revealed, given the present manipulations of the linguistic stimuli. Furthermore, the empirical measurement of cognitive resources, WM capacity, was first carried out in this study in order to shed more light on the crosslinguistic competition account. With the present findings, this study contributed to a growing body of knowledge and debates in L2 agreement processing and L2A by establishing a linkage between cognitive variables and linguistic variables, whose interactions played a pivotal role in the processing. The pertinent effects of these variables found in this study were expected to give indication as to how they acted as contributing factors in the processing, yielding better understanding of processing differences in native and nonnative agreement processing to reflect the underlying complexity of the nature of morphosyntactic computations during reading for comprehension. Such understanding of modulations in the efficiency of processing mechanisms is hoped to highlight the importance of the roles of WM capacity and the distance-based complexity in L2 sentence processing, specific to the processing and acquisition of L2 agreement morphology.

## 1.8 The organization of the dissertation

This dissertation is organized into five main chapters.

**Chapter I** gives introduction to and background of the present research. The objectives of the study, research questions, and statements of hypotheses are also proposed. The scope of the study, key operational definitions of terms, and significance of the study are also included in this chapter.

**Chapter II** sees relevant literature and previous research studies relevant to the present research. Two key theoretical concepts, namely WM and L1-L2 structural competition, are described. A contrastive analysis of the target verbal expressions and RC constructions in L1 Thai and L2 English is reported. Relevant literature on inflectional morphology processing and RC processing is also elaborated. Furthermore, previous research findings associated with WM capacity effects, the L1-L2 structural competition account, and the processing of agreement inflectional morphology, are presented and discussed.

**Chapter III** provides information about the research methodology decisions of the present study, including those on defining populations, selection of participants, research instruments, materials design and procedure, scoring and data analyses. The pilot study, as well as its applications, is reported in this chapter.

**Chapter IV** reports on the results and provides discussions of the present empirical findings. The reading time data are reported based on the research questions and hypotheses. This is followed by the discussions related to the theoretical framework which this research was based on as well as previous research findings.

**Chapter V** is devoted to conclusions, implications, recommendations for the learning and teaching of L2 agreement morphology, and limitations of the study and directions for future research.

**APPENDICES** incorporates all relevant information used in the present study. This section encompasses the experimental sentences in the RSPAN task and the SPR task. The results of the evaluation of the SPR task validity are presented. The participants' demographical data and their scores of WM capacity and L2 English proficiency are provided. The results of the plausibility norming are reported, and the documents related to research ethics in human subjects are also appended in this section.



## **CHAPTER II**

### **REVIEW OF LITERATURE**

This chapter deals mainly with relevant literature which was taken into account in order to establish the research framework and the design of the present experiments. It encompasses three major subsections, namely 2.1) related concepts and theories, 2.2) temporal-aspectual expressions of the Present in English and Thai, and 2.3) previous studies on L2 sentence processing.

#### **2.1 Related concepts and theories**

This section discusses concepts and theories associated with L2 sentence processing and L2A. 2.1.1 is devoted to the conceptualizations of language aptitude, the memory system, models of WM, and the relationship between WM and L2 processing. 2.1.2 concerns the distance-based complexity and the dependency locality theory, and 2.1.3 deals with the notion of emergentism, the constraint-satisfaction approach to L2 processing: the competition account, and L1-L2 structural competition and L2 processing.

##### **2.1.1 Language aptitude**

In cognitive psycholinguistics, various psychological constructs have been empirically examined in order to discover the underlying factors influencing how humans learn to perceive and produce language. Those psychological constructs have been much discussed in association with processing, and not just with production (Ellis, 2015). With reference to Ellis (2015) and Ortega (2009), the psychological factors can be classified into three types: 1) conative factors, 2) affective factors, and 3) cognitive factors. In L2A, the conative factors are mainly concerned with the learners' motivation and willingness to communicate. The

affective factors are variables affecting how positively or negatively an L2 learner responds to a particular learning situation, such as language anxiety and personality. The cognitive factors, which are the interest of the present investigation, deal specifically with information processing. This mainly includes the ability to process, store, and retrieve information. One psychological construct gaining considerable attention in L2A is language aptitude since it is mostly concerned with language learners' cognitive ability (Ortega, 2009). According to Ellis (2015), language aptitude refers to the special distinct abilities which facilitate L2 learning and is believed to influence the processing of an L2. Knowing how these factors play a role in L2A would yield a better understanding of how individual differences contribute to the successful mastery of an L2 (Ellis, 2015). In Skehan's (2002) model of language aptitude and L2A, aptitude is categorized into four sequential stages: 1) noticing input, 2) patterning, 3) controlling, and 4) lexicalizing. Noticing input is the ability which a learner uses to attend to a particular feature presented in the input. Patterning concerns the ability a learner uses to make a hypothesis about the feature, either explicitly or implicitly, recognize, restructure, and integrate it into his or her interlanguage development. Controlling can be observed when a learner is capable of using the stored feature with greater ease and accuracy. Finally, lexicalizing is the stage showing that a learner is able to access and produce the stored feature as a whole chunk, as opposed to applying a rule to that feature. In the model, several components of language aptitude were proposed to be active in each stage, such as attention and grammatical sensitivity (e.g., see Sato & Felser, 2010, for sensitivity to number agreement among L1 German, Japanese, and Chinese; Simoens et al., 2018, for perceptual salience on processing L2 inflectional morphology by L1 Dutch;

Trenkic & Pongpairoj, 2013, for referent salience and attention given by L1 Thai and French). The attribute of language aptitude components, especially in the first two stages of the model, is mainly concerned with WM (Skehan, 2002). WM is assumed to be active during L2 processing and plays a vital role in the success in comprehending L2 features presented by the input (e.g., see Coughlin & Tremblay, 2013, for sensitivity to number agreement among L1 English learners of L2 French; Kim & Christianson, 2017, for relative clause ambiguities among L1 Korean learners of L2 English).

#### **2.1.1.1 Memory system**

To understand how an L2 learner learns a new language, it is intriguing to investigate factors influencing language processing performed by L2 learners. One of the psychological constructs having been widely studied in relation to L2 processing in the past decades is working memory (WM), which is a term evolving from the unitary store, short-term memory (STM) (Baddeley & Hitch, 1974). WM has been regarded as a variable modulating the capacity L2 learners can have in processing complex structures of an L2. Numerous recent studies have attempted to provide an evidence-based explanation for a particular phenomenon that is expected to help explain how an L2 learner processes L2 sentences (e.g., Coughlin & Tremblay, 2013, for sensitivity to morphosyntactic violations in L2 French; Juffs, 2004, for garden-path effects in L2 English; Kim & Christianson, 2017, for relative clause attachment ambiguities in L2 English; Sagarra & Herschensohn, 2010, for gender and number agreement in L2 Spanish). Before the discussion of the WM models and their association with L2 processing and acquisition, it is worth taking

consideration into the basic conceptualization of the model of a human memory system.

Memory is assumed to play a crucial role in learning, including learning a new language. Atkinson and Shiffrin (1968) proposed that a human memory system has three separate components. It is known as a multi-store model. The model is also viewed as a structural model, which includes the sensory register, short-term memory (STM), and long-term memory (LTM).

Firstly, the sensory register is believed to be the first part of the system when input is perceived through human senses, such as visual or auditory inputs. It is important to note that only information that is attended to will be transferred to the STM while the information with non-attention will be subject to the process called “forgetting”. The duration of information held at this stage is very limited. Information received through the sensory register is sensitive to decay and can be lost very easily if it is not attended to (Atkinson & Shiffrin, 1968).

Secondly, the short-term store, also known as short-term memory, functions as a unitary store holding information from both the sensory register and LTM. The information in the STM can be held in the STM relatively longer through rehearsal (Atkinson & Shiffrin, 1968) but only for a certain amount of time. The amount of information exceeding the capacity that the STM can cater to will go through a process called “decay” and “forgetting,” respectively. In a similar vein, if the information goes over the limited amount of time the STM can serve, it will undergo the same processes (Atkinson & Shiffrin, 1968). Nonetheless, this is not the case if such information is repeated through the process called “rehearsal”. This means

rehearsal can facilitate any information entering a human memory system in an excessive amount or requiring an excessive amount of time. To illustrate this point, rote learning can be a good example. When a learner tries to produce their utterances in an L2 in a repeated manner, there is a tendency that the information will be remembered and transferred to their LTM.

Finally, the LTM stores information that has gone through a rehearsal loop and successfully been encoded and transferred to the LTM. That piece of information can be held for a longer period of time and is retrievable for future uses. This, however, might not be true at all times as some information may be irretrievable. In brief, each of the three stores can hold a different amount of information for a different amount of time. The information stored in these three structural features of the memory system can be subject to forgetting—loss of information from storage, unless attended to in the sensory register or rehearsed in the short-term memory (Atkinson & Shiffrin, 1968).

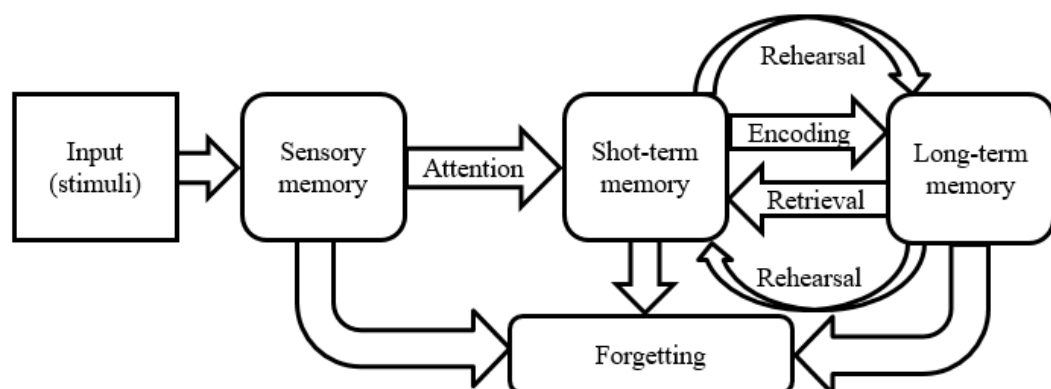


Figure 1: A multi-store model of a memory system  
(Atkinson & Shiffrin, 1968, pp. 89-195)



Despite numerous studies being generated as the result of Atkinson and Shiffrin's multi-store model of a memory system, it is not without criticism, especially with regard to the STM. The notion has been extended further and some psychologists have proposed a new term for it, i.e., *working memory*, as a challenge to the unitary STM viewed by those with a traditional view of a human memory system (Baddeley & Hitch, 1974; Cowan, 1999; Engle et al., 1999). Although there have been different proposals of WM models, which will be discussed in the following section, the integral notion that these subsequent models of WM share in common is that it involves dynamic processing of the received input rather than merely functioning as a passive unitary store to hold information temporarily, as suggested by the STM, posited by Atkinson and Shiffrin (1968).

#### **2.1.1.1.1 Models of working memory**

This section deals with different accounts of how the mechanisms of WM have been viewed. Several theoretical perspectives, differing in details, have been postulated to explain the elements constituting WM and how they function. More specifically, the three main models of WM are discussed, i.e., 1) Baddeley's multi-component model, 2) Cowan's embedded-process model, and 3) Engle's resource-dependent inhibition model.

Several cognitive psychologists define WM differently; however, the central notion of WM is that it is not simply unitary short-term storage of information but a combination of temporary storage of information and its manipulation while cognitive tasks, such as L2 processing, are carried out (Baddeley, 2012). Three widely discussed WM models that have been in the literature in L2A research include: 2.1.1.1.1 Baddeley's multi-component model (Baddeley & Hitch, 1974), 2.1.1.1.2 Cowan's

embedded-process model (Cowan, 1999), and 2.1.1.1.1.3 Engle's resource-dependent inhibition model (Engle et al., 1999). This section discusses each of the models in turn.

#### **2.1.1.1.1.1 Baddeley's multi-component model**

The multi-component model, which was the first elaborated model of WM, was proposed by Baddeley and Hitch (1974). Based on this view, WM is a system of limited capacity to deal with temporary storage of information as well as its manipulation. This notion has been posited to extend the concept of short-term memory proposed earlier in Atkinson and Shiffrin's (1968) multi-store model of human memory. The short-term store originally refers solely to a passive storage of information. However, Baddeley and Hitch (1974) suggested that the system functions beyond only holding information for a short period of time, elaborating more on how WM functions through three components. The original model of WM proposed by Baddeley and Hitch (1974) consisted of three major components: the central executive, the visuo-spatial sketchpad, and the phonological loop.

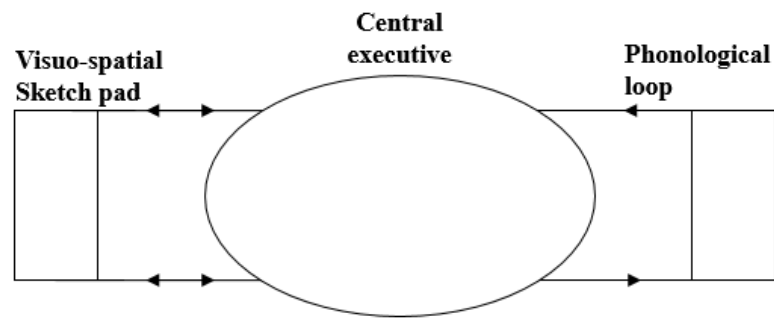


Figure 2: The original WM model

(Baddeley & Hitch, 1974)

The model was subsequently revised and the latest revision is comprised of four components, with the additional fourth component called the “episodic buffer” (Baddeley, 2000). The central executive is assumed to be operative of four processes, namely, 1) focusing, 2) dividing, 3) switching attention, and 4) linking WM and LTM. It is the central executive that functions to connect to the other three subcomponents, allocating mental resources necessitated by the currently competing cognitive demands. The phonological loop serves to store and rehearse verbal information for a limited duration while the visuo-spatial sketchpad allows visual and spatial information to be temporarily stored as a mental image and rehearsed. In language processing, it is the phonological loop that plays a vital role. The phonological loop is assumed to be composed of two subcomponents: 1) phonological storage and 2) a subvocal rehearsal system. According to Baddeley (1992), the phonological storage is responsible for holding sounds or speech-based information temporarily. The subvocal rehearsal system serves to maintain information within the phonological loop by means of subvocal repetition and it subsequently takes visual information, e.g., words in reading, and registers them in the phonological store by means of silent speech, also known as subvocalization. The fourth additional component, known as the episodic buffer, serves as a place to momentarily store and integrate various types

of information, i.e., verbal, visual, and spatial information. With the episodic buffer added to the model, the central executive now primarily functions as a control system without any storage capacity (Baddeley, 2003). According to Baddeley (2003), the episodic buffer has the capability of integrating information from various sources into chunks or episodes, as the term “episodic” suggests. It functions as a buffer in the sense that it provides “...a way of combining information from different modalities into a single multi-faceted code” (p. 203), resulting in integrated information that can be both speech-based and visual/spatial-based.

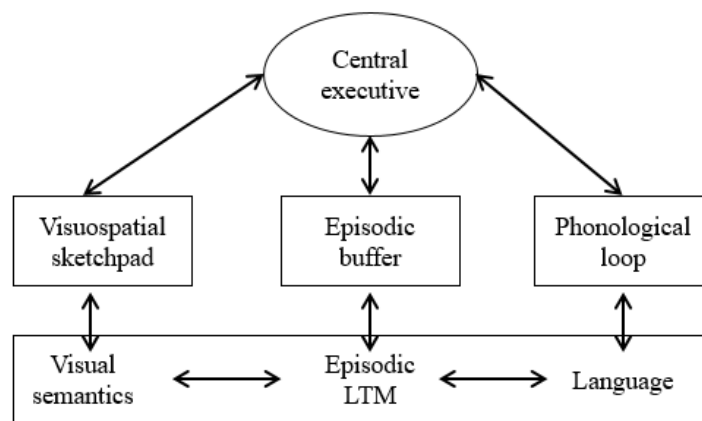


Figure 3: Baddeley's multi-component model  
(Baddeley, 2000, p. 421)

To illustrate this point, as Figure 3 shows above, the episodic buffer capacity serves as limited storage that temporarily holds information from the visuo-spatial sketchpad and phonological loop while allowing such pieces of information from the two subcomponents to be combined with other information from the LTM to form chunks of information. The episodic buffer is essential in that it serves to constitute the capacity for conscious awareness, which is greatly dependent on the central executive's processing of information (Baddeley, 2003). In relation to LTM, the

episodic buffer provides a link between WM and LTM, allowing information gained from the subcomponents of WM to be combined with the long-term stored information such as visual semantics and language, as shown in Figure 3 (Baddeley, 2000, 2012, 2015). These three subcomponents are sometimes referred to as “slave” systems to reflect their passive roles as a temporary store responsible for the different types of information an individual experiences in the real world to be controlled by the central executive.

#### **2.1.1.1.2 Cowan’s embedded-process model**

The embedded-process model has been described as a model for information processing. Unlike that of the multi-store model proposed by Baddeley and Hitch (1974), the central notion of the WM suggested by Cowan (1999) is that WM is not comprised of multiple components with different storage of information, but it is the temporary activation of areas of the LTM. The model hypothesized that memory activation, the focus of attention and awareness, and LTM constitute WM (Cowan, 1999). The WM model of embedded-processes involves information processing from various parts of the memory system being accessible for a cognitive task that is being carried out. That is, the information which is necessary for performing a cognitively complex task must be made temporarily accessible. Several pieces of information must be concurrently activated and exploited to perform the given task (Cowan, 1999). Such pieces of information may be made available through different mechanisms. Cowan’s model of WM consists of 1) central executive, 2) LTM, 3) active memory, a subset of LTM in the temporary state of activation, and 4) the focus of attention and awareness.

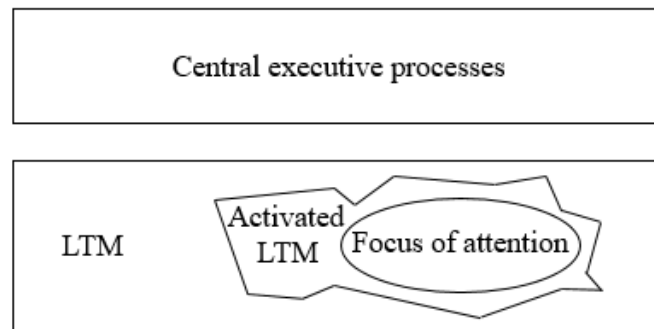


Figure 4: Cowan's embedded-processes model  
(Cowan, 1999, p. 93)

As illustrated in Figure 4, the central executive manipulates the direction of the attentional focus (Cowan, 1999). While some information needed for carrying out a cognitive task may be in the focus of attention, there may also be some that is in an active state, meaning that piece of information is not directly in the focus of attention. However, it can be readily prompted to enter the focus of attention. Finally, some information may be in the inactive state in the LTM, but it has relevant contextual coding and can be made available quickly to execute the cognitive tasks (Cowan, 1999).

#### 2.1.1.1.3 Engle's resource-dependent inhibition model

The resource-dependent inhibition model of WM places an emphasis on the connections between the central executive, STM, LTM, and how the activation is maintained. Engle et al. (1999) proposed that the essence of WM lies in the fact that inhibition, or the ability one has to control attention, plays a vital role in WM. It assumed that while a cognitive task was being carrying out, once attention was actively controlled, irrelevant information would be suppressed. This process can be referred to as "executive attention", which means "the ability to maintain stimulus and response elements in active memory" (Engle & Kane, 2004),

especially when the attention can be influenced by other irrelevant environments or conflicts. One proposal associated with WM capacity made by Engle et al. (1999) is that WM capacity should not be regarded as a capacity store or memory itself, as posited by Baddeley and Hitch (1974), rather it should be viewed as “...the capacity for controlled, sustained attention in the face of interference or distraction” (Engle et al., 1999). It was also suggested that individual differences based on WM capacity should be measured by the differences in their capability for controlled processing.

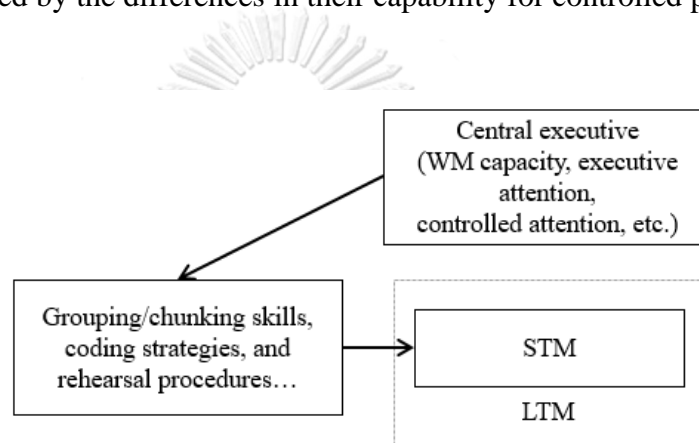


Figure 5: Engle's resource-dependent inhibition model (Engle et al., 1999, p. 106)

To illustrate based on Figure 5, the ability to maintain the information relevant to the goal should be highly active in order to suppress any conditions interfering or competing during the cognitively demanding tasks (Engle & Kane, 2004). Performance differences may arise from WM capacity, or as referred to by Engle and Kane (2004), “executive attention”. In their two-factor theory of this executive control, it is postulated that 1) the executive attention is crucial for maintaining information in activated memory, and 2) the executive attention serves as a resolution

of conflict which may be presented by the competition between a task-appropriate and a more influential task-inappropriate response (Engle & Kane, 2004).

To summarize so far, having considered the three major models of WM proposed with differing perspectives, we can observe that the ubiquitous process these models tended to place an emphasis on is the attention control. That is, the executive control in Baddeley and Hitch's (1974) model offered a control system which is heavily based on amounts of attention, directing the flow of information among its subcomponents. Cowan's (1999) model offered a central executive system that regulates the directions of the attentional focus in the temporary state of memory activation. Engle et al.'s (1999) model postulated that abilities to control attention, referred to as "executive attention", are necessary during information processing, especially in the event that internal or external distractions divert attention away from the current tasks being carried out. Even though these models differ in that WM is comprised of separate subsystems responsible for storing and processing different types of information (Baddeley & Hitch, 1974), the temporary activation of areas of the LTM (Cowan, 1999), or how the temporary process of how memory activation is maintained in order to inhibit irrelevant environments at the time of the current cognitive tasks (Engle et al., 1999), they are sufficiently informative and compatible in explaining how dynamic a WM system is. While the information is stored temporarily, the three models assume that WM manipulates it with attention. Like other domain-general cognitive tasks, learning a second language may not be possible without attention to the input or stimuli. It is now apparent that WM is viewed not only as a place for storing information momentarily but as a place for manipulation of



information, which is necessary for executing cognitively-demanding tasks, such as L2 sentence processing.

#### **2.1.1.2 Working memory and L2 sentence processing**

This section deals with working memory, an essential component of language aptitude (Skehan, 2002), and its roles in L2 sentence processing. The abilities to process L2 sentences appropriately may not be dependent merely on possessing or lacking the required L2 knowledge to execute an L2 task. This means such abstract representation of the L2 or grammar alone may not fully account for L2 learners' problems in terms of their comprehension and production. It is generally known that individuals differ from one to another, especially in terms of their language aptitude, which may probably give rise to differences in their L2 proficiency achievements and abilities to handle multiple demands of the cognitive tasks carried out in an L2 (Ellis, 2015).

WM has been deemed a key cognitive individual attribute which may potentially have influence on L2 learning performance and outcome. Abundant research in the past decades has shown that tasks associated with L2 processing can be modulated by individual differences in terms of WM capacity (e.g., Coughlin & Tremblay, 2013; Dussias & Piñar, 2010; Kim & Christianson, 2017; Sagarra, 2021; Sagarra & Herschensohn, 2010). This means L2 performance based on information processing differences may be the result of differences in each individual's amounts of cognitive resources available at the time the cognitive task is being executed. According to the multi-component model of WM (Baddeley, 2010), two WM components, namely the central executive and the phonological loop, appear to be mainly involved in the L2A literature (Wen, 2012; Wen & Jackson, 2022). The

former deals with the active processing of the cognitive task, whereas the latter is responsible for verbal information in the information processing. WM capacity can be viewed as cognitive resources which are limited and vary from one individual to another.

Most previous research employed various measures to determine L2 learners' WM capacity, such as a reading span test. Two widely recognized notions of WM span tests in L2A literature include the reading span test devised by Daneman and Carpenter (1980) and that of Waters and Caplan (1996). Much literature from empirical studies involving WM capacity as an independent variable has been generated from these two conceptualizations. The similarity between the two types of reading span tasks is that in both tasks, the participants perform a serial recall of the last word, i.e., recall prompts, after reading a sentence in each set. The difference is that, in Waters and Caplan's (1996), the participants were also asked to make judgments on the processing task, based on the semantic plausibility of each sentence they had just read. That is, each sentence in the span task is usually followed immediately by a comprehension question to ensure the participants pay attention to the content meanings of the sentences. The reading of the sentences and the judgments on semantic plausibility serve as a reflection of the processing capacity while the serial recall subtask reflects the capacity of the temporary storage.

According to Osaka and Osaka (1992), WM may be viewed as a language-independent construct. WM span tests used to measure individuals' WM capacity may be independent of the learners' L2 abilities, given that L1 abilities to perform the task are less inconsistent when compared to L2 abilities. For instance, in a reading span

test, since the primary purpose is to measure individuals' WM capacity, an L1 version could be utilized to avoid any language-related confounds which may arise from using an L2 in such a test. Several past studies on L2 sentence processing decided to use the task presented to the participants in their L1 due to the fact that the L1 is common to all of the participants and should cause fewer inconsistencies compared to tasks presented to them in an L2 (e.g., Sagarra & Herschensohn, 2010, for L1 Spanish). This means the efficiency of a WM capacity measure is not dependent on or associated with the language used in the WM span task (Osaka & Osaka, 1992).

The relationship between WM and computational complexity has been studied in the realms of cross-language studies and processing extensively (e.g., Coughlin & Tremblay, 2013; Keating, 2010; Kim & Christianson, 2017; Reichle et al., 2016; Sagarra, 2021; Wen et al., 2015). Mixed research results have been revealed, and the debate whether WM capacity influences how L2 learners process L2 sentences is still ongoing and has attracted considerable interest among cognitive linguistics and psycholinguistics researchers. The mainstream L2 processing research that shows the effects of WM capacity on L2 processing is usually concentrated on structural ambiguity resolution (e.g., Dai, 2015; Kim & Christianson, 2017), morphological processing, especially sensitivity to number agreement and gender agreement (e.g., Coughlin & Tremblay, 2013; Foote, 2011; Keating, 2010; Sagarra, 2021; Sagarra & Herschensohn, 2010), and syntactic parsing using garden-path sentences (e.g., Juffs, 2004). These investigations took the participants' WM capacity as a determinant which was predicted to modulate how well they could process complex L2 sentences. However, not all previous studies regarding WM capacity in L2 processing had conclusive evidence that an individual's WM capacity influenced how L2 learners

process L2 sentences. There have been mixed research results concerning WM capacity advantage in L2 sentence processing. Some studies found support for WM capacity which could be one of the factors to account for in L2 sentence processing (e.g., Coughlin & Tremblay, 2013; Dussias & Piñar, 2010; Kim & Christianson, 2017; Sagarra, 2021), whereas other investigations found no correlations between individual WM capacity and how L2 learners performed L2 sentence processing tasks (e.g., Foote, 2011; Juffs, 2004). The phenomena found so far have yet to be conclusive, and more evidence with regard to L2 processing performance should be provided to shed more light on the mechanisms of L2 individuals' WM capacity in association with L2 sentence processing.

### **2.1.2 Dependency Locality Theory**

The dependency locality theory (DLT) is a processing theory based on the exploitation of human cognitive resources in sentence comprehension (Gibson, 1998, 2000). Its premise mainly concerns the processing explanation which involves filler-gap dependencies, such as the processing of the filler and gap in relative clause constructions. This memory-based account proposes that processing involving distance between the filler and gap is dependent on the WM costs of temporary storage and integration (Gibson, 2000). This notion is closely congruent with the notion of WM, which is also comprised of two important components: the temporary storage component and the processing component of information (Baddeley & Hitch, 1974; Just & Carpenter, 1992).

The central tenet underpinning the DLT is “locality”. Locality can be defined as the cost of integrating two sentential elements, e.g., the head and its dependent, which depends on the distance between them (Gibson, 2000). This distance-based

complexity theory has been adopted by a large body of research in psycholinguistics on sentence processing (e.g., Kim & Christianson, 2017; Liu & Wang, 2019). Based on the DLT, the filler-gap distance can be exemplified by the linear distance between the head noun and the gap, intervened by new discourse referents (i.e., nouns and verbs). That is, it is the distance between the syntactic head and the newly integrated element, such as in center-embedded or nested English SRCs and ORCs. The fact that the different types of distance-based complexity assume varying degrees of burden on WM serves as the point of departure of the present investigation into WM and distance effects on L2 agreement processing. Consider the following examples of a short-distance SRC and a long-distance ORC.

SRC: The reporter<sub>*i*</sub> [ *who<sub>i</sub> t<sub>i</sub> attacked the senator* ] disliked the editor.

ORC: The reporter<sub>*i*</sub> [ *who<sub>i</sub> the senator attacked t<sub>i</sub>* ] disliked the editor.

(Gibson, 2000, p. 114)

To explain according to this distance-based complexity theory, the gap is assumed to be immediately activated at the filler in both SRCs and ORCs (Frazier & Clifton, 1989). The DLT posits that it is more cognitively demanding in ORCs as the parser relates the gap, the object of the verb “attacked”, to its wh-filler such that the process crosses the subject of the relative clause, the noun “senator”. This, thus, creates longer distance or locality between the two elements, causing processing the ORC to become more costly owing to memory decay over distance. This process, however, differs in the processing of the filler-gap dependency in SRCs. That is, the distance between the wh-filler and its gap is shorter and can be integrated without crossing the subject of the RC since there are no new discourse referents intervening

between the wh-filler and the gap. The process is deemed more local; that is, the parser can relate the gap, the subject of the verb “attacked”, to its wh-filler without processing any new intervening discourse referents; hence, the processing becomes less cognitively demanding to the cognitive resources (Gibson, 2000).

Given the processing phenomena, the two types of ERC constructions could serve as lending support to the L1-L2 structural competition account, particularly on the assumption that processing could be less efficient as more cognitive resources are consumed by syntactically more complex structures (Austin et al., 2015). Accordingly, the two types of forward filler-gap dependencies of English SRCs and ORCs were employed as one of the explanatory variables in the stimulus manipulations. They served to create distance in the non-adjacent agreement dependencies, i.e., short-distance SRCs and long-distance ORCs. These two conditions were manipulated to examine the effects of WM capacity on the agreement computation.

Therefore, consistent with the notion of the DLT (Gibson, 1998, 2000), the present research took advantage of these two constructions of semantically reversible ERCs since they were assumed to tax cognitive resources in a different manner (Gibson, 1998; Just & Carpenter, 1992; Suda, 2015). That is, in resolving long-distance agreement dependencies, the learners had to hold the filler (the head noun) along with its number features active in the WM whilst incrementally processing the filler-gap dependency in the two distance conditions. Such complex computations of keeping track of incomplete agreement dependencies, which were later satisfied at the matrix verbs, were assumed to add additional WM loads and tax WM capacity

differently, with the long-distance ORC condition becoming cognitively more demanding. Distance manipulations based on the DLT were, therefore, appropriate for tackling the complex mechanism of crosslinguistic competition, in line with the notion of the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013).

### 2.1.3 Emergentism

Developed in the late 1990s, emergentism is a contemporary linguistic approach to language acquisition. This approach proposes language is a complex adaptive system, whose emergence is from usage (Gass & Mackey, 2012). Emergentist approaches to L2A entail theories assuming mainly that the frequency offered by linguistic forms prevalent in the input plays an important role in L2A. They are also known as constructivist approaches, whose primary emphasis is on usage of language, rather than innate faculty (Ellis, 2015; Gass et al., 2013).

Emergent properties of grammar are subsumed under the notion of *connectionism*, an approach in the field of cognitive science. Its main aim is to describe mental phenomena related to the notion of how an actual human neural network works. To elaborate, according to Ellis (1998), connectionist approaches to language learning provide "...computational tools for exploring the conditions under which emergent properties arise" (p. 645). The implementation of connectionism utilizes the concept of computer models which are composed of a number of artificial interconnected neural networks to mimic the human language learning process. The focus of interest in connectionist models is to investigate how associations between forms and meanings are acquired through simple learning mechanisms offered by

artificial neural networks (Ellis, 1998). In contrast to nativism<sup>2</sup>, connectionism sees language behavior as being rule-like, rather than rule-governed. This means representations are viewed as the product emerging when simple learning mechanisms are employed to statistically abstract information from a large amount of language input to which the learners are exposed in a parallel and simultaneous manner (Ellis, 1998). Holme (2013) also points out that such information abstraction is not the abstraction of hidden rules or structures from the linguistic input; instead, language acquisition may be induced by the information abstraction of the actual forms actually experienced by the learners. Accordingly, it is assumable that the emergence of forms and behavior can be viewed as the result of interactions at all levels, ranging from biological genes to the environment the learners are exposed to (Elman et al., 1996; MacWhinney, 1998).

According to Ellis (2015, p. 22), in emergentist approaches to language learning, it can be postulated that "...learning a language is like learning any other skill and that all that is needed to explain it is a simple learning mechanism that can handle the information available from a massively complex environment." In support of this view, Ellis (1998, 2002) argued that it may not be obligatory to account for the assumptions of a language acquisition device, which assumes that language acquisition is based on innate capacity as proposed by Chomsky (1986), and he

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<sup>2</sup> Nativism is an approach to language acquisition postulated by Chomsky (1965) to account for L1 acquisition. According to this view in L2A, nativists assume that the ability to acquire a human language is constrained by universal innate language knowledge rather than by learning from the environment. Universal Grammar, the innate principles and properties common to all human languages, was proposed to account for how children's language development is possible with rapidity and a high rate of accuracy. L2A researchers have also used the notion to explain linguistic phenomena in L2A (Ortega, 2009).



focuses on the language acquisition process instead. That being the case, the statistical regularities prevalent in the learners' massively complex environment are deemed essential for learning of an L2 to take place. Language learning and acquisition are thus believed to be driven by the usage-based frequency as presented through the input (Ellis, 2002). On this view, language acquisition can be seen as the result of the learners' ability to perform a lifetime analysis of structural regularities, i.e., language rules from the phonology to discourse levels, which emerge from the experience by which the learners unconsciously analyze the distributional characteristics of the input (Ellis, 2002). It is believed that once the regularities of the patterns are repeatedly used on a regular basis, they become more strengthened, thus leading to acquisition.

As an approach to L2A and language acquisition process, emergentism has informed several theories. One widely discussed concept under this approach is the Competition Model (CM) (MacWhinney, 2001), which is a model involving language processing and is primarily based on how language learners interpret sentences. 2.1.3.1 discusses the CM as a departure point for the L1-L2 structural competition account, which this study is primarily concerned with. Both utilize a similar notion which assumes that language acquisition can be explained by the fact that language features compete for selection during the processing, necessary for learning to take place (Austin et al., 2015; MacWhinney, 2001; Trenkic & Pongpairoj, 2013).

#### **2.1.3.1 Constraint-satisfaction approach: The competition account**

The primary goal of sentence processing research is to provide fundamental understanding of how mechanisms and representations can be accounted for in order to comprehend or produce sentences in the real-time processing (Harrington, 2001). In the realms of sentence processing, according to Harrington

(2001), the three main approaches to L2 sentence processing relative to sentence comprehension are 1) principle-based approach, 2) referential or discourse-based approach, and 3) interactive or constraint-based approach.

With reference to Harrington (2001), the principle-based approach regards language processing as confined to solely syntactic knowledge irrespective of other kinds of knowledge, such as lexical and real world knowledge, in the structure building processing. This approach assumes the learners' syntactic representations. Its processing mechanism is viewed as modular; that is, syntactic representations are mainly used to arrive at a proper interpretation of a sentence. The referential approach focuses on sentence processing at the discourse level. Like the principle-based approach, it also assumes that syntactic processing autonomously generates interpretations on the basis of prior discourse contexts appropriate for interpretations. These two approaches may not be suitable for the purpose of this present research because they tend to place emphases on syntactic representations and discourse knowledge in a modular manner, applying some types of knowledge before or independent of the others. The constraint-satisfaction approach differs from the first two approaches in that it does not consider sentence processing as modular but rather takes various aspects possible into consideration in a parallel manner. It does not assume syntactic representations (Harrington, 2001).

Since the present research aims to address variables involving the processing of inflectional morphology in complex sentences, it is more appropriate to consider various aspects interacting to constrain the processing as a reflection on how an L2 learner comprehends and produces grammatical categories in the L2. Constraint-based

or constraint-satisfaction models are primarily based on an interactive, connectionist view of the human mind in processing language in real time (Harrington, 2001; Jiang, 2018; MacDonald et al., 1994). It was originally proposed to account for research work including sentence comprehension in L1 processing (MacDonald et al., 1994). In the constraint-based perspective, throughout the processing of a sentence, all information including both syntactic and non-syntactic information is assumed to be operative continuously at the same time; such dynamic processes can thus lead to multiple sentence structures being considered simultaneously. These structures can be viewed as candidates subject to competing for selection, and the final outcome, i.e., comprehension, is assumed to result from those possible multiple interpretations (Jiang, 2018).

In crosslinguistic sentence processing inquiry considering the effects of L1 on L2 sentence processing, the CM has yielded accountability for linguistic phenomena concerning interlanguage variations (Austin et al., 2015; Kilborn & Ito, 1989; Trenkic & Pongpaiboj, 2013). In this research, we are particularly interested in one constraint-based model gaining considerable interest in the literature regarding L2A, the CM (MacWhinney, 1987, 1997)). The CM is subsumed under the constraint-based approach to sentence processing in language acquisition. This model holds that sentence interpretation can be characterized by a cue-based process, taking into account complex relationships between available surface cues, i.e., forms and the meaning in a particular context, i.e., functions, in order to represent the linguistic knowledge of a learner (Harrington, 2001). The conceptualization of the CM was first proposed by MacWhinney (1987, 1997) to account for how monolinguals acquired their L1. This model considers both L1 and L2 acquisition as a process where one

acquires a particular language system from the language input. Language processing in the CM perspective is hypothesized to involve various cues to help learners arrive at a proper analysis of a sentence. Various sentential elements or cues serving a particular language function in a sentence give rise to competition during the processing. Such probabilistic cues function to relate linguistic forms and meanings in non-linear associations, characterizing various sources of knowledge interacting in parallel from the initial sentence process stages. This language acquisition model proposes that cues and strength of cues are two key determinants which function to help speakers arrive at a proper interpretation of a sentence. The establishment of such knowledge then serves as a foundation for sentence comprehension and production. The CM, as a constraint-based model, contrasts sharply with generative approaches to L2A, whose descriptions primarily focus on the assumption that all and only well-formed sentences are generated by rules. The CM holds that forms and functions are inseparable. Hence, the associations between forms and functions must take place during the real time processing (Kilborn & Ito, 1989).

#### **2.1.3.2 L1-L2 structural competition and L2 processing**

Crosslinguistic influence has been of fundamental theoretical significance in empirical studies concerning L2 acquisition and L2 processing (Bardovi-Harlig & Sprouse, 2018; Jarvis & Pavlenko, 2008; Jegerski, 2018; McManus, 2022; Odlin & Yu, 2016). From a psycholinguistic perspective, one prominent psychological construct related to this notion concerns linguistic nonselectivity (Hopp, 2017; Jegerski, 2018; Jiang, 2007; Kroll et al., 2015). Cognitively speaking, non-selective activation or parallel activation occurs when languages in a bilingual's or multilingual's mind are assumed to be activated to some

extent and thus probably give rise to non-native language processing (Kroll et al., 2015; Sharwood Smith, 2019). Inquiry in this realm often questions whether and to what extent language comprehension and production involve the activation of both languages during online sentence processing (e.g., Hopp, 2017; Rankin et al., 2019).

In line with the view of nonselectivity in language processing, the notion of crosslinguistic competition in language processing and acquisition has recently been extended to studies in L2A, especially in the acquisition of L2 grammatical categories (Trenkic et al., 2014; Trenkic & Pongpairoj, 2013). According to Trenkic and Pongpairoj (2013), Trenkic et al. (2014), and Austin et al. (2015), an L1-L2 structural competition account has been proposed. This crosslinguistic competition account posits that "...L2 learners acquire new L2-licensed patterns for encoding a particular meaning but that these patterns compete with existing L1 patterns, contributing to variability..." (Austin et al., 2015, p. 706). Such L1-L2 crosslinguistic differences presumably result in crosslinguistic competition, where successful comprehension as well as production can take place when cognitive resources are sufficiently available for the processing. Based on the L1-L2 structural competition account, the extent to which L2 learners suffer crosslinguistic competition between the two languages may be ascribed to their already existing L1-specific experience and processing routine, which is more firmly established, in association with their individual differences in terms of cognitive resources (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013).

In morphological learning, L2 learners are assumed to struggle with the options made available by both their L1 and L2 systems with L1 options competing

with the newly learned L2 options for selection, even when only one language is processed. To be successful in comprehending or producing the target L2 constructions, the target L2 forms must win out over the L1 counterparts which are usually different from those in the target language. Even though L2 learners may have already formed a new form-meaning association of a novel L2 grammatical feature, the strength of this association could suffer crosslinguistic competition as two grammatical features in a bilingual's mind compete for selection (Austin et al., 2015; McManus, 2022). This may thus lead to variable performance in language processing. Furthermore, the L1-L2 structural competition account proposes that, in essence, such variable processing among L2 learners may be dependent on individual differences in terms of cognitive resources relative to the complexity of the linguistic environment. That is, in a less complex linguistic environment, cognitive resources may be left sufficient for suppressing the more entrenched L1-alternative competitors in real-time processing, and thus can lead to successful computations in the learners' mental operations.

In this regard, the crosslinguistic competition account conforms to a general consensus in psycholinguistic inquiry that bilingual or multilingual processing is non-selective (Jegerski, 2018; Jiang, 2007; Kroll et al., 2015; Rankin et al., 2019; Sharwood Smith, 2019). That is, non-native language processing may be ascribed to the fact that bilinguals or L2 learners simultaneously hold two linguistic systems in their mind, and both languages are activated to some extent irrespective of the current language being processed (Austin et al., 2015; Kroll et al., 2015; Sharwood Smith, 2019). The account contributes to this view by providing an interplay of both linguistic variables and individual differences in terms of cognitive resources to

account for inefficient computations and divergent processing patterns between native and nonnative processing.

In this study, the notion of the L1-L2 structural competition can be observed in the learners' well-established system, L1, and their ongoing system of L2. The fundamental assumption is that even if one system is required for L2 learners to produce or comprehend L2 target constructions, two linguistic systems in a bilingual speaker are often simultaneously in activation and compete for selection. That is to say, central to the crosslinguistic competition account is the assumption that the co-existing L1- and L2-licensed structures will compete for selection during L2 grammatical processing, in which cognitive resources are more increasingly demanded by complex L2 structures. In particular, such cognitive demands have been operationalized and studied in the English 3S inflectional agreement morphology processed within two different constructions manipulated by distance-based complexity (Gibson, 1998, 2000), i.e., short-distance subject-extracted and long-distance object-extracted ERCs, in which the target agreement morphology is obligatory.

## **2.2 Temporal-aspectual expressions of the Present in English and Thai**

This section compares and contrasts linguistic features involved in the expressions of verbs in the present as well as relative clause constructions permitted by English and Thai. Since the emphasis of the present research is placed on the processing of the English present tense morphology in ERCs, both the processing mechanisms of verbal agreement and RCs are described. According to Chiravate (2018), English and Thai temporal-aspectual realization differ in that English has overt tense and aspectual markings, whereas Thai is a tenseless language and does not

inflect its verbs for tense or aspect. In expressing temporal locations, English employs inflectional suffixation to the verbs while Thai utilizes pragmatic devices, such as context clues and chronological order in narration. Lexical expressions also facilitate the realization of temporal locations in Thai, such as “yesterday” and “last week”. Thai has aspectual markers, such as / *kamlaj* / for the progressive aspect; however, such markers differ from those in English in that they are not expressed through verbal suffixation. These distinctions between the two linguistic systems may pose difficulties in an attempt to process the target language verbs, whose temporal locations are realized through the inflectional system. In this respect, it is necessary to consider how English and Thai express the present.

### **2.2.1 The Present in English**

This section deals with tense and aspect concepts in English and describes the characteristics of English present tense verbs.

#### **2.2.1.1 Temporal-aspectual expressions of the Present in English**

According to Comrie (1976), “Tense relates the time of the situation referred to to some other time, usually to the moment of speaking” (pp. 1-2). This means that the notion of tense provides temporal locations of a given situation relative to the time of the utterance. In addition, Larsen-Freeman and Celce-Murcia (2015) suggests that *tense* refers to a “grammatical device for situating events, states, or actions in time” (p. 105). A tense language, like English, is usually concerned with the time and aspect of a given situation. That is, tense literally functions to indicate, relative to the present moment, whether a situation 1) has already taken place, i.e., past tense (e.g., “The man cooked.”), 2) ongoing at the very same moment of the utterance, i.e., present tense (e.g., “The man is cooking.”), or 3) is going to take place,



i.e., future tense (e.g., “The man will cook.”). With this conceptualization, tense is also known as “absolute tense” (Comrie, 1976, p. 2), namely, the past, present, and future tense.

In particular, the present tense may refer not only to the event that holds at the present moment of utterance but also the situation that encompasses a situation over a period of time including the present moment, as proposed by Comrie (1985).

- (1) a. Eiffel Tower stands in Paris.  
b. John goes to work at eight o'clock.

(Comrie, 1985, p. 39)

Sentences in (1a) and (1b) serve as an illustration here. The present tense may refer to a situation that holds at the present moment of the utterance (1a) or a larger part of the situation other than the moment of the utterance (1b). With this habitual aspectual meaning, it is not necessary that “John” be on the way to work at the time the sentence is uttered, whereas it literally holds true that “Eiffel Tower” stands in Paris at the moment of speaking.

Moreover, tense can also be used to indicate time locations relative to a time other than the present moment of the utterance, which is also known as “relative tense” (Comrie, 1976, p. 2). This notion can be illustrated by the sentences below.

- (2) a. When walking down the road, I often meet Harry.  
b. When walking down the road, I often met Harry.

(Comrie, 1976, p. 2)

As seen here, the non-finite present participle “walking” here provides relative time reference of an event concurrently occurring to the time of the finite verbs. That is, such non-finite forms can be realized as tense in relation to the time of the main verbs. To explain, the event of “walking” in (2a) is viewed as the present time in reference to the present time indicated by the finite verb “meet”. In the same vein, the event of “walking” in (2b) is held in the past as indicated by the finite verb “met”. On this ground, tense may reflect not only the time of a given situation in relation to the time of the moment of utterance, but also to the time of some other situation (Comrie, 1976).

The past, present, and future tenses are, therefore, conceptualized as a natural division of time. Different languages express tenses in different ways. English is a tense language, a language with time orientation, which uses a verbal inflectional system to signify tenses.

In addition to the notions of tense, *aspect* is essential for generating form-meaning combinations. Aspect can be defined as different ways in which a situation can be viewed based on its internal temporal structure (Comrie, 1976). As an illustration, Comrie (1976) demonstrated that a clear distinction between tense and aspect can be observed in sentences like (3a) and (3b). That is, both sentences have a time reference in the present tense but differ in aspectual properties. In English, for instance, the difference between these two sentences lies in an aspectual distinction.

- (3) a. He is reading.  
b. He reads.

(Comrie, 1976, p. 3)

Furthermore, with reference to Larsen-Freeman and Celce-Murcia (2015), aspect of verbal expressions in relation to time deals specifically “with the internal structure of the action occurring at a given time” (p. 106). Aspect is distinctive from tense in that aspects do not represent any temporal locations in the time periods, i.e., present, past, and future; however, aspects show particular relationships between how an event is viewed by a speaker and how it is interpreted for a specific event, irrespective of time of the utterances (Larsen-Freeman & Celce-Murcia, 2015; Quirk et al., 1985; Tawilapakul, 2008). Consider the example sentences below for the constructions of aspects and their meaning.

- (4) a. Joan *sings* well.  
b. Joan *is singing* well.

(Quirk et al., 1985, p. 197)

- (5) a. I *have* already *met* your sister.  
b. The flight was cancelled after we *had paid* for the tickets.

(Quirk et al., 1985, p. 190)

According to Quirk et al. (1985), two major grammatical aspects in English are progressive and perfective aspects. Progressive aspect, also known as durative or continuous aspect, signify continuous actions happening at a particular point of time (Quirk et al., 1985). As shown above, (4a) and (4b) have the same tense, i.e., the present tense, but different aspects. While the third-person singular in the present tense verb in (4a) “sings” is realized by the base form, the sentence in (4b) is formed by an auxiliary “be” and the *-ing* progressive marking of the verb “sing”. In terms of meaning, (4a) denotes the subject’s singing ability, whereas (4b) refers to the subject’s singing performance taking place at a particular time. Perfective aspects

indicate whether an action is complete, assuming its occurrence at any preceding time suggested by tense (Quirk et al., 1985). For example, the perfective aspect in the present tense denotes past time with current relevance as illustrated in (5a). It can also occur with other tenses, such as the past tense, as demonstrated in (5b).

Verb formations which occur in different ways thus facilitate the interpretations of specific temporal properties of the inflected verbs in English. With the temporal-aspectual system in English, its subsequent combinations facilitate both the speakers to convey a meaning through a verb form for a given situation and the comprehenders to interpret the utterance in correspondence to the intended meaning of the verb.

#### **2.2.1.2 Characteristics of verbs and nouns in English present temporal expressions**

In English, verb forms are expressed in relation to their meanings by means of suffixation. English verbs are grammaticalized by overt morphological marking which denotes the meanings associated with temporality and aspect. To be more specific, inflectional morphemes or suffixes (e.g., third-person singular *-s* marking in the present simple tense and *-ed* marking in the past simple tense) are attached to a finite verb in order to express a meaning relative to the time at which the situation takes place. However, applying tense morphological markings is not straightforward; they necessitate certain linguistic features in the formation of the verb tense. As regards the verb forms in the English present tense, three core features must be taken into consideration, namely, 1) finiteness, 2) person, and 3) number features, in order to successfully convey a meaning with the present time. In the present tense, the finite verb remains in its bare form, except for the third-person

singular (Larsen-Freeman & Celce-Murcia, 2015). That is, two forms of verbs are used. The uninflected bare form of verbs can express a present situation when the subject argument is first person, second person and third person plural (e.g., “I”, “you”, and “my parents”, respectively). However, if the subject argument is a third person singular (e.g., “the teacher”, “she”, and “it”), it is obligatory that the verb be inflected with the 3S morpheme *-s* to agree in person and number with the subject (Timyam, 2022). The sentences below illustrate the three features required when constructing a verb in English present simple tense expressions: finiteness, person and number features.

- (6) a. Present tense verbal expressions with a first-person subject  
 “I walk to school every day.”
- b. Present tense verbal expressions with a second-person subject  
 “You need to see the doctor.”
- c. Present tense verbal expressions with a third-person plural subject  
 “My parents have dinner at home.”
- d. Present tense verbal expressions with a third-person singular subject  
 “The teacher likes hot tea.”

As illustrated above, present tense verbs are formed differently depending on the three major features. To elaborate, the morphological marking *-s* is applied only when the verbs are finite. In (6a) and (6b), there are no changes made to the bare forms of the verbs when the subject is a first-person or a second-person. As regards a third-person subject, number features, i.e., singularity and plurality, need to be considered. In (6c), an inflectional suffix *-s* is not required when the subject is a third-person plural, whereas when the subject is a third-person singular, the *-s* marking is obligatory as shown in (6d).

With respect to meaning, Reid (1991) posited that the uses of the subject-verb concord in the English present tense reflect a series of semantic choices and the speakers or writers' decisions to use it. Reid (1991) further suggests the reason why one chooses a singular or plural verb to express meanings. In the present tense, English verbs have a number feature as English nouns do. That is, a number which is either one or more than one is assigned to a noun phrase (NP) in the subject position. The number greater than one can be encoded lexically (e.g., "people") or morphologically (e.g., "girls"). In the English present tense, the number encoding principle is employed by English verbs. Table 1 exemplifies this point.

Table 1 Present tense verb meaning in relation to the morphological markings

Present tense		
<i>Verb ending</i>	<i>Meaning</i>	<i>Example</i>
-s	One	The boy runs.
-∅	More than one	The boys run.

(Larsen-Freeman & Celce-Murcia, 2015, p. 63)

With reference to Reid (1991), it is worth noting that a particular choice of number is made separately for both the subject noun and the verb, and it independently contributes to the speaker's intent. It is explained that the choices of number of the subject and verb should be treated as a separate entity. That is, all subject-verb combinations are possible, but they do not equally frequently occur. To illustrate this point, consider Table 2 below.

Table 2 Number features in present tense verb formation

Verb	Noun subject	
	<i>One</i>	<i>More than one</i>
<i>One</i>	The boy likes candy.	Ten dollars is not a lot of money.
<i>More than one</i>	The family are all here.	The boys like candy.

(Larsen-Freeman & Celce-Murcia, 2015, p. 63)

When the subject entity is complex, i.e., “Ten dollars” (overtly plural subject but reinterpreted as singular) and “The family” (overtly singular but reinterpreted as plural), the choice will be made dependent on the speaker’s intention for each particular situation (Reid, 1991). 2.2.2 sees features relevant to the expressions of the Present in Thai.

### 2.2.2 The Present in Thai

This section is devoted to how temporal-aspectual concepts are viewed and expressed in Thai and the characteristics of the Present in Thai verbs in relation to those in its English counterparts.

#### 2.2.2.1 Temporal-aspectual expressions of the Present in Thai

Unlike English, Thai, as an isolating language, expresses the concept of tense through other means, e.g., lexical means, i.e., particles, modals, time markers, and contextual means, i.e., in chronological order in narration, to convey the verb meanings relative to time (Chiravate, 2018; Smyth, 2002; Tawilapakul, 2008). That is, Thai verbs neither inflect for tense nor aspects. In contrast to English, Thai does not express a verb meaning in relation to time through a verb tense inflectional system. Although Thai is a tenseless language, it does not mean that Thai is a language without time concepts (Scovel, 1970). According to Kanchanawan (1978) and Chiravate (2018), it is suggested that the time concepts in Thai exist and are

conveyed through various devices, such as temporal lexical expressions like “yesterday” for a past situation. However, when used to refer to present, past, or future actions, Thai verbs remain in the same uninflected form and could signify any time locations in the time periods (Goddard, 2005). Nevertheless, when Thai sentences without overt morphological marking are translated into a time-oriented language like English, ambiguity may result (Goddard, 2005; Smyth, 2002; Tawilapakul, 2008). They can be interpreted as either a present or past situation. The interpretation of such a phenomenon depends on the context. Consider the Thai sentence below when translated into English.

- (7) /khǎw nâng long/  
 he/she sit down  
 “He/She sat/is sitting down.”

(Goddard, 2005, p. 3)

As seen from the above instance, without any changes made to the verb form, it is necessary that a Thai verb make use of other means, such as time markers, and discourse contexts to help the comprehenders appropriately decode the intended meaning of the verb. Detailed descriptions for Thai noun and verbal expressions in relation to the Present are provided in 2.2.2.2.

### **2.2.2.2 Characteristics of verbs and nouns in Thai present temporal expressions**

Since Thai is considered an isolating language, its verb forms are expressed without any inflections. That is, a single verb form can be used in conjunction with other devices to denote the meaning of any temporal locations and aspects. A verb meaning may be conveyed through discourse contexts associated with



time or in conjunction with other lexical means that represent time. Unlike English, Thai lacks verbal inflectional systems for functional categories, such as gender, number, and tense (Goddard, 2005; Iwasaki & Ingkaphirom, 2005). On this ground, it is viewed as an analytic language, which means Thai conveys its grammatical relationships more on constituent order or particles than inflections (Boonkwan & Supnithi, 2008; Smyth, 2002).

Another point of concern is related to number features in Thai. The notion of number features in Thai differs in a number of ways when compared to that of English. In terms of plurality of a noun phrase, unlike English, Thai expresses its numeral modifier in the postmodifying position. That means the modifiers follow the noun. The examples below show how the concept of number is expressed in a Thai noun phrase.

(8) a. /mǎa nùŋ tua/  
 dog one classifier  
 “one dog”

b. /mǎa tua nùŋ/  
 dog classifier one  
 “a dog”

(Iwasaki & Ingkaphirom, 2005, p. 62)

(9) /kaafɛɛ sǎwŋ kɛ̃w/  
 coffee two glass  
 “two cups of coffee”

(Iwasaki & Ingkaphirom, 2005, p. 62)

- (10) /thoorasàp sǎam khrûaŋ/  
 telephone three classifier  
 “three telephones”

(Iwasaki & Ingkaphirom, 2005, p. 62)

In (8a), the head noun “mǎa” is followed by a cardinal number “nùŋ” and a classifier “tua”. The concept of singularity is expressed here in the noun-number-classifier structure. This structure is especially preferred when number is in the focus. However, in a structure where the classifier and number are in the reverse positions, indefiniteness may be posed as in (8b). This phenomenon is particular to singular noun expressions in Thai (Iwasaki & Ingkaphirom, 2005). For the general patterns of plurality, a noun precedes a number and classifier as shown in (9) and (10). From these examples, it is shown that number features in Thai nouns are not morphologically marked like in English. Consequently, without number features in the nouns, the formation of subject-verb number agreement is nonexistent in Thai. In this regard, neither Thai noun phrases nor Thai verbs are morphologically marked to express number agreement between the subject and the verb in the expressions of the Present temporal location of a situation.

Even though Thai nouns do not inflect for the number category, i.e., singularity and plurality, the notion can be expressed using strategies related to semantics and pragmatics by native Thai speakers. Apart from the noun-number-classifier pattern that exhibits number in Thai nouns, it is the contextual interpretation that is also important for determining plurality of the subject. This is because Thai verbs do not have an overt morphological marker for plurality (Goddard, 2005; Thapthimhin & Pongpairoj, 2015).

In addition to how numeral features are differently expressed to generate the intended meaning in Thai, there are both similarities and differences between Thai and English verbs. In terms of similarities of the two verbal systems, first and foremost, a Thai verb follows the subject of a sentence in a Subject-Verb-Object (S-V-O) pattern, which is identical to that of English sentence constructions with a transitive verb. An example of a Thai transitive verb in the S-V-O construction is illustrated in (11).

(11) a. /lék tè nóy/  
 (name) kick (name)  
 “Lek kicks Noy.”

b. /nóy tè lék/  
 (name) kick (name)  
 “Noy kicks Lek.”

(Iwasaki & Ingkaphirom, 2005, p. 110)

As shown above, Thai verbs primarily hinge on the constituent order to distinguish the relationship between the subject argument and the object argument in relation to the verbs of the sentences. Another similarity lies in fact that Thai verbs can also be broadly categorized into transitive, intransitive, and ditransitive verbs as in (11), (12), and (13), respectively.

(12) /lom phát/  
 wind blow  
 “The wind blows.”

(Iwasaki & Ingkaphirom, 2005, p. 111)

- (13) /phíchay hây náηsǎη sùmaalii/  
 (name) give book (name)  
 “Pichay gives Sumalee a book.”

(Iwasaki & Ingkaphirom, 2005, p. 113)

As seen in these three main ways of expressing Thai verbs in sentences in terms of their transitivity, it is apparent that there are no syntactic relationships between the subject and the verb based on person and number agreement features as there are in English (Goddard, 2005; Timyam, 2022).

In a comparison of L1 Thai and L2 English verb expressions in association with the temporal location of the Present, it can be seen that English has a richer and more complex morphological system concerning the verb forms, whereas Thai is known for its lack of inflectional systems, not only for the verb tenses but also the grammatical roles of the noun phrases in a given sentence.

### **2.2.3 Relative clause constructions in English and Thai**

Two types of relative clause (RC) constructions existent in both English and Thai are compared since they serve as the target structures particular to the present study. They are 1) subjective RCs or subject-extracted RCs and 2) objective RCs or object-extracted RCs. The target experimental sentences are also concerned with the clausal positions where an RC is embedded in the matrix clause, namely 1) right-embedded RCs and 2) center-embedded RCs. A comparison of both types of RC positions is also made.

Relative clauses can be defined as dependent or subordinate clauses usually introduced by a relative marker. Such clauses are used to add information to or modify a noun phrase. RCs are formed differently in different languages. Since the

target morphosyntactic feature, i.e., present tense morphology *-s*, is investigated under syntactically complex constructions, it is worth describing similarities and differences between ERCs and Thai RCs. 2.2.3.1 and 2.2.3.2 provide descriptions of ERCs and Thai RCs, respectively.

### 2.2.3.1 Relative clause constructions in English

English relative clauses (ERCs) are subordinate clauses used to postmodify a noun phrase and give additional information to it. In English, an ERC follows its head noun, and in terms of branching, ERCs are considered head-initial. ERCs are among those syntactically complex constructions having been widely investigated and used as stimuli to investigate comprehension and production problems among nonnative English speakers (e.g., Amornwongpeeti & Pongpairoj, 2014; Kaan et al., 2015; Phoocharoensil, 2009; Rattanasak & Phoocharoensil, 2014, among others). Since this study primarily aims at examining how L1 Thai learners process the L2 English 3S morpheme in ERCs, the relevant target structures can be illustrated using the classic hypothesis associated with difficulty in a human's perception and RC formations. The hypothesis is known as the Perceptual Difficulty Hypothesis (PDH), which was formulated by Kuno (1974). As an illustration, consider the following embedding positions of ERCs as posited by the PDH.

- (14) a. SS<sup>3</sup>            The student *who sits in the library every day* works very hard.  
       b. SO             The man *who my brother sees at the club* wants to meet you.

---

<sup>3</sup> The first letter represents a grammatical function of a head noun, and the second letter means the grammatical function of the relativized noun within an ERC,—S denotes a subject function, while O signifies an object function. According to the PDH, object-modifying RCs, i.e., OS and OO tend to put L2 learners at greater ease than subject-modifying RCs, i.e., SS and SO. More precisely, SS and SO types are regarded as more perceptually difficult to process and acquire than OS and OO, respectively (Kuno, 1974).

- c. OS            The teacher knows the student *who plays the violin very well*.
- d. OO            The boy likes the girl *who he sees in the park every morning*.

The examples demonstrated here are each type of the relativized nouns or extractions, i.e., subject-extraction in (14a) and (14c) and object-extraction in (14b) and (14d). The positions an RC modifies are also illustrated, i.e., center-embedding or subject-modifying ERCs in (14a) and (14b) and right-embedding or object-modifying ERCs in (14c) and (14d). As regards the processing of the subject-extracted and object-extracted ERCs, see 2.2.5.1.

In relation to the limited capacity of a human's memory, PDH can be viewed as a concept which illustrates how delimitation in human temporary memory has an influence on sentence processing. Kuno (1974) suggested that a sentence with an RC inserted into the matrix clause to modify a subject is usually regarded as more perceptually complex to process. This is mainly due to the fact that the RC may interrupt the processing of the sentence. In other words, subject-modifying ERCs would presumably be more difficult to process (Just & Carpenter, 1992) and acquire than object-modifying ERCs since the embedded clause sets apart the subject NP and its verb in the matrix clause.

### **2.2.3.2 Relative clause constructions in Thai**

In Thai, RC constructions are similar to those of English. A Thai RC is a subordinate clause introduced by an RC marker and used to postmodify a head noun phrase or an antecedent (Iwasaki & Ingkaphirom, 2005). In terms of branching, like ERCs, Thai RCs are head-initial. More specifically, Thai RC markers include “thîi”, “sîŋ”, “?an”, “phûusîŋ”, and “phûuthîi” and the like. Even though

various forms of Thai RC markers can be used, “thîi”, “sîŋ”, and “ʔan” appear to be the major RC markers and are more ubiquitous in Thai RC constructions. There are three types of Thai RCs based on the three RC markers as shown in (15), (16), and (17) (Yaowapat & Prasithrathsint, 2009).

(15) mêe [thîi yùu chianmày] sàʔbaay dii máy

mother REL stay Chiangmai fine good Q

“Is (your) mother who lives in Chiangmai fine?”

(Yaowapat & Prasithrathsint, 2009, p. 11)

(16) khǎw tŏŋkaan khon [sîŋ mii prǎʔsòpkaan]

3SG want person REL have experience

“He/She wants (to get) a person who has experience.”

(Yaowapat & Prasithrathsint, 2009, p. 11)

(17) nîi pen raanwan [ʔan yîŋyà y thîisùt nay chiiwít]

this COP prize/reward REL big/great superlatively in life

“This is the prize which is the biggest in (my) life.”

(Yaowapat & Prasithrathsint, 2009, p. 11)

In (15), the relativizer “thîi” can be used to modify both human and non-human head nouns in any grammatical functions they have (Suktrakul, 1975). While the relative marker “thîi” tends to appear in a variety of registers of discourse, “sîŋ” in

(16) can be found more in a formal register of both written and spoken forms, and “?an” in (17) is mainly used in the literary style (Iwasaki & Ingkaphirom, 2005).

With reference to Iwasaki and Ingkaphirom (2005), Thai RC functions can be categorized into two types, i.e., subject-relative and object-relative, similar to the subject-extracted and object-extracted RCs that exist in English (Gass, 1979). The subject-relative type modifies the head noun phrase functioning as a subject of the verb in the RC, as illustrated in (18), while the object-relative type which serves to describe the head noun that functions as an object of the verb in the RC, as shown in (19).

(18) Subject relative

èk pen dèk [thîi rian kèn]

(name) copula child SBR study well

“Ek is a child who studies well.”

(Iwasaki & Ingkaphirom, 2005, p. 250)

(19) Object relative

nîi khuu panhãa [thîi kháv mii kan yuu]

this copula problem SBR 3SG have REC stay

“This is the problem that they have now.”

(Iwasaki & Ingkaphirom, 2005, p. 246)

The relative marker “thîi” “who” in (18) modifies its antecedent, “dèk” “a child”. This type of RC is referred to as subject-relative because the noun phrase “dèk” serves as the subject of the verb “rian” “studies”. In (19), the RC marker “thîi” “that” modifies the head noun phrase “panhãa” “problem”; therefore, it is an object-



relative type since the noun phrase “panhăa” serves as an object of the verb “mii” “have” in the RC (Iwasaki & Ingkaphirom, 2005, p. 243).

In sum, Thai RC constructions are similar to those of English in terms of the grammatical functions of the relativized or extracted materials within an RC. That is, like ERCs, Thai RCs have both subject-extracted and object-extracted constructions. In addition, Thai RCs can be used to modify various positions of the antecedents in the matrix clause, including subject-modifying (center-embedded) and object-modifying (right-embedded) positions (Suktrakul, 1975).

Since equivalent RC constructions can be found in both English and Thai, ERCs seem appropriate for uses in the experiment as the present study assumes that other relevant constructions in the formation of RCs are comparable in both the learners’ L1 Thai and L2 English. The ERC constructions merely serve to pose varying degrees of structural complexity of the sentences. In this respect, the incongruence of the target 3S present tense morphology, a linguistic feature licensed differently in Thai and English, is the only primary concern to be examined during the L2 sentence processing. Next, 2.2.4 describes the processing of verbal agreement morphology in English. Now that the descriptions of both ERC and Thai RC constructions are provided, 2.2.5 discusses how ERCs and Thai RCs are processed and what strategies can be used in the processing of these complex constructions.

#### **2.2.4 The processing of verbal agreement morphology in English**

Influenced by the emergentist perspective, O’Grady (2005) proposed that the processing mechanisms of verbal agreement in English subject-verb concords can be explained by the computational system rather than a rule-based one. Long-term

memory (LTM) models are exploited to explain such processing phenomena. To be specific, LTM is assumed to consist of two major types: 1) *declarative* or explicit memory and 2) *procedural* or implicit memory (Ullman, 2001). On the one hand, the declarative memory mainly deals with learning and information storage of lexicon. This includes its meaning, pronunciation, and use. This type of memory is hypothesized to be conscious, which means it is used when the speaker has awareness of its use. To exemplify, the declarative memory facilitates when we try to recall the word “people”, which is invariably plural (O'Grady, 2006). On the other hand, the procedural memory primarily supports learning and computational operations in a wide variety of cognitive skills, particularly those that involve procedures or sequences, such as solving math problems. In relation to language processing, O'Grady (2006) suggests that it is the procedural memory that subserves the processing of various linguistic aspects, including phonology, morphology, non-lexical semantics, and syntax. The procedural memory is assumed to be unconscious, which means it comes into play without the speaker's awareness of what features are available for forming or interpreting a sentence. The processing of English 3S agreement morphology is a case that supports this notion well.

The internal structure or inflection of the English 3S morpheme *-s* is in part problematic due to lack of salience or saliency effects. When compared to other types of inflections, such as the inflection for progressive aspect *-ing*, the 3S morpheme *-s* is considered comparatively low in perceptual salience (O'Grady, 2006). Since salience appears to facilitate the acquisition of morphology (Simoens et al., 2018), this important factor should be taken into account when dealing with different types of inflectional suffixes. Nevertheless, apart from salience, the complexity of inflection

per se seems to be one of the major factors influencing the processing and use.

It has been pointed out in L2A literature that despite L2 learners' ability to demonstrate their knowledge of English 3S agreement morphology through an offline task, it is inherently challenging for them to process this type of inflection in their real-time processing. In this regard, verbal agreement morphology in English can be explained in light of the procedural approach to agreement, which assumes that resources are drawn from the procedural memory. According to O'Grady (2005, 2006), English verbal agreement involves both lexical and computational factors interacting during the processing. To elaborate, in a linear order from left to right, the lexical item, or the first argument of the verb, brings about an agreement dependency<sup>4</sup>. Two important features a nominal is assumed to possess are person and number features, also known as basic features. An agreement dependency involves person and number features and can be resolved if the first argument features provided by a nominal match with the dependent features (person and number features) of the verbs. These dependent features are in both regular and irregular verbs. For example, in the case of irregular verbs, "am" satisfies the agreement dependency when its first argument is a first-person singular. Similarly, "has" creates an opportunity to resolve dependency when its subjective argument is a third-person singular. Figure 6 is the representation of this notion.

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<sup>4</sup> Morphological dependencies and syntactic dependencies are subsumed under the notion of dependency grammar (Polguère & Mel'čuk, 2009). In brief, dependency grammar, as opposed to generative grammar (Chomsky, 1986) due its lack of phrasal nodes, assumes the dependency relation instead of the relation of a phrase structure. Agreement dependency is a manifestation of morphological dependencies. For instance, agreement dependencies can be observed between words or parts of words. That is, when a given word in an utterance, e.g., a subject argument, influences how another word is formed, e.g., a verb, it can be viewed that, in this case, the verb is assumed to morphologically depend on the subject (Polguère & Mel'čuk, 2009).



Figure 6: The representation of the dependent features of English number agreement (O'Grady, 2005, p. 92)

Furthermore, in the more ubiquitous cases of regular verbs, an inflectional system of *-s* verb suffix is employed. The *-s* verb suffix is attached to a verb with a third-person singular subject argument, and the  $-\emptyset$  suffix is used for all other types of arguments. As for the internal structures of the verbs when suffixed with *-s*, the suffixation effects are depicted below.

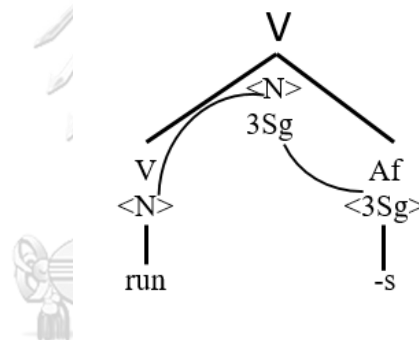


Figure 7: The internal structures of present tense verbs (O'Grady, 2005, p. 93)

As illustrated here, the verb “runs” here shows its finite form deriving its argument feature, i.e., number, from the stem “run” and its agreement feature, i.e., third-person singular, through *-s* suffixation. Now that the internal structures of the finite verb in the present tense verbal agreement have been described, it is useful to observe how the agreement dependency functions. To illustrate, consider (20), Figure 8, and Figure 9. The combination of the subjective argument “Harvey” and the thematic verb “runs” generates an opportunity for agreement dependency to be resolved.

(20) “Harvey run-s fast.”

(O'Grady, 2005, p. 94)

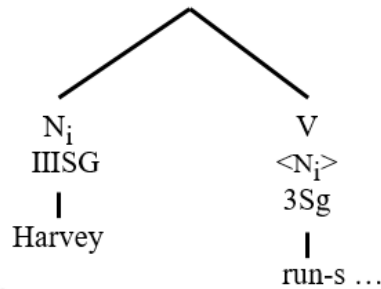


Figure 8: Combination leading to resolution of the verb's argument dependency

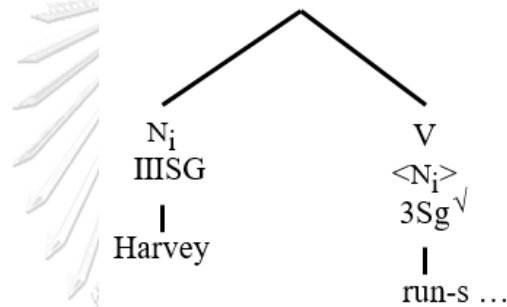


Figure 9: Resolution of the agreement dependency

(O'Grady, 2005, p. 94)

Under this assumption of agreement dependency, first, the verb must combine with the argument. Simply put, the agreement dependency can be successfully resolved only when a feature-bearing nominal is encountered. In this example, the verb “runs” combines with the nominal “Harvey”, which carries number and person features, thereby resolving the argument dependency. It is only at this point of time that the person and number features are made available to create an opportunity to resolve the agreement dependency of the third-person singular verb “runs”, which matches with the basic features, i.e., number and person, that the nominal “Harvey” carries (O'Grady, 2005, p. 94).

With respect to the acquisition of agreement morphology, a procedural approach to agreement seems to fit the computational operations in real-time processing as the learners spontaneously resolve agreement dependency during the time at which a combination between a finite verb and its subjective nominal argument is created. This processing mechanism is believed to be manipulated by the procedural memory in an unconscious manner, being automatized without awareness (O'Grady, 2006).

Furthermore, it has been pointed out that other factors may contribute to the computational operations of verbal agreement in English. The area of inflection difficulty may lie in age effects. With the assumption that agreement dependency is a procedural phenomenon, the resources offered by the procedural memory as well as the ability to use procedural memory for language computations and uses may decline as the learner's age increases (O'Grady, 2005; Ullman, 2001). This is unlike the declarative memory, which tends to improve as a child learns more vocabulary as they grow older. In addition to age effects, transfer in terms of processing may arise. L2 learners whose L1 instantiates verbal agreement may be more at ease as the computational routines in the processing of agreement are assumed to have been developed. That is to say, similar computational operations should yield facilitative effects when it comes to the processing in L2. Nevertheless, the absence of such a computational routine development in L1 may result in a delay in the development of the processing in L2. It is presumable this may trigger adult L2 learners to resort to their declarative memory, which may not be useful for the computational operations in L2 (O'Grady, 2006).

### **2.2.5 The processing of relative clauses in English and Thai**

Understanding the processing mechanisms involved in the experimental sentences in both English and Thai is fundamental to the investigation of the present research. This will provide a baseline for the similarities and differences between the two language systems in the processing of ERCs and Thai RCs, which may contribute to the processing of the target 3S present tense morphology during real-time processing. 2.2.5.1 and 2.2.5.2 provide analyses of how ERCs and Thai RCs are processed, respectively.

#### **2.2.5.1 The processing of relative clauses in English**

Constructions of English relative clauses are complex in nature. To form an ERC, L2 learners may be faced with challenges regarding the structures when trying to achieve full mastery of ERCs. For instance, L2 learners need to take into consideration where to embed an ERC in a coreferential relationship with the head noun, which relative marker to select, and the internal structure of the ERCs (Larsen-Freeman & Celce-Murcia, 2015). This could be problematic for L2 learners since a verb phrase is obligatory in any English clause, and English is one of the languages rich in inflectional systems. In particular, the 3S morpheme *-s* in the present tense requires an explicit form of inflection to mark number agreement between the subject argument and its finite verb. This agreement morphology is required only when the subject argument is a third-person singular. ERCs with the present tense are no exception to this inflectional suffixation. Consider the example below, replicated as (21) where both verbs, one in the matrix clause and the other in the RC, inflect for the present tense with the 3S morpheme.

(21) The boy *likes* the girl who he *sees* in the park every morning.

Based on the emergentist perspective (see 2.1.3 for more details), O'Grady (2011) describes the processing of ERC structures with respect to clausal positions and distance factors which might lead to difficulty in the processing. Factors accounting for the processing and acquisition of RCs in languages with head-final and head-initial RCs have been proposed. In addition to a frequency-induced familiarity factor, two essential factors, i.e., salience or prominence, and distance factors, have been identified to play a crucial role in the processing of ERCs.

Salience, also referred to as prominence, is the salience effects of the relativized material within an ERC, i.e., the subject and object arguments being relativized (O'Grady, 2011). Referents of the relative clauses' subject are prone to be internally focused on since they are the most salient arguments. Thus, when the head NP corresponds to the relativized referent in the subject position of the relative clauses, the salient properties tend to be more prevalent in the subject argument. It has been put forward that the more salient the referent of the head noun within the relative clause, the more ease the processor will have in processing relative clauses.

The other factor concerns the distance between the filler, i.e., the head NP, and the gap, i.e., the relativized element. In the analysis of this factor, O'Grady (2011) demonstrates that the processing of ERCs may become more difficult if the length of the filler-gap dependency increases. Such a length refers to when each new discourse referent intervenes between the filler and the gap. To illustrate the two factors contributing to the complexity of the ERC sentence processing, consider (22) for the more salient subjective relative clause, i.e., a subject-extracted ERC.



(22) “the student that \_\_met the teacher”

(O'Grady, 2011, p. 19)

There is only one intervening element, “that”; however, it is not a new discourse referent between the filler and the gap, thus there is minimal cost to WM (O'Grady, 2011). Nonetheless, the difficulty of processing an ERC may increase when a new discourse referent is introduced, keeping more distance between the filler and the gap. Consider the less salient object-extracted ERC in (23).

(23) “the student that the teacher met \_\_”

(O'Grady, 2011, p. 19)

As can be clearly seen in (23), two new discourse referents “the teacher” and “met” are introduced between the filler and the gap, which is assumed to result in more cost to WM.

In sum, considering both factors together, it can be seen that the most salient subject-extracted RC is closer to the head noun while the less prominent object-extracted RC is more distant. Therefore, when focusing on factors contributing to the processing of ERCs, salience and distance factors need to be taken into consideration since ERC processing seems to involve the synergistic interaction between them. On this ground, it is presumable that RC constructions can be complex and problematic for L2 learners to process. With the effects of the complexity of ERCs described above, the target inflection of verb phrases in ERCs may be morphologically influenced. Problems concerning comprehension and production may arise given that processing a complex sentence requires more cognitive resources to construct a

syntactically target-like form with proper inflection, which, in the case of the present research, is not instantiated by the learners' L1.

### 2.2.5.2 The processing of relative clauses in Thai

In the traditional analysis of relativization strategies, the gap strategy, which is similarly used to form ERCs, can be demonstrated by a missing noun phrase within an RC coreferent with its head NP (Jenks, 2014; Kullavanijaya, 2010; Yaowapat & Prasithratsint, 2009). In Thai, RC formations with gaps seem to be the most dominant (Yaowapat & Prasithratsint, 2009). However, there is a different point of view in which the so-called gap is analyzed as a zero pronoun, suggesting that Thai RC formation may not be explained by such a relativization process (Comrie, 1996) but by replacement of a noun in an RC with a zero pronoun. Comrie's view accounts for overt reference retrievable from the context surrounding a head noun that causes the noun in an RC to be dropped, a characteristic of pro-drop languages (Siriwittayakorn, 2018). As an illustration, (24) shows how a gap strategy/zero pronoun as a relativization strategy is analyzed in Thai RC formation.

- (24)   phîen thî: [∅   cà?   pāi rīen tò:       tàngprà?thê:t]  
           friend that       modal go study continue abroad  
           “the friend that will continue his study abroad”

(Siriwittayakorn, 2018, p. 183)

In regard to Thai RC constructions, Yaowapat (2005) offers an alternative analysis of pronoun retention strategy, stating that “the resumptive pronouns can occur if the relativized noun phrase is any of subject, direct object, indirect object, or possessor” (p. 129). Pronoun retention strategy can also be found in the formation of

Thai RCs. Different from that of ERCs, this strategy allows a resumptive pronoun to occur, replacing the noun that is coreferent with the modified head NP (Kullavanijaya, 2010; Yaowapat, 2005; Yaowapat & Prasithratsint, 2009). The pronoun retention strategy of Thai RC formation is illustrated in (25).

- (25)           phîən thî: [khǎw cà?   pāi rīən   tò:           təŋprà?thê:t]  
                   friend that he       modal go study continue abroad  
                   “the friend that will continue his study abroad”

(Siriwittayakorn, 2018, p. 183)

Although previous linguistic analyses have shown the inconclusiveness of the strategies employed to form Thai RCs, especially the gap and zero pronoun strategies, the present investigation follows the notion of gap strategy. This is mainly because it tends to closely approximate the filler-gap dependency suggested by the emergentist view of how ERCs are processed. As seen from the examples, the gap strategy is seemingly similar to that used in processing ERCs. In this regard, such a processing strategy does not seem to differ radically between the L1 Thai and L2 English. Given the similarities in the RC formation in both languages, it is possible that factors relevant to processing differences between the Thai and English RCs should minimally affect the processing of the 3S morphology within ERC sentences.

In summary, based on the body of knowledge provided by these linguistic theories and analyses, the manipulations of materials and designs for the present experiments took into account factors that might potentially influence or bias the results, especially those involving typological differences between L1 Thai and L2 English in terms of both the structures and processing of the present tense

morphology and ERCs. Table 3 below summarizes the crosslinguistic differences involving the structures utilized as experimental materials in this study.

Table 3 Crosslinguistic differences involved in experimental stimuli between Thai and English

	Thai	English
Basic word order	SVO	SVO
Center-embedded relative clause position	Yes	Yes
Subject- and object-extracted relative clauses	Yes	Yes
Relative clause marker for both animacy and inanimacy	Yes ( <i>thii</i> )	Yes ( <i>that</i> )
Subject-verb agreement	No	Yes

### 2.3 Previous studies on L2 sentence processing

In order to identify the research gap in the realms of L2 sentence processing inquiry, previous research is reviewed. Three specific areas concerning the present investigation, namely WM and L2 processing, L1-L2 structural competition and L2 processing, and English agreement morphology and L2 processing, are reported in 2.3.1, 2.3.2, and 2.3.3, respectively.

#### 2.3.1 Previous studies on working memory and L2 processing

With reference to the multi-component model of WM proposed by Baddeley (2010), the relationship between WM mechanisms and L2 sentence processing mainly subsumes two WM components, the executive function and the phonological loop (see 2.1.1.1.1 for more details) (Wen, 2012). Empirical L2 processing evidence has been found to account for several phenomena as the functions of the two WM components.

Just and Carpenter (1992) were the first to explore and integrate the notion of the restricted cognitive resources of WM in the study of sentence processing in L1

English. The main purpose of the study was to investigate how WM capacity constrained comprehension with the main assumption being that the readers with lower a WM span would not be able to maintain the processing and storage capacities demanded by cognitive tasks as higher WM span readers. The cognitive task concerned sentence processing in their L1, English. In this research, WM was viewed as a single source model assumed to consist of two primary roles necessary for language comprehension, which are the processing and the storage. If a cognitive task causes the processing capacity to increase, the storage capacity is believed to be affected. This view is dissimilar to that of Baddeley and Hitch's (1974) multi-component model, which assumes there are different components that are responsible for processing and storing different types of information during the execution of cognitive tasks, e.g., the phonological loop for verbal information processing, and the visuospatial sketchpad for visual and spatial information (Baddeley, 2000). Just and Carpenter (1992) referred to WM capacity in their constraint capacity model as the amount of "activation" made available by an individual in order to be shared between the processing capacity and the storage capacity. It was proposed that individuals vary in the amount of activation required to meet the demands of the computation and storage, which is required for language comprehension. The capacity constraint model predicted that "when the task demands exceed the available resources, both storage and computational functions are degraded" (Just & Carpenter, 1992, p. 124). The analysis on syntactic complexity as related to WM capacity constraints offered empirical evidence based on RT data which showed that different degrees of structural complexity influenced sentence processing. That is, subjective ERCs were read faster than objective ERCs. The findings showed that the participants took longer

to read the main verbs in objective ERCs, e.g., “The reporter that the senator attacked admitted the error.” than those in subjective ERCs, e.g., “The reporter that attacked the senator admitted the error.” To be specific, when compared to the mid and high WM-span readers, the low WM-span readers read longer at the point of difficulty of the ERCs, i.e., the verb “admitted”. The objective ERCs, overall, tended to pose greater difficulty than the subject relative clauses for the readers with different capacities, the high, mid, and low WM-span groups, respectively (Just & Carpenter, 1992, p. 130). Since the longer RTs were observed only when the participants processed the more complex sentence structures with the objective relative clauses, speed of lexical access could not be deemed responsible for this occurrence as the lexical uses in the experimental sentences were identical. In addition, a statement verification subtask was employed to investigate the participants’ comprehension. The sentence “The senator admitted the error.” followed each experimental sentence, and the participants were asked to verify whether it was correct according to the sentence they read. The results indicated that the low WM-span readers were less accurate in their comprehension. In this regard, the limited pool of cognitive resources, WM capacity, was suggested to account for this phenomenon.

Juffs (2004) investigated the effects of the garden-path in L2 sentence processing. The study concentrated primarily on the learners’ linguistic competence and the influence of WM capacity of individual learners in the L2 sentence processing in their parsing performance. This research was conducted on L2 learners of English from various L1 backgrounds: 30 Chinese-speaking learners, 28 Japanese-speaking learners, and 46 Spanish-speaking learners. A group of 21 native speakers of English participated as control. A reading span test in the participants’ L1 and a word-span

test in their L1 and L2 were adopted to measure each participant's WM capacity. The L2 participants were tested on their English proficiency using the Michigan Test of ESL. The main research instruments used to reveal their parsing performance were an SPR task and a grammaticality judgment task in a moving window procedure. The participants read each sentence word by word non-cumulatively at their own pace, and they were then asked to judge whether the sentences were possible in English once the last word of each sentence disappeared. The findings in terms of accuracy revealed that although the L2 learners processed garden-path sentences more slowly—showing much difficulty in their processing load, they processed the sentences in a similar way to how native speakers did, such as in “After the children cleaned the house looked very neat and tidy.” To illustrate, despite having pro-drop languages as their L1s, they seemed to have awareness of a required overt subject in L2 English. The verb “looked” in the sentence served as a critical region and was expected to demand a high processing load with potentially longer RTs since the participants had to determine who was doing what to whom in the sentence. Juffs' work raised an important point regarding the types of WM capacity measures that should be accounted for in research involving individuals' WM capacity. In his analysis of the learners' WM capacity measured by a reading span test, a weak correlation was found to be the cause of individual variation in their L2 sentence processing. It was, however, indicated that a word span test may be a better WM capacity measure when used to predict L2 learners' sentence processing. L2 learners whose word span was larger tended to be more able to accumulate chunks of information for internal analysis, resulting in their better parsing performance during the online processing task. That is, the L2 learners with lower word spans took a

longer time in their sentence processing to resolve and reanalyze sentences such as those with garden-path effects as compared to ones with higher word span.

Rungrojsuwan (2007) investigated 18 L1 Thai learners with different levels of L2 English proficiency and their language processing in relation to short-term and long-term memory. The learners were divided into two groups: low- and high-proficiency groups. The data were elicited through a simple text copying task which was assumed to reflect how the learners processed the information. The subjects were asked to perform the task by reading and memorizing the original text consisting of 55 words, and writing it on a piece of paper. Their performance in chunking information was analyzed based on the pause defined unit (Luksaneeyanawin, 1988). The results showed that despite the underspecified categories of verbal inflections in their L1, the Thai learners were seen to have stored knowledge of English morphology in the LTM. To be more precise, the low proficiency group tended to divide the target language structures into smaller chunks in a higher number than did the high proficiency one. More pauses within words and between word boundaries were more frequently found in the low-proficiency learners, whereas the learners with higher proficiency tended to have more pauses between syntactic boundaries, i.e., between phrases and sentences. In this regard, L2 proficiency plays an important role. It was proposed that repetition in such a task might help the learners to better observe, recognize, and finally store the morphological knowledge in their long term memory.

In line with this study, Rungrojsuwan (2015) further examined morphological processing difficulty among L1 Thai learners of L2 English. Error identification test and memory retrieving test were employed. It was found that higher-proficiency



learners tended to incorrectly omit and add inflectional morphemes, suggesting that they could relate the input with their morphological knowledge in their LTM but might not have fully acquired them. It was also found the high-proficiency learners could retrieve the whole target sentences correctly, which indicates they could process the input in their WM and were able to match it with their morphological knowledge in their LTM. The low-proficiency ones, however, showed partial retrievability, suggesting their memory spans were limited.

Keating (2009) showed that distance between the agreement source and agreement target affected L2 learners' processing of gender agreement. His investigation involved L1 English speakers of L2 Spanish at three different proficiency levels, using eye-movement experiments. Three types of gender agreement distance were employed: within the same determiner phrase, verb phrase and complementizer phrase of the noun. The experimental sentences are illustrated below.

(26) a. Una *casa pequeña* cuesta mucho en San Francisco.

“A small house costs a lot in San Francisco.”

b. La *casa* es bastante *pequeña* y necesita muchas reparaciones.

“The house is quite small and needs a lot of repairs.”

c. Una *casa* cuesta menos si es *pequeña* y necesita reparaciones.

“A house costs less if it is small and needs repairs.”

(Keating, 2009, pp. 505-506)

The results indicated that only the learners at the advanced level, similar to the native speakers, showed sensitivity to agreement violation on adjectives that were within the determiner phrase as in (26a). They, however, did not show sensitivity to violations in the other two distance types, which were more distant. This suggested that L2 learners at the advanced level were able to acquire L2 gender agreement, while the beginning and intermediate learners were not. Nevertheless, distance played an important role in their L2 agreement processing. Such non-native sensitivity was ascribed to processing deficit, which may be rooted in the lack of cognitive resources necessary for holding L2 gender information long enough in WM, particularly in the long-distance agreement processing.

Expanding on the work of Keating (2009), Keating (2010) examined the processing of noun-adjective gender agreement by L1 English speakers of L2 Spanish, placing an emphasis on the learners' WM capacity, which was not tested in Keating's (2009) study, and linear distance. A total of 18 native speakers of Spanish and 13 advanced L1-English learners of L2 Spanish participated in this eye-tracking investigation. They read a total of 48 sentences with gender agreement manipulated in three distance conditions. Measured by the raw number of words, the linear distance was manipulated in three conditions: one-word, four-word, and seven-word distance from a controller noun. Prepositional phrases were used to separate the agreement concord: one prepositional phrase in the four-word condition and two prepositional phrases in the seven-word condition, keeping the structural distance, determined by the number of nodes, constant. That is, the structural distance is invariably one verb phrase node. The stimuli are illustrated below.

## (27) a. One word

La tienda está abierta/\*abierto los sábados y domingos por la tarde.  
 “The store is open Saturdays and Sundays in the afternoon.”

## b. Four words

La mochila de la estudiante está llena/\*lleno de libros de texto.  
 “The backpack of the girl is filled with textbooks.”

## c. Seven words

La falda en la tienda de ropa femenina es roja/\*rojo y viene de Italia.  
 “The skirt in the store of women’s clothing is red and comes from Italy.”

(Keating, 2010, p. 119)

A reading span task in the participants’ L1 was used as a WM measure. It was found that the native speakers were sensitive to one-word and four-word distance agreement violations with early effects detected in their first pass reading. The learners’ sensitivity was also found, but this was later in the second pass reading. Their sensitivity to gender agreement violation was observed only in the one-word distance condition. The findings suggested distance modulated both NSs’ and NNSs’ sensitivity to morphosyntactic violation. The results which showed that the NSs were not sensitive to seven-word distance agreement violations hinted that shallow processing can be induced not only by NNSs. According to the Shallow Structure Hypothesis (Clahsen & Felser, 2006), it is assumed that non-native syntactic computations are less detailed when compared with those of NSs, and the morphosyntactic processing by NNSs is limited to local domains (i.e., closely adjacent agreement). This can be explained by the relationship between grammar and parser. The NSs’ full parsing is assumed to be guided by the grammar, but the NNSs’ shallow parsing is guided, for example, by lexical-semantics and pragmatics. Nevertheless, Keating’s (2010) findings suggested that the seven-word distance

agreement processing could also induce shallow processing of a morphosyntactic feature among the NSs. With regard to individual differences in terms of cognitive capacity, a positive correlation between reading span and the native-like processing, particularly in one-word and four-word distance conditions, suggested that the difficulties the learners experienced may stem from the limited pool of cognitive resources rather than their L2 representational deficits.

Dussias and Piñar (2010) investigated the role of WM on parsing L2 English sentences with filler-gap dependency, wh-subject and wh-object extraction interrogative structures. L1 Chinese and native speakers of English participated in the experiments. Both groups were divided into high WM-span and low WM-span groups by means of their WM capacity scores. A reading span test consisting of 80 sentences was employed to assess the participants' WM capacity. This test consisted of sets of two-six sentences, requiring the participants to read the sentences, making judgments on their semantic plausibility and grammaticality, remembering and recalling the last word of each sentence in the given order. The accuracy scores were considered as a measure of their WM capacity, which reflected their cognitive resources. The experimental instrument adopted to examine the participants' performance in parsing was a non-cumulative word-by-word reading task with the moving-window technique alongside the grammaticality judgment on long-distance wh-extraction questions constructed in L2 English. The stimuli used in this research were sentences with different subject-extracted elements in the semantically plausible condition—with plausible wh-filler for the main verb, and the implausible condition—with implausible wh-filler for the main verb, e.g., “Who did the police know killed the pedestrian?” and “Who did the police declare killed the pedestrian?”, respectively. The same conditions

applied to the stimuli with object-extracted elements in semantically plausible and implausible conditions, e.g., “Who did the police know the pedestrian killed?” and “Who did the police declare the pedestrian killed?”, respectively. RTs in the moving-window reading task were recorded to reveal how the participants used plausibility information in parsing performance as compared to native speakers. The results showed that only participants with high WM capacity, based on their reading span capacity, could show they were able to sufficiently allocate their cognitive resources to perform the complex parsing task in their reading comprehension, processing L2 sentences by using plausibility information in an incremental way like L1 English monolinguals could. That is, they had longer RTs for subject-extraction sentences than for object-extraction ones across both plausible and implausible conditions, and plausibility effects were shown only for subject-extraction sentences.

Sagarra and Herschensohn (2010) carried out research based on the generative approach to L2A, attempting to establish evidence to indicate whether late L2 learners can develop their processing patterns in a way similar to native speakers. The emphases of this research were placed on the role of age of acquisition and that of language proficiency and WM in gender and number agreement processing by L2 learners with an ungendered language background, i.e., English. The learners’ sensitivity to morphosyntactic violations by L1 and L2 Spanish speakers was examined in relation to their L2 proficiency and WM capacity. The participants were L1 English-speaking adult learners of L2 Spanish with different proficiencies: 69 beginning learners, 64 intermediate learners, and 63 Spanish monolinguals. All L2 learners began their Spanish learning after puberty. Two research instruments aiming to address the dual qualities of linguistic competence, which are the learners’

knowledge of grammar and how they implement it in their real-time processing, were used; therefore, both offline and online processing tasks were employed in the experiment, namely, a grammaticality judgment task and a non-cumulative word-by-word SPR task, respectively. The stimuli used in the experiments were sentences with grammatical agreement and disagreement of gender number. The learners' WM capacity was measured using a reading span test in L1 Spanish, which asked them to read plausible and implausible sentences. After reading, in each set of the sentences, the participants indicated the plausibility of the sentences and remembered the last word of each sentence for a recall. The findings showed that all research participants performed with high accuracy in the offline grammaticality judgment task, whereas in the online processing task, only intermediate L2 Spanish learners and native speakers of Spanish demonstrated their sensitivity to gender and number agreement violations. It was also found that intermediate L2 Spanish learners tended to show greater accuracy in performing some comprehension questions presented to them after each sentence in the SPR task. In this regard, WM was found to account for the phenomenon since this occurred to only intermediate L2 learners of Spanish with higher WM capacity. As the results showed, this research suggested late L2 learners were able to develop native-like processing patterns, and this could be attributed to the increase in L2 proficiency as well as the learners' WM capacity, which plays an important role in L2A.

Footnote (2011) conducted a research study on nonnative speakers' sensitivity to morphosyntactic violations, including WM capacity as a determinant in her study. The participants in this investigation were 40 English-Spanish bilinguals: 20 early and two late L1 English learners of L2 Spanish. Moreover, a group of 20 native speakers

of Spanish also participated in the experiment. A reading span task in Spanish, which was adapted from Waters and Caplan (1996), was employed to determine the participants' WM capacity. In the experiment, English-Spanish bilinguals were tested on their performance in an SPR task, reading Spanish sentences with or without number agreement or gender agreement errors. A total of 128 sentences were used as stimuli. There were 32 Spanish sentences containing subject-verb number agreement errors and another 32 sentences with noun-adjective gender agreement errors. In the experimental materials, two distance conditions were manipulated: 1) the agreement source and the agreement target were adjacent, and 2) the agreement source and the agreement target were separated by intervening material, i.e., a prepositional phrase. An example of a number agreement error with adjacent agreement source and target is “\*Veo que tu *padre son* de Texas”, which is equivalent to an English sentence “\*I see that your *father are* from Texas.” To illustrate, the noun “*padre*”, which means “father”, was used as an agreement source, and a copula “*son*”, which means “are”, was used as an agreement target, showing number disagreement in the position adjacent to the noun. The second condition characterized distant number agreement errors, as shown in “\*El *reloj del hombre son* de Suiza”, which means “The watch of the man is from Switzerland.” The noun “*reloj*”, which means “watch”, was used as an agreement source, and a copula “*son*”, which means “are”, was used as an agreement target. In this second condition, as the example showed, they were intervened by a prepositional phrase “*del hombre*”, which means “of the man”. These two conditions were applied to the stimuli regarding noun-adjective gender agreement errors. The results from the RT data showed that all three groups of participants displayed sensitivity to subject-verb number agreement and noun-adjective gender

agreement violations in L2 Spanish by reading ungrammatical sentences containing agreement violations more slowly. It was, however, found in the late bilingual group that the adjacent target constructions resulted in greater sensitivity when compared with those agreement constructions that were separated by intervening material. Concerning WM capacity, the results showed that no association between the research participants' WM capacity and their L2 sentence processing was found in both subject-verb number agreement and noun-adjective gender agreement. WM capacity could not be accounted for as the findings showed; however, the distance of disagreement errors presented by the stimuli might be attributed to the phenomena since the results showed that the late bilingual participants showed sensitivity to the morphosyntactic violations in relation to the distance of disagreement errors.

Coughlin and Tremblay (2013) placed an emphasis on the effects of WM capacity and L2 proficiency in L2 sentence processing. They particularly examined sensitivity to grammatical violations in the processing of short- and long-distance number agreement by L1 English learners of L2 French. The participants were 52 adult L2 French learners whose native language is English. In addition, 16 native French speakers served as controls in the study. The participants' L2 French proficiency was determined by a cloze test, and they were divided into middle-level and high-level proficiency groups, each of which consisted of 26 participants. The participants' WM capacity was measured both in their L1 English and L2 French. The two main research instruments involved in the experiment were an acceptability judgment task and an SPR task. The acceptability task revealed that both groups showed sensitivity to the number agreement violations. However, it was found in the SPR task that only the high-level proficiency learners were sensitive to such



ungrammaticality. Based on the short- and long-distance agreement dependencies, only the learners with high proficiency showed sensitivity to both close and distant number agreement constructions in the online task. The findings indicated that there was a weak relationship between the learners' WM capacity and their sensitivity to the number agreement violations. In L2 morphological processing, the learners' WM capacity and L2 proficiency should be taken into account as they could have influence on the L2 learners' sensitivity to agreement morphology.

Suda (2015) investigated asymmetries in online sentence comprehension of SRCs and ORCs by Japanese learners of English. The learners' individual differences in terms of L2 English proficiency, i.e., intermediate and elementary, and WM capacity were examined in relation to their ability to comprehend the complex constructions of ERCs. The RT data from self-paced reading revealed that the learners found object RCs with animate antecedents more difficult to process and comprehend. In addition, the learners with a larger pool of cognitive capacity appeared to show advantages in their processing, reading the embedded verbs faster than those with a smaller pool of cognitive capacity. In terms of SRC and ORC asymmetries, the learners took a shorter time to read the verb regions in the SRCs than in the ORCs. This study suggested that WM capacity facilitated L2 sentence comprehension processes, which was consistent with previous findings on L1 online sentence comprehension of SRCs and ORCs (e.g., Just & Carpenter, 1992; King & Just, 1991), whose findings from self-paced reading also demonstrated that L1 English participants tended to need longer RTs to process the ORCs than the SRCs. The phenomena suggested that the English ORCs were more difficult to process than the

SRCs. These findings provided essential evidence to support the manipulations of the stimuli of the present study.

In psycholinguistic inquiry, time-sensitive techniques, such as self-paced reading and eye-tracking, are usually employed as they can effectively provide behavioral-based evidence that is observable and relevant to language processing. In the neurolinguistics realm of L2 morphological processing, an online event-related (brain) potentials (ERP) technique is commonly used. According to Reichle et al. (2016), in brief, ERP measures electrical activity of the brain through a link between the presentation of a stimulus and electroencephalographic data (EEG). EEG data, measurements of voltage resulting from the firing of many neurons, are obtained from electrodes placed on a participant's scalp while they performed cognitive processing tasks. Three important language-related ERP effects are N400 (negative increase of voltage 400 milliseconds (ms) after the stimulus presentation, for semantic or lexical violations), P600 (positive increase of voltage 600 ms after the stimulus presentation, for morphosyntactic violations), and LAN (left anterior negativity between 150 and 500 ms after the stimulus presentation, reflecting automatic response to morphosyntactic violations). In a more recent study by Reichle et al. (2016), it was found that L1 English learners of L2 French showed effects of the WM capacity in their L1 on their L2 processing of subject-verb agreement. Their WM capacity was measured by an RSPAN task in their L1 and L2, and their L2 proficiency was measured by a cloze test. In two experimental sessions, they were asked to read L2 French and L1 English sentences with subject-verb agreement violations manipulated by short- and long-distance agreement dependencies. The sentences were followed by true/false comprehension questions in some items (25% of all experimental items).

The results showed that, in short-distance agreement dependencies, P600 effects were found in L1 English agreement violations, whereas N400 effects were observed in response to agreement violations in L2 French. Only one participant, who might have been under the development of native-like L2 short-distance agreement morphology processing, from 12 participants showed P600 effects. The lack of P600 effects in L2 French agreement morphology processing may be ascribed mainly to the limited L2 proficiency and the nature of the following comprehension questions subtask (as compared to when sentences are accompanied with an acceptability judgment task for every item). The findings supported WM capacity, as measured in L1 English, could better serve as a predictor of ERPs than WM capacity measured in L2. In this regard, the computational resources, i.e., WM capacity, could be used to account for the N400 effects in L2 French sensitivity to agreement morphology violations as a factor modulating L2 morphological processing. In the computation of subject-verb agreement morphology, access to cognitive resources, i.e., WM capacity, explained the difference in phenomena between L1 and L2 processing. With respect to the ERP technique, robust L2 processing evidence has been revealed and added to the body of knowledge relevant to L2 agreement morphology processing.

Kim and Christianson (2017) conducted research on working memory capacity affecting the systems of L1 and L2 processing in ambiguous structures of relative clauses (RCs). Two linguistic factors predicted to modulate processing difficulty in this study were 1) the RC modifying positions, i.e., subjective and objective RCs, and 2) the referential loads featured by full noun phrases, i.e., “the + noun”, such as “the witness” (high referential load) or a pronoun, such as “me” (low referential load) as shown below. These four conditions were used across the

experimental stimuli. Globally ambiguous RC constructions, which are those that cannot be disambiguated by the end of the sentence as opposed to the temporarily ambiguous structures which have one single correct interpretation, were used in the experiments, for example, a subject-modifying RC construction with high referential load, “The lawyer of the client who insulted the witness during the trial was intelligent.” and an object-modifying RC construction with low referential load, “The judge rebuked the lawyer of the client who insulted me during the trial.” The participants were 34 advanced L1 Korean learners of L2 English. An SPR task followed by an RC paraphrase decision task was adopted. The learners’ RTs and response times were recorded. It was found that as the learners maintained the processing load, those with higher WM capacity showed their sensitivity to the ambiguity through slowdowns of their RTs at the critical region and longer response times in order to make a decision on the correct resolution to the globally ambiguous RC constructions. Furthermore, as regards the high processing difficulty of the RC modifying positions, there was an association between higher WM capacity and the more complex structures of the RC position, i.e., the subject modifying RCs.

Indrarathne and Kormos (2017) investigated attentional processing of L2 written input in association with WM in implicit and explicit instructional conditions. The main research aim was to examine the role of the central executive functions, one of the WM components in the multi-component WM model posited by Baddeley (2015) (see 2.1.1.1.1.1). The central executive was assumed to regulate attention paid to pertinent linguistic features while maintaining chunks of linguistic information for further processing in memory. A total of 80 L1 Sri Lankan undergraduate learners of L2 English participated in the experiments. Four WM tests were employed. First, the

forward digit-span test, which asked the participants to remember a series of numbers and recall them by writing them in the order presented, as opposed to the reverse one, was used to determine the participants' storage capacity of the participants' phonological STM. Second, the Keep Track task was used to assess the "updating function" of the central executive. It asked the participants to attend to relevant incoming information, delete irrelevant information, and recall the last words of the target categories, e.g., colors, animals, and countries, which were presented to them in L2 English. Third, the Stroop task, which asked the participants to perform an inhibition task concerning color reading interference, was adopted to measure the participants' RTs taken to show their inhibition of irrelevant information. Finally, there was the Plus Minus task, which involves numerical calculations. This task was employed to measure attentional shifting as the participants were provided with three lists of numbers and they were asked to either add or subtract the numbers as quickly and accurately as possible. The time the participants took to perform the task was measured to show their WM ability. In the experimental materials, the target syntactic construction was the use of an L2 English causative verb, i.e., "had", such as in "He had the house painted." The sentences with the target construction were presented to the participants in four conditions: 1) input flood, which featured an increase in the frequency of the target construction, 2) textual enhancement, which exhibited the highlighted target construction in the textual input, 3) an instruction, which aimed to have the participants pay attention to the highlighted target construction, and 4) a metalinguistic explanation of the highlighted target construction with an instruction to pay attention to it, which explicitly explained the target construction. The first two conditions were regarded as implicit, whereas the latter two were considered explicit.

Moreover, in order to assess the participants' comprehension and production, a sentence reconstruction task and a grammaticality judgment task were employed in the pre-test and posttest. In order to measure the participants' attentional processing, an eye-tracking technique was adopted to obtain total fixation duration as a dependent variable. The participants were divided into four experimental groups with 20 participants in each, and they took the pre-test. They then read three written texts in a series of sessions on the eye-tracker every other day. They were then asked to take the posttest and the four WM tests. The findings showed that the L2 learners who possessed higher WM abilities tended to show better learning of novel grammatical features presented to them in written input in both implicit and explicit instructional conditions. It was also found that WM abilities and the participants' gains in the receptive knowledge of the target construction were closely related in all conditions. While WM played a vital role in the acquisition of explicit knowledge through explicit instruction, a weak relationship was observed between WM abilities and the participants' productive knowledge, particularly in the implicit instructional conditions.

Zhou et al. (2017) carried out a study in an attempt to examine how WM capacity and differences in task types affected Chinese-English bilinguals' processing of L2 complex sentences. There were two experiments in this study. One was conducted with SPR followed by a grammaticality judgment task, and the other was carried out by using SPR followed by a translation task. Different task types were chosen in anticipation of different reading goals conceived of by the learners. The participants' WM capacity was measured by an operation span task in both experiments. This operation span task required the participants to perform a series of

math operations while remembering a set of English letters. This task was chosen instead of other WM span tests because it was believed to lessen the interaction effects between WM and L2 proficiency compared to when a measure based on verbal ability, such as a reading span task, was used. The primary data were the RTs and accuracy rates. WM capacity effects on L2 sentence processing was expected to be modulated by the two types of experimental tasks. The materials were L2 English subject- and object-extracted wh-questions with a noun phrase being substituted by a filler wh-question word “who”, leaving a gap or trace (represented by *t*) in the original subject as in (29a) or object location as in (29b) within a complement clause.

(29) a. Subject-extraction

“Who do you think *t* loved the comedian with all his heart?”

b. Object-extraction

“Who do you think the comedian loved *t* with all his heart?”

In experiment 1, the participants were 50 Chinese-English bilinguals who started learning English as an L2 after the age of 12. They were equally proficient in their L2 English, which was at an intermediate level according to their scores on the Oxford Placement Test. Their ages ranged from 16 to 26 with a mean age of 22.96 years. They were then divided into two groups: low- and high-WM capacity, in accordance with their scores obtained from the operation span task. The results showed that both groups were more accurate overall in the subject-extractions than in the object-extractions in their grammaticality judgment. They did not show WM capacity effects based on the accuracy in their responses to the grammaticality judgments; however, their RTs in the second critical region, e.g., “loved the

comedian” in the subject-extractions and “the comedian loved” in the object-extractions in the correctly judged items, showed that the high-WM capacity group tended to read significantly faster in this region, suggesting that WM capacity affected their processing of wh-extractions. Both groups were not found to be significantly different in terms of the sentence types.

In experiment 2, another group of 50 Chinese-English bilinguals whose ages ranged from 18 to 33 years, with a mean age of 23 years, participated in this experiment. They started learning English after the age of 12. It was ensured that they were equally proficient in their L2 English, which was at the intermediate level according to the same Oxford Placement Test. Their WM capacity was also measured by the same operation span test, which was thus used to separate them into two groups of low- and high-WM capacity learners. Each group also consisted of 25 participants. They were asked to verbally translate 16 subject-extracted wh-questions and 16 object-extracted wh-questions from the target L2 English into Chinese after self-paced reading of the stimuli. The two critical regions were exactly the same locations as the first experiment. Based on the data from the correctly translated items, the findings showed that sentence types had a significant main effect. That is, the participants were more accurate overall in processing subject-extractions than object-extractions. Unlike experiment 1, experiment 2 revealed that WM capacity affected the participants’ accuracy in processing wh-extractions, i.e., the high-WM capacity group performed more accurately. With respect to the RTs during the SPR task in this experiment, no relationships were found between differences in WM capacity and sentence types in either of the two critical regions.



Sagarra (2021) investigated L2 learners' online morphosyntactic sensitivity in the processing of adjacent subject-verb number agreement in L2 Spanish. Three primary variables were included: L1 transfer, L2 proficiency, and WM. Two L1 groups consisting of L1 English ( $n=62$ ) and L1 Romanian ( $n=62$ ) learners of intermediate and advanced L2 Spanish participated in an eye-tracking experiment. English is considered relatively poorer in its verbal agreement morphology, which is limited to the third-person singular *-s* agreement suffix, compared with Romanian and Spanish, which have a vast variety of agreement suffixes, such as number and gender agreement marked by different suffixes. The participants' L2 proficiency was determined by their scores on 56 multiple-choice questions in an adapted version of the grammar test section which can be used to obtain the Diploma of Spanish as a Foreign Language, following previous work involving L2 Spanish learners, e.g., in Sagarra and Herschensohn (2010). A group of 22 Spanish monolinguals also served as control. The participants read on the screen a total of 80 sentences, 16 of which were experimental sentences; half of these were ungrammatical based on the number features, i.e., singular and plural of the verb in the Spanish past tense. English does not morphologically mark past tense verbs for number, i.e., *-ed* past tense morpheme is used for both singular and plural nouns. Among the eight experimental sentences, there were four with singular subject nouns and four with plural nouns. An example of the experimental sentences is "Por la noche la chica cocinó / cocinaron el pollo para el chico" "At night the<sub>SG</sub> girl<sub>SG</sub> cooked<sub>SG</sub> / \*cooked<sub>PL</sub> the chicken for the boy." On a new screen, they were instructed to click to select one of the four pictures that best corresponded to the sentence to probe their comprehension. A letter-number sequencing test was used as a WM measure, which required the participants to

memorize a set of two to nine letters and numbers silently and supply their answer by typing the numbers in ascending order followed by the letters in alphabetical order, respectively. After the WM test, they were tested on their L2 knowledge of subject-verb agreement formation in an offline task and a vocabulary test asking the learners to match nouns and verbs with their L1 equivalents to avoid the effects of lack of vocabulary knowledge. It was found that both intermediate and advanced L1 Romanian and intermediate and advanced L1 English learners of L2 Spanish showed sensitivity to subject-verb number agreement violations, similar to the Spanish-speaking NSs. However, each group showed that they used different strategies in resolving the violations based on the three variables. First, L1 transfer was observed in the less morphologically rich language, English, such that the L1 English learners tended to rely more on the subject nouns, whereas the L1 Romanian learners were reliant on both nouns and verbs and the NSs mostly relied on verbs. This suggested that, with greater similarity between L1 and L2, the learners tended to show similar processing behaviors to the NSs. Second, the effects of L2 proficiency were evident such that the more advanced learners were more likely to rely on the verbs in their agreement resolutions, similar to the NSs. Finally, with regard to individual differences in WM capacity, the higher-span learners showed a longer gaze duration (time spent on verbs before continuing or regressing in their reading), indicating that they tended to be more sensitive to agreement violations than the lower-span ones. In addition, WM affected both intermediate and advanced groups, contradicting prior studies finding no WM effects in advanced learners (e.g., Foote, 2011; Sagarra & Herschensohn, 2010). According to the study, this discrepancy may be due to the fact that the advanced participants in this study were less advanced than those in previous

studies. Moreover, a relationship between WM and L1 transfer was found such that when the learners' L1 was less similar to the L2, the effects of WM on the processing appeared to be stronger than when the L1 was highly similar to the L2. This may suggest that the learners whose L1 differs more greatly from the L2 may be more dependent on their cognitive resources when it comes to L2 morphosyntactic processing as a result of L1-L2 differences. These findings highlight the interplay among the three determinants which contributed to L2 learners' morphosyntactic processing.

With the findings, evidence that WM capacity came into play when a task required careful consideration of each sentence element was observed in the data from the RTs in the grammaticality judgment task. The learners with higher WM capacity demonstrated they could store and process information more effectively when compared with those with lower WM capacity as they kept processing each region until the end of the sentence in order to make a judgment. L2 processing advantages were found in the participants with higher WM capacity as evinced in the higher rates of translation processing accuracy. The research reported that differences in WM capacity may manifest in processing L2 complex structures in that WM effects may be modulated by the task types as the learners read with a different goal but not the sentence types.

### **2.3.2 Previous studies on L1-L2 structural competition and L2 processing**

In mainstream L2 processing research, constructions that are prone to crosslinguistic conflicts have usually been exploited in experiments (see Hopp, 2010, 2017; Kaan et al., 2015; Rankin et al., 2019) to observe the effects of L1-L2

mismatches in sentence processing, whereas others have focused on variability<sup>5</sup> occurring as the results of morphological incongruences between the learners' L1 and the attempted L2 target (Austin et al., 2015; Thapthimhin & Pongpairaj, 2015; Trenkic & Pongpairaj, 2013; Yao & Chen, 2017). This section sees the effects of L1-based constructions in recent empirical findings in research on L2 English sentence processing.

Chen et al. (2007) carried out research on L2 morphosyntactic processing, placing an emphasis on English subject-verb agreement processing. This study compared 15 L2 Chinese learners of English and 15 L1 English speakers, using event-related potential (ERP) responses as an indication of their responses to sensitivity to the L2 agreement feature, which is not instantiated in the learners' L1. The materials were of four conditions, each of which consisted of a prepositional phrase intervening the agreement source and target. The agreement target was the English past-tense copula, i.e., "was" and "were". The agreement source was invariably a singular NP.

- (30) a. Grammatical, congruent  
           "The price of the car was too high."  
 b. Grammatical, incongruent  
           "The price of the cars was too high."  
 c. Ungrammatical, congruent  
           "\*The price of the cars were too high."  
 d. Ungrammatical, incongruent  
           "\*The price of the car were too high."

(Chen et al., 2007, p. 163)

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<sup>5</sup>According to Pongpairaj (2007), variability results when two or more variants of an L2 form are produced in an attempt to acquire an L2 functional morphology. L2 learners, especially those who are post-childhood L2 learners, may omit or supply a certain functional morpheme in inappropriate contexts, whereas the L1 monolinguals do not.

The participants read experimental sentences in a word-by-word fashion; each word appeared in the center of the screen. The stimuli were presented in a timed grammaticality judgment task. Each word appeared on the screen for 500 ms followed by a 200 ms blank screen until the end of the sentence was reached. Accuracy was based on the judgments, and reaction times from the items correctly responded to were computed. The findings showed that the learners were able to detect subject-verb agreement violation in both ungrammatical-congruent (90%) and ungrammatical-incongruent (89%) conditions as evident in their accuracy in judgment. Furthermore, despite their ability to detect the agreement violation, the learners' neuron response patterns were found to be different when compared to those of the native speakers, suggesting that NSs and NNSs were fundamentally different in their morphosyntactic processing in reading comprehension. Unlike the NSs who showed an early left anterior negativity (LAN) effect--reflecting their automatic response to morphosyntactic violation and a late P600 effect--reflecting their syntactic integration, the learners did not show an early LAN; in the learners' ERP data, such ERP responses were absent in the ungrammatical conditions. They, however, produced a pattern of a late negativity in the 500-700 ms time window; this was a distinctive pattern which, though an unknown index in relation to sentence processing studies, allowed the researchers to speculate that the morphosyntactic processing features of the NSs and NNSs were essentially different. The differences in processing patterns between the two populations were attributed to the learners' language-specific experiences; that is, the learners' well-established L1 system influenced their L2 processing and learning.

Hopp (2010) examined subject-verb agreement processing in L2 German, attempting to establish whether ultimate attainment in L2 morphosyntactic processing could be accounted for by age-related factors or other factors, such as processing efficiency. In total, 59 NNSs of German and 20 German-speaking NSs participated in this research. The learners from different L1 backgrounds, namely, English, Dutch, and Russian, were classified into two groups: an advanced group and a near-native group. A non-cumulative moving-window self-paced reading experiment was conducted using case marking and subject-verb agreement to investigate whether the learners could use morphosyntactic information incrementally during online sentence processing. The findings showed that the near-native and native groups performed similarly, showing slowdowns at the critical segments for disambiguating subject-verb agreement. This suggested that the underlying processing mechanisms of L1 and L2 are comparable and that the differences in the processing patterns may be due to linguistic experience in the learners' L1 leading to less efficiency in computations. He argued that native-likeness in L2 inflection processing may be attainable. That is, ultimate attainment in processing L2 inflectional morphology is possible for late L2 learners starting to learn an L2 after their critical period. The study suggested that L2 learners' processing difficulty in morphosyntactic processing may be due to their processing efficiency as well as L1 transfer, which could account for non-target-like inflection. Less efficiency in L2 computations may be ascribed to the influence of co-activated L1 or other factors, such as WM capacity during real-time processing, which awaits further investigations.

The study conducted by Trenkic and Pongpairroj (2013) indicated the important role of referent salience in relation to the use of the English definite article

by L1 Thai and L1 French learners of L2 English. French has an article system, and most of its uses are similar to those in English, while Thai does not. Thus, the researchers compared the learners' use of the L2 English article so as to investigate whether or not the salience effect would come into play regardless of the instantiation of the article system in the learners' L1, especially when the data were from a manipulation of a real-time processing task. Moreover, the study was also aimed at examining whether the pragmatic notion of redundancy in the linguistic context would be the only factor influencing the salience effect in the learners' use of the article—that is, when definiteness marking is present, articles are thus redundant in some linguistic contexts. The participants in this study were 40 Thai learners and 40 French learners of English, whose English proficiency was determined by the Oxford Placement Test. Each group was then divided into two groups in accordance with their L2 proficiency level, i.e., 20 intermediate and 20 advanced learners in each. A control group consisting of 10 native speakers of English was also included. The elicitation task was a short animated film employed to elicit the learners' oral production. The task involved the target referent in the subject position being visually cued by a flashing arrow to attract the attention of the learners, which a referent may do in an authentic situation at the point of utterance formation. The individual participants' voices were then recorded and analyzed. The findings showed that both intermediate and advanced L1 Thai learners, whose L1 does not have an article system, omitted articles with more salient referents more frequently than those with less salient ones, whereas neither of the French learners' groups did. In relation to the learners' proficiency, although the advanced Thai learners made fewer omissions, the omissions of the articles with more salient referents were found to be in a significantly

higher number compared to those of the articles with less salient ones. The researcher concluded the salience effect still persisted despite the learners' higher proficiency level. The other major findings of this study showed empirical evidence, providing convincing arguments against the general claim of the redundancy of discourse-pragmatic factors. To elaborate, such pragmatic notions of clarity of discourse reference and the redundancy of definiteness marking assumed that when the same referent was obvious in the subsequent linguistic contexts, i.e., the second or subsequent mention referents, hence more salient in memory, omissions of articles were more likely to occur. It was revealed that, even when the clarity of discourse reference was kept constant, i.e., using the same context without definiteness marking to refer to the evoked entities, omissions of articles still occurred. Therefore, it was evident from the findings that the redundancy of discourse-pragmatic factors might not be sufficient to account for the omissions of articles. It was suggested that structural competition between L1 and L2 grammars in the learners' language processing seemed to be a more plausible explanation for the phenomena. Since the results tended to show that the learners' syntactic representations of both L1 and L2 contributed to their production, thus leading them to either select or suppress the target features from one of the two language systems. Those omissions showed that they failed to select the L2 structures, which hampered their achievement in the target L2 structures.

Trenkic et al. (2014) examined L2 real-time grammatical processing, focusing on L2 learners' ability to incrementally build their L2 representation in online comprehension of constructions that are unique to L2, i.e., uses of articles. Typologically speaking, Mandarin lacks use of articles while English does not. This



research tested Mandarin speakers of English, using visual world eye-tracking, investigating the facilitative role of L1 with a non-violation paradigm in online processing. Participants were instructed to listen to auditory stimuli containing information about a goal object of a verb “put + the...” or “put + a...” (e.g., “The pirate will put the cube inside the/a can.”). On the screen, they were presented with one or more compatible goals, and were asked to indicate the goal where the referent being described would end up by mouse-clicking. For example, the visual scene depicted one unopened can and one open can (one-compatible referent condition) / two open cans (two-compatible referent condition). To explain, “the can”, a definite NP, suggested that the noun can be uniquely identified while “a can”, an indefinite counterpart could mean there are two or more cans serving as compatible goals. Only the correct trials were included in the eye movement analyses. To investigate how the two groups reached referent resolution at the earliest opportunities, the proportion of looks to the target diverging from looks to the competitor was observed. The findings showed that both the native speakers of English and the late article-lacking Mandarin speakers of English at the intermediate level of proficiency were able to utilize the information associated with the L2 English articles to identify a single object upon hearing “the” and indicate more than one possible object upon hearing “a”. A proposal concerning competing grammar within a bilingual’s mind was suggested. The findings suggested that processing difficulties, despite its presence in production (Austin et al., 2015; Trenkic & Pongpairroj, 2013), may not hold true in processing for comprehension of unique-to-L2 structures. Establishing form-meaning connections without L1 elements competing with the L2 articles during online comprehension may be possible as the learners could incrementally utilize the information in referent

resolution in a target-like manner. Nevertheless, the crosslinguistic competition account maintains its prediction that structural violation in processing for comprehension in cases where there is an omission of L2 feature and its L1 counterpart favors it (i.e., stimuli involving the absence of article uses in L2 structure) may essentially be non-target-like. This aspect of the L1-L2 structural competition account awaits further investigation with respect to L2 grammatical processing during online comprehension. The findings also stressed that the essence of difficulties in production may not be comparable to processing strategies, given the converging evidence between the NSs and NNSs in the processing of structures unique to L2.

Austin et al. (2015) investigated whether the notion of L1-L2 structural competition in the L2 learners' oral production could account for the processing of the functional categories of L2 English in complex immediate contexts, i.e., "article+noun" in a definite-plural construction, by L1 Thai learners of L2 English. The participants were 20 intermediate L1 Thai learners of L2 English at the undergraduate level, and six age-matched English speaking natives served as controls. Their L2 English language proficiency was determined by the Oxford Placement Test. Two experiments focusing on spoken production were conducted: the story recall and elicited imitation tasks. In the story recall task, the participants were asked to recall the story which they had heard. Keywords from the story, i.e., nouns, verbs, and adjectives in bare forms, were used as prompts to guide their recalling of the story. In the elicited imitation task, they listened to each sentence from the story, one by one, and were asked to repeat each of them. Two predictions were made. Since Thai lacks inflectional markers for both definiteness and plurality, it was predicted that in a complex immediate linguistic context presented by a definite-plural construction, e.g.,

“the trucks”, omission rates would be higher than in a less complex structure presented by a definite-singular construction, e.g., “the drum”. In a similar vein, omission rates of plural markers *-s* were predicted to be higher in such complex structures manipulated by a definite-plural construction, e.g., “the pans”, than in less complex structures presented by a bare-plural construction, e.g., “planes”. The results showed that the learners supplied the functional morphology less consistently in more complex contexts than in less complex contexts. That is, in the story recall, Thai learners of L2 English tended to omit the definite article “the” more often when used with plural nouns than with singular nouns. In the elicited imitation task, the learners were found to omit the plural marker *-s* at a higher rate in definite-plural contexts than in indefinite bare-plural contexts. Such complex immediate linguistic contexts involving two functional categories absent in the learners’ L1 presumably posed difficulties for them in suppressing the inappropriate L1-licensed structures, thus triggering omissions during the processing of the L2 functional morphology. The findings corroborated the L1-L2 structural competition account (Trenkic & Pongparoj, 2013), which postulates that co-existing L1- and L2-licensed constructions compete for selection. The phenomenon can be described mainly due to increasing cognitive resource demands in processing complex L2 structures.

In research conducted by Kaan et al. (2015), the processing of L2 English subject-verb agreement in objective relative clauses was examined in order to reveal the effects of reading speed on L2 sentence processing. In particular, it was aimed at examining whether L1-L2 differences in processing could be ascribed to differences in reading speed and whether L2 learners would show their sensitivity to cross-language conflicts. This was featured by a construction in which “a particular

sequence of words corresponds to a particular construction in the L2 (e.g., an object relative clause) but to a different construction in the L1 (e.g., a subject relative clause) when translated word-by-word” (Kaan et al., 2015, p. 801). To elaborate, the cross-language conflict under study lies in the fact that L1 Dutch RCs have an identical word order to ERCs. For instance, an L2 English object relative clause like the one in (31b) is clearly ungrammatical based on subject-verb agreement; however, it is considered grammatically correct in a corresponding Dutch subject RC in a word-by-word translation. In both Dutch object and subject RCs, the verb follows two noun phrases (i.e., “the instructor” and “the students”). Consequently, without agreement marking, a Dutch RC construction which is equivalent to an L2 English counterpart in such a structure, where both noun phrases are singular, as in (31c), is grammatical but ambiguous in relation to a subject-object and object-subject sequence.

- (31) a. Mark may know the instructor who the students *have* avoided since last semester.
- b. Mark may know the instructor who the students *\*has* avoided since last semester.
- c. Mark may know the instructor who the student *has* avoided since last semester.
- d. Mark may know the instructor who the student *\*have* avoided since last semester.

(Kaan et al., 2015, pp. 802-803)

Advanced L1 Dutch speakers of L2 English and native speakers of American English participated in this study. They performed an online SPR task and an offline end-of-sentence statement verification task. The results showed that effects of cross-language conflict were not found from their online RTs. Overall findings revealed that the L2

learners read faster than the native speakers did. However, when the participants' reading speed in both groups was controlled for, similar processing patterns were found between the L2 learners' group and the native speakers' group. This means both groups were not different in their sensitivity to grammaticality when they were matched for reading speed. Furthermore, when comparing the two groups based on the matched reading speed, both groups appeared to differ in their performance of the offline end-of-sentence statement verification task. Specifically, only L2 learners who read faster showed processing patterns similar to native speakers. That is, in the offline statement verification task, the L2 learners tended to assign subject-object order interpretations more frequently than the object-subject order ones in the ungrammatical items, as predicted by the condition in which ungrammatical L2 structures (i.e., object RCs) are compatible with the learners' L1 structures (i.e., subject RCs). Only when the speed of reading was controlled did the L2 learners differ from native speakers in their responses to the task. Data showed that only those L2 learners who read faster appeared to show similar native-like patterns. Since no evidence was found to support L1-licensed structure co-activation during online processing as L2 learners and native speakers showed similar patterns in their RTs, the competition account cannot be adequately accounted for. It was suggested that processing difficulty as the result of ungrammaticality may have caused the L2 learners to resort to their L1 default in their sentence interpretation.

Hopp (2017) investigated the effects of L1 transfer, L2 English proficiency, and inflectional markings on the processing of English which-questions by L1 German learners. This research aimed to compare and contrast the subject and object which-question processing in adult L1 German learners with monolingual child

learners and adult L1 speakers. A visual world eye-tracking paradigm was adopted. The participants were 57 adult L1 German learners with different English proficiencies: intermediate, high-intermediate, and advanced, measured by scores from the Lexical Test for Advanced Learners of English, or LexTALE, as an indication of the learners' general L2 English proficiency. The experimental sentences were manipulated based on two factors: 1) sentence type, i.e., subject and object which-questions, and 2) number matching, i.e., singular-singular and singular-plural.

- (32) a. Subject type (singular-singular, number match)  
 “Which cow is pushing the goat?”
- b. Object type (singular-singular, number match)  
 “Which cow is the goat pushing?”
- c. Subject type (plural-singular, number mismatch)  
 “Which cows are pushing the goat?”
- d. Object type (singular-plural, number mismatch)  
 “Which cow are the goats pushing?”

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(Hopp, 2017, p. 113)

It was predicted that if L1 grammatical options were recruited during L2 sentence comprehension, the learners would show their greater preference for subject questions over object questions. English object which-questions with number match as in (32b) may become ambiguous as the structure also allows for subject interpretation when translated word-by-word into German. To illustrate this point, a sentence like (32b) would be interpreted as either (32a) a subject which-question or (32b) an object which-question. However, facilitation may take place if the two noun phrases, i.e., the

subject and object, differ in number as in (32d). That is, when the number mismatch conditions manifest, the inflectional number marking on the auxiliary would help the learners to disambiguate the structures and interpret them as object which-questions as in (32d). The participants were asked to look at two pictures on a computer screen and listen to either a subject or object which-question. After they heard the sentence, they were asked to respond by pressing a left or right button in correspondence to the picture of the sentence which they heard. The findings based on comprehension accuracy in the learners' judgments showed that, unlike L1 child learners and adult L1 speakers, the intermediate group was more accurate in subject wh-questions than in the ambiguous object wh-questions, suggesting that number mismatch did not serve as a cue to help them reach the target object which-question picture. This was not the case for the high-intermediate group, which exhibited sensitivity to English number marking. That is, the number mismatch condition tended to facilitate them to arrive at the target object which-question picture. The advanced group demonstrated high accuracy unrelated to number matching features, which was similar to adult L1 speakers. Overall, they showed high accuracy regardless of number matches, which was similar to the results of adult L1 speakers. Moreover, based on the accurately comprehended items, the results from the eye-tracking data recorded while the participants were listening to the sentences showed that there were invariable patterns in the proportions of looks with regard to match and mismatch features in the subject which-questions. The proportion of looks at the target pictures steadily rose from the onset at 0 milliseconds, i.e., the auxiliary. However, the learners' proportions of looks tended to differ between the match and mismatch features in the object which-questions. They initially showed their L1-biased preference for the subject

interpretation by looking longer at the competitor, and then made a revision of their interpretation to the target object interpretation. Such phenomena exhibited concurrent activation of the L1 and L2, suggesting that the learners' L2 grammatical representation may be competing with that of their L1 for selection in comprehension. Furthermore, the gaze patterns for object which-questions also differed when taking L2 proficiency into account. The intermediate group was found to have initial L1-biased subject preference merely in the match condition, i.e., singular-singular noun phrases, taking longer looks at the target sentence for the subject interpretation rather than object interpretation. This suggested that they recruited their L1 grammatical word order to parse the L2 object which-questions. The high-intermediate group also initially showed a strong preference for subject interpretation, and the number mismatch features tended to help them perform reanalysis more quickly than the number match features did. This indicated that the high-intermediate group was sensitive to number marking feature in their L2 processing. In contrast, regardless of number matching features, the advanced group appeared to quickly revise their analysis to correctly parse the object which-questions with object interpretation, indicating a resemblance to native-like processing patterns in comprehension. Based on these findings, it could be seen that despite having relatively high proficiency, the L2 learners may have recruited their L1 syntactic options when comprehending an L2 sentence. As their L2 was progressing, they may have relied upon inflectional morphology to help them parse an L2 sentence, which led them to reach ultimate attainment of L2 English which-question comprehension.

Yao and Chen (2017) investigated the effects of crosslinguistic influence on the processing of English tense and aspect in late L1 Chinese learners of L2 English.



The learners were assigned to low- and high-proficiency groups as determined by their self-assessment and the Oxford Placement Test scores. To be classified as late learners, the mean age at which they first acquired English had to be more than 10 years. In particular, various types of inflectional markings, reflecting crosslinguistic differences between Chinese and English tense and aspect expressions, namely past tense, the progressive, and present third-person singular were examined. English verbs are grammaticalized and morphologically marked. Chinese verbs differ from those in English in various aspects. There are two equivalent morphemes (i.e., “le” and “guo”) to mark past tense in Chinese, but they are not considered grammaticalized as the morphemes “le” and “guo” can be substituted without any changes in meaning, thus failing to meet the criteria for grammaticalized knowledge (Dahl, 1985). The progressive is grammaticalized and morphologically marked by “zai” before a verb. The present third-person singular is neither grammaticalized nor morphologically marked since there is no morpheme for present third-person singular in Chinese; verbs remain in the bare forms irrespective of the person features. In the first experiment with 60 late Chinese-English learners, an SPR task was adopted to collect RT data. The second experiment with a different population of 56 late Chinese-English learners employed an eye-tracking technique to observe the participants’ first-fixation duration as well as their gaze time. The representational deficit account and the performance deficit account were used as the main hypotheses in association with the morphological congruency hypothesis in this study. The former assumed that late L2 learners could automatically process and acquire only congruent morphological features licensed by both L1 and L2, i.e., progressive. In contrast, the latter claimed that late L2 learners could reach ultimate attainment irrespective of morphological

incongruence between the two languages when their L2 proficiency was high. That is to say, their variable L2 performances were assumed to have been caused by the increasing processing load of the task. The results from the SPR task revealed both groups showed sensitivity to progressive inflectional violation; however, for the past inflectional morpheme, only the high-proficiency group was sensitive to the violation. The third-person singular appeared to be the most problematic in their online processing. In particular, neither of the two groups showed sensitivity to the ungrammaticality of the morpheme *-s*. As regards the third-person singular inflection, the findings from the eye-tracking data were striking since only high-proficiency learners showed the ability to detect agreement violations of the third-person singular through their longer gaze times in the ungrammatical sentences. The findings found support for the performance deficit account as differences between L1 and L2 influenced the learners' online processing of English tense and aspect. L1 Chinese learners could reach target-like online processing of tense and aspect as their L2 English proficiency increased. The variations might have been from the differences in the task processing loads; the SPR was more cognitively demanding than the eye-tracked reading.

Rankin et al. (2019) investigated the effects of L1 co-activation in online bilingual processing of L2 English *wh*-questions by L1 German learners. This study involved 27 native speakers of English and 41 L1 German learners of L2 English. All of them were university students. Their L2 proficiency was at the intermediate and advanced levels, as determined by a lexical-based English proficiency test. A visual world paradigm eye-tracking technique was employed to examine the learners' processing of English *wh*-questions. The target constructions under investigation were

assumed to pose potential crosslinguistic conflicts, i.e., the constructions in which two different syntactic structures and two different semantic interpretations are possible when translated word-by-word. Two types of wh-questions, subject and object, were manipulated with two tenses, present simple tense and present perfect tense. Both sentences with and without crosslinguistic conflicts were included in the experiment. There were three factors manipulated: 1) wh-question types including subject and object, 2) tenses including the present and perfect, and 3) lexical-disambiguation—presented by distinct animal names as a cue facilitating picture-selection, and syntactic-disambiguation—presented by depicting the named animal taking either the agent or patient role in two scenes, thus necessitating syntactic knowledge to select the target pictures. Crosslinguistic conflicts were predicted when English present simple tense subject wh-questions as in “Which animal pushes the cat?” and English present perfect object wh-questions as in “Which animal has the cat pushed?” are translated word-by-word into German, two different interpretations were possible. That is, they could be interpreted as either subject or object wh-questions by L1 German speaking learners if they resort to their L1 parses. This could then potentially allow for non-target L1-licensed interpretations, which was predicted to reflect L1 syntactic co-activation during online processing. It was predicted the learners may parse these two constructions in a manner that differed from the norm or the target language, English. Data were collected through a visual world eye-tracking experiment. The participants were asked to listen to spoken wh-questions in L2 English manipulated by the three factors. The findings showed there were no significant differences based on the comprehension accuracy. However, the findings from the participants’ eye-fixation during the processing indicated that L2 learners

appeared to have greater processing difficulty due to crosslinguistic conflicts. In present simple tense subject wh-questions, the learners were found to fixate more consistently in lexical trials than in syntactic trials, while the native speakers showed subtle differences between the two conditions. In present perfect tense object wh-questions, the learners also showed signs of crosslinguistic conflict by fixating in the lexical trials more consistently than in syntactic trials which was expected as a consequence of crosslinguistic conflicts. Subtle differences in eye-fixation were found between the two trials among monolinguals, indicating they had no difficulties processing the constructions. As exhibited by the findings, it was suggested that L1 influence prevailed even in the advanced stages of adult late learners of L2 English during online processing. Their interlanguage grammars showed evidence of the influences of L1 parametric settings, which were found to be a resort as parsing options in their online processing.

### **2.3.3 Previous studies on English present tense morphology and L2 processing**

The complexity of acquiring grammatical morphemes has been manifest. Their difficulties have been reported in functional morpheme order studies not only in young L2 learners (Dulay & Burt, 1974) and adult L2 learners of English (Bailey et al., 1974; Larsen-Freeman, 1975), but also among L1 monolinguals in their language development (Brown, 1973; de Villiers & de Villiers, 1973). From the past findings on the L2 acquisition order of grammatical morphology, the English third-person singular morpheme *-s* has been shown to be one of the most problematic inflectional morphemes and is usually acquired last (Bailey et al., 1974; Dulay & Burt, 1974). Since this area appears to be problematic for L2 learners, several studies have been

conducted to uncover the underlying mechanisms involved in the processing of the morpheme. The sections below describe recent L2A and L2 sentence processing literature relevant to English agreement morphology.

Jiang (2004) investigated late Chinese-English bilinguals' reading comprehension, focusing on L2 English subject-verb agreement violations. The main purpose of the study was to examine their sensitivity to morphosyntactic errors and whether they could develop native-like processing patterns. The participants were adult L1 Chinese learners of L2 English. In word-by-word SPR experiments, they were asked to read sentences involving subject-verb agreement errors, such as in "The words on the screen were hard to recognize." and "\*The word on the screen were hard to recognize." The results revealed that despite showing knowledge of English subject-verb agreement on the untimed written task, the learners did not show any differences in their read times in the critical regions in both grammatical and ungrammatical subject-verb agreement, whereas the native speakers of English did. Such a lack of L2 sensitivity indicated that the learners did not have the ability to process the L2 plural morpheme spontaneously in their comprehension during the processing. The morphological difficulties appeared to indicate their incomplete L2A of morphological knowledge, thus reflecting their lack of automatic L2 competence<sup>6</sup> in processing the English plural morpheme. It was suggested that such L2 morphological knowledge was not part of their integrated knowledge, which means that even though the learners showed they had the knowledge of all the rules relevant to L2 English plural morphology, they were unable to put such knowledge into use

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<sup>6</sup> Automatic competence can be defined as "the ability to apply one's linguistic knowledge spontaneously in both the productive and receptive use of language" (Jiang, 2007, p. 2).

during the processing. While the sources that resulted in the phenomena were not clear, age of L2A as well as morphological incongruence between L1 and L2 were proposed to account for the insensitivity to the L2 English plural morpheme displayed by the late Chinese-English bilinguals.

Shibuya and Wakabayashi (2008) examined L1 Japanese adult learners' sensitivity to L2 English subject-verb agreement. Specifically, the research attempted to find out whether the different ways of marking number features offered by the sentential subjects affected the sensitivity to the overuse of the 3S morpheme. A total of 20 L1 Japanese undergraduates whose English proficiency was at the intermediate level, as measured by the Oxford Placement Test, participated in the experiment. Moreover, nine native English speakers participated as controls. RT data on the learners' sensitivity to the inflectional morphemes were collected from a word-by-word SPR task. Five types of plurality were manipulated in the target materials (Shibuya & Wakabayashi, 2008, pp. 244-245): 1) second person as in “\*You eats a good meal for health every day.”, 2) proper noun and proper noun as in “\*Tim and Paul bakes an apple pie every Sunday.”, 3) simple plural subject as in “\*The chefs cooks the shrimp in butter every time.”, 4) These + quantifier as in “\*These two secretaries gets a cup of coffee for their boss every morning.” and 5) third-person singular as in “\*The child speak a lot of English during dinner.” The findings showed that when the person features between the subjects and verbs were incongruent, the Japanese learners of English manifested variability in their sensitivity. That is, when the sentential subjects showed plurality based on syntax, i.e., “Tim and Paul”, and a demonstrative and a numeral quantifier, i.e., “These two secretaries”, the learners tended to show their sensitivity to the ungrammaticality. Nevertheless, when the

number feature disagreement was presented by a plural marking -s (e.g., “The chefs”), they did not seem to show sensitivity to such ungrammaticality. This suggested that the problem might stem from the learners’ ability to identify the number feature rather than the difficulty of L2 English subject-verb number agreement.

Hsieh (2009) carried out a study on the acquisition of English agreement and tense morphology by L1 Chinese learners. A total of 20 Taiwanese learners whose L1 is Chinese participated in the study. The data were elicited from spontaneous speech production, an interview and storytelling tasks. The findings showed that the problems the learners encountered were mainly omission (78%), while the correct use was infrequently found (17%), and very few inappropriate uses of the morphemes were found (5%). It was suggested that the participants possessed the knowledge of this verbal tense and agreement to a certain level. Three factors were proposed to account for the learners’ production of the 3S morpheme: negative transfer, positive transfer, and other factors in L2A, i.e., individual differences in proficiency, and effects of morphophonemic realizations of the 3S morpheme.

Sato and Felser (2010) conducted research on sensitivity to subject-verb number agreement in L2 English sentence processing by L1 learners from different language backgrounds: German, Japanese, and Chinese. The participants were regarded as mid-intermediate or advanced learners. Speeded grammaticality judgment task and untimed sentence completion task were adopted to investigate the morphological sensitivity. All learner groups regardless of their L1 backgrounds showed less sensitivity to subject-verb agreement violations in sentences such as “\*She rarely flirt.” than case errors regardless of L1 background in the speeded

grammaticality judgment task. The learners were also reported to be slower in their response times in detecting the ill-formed sentences than the native controls. This study suggested the phenomena may be attributable to the role of L1 influence on L2 morphosyntactic processing as well as a lack of ability to build native-like syntactic representations.

Wong (2012) examined the L1 Malay and L1 Chinese learners' interlanguage of the target L2 English morphology. Specifically, the researcher carried out research into the acquisition of English tense and agreement morphology by the learners from two different L1 backgrounds. This study was influenced by the generative approach to L2A. The framework used in the study was the Failed Functional Features Hypothesis (FFFH), postulated by Hawkins and Chan (1997), that proposes L2 learners, especially those who started learning an L2 after puberty, would experience syntactic deficits provided that specific parameterized features in an L2 were not instantiated in the learners' L1 systems. This research set out to 1) determine the contexts in which English non-past tense and agreement morphology posed greater difficulty for the two groups of learners and 2) analyze the nature of interlanguage representations of the English non-past tense and agreement morphology acquired by the learners. The participants were 39 L1 Malay speakers, divided into two groups of 22 intermediate and 17 advanced learners, and 21 L1 Chinese speakers, classified into two groups of 12 intermediate and nine advanced learners. Their L2 English proficiency was determined by their Malaysian University English Test scores. A grammaticality judgment task was used to elicit data on learners' underlying grammatical knowledge of tense and agreement morphology in English. The test consisted of 48 items with 16 correctly inflected items and 32 incorrectly inflected



items. Three L2-licensed features of English finite verbs associated with tense, namely [ $\pm$ past], [ $\pm$ finite] and [ $\pm$ agreement], are not specified in the learners' L1 systems. The target verbs used in the investigation included thematic verbs, auxiliary verb "be", and copula "be" with an adjective. Both grammatical and ungrammatical items were included in the grammaticality judgment task. The task was presented bimodally. That is, the participants both read and listened to the target sentence simultaneously before making their judgments. The findings showed that the learners appeared to have no difficulty judging the grammaticality of grammatical items with all three verb types. This suggested that L1 Malay and L1 Chinese learners' interlanguage grammars seemed to reach native-like level as they could restructure their surface morphology at a high rate of above the 80% cut-off point. This also showed that their interlanguage grammars converged toward the target language as their L2 proficiency increased. However, this was not the case in the ungrammatical items. The learners found the ungrammatical items more problematic to judge, suggesting their syntactic representations in their interlanguage seemed to diverge from those of the native speakers with respect to the target functional categories in L2 English. This was mainly because the L2 language-specific features were not formally specified in the learners' L1 systems. This study confirmed the FFFH in that L2 learners who started learning an L2 after puberty were not able to acquire the L2 functional categories underspecified in their L1.

Ocampo (2013) examined subject-verb agreement processing by native speakers of English and L1 Spanish learners of L2 English. A self-paced reading task in a moving-window paradigm was employed to investigate the time course in real-time processing of agreement across two types of distance: a prepositional phrase and

a subject-extracted relative clause. The results showed that L2 learners were less sensitive to agreement violations on the condition that the intervening material was an RC (“who asked about Africa”) which was more complex compared with a prepositional phrase (“from hot northern Africa”) in a sentence such as “The singer(s) from hot northern Africa / who asked about Africa never practice(s) before a performance.” In addition, plural markedness tended to play an important role in long-distance agreement processing. Both native speakers and L2 learners seemed to experience plural markedness effects. While the native speakers showed processing advantages for plural subjects in agreement processing intervened by a prepositional phrase, no such advantages were found when the intervening materials were an RCs as they showed similar sensitivity to agreement violation irrespective of the number manipulations of the agreement controller. However, L2 learners tended to benefit from the plural markedness effects as the distance between the subject-verb agreement concord increased. They tended to read longer in the ungrammatical condition regardless of the number manipulation in the prepositional phrase distance type. In the RC distance condition, their processing tended to be facilitated by the plural markedness effects, but it did not when the subject was singular as significant differences in RTs were found only in the plural subject condition.

Kahoul (2014) conducted research on production, perception, and processing of past tense and subject-verb agreement morphology by L1 Arabic and Chinese learners of L2 English. The participants were 37 L1 Chinese speakers, 34 L1 Arabic speakers, and 10 native speakers of English as controls. They were proficiency-matched L2 learners at three different levels: low, middle, and high. Data were collected through a sentence elicited imitation task for production, while data for

perception and processing were collected from a computerized picture-choice task. More precisely, in the first task the participants were asked to repeat the sentences and their imitation responses were recorded. The stimuli in this task were composed of verbs with various phonological structures when inflected with the past tense and present tense morphemes. This elicited imitation task had the underlying assumption that if the target structures are correctly imitated, they are part of the learners' linguistic competence. In the second task, they were asked to choose one appropriate picture. In each item, there were three pictures accompanied by aurally presented sentences. The choice of picture indicated whether or not the participants perceived verbal morphology. In the processing of the two types of morphology, their RTs and eye movements were recorded. This task assumed that it is possible to tap into linguistic competence through comprehension, or more precisely, the target sentence for number agreement. Kahoul (2014) used aural subject-drop sentences assuming that if the participants can successfully perceive the L2 morphology of the 3S morpheme added to the verb, it will lead them to choose the picture with a singular subject. The overall findings suggested that regarding learners' production and perception, the Chinese learners produced and perceived the two types of morphology with large variability across L2 proficiency levels. Similarly, the Arabic learners with low and middle proficiency were found to show variability in their production and perception. The high-proficiency Arabic learners, however, appeared to produce and perceive the target structures more consistently as their L2 proficiency increased. It was predicted that phonological effects based on allomorphic variants (i.e., last segments of the verb syllable) were not found to influence the production or perception of the morphology by both groups of learners. Thus, production and

perception difficulties tended not to be associated with L1 transfer. In terms of processing, data gathered from RTs and eye movements showed that only L1 Arabic speakers showed evidence for automatic competence and syntactic representations of the target morphology. They displayed higher sensitivity to the target morphology through shorter RTs when choosing the appropriate picture, thus reflecting their automatic competence (Jiang, 2007). Moreover, their longer lengths of time spent looking at the target visual stimuli, and higher speeds of the first look to the target visual stimuli showed evidence for their underlying syntactic representations, and these can be seen increasing as their proficiency in L2 rises. Morphological variability in the lower proficiency group could be accounted for by absence of syntactic representations, which can increase in relation to L2 proficiency.

Thapthimhin and Pongpairroj (2015) investigated one aspect of the morphosyntax of English present tense acquisition, number agreement. The emphasis of the study was placed on syntactic representation of English number concord by L1 Thai adult learners of L2 English. Two major hypothetical frameworks in the generative approach to L2A were investigated: 1) Missing Surface Inflectional Hypothesis (MSIH), a non-impairment view in the acquisition of L2 functional features, and 2) Failed Functional Feature Hypothesis (FFFH), an impairment view in the acquisition of L2 functional features. The participants were 103 learners whose L1 is Thai. They were divided into two groups based on their English proficiency measured by the Quick Placement Test. A grammaticality judgment task and a cloze test were used to elicit the learners' perception and production of the number agreement features in English. The findings showed that the learners reflected their target-like linguistic competence through accurate production of the structure despite

the non-existent structure in their L1. They did not seem to have perception problems as their accuracy based on singularity and plurality was above 80%. However, they were found to have production problems, and this may be attributed partly to the incomplete or pressurized computational process. Moreover, the rarity of the irregular nouns could also be problematic for the participants. It was further reported that the inaccuracy found on those irregular nouns was the result of incomplete knowledge of L2 lexicon. L2 learners seemed to be less primed for the L2 lexical items than native speakers. It was not the syntactic representations that were non-target-like but the lexicon or grammatical properties of the lexical items. It was suggested MSIH be accounted for in the definition of L1 Thai learners' problems in the acquisition of L2 English number agreement.

Lim and Christianson (2015) employed an eye-movement tracking paradigm to investigate sensitivity to subject-verb agreement violations by L1 Korean learners of L2 English with different proficiencies, determined by a cloze test. Korean does not have subject-verb number agreement. The subjects' eye fixation was observed when processing sentences with subject-verb number agreement in L2 English in sentences like "The teacher(s) who instructed the student(s) were very strict." With the region "were" and the following region "very" (for spillover effects) as critical regions, it was found that the learners showed their sensitivity to agreement violations through longer eye fixation in the critical regions. In addition, a more demanding subtask goal (offline oral translation) that followed the detection of the broken agreement in L2 morphological processing appeared to trigger greater sensitivity to such violations among L2 learners with higher proficiency.

Timyam (2018) conducted research on the uses of English verbal inflectional morphology by L1 Thai learners. This study attempted to analyze how the learners' uses of English inflectional morphemes deviated from the native speakers' norms. Particularly related to the present study were the deviations found in the uses of the present tense morphology *-s*. The participants were 100 undergraduates and 16 graduates majoring in English, regarded as upper-intermediate or advanced learners. Data were collected from 232 essays in academic writing. The findings showed that despite a large number of correctly inflected verbs, omissions of the present tense morphology were found. Such deviations from the native speakers' norms could be attributable to three major factors: the long distance between the main subjects and the main verbs, heavy subjects with a head and modifiers, and the complexity of the syntactic categories of the subjects. They tended to leave out the obligatory morphology, especially when the sentence became more complex, and when their attention was turned to the overall meaning of the sentence.

Siriwittayakorn and Miyamoto (2019) examined sensitivity to the English subject-verb number agreement violations by Thai-speaking learners of L2 English. A total of 32 L1 Thai undergraduates participated in a self-paced reading experiment. Stimuli involved non-adjacent agreement dependencies between the subjects and the verbs, which were separated by a prepositional phrase. The agreement attractions were kept constant, using a singular local noun. The agreement controller nouns were plural in the grammatical sentences and singular in the ungrammatical sentences with the manipulation of a copula "were" in both grammatical and ungrammatical conditions. The participants read 16 experimental sentences (half ungrammatical), such as "The chickens in the oven were completely burned." and "\*The chicken in the

oven were completely burned.” They were interspersed among 48 fillers, and each was followed by a yes/no comprehension question. It was found that the L2 learners showed reading slowdowns in the spillover regions in the ungrammatical condition, indicating that they were sensitive to number agreement violations. However, the learners’ proficiency, measured by a c-test, was not found to contribute to their sensitivity. It was suggested that L2 learners could use their L2 morphosyntactic information during real-time processing in sentence comprehension and that their L1 did not prevent them from successfully acquiring the L2. This robust native-like processing was found among Thai undergraduates majoring in English, which leads to speculation that their intensive exposure to L2 English may contribute to processing which is similar to that of the native speakers of English.

Furthermore, it has been well documented in L2A literature that the 3S agreement morpheme *-s* has long been a problem for L1 Thai learners of L2 English (Singhapreecha, 2000). In the L1 Thai learners’ context, the problem has been evident in many written production studies based on rates of errors made by L1 Thai learners of L2 English (e.g., Phoocharoensil et al., 2016; Pongpairroj, 2002, among others).

Chapter II, overall, sees the theories and the development of the theoretical accounts relevant to the primary factor under present investigation, WM, and the notion of L1-L2 structural competition account has also been described. Contrastive analyses of the experimental stimuli, including the RC constructions and the present temporal expressions, and their processing mechanisms in L1 Thai and L2 English are illustrated to help identify potential factors which may arise from the differences between the two linguistic systems. In addition, the findings from previous studies

related to the processing of L2 sentences in association with WM, L1-L2 structural competition, and English subject-verb number agreement have been reviewed. The growing body of knowledge offered by these theories, assumptions, hypotheses, methodologies and implications of findings was taken into consideration in the design of the research methodology of the present investigations.

After reviewing the literature associated with WM, L1-L2 structural competition, and the processing of the L2 English present tense morphology, four major research gaps in L2 sentence processing by L1 Thai learners were identified. Firstly, to the best of my knowledge, none of the past studies in the L1 Thai learners' context had taken into account the measurement of the research participants' WM capacity in L2 morphosyntactic processing even though WM effects have often been accounted for as a potential source of L1-L2 asymmetry (e.g., Trenkic & Pongpaibroj, 2013). Secondly, in terms of the research methodology, very few research studies in the L1 Thai learners' context adopted time-sensitive online processing tasks, such as a non-cumulative moving-window SPR task. This task is useful for examining the processing mechanisms involved during the real-time processing of L2 functional morphology as it is believed to help minimize the effects of other conscious strategies, e.g., use of metalinguistic knowledge to perform the experimental tasks. Thirdly, the L1-L2 structural competition account has yet to be extensively investigated amid various other types of L2 structures, especially in the L1 Thai learners' context (see Austin et al., 2015, for definite articles and plural marking; Trenkic & Pongpaibroj, 2013, for definite articles). Finally, based on the experimental materials, employing ERCs with different types of material extractions in order to increase the distance between the subject-verb agreement concords rather than simple sentences was



expected to provide insightful linguistic phenomena. These important considerations were taken into account to reveal how the L2 English agreement inflectional morphology was processed in syntactically more complex constructions and how it was influenced by individual differences in terms of WM capacity in this empirical study.

On this ground, the experiments in the present research were designed to bridge these research gaps in L2 sentence processing by L1 Thai learners of L2 English. The experimental methods, which are described in Chapter III, were expected to provide useful data from both the NSs of English and the L2 learners on their agreement processing during online sentence comprehension to provide better understanding of how morphosyntactic features not instantiated by the learners' L1 were processed in comparison with the NSs.

## **CHAPTER III**

### **RESEARCH METHODOLOGY**

This chapter deals mainly with the research methodology employed in the present study. The present research was carried out to investigate the effects of WM capacity and distance-based complexity and their influence on L1-L2 structural competition in the processing of the English subject-verb number agreement by L1 Thai learners of L2 English in their online processing for comprehension. It is essential to detail the methodology relevant to the experiments. 3.1 deals with the description of the research participants, recruitment criteria and procedure. 3.2 is devoted to the research method in the main experiment, the self-paced reading task, providing details about the materials and design, procedure, and predictions, including scoring and analysis. The pilot study is reported in 3.3. Finally, 3.4 provides information about research ethics for research involving human subjects.

#### **3.1 Populations and samples**

In L2 sentence processing and L2A research, most cross-sectional studies have been conducted with specific sample groups to address the research objectives and questions. It is, therefore, important to provide the descriptions of the populations and samples recruited to participate in the present experiments.

##### **3.1.1 The target populations**

To address the two research objectives and research questions, two populations, which were 1) adult L1 Thai learners of L2 English and 2) English-speaking native speakers, were used. Both populations consisted of those involved in academic settings. That is, they were Thai students at the undergraduate level at a public university in Thailand. They were learning English in addition to their L1,

Thai, and their general exposure to L2 English was mainly through formal classroom instruction. The English NSs were students at the undergraduate and graduate level at a public university in the United States of America.

### **3.1.2 The selection of participants**

A total of 80 L1 Thai undergraduates (40 in Experiment 1 and 40 in Experiment 2) were recruited by the employment of a purposive sampling technique. That is, the researcher recruited target participants who satisfied the recruitment criteria in terms of L1 background and L2 English proficiency. Since the experiments concerned reading on a computer screen, all participants reported having normal or corrected to normal vision, and they were naive to the purpose of the research. The learners' L2 English proficiency, which was at the upper-intermediate level, was determined by their scores obtained from the Lexical Test for Advanced Learners of English, or LexTALE (Lemhöfer & Broersma, 2012) (see 3.1.2.1 for the task details). In Experiment 1, the learners' mean LexTALE score was 68%, with a range between 60% and 78.75%. In Experiment 2, their mean score was 66.72%, with a range from 61.25% to 78.75%. The task used to obtain the data on the participants' WM capacity was a reading span (RSPAN) task (see 3.1.3.1 for the task details) (Conway et al., 2005; Daneman & Carpenter, 1980; Redick et al., 2012; Unsworth et al., 2005; Unsworth et al., 2009; Waters & Caplan, 1996). In Experiment 1, the learners' mean RSPAN score was 53.80, with a range between 32 and 74 (with a possible maximum score of 75) while in Experiment 2, their mean RSPAN score was 54.40, with a range between 33 and 75. In this study, the Thai-speaking participants participated in the LexTALE, the SPR task, the language background questionnaire, and the RSPAN task, respectively.

In order to examine differences in native and nonnative agreement processing patterns, 80 native speakers of English were recruited to participate as a control group: 40 in Experiment 1 and 40 in Experiment 2. The NSs' data served as baseline data for the comparison of the processing patterns with those of the L2 learners. The NS participants were also asked to perform the LexTALE task, and their performance was at ceiling in both experiments. In Experiment 1, the NSs' mean LexTALE score was 95.94%, with a range between 90% and 100% while in Experiment 2, their mean score was 94.69%, with a range between 87.50% and 100%. The data obtained here helped ensure that the L2 English proficiency measurement employed in this study could distinguish the learners' level of L2 English proficiency since the performance of all the NS participants was at the advanced level. Although this research primarily attempted to understand how L2 learners' morphosyntactic processing patterns differed from those of the NSs, it was important to incorporate the measurement of cognitive resources, i.e., WM capacity, in both the learners and NSs, especially when the experimental materials involved manipulations of syntactic complexity. Since the materials involved agreement processing in complex constructions of ERCs, WM capacity could even play a role among the native speakers (Just & Carpenter, 1992; King & Just, 1991). In this regard, the native controls were also tested on their cognitive capacity, using the RSPAN task in their L1 English (Osaka & Osaka, 1992; Redick et al., 2012). In Experiment 1, the NSs' mean RSPAN score was 60.05, with a range between 39 and 75 (with a possible maximum score of 75). Similarly, in Experiment 2, their mean RSPAN score was 59.75, with a range between 35 and 73. The English NSs participated in the LexTALE, the SPR task, the language background questionnaire, and the RSPAN task, respectively.

One primary independent variable under investigation was the participants' WM capacity. Thus, for the purpose of homogeneity, the participants' L2 English proficiency was controlled for. All L1 Thai participants had an L2 English proficiency which was at the upper-intermediate level. The learners at this proficiency level were targeted as their interlanguage was assumed to be at the developmental level, thus it was appropriate to examine whether there were other underlying individual variables, other than L2 proficiency, which might come into play during the processing in the L2. Another advantage of having upper-intermediate learners participate in this study was to reveal whether the learners at this crucial proficiency level were able to develop native-like morphosyntactic processing patterns in the course of their L2 development, which was important for their L2 learning in general. Furthermore, as their English proficiency was at the upper-intermediate level, it was reasonable to assume that the concepts of English present tense inflectional morphology and English relative clauses had been introduced to them. To address the concern about their knowledge of the sentence structures employed in the manipulations, a statement verification subtask was adopted to ensure their comprehension of the sentences. Moreover, only the items that were correctly comprehended were included for further analyses (see 3.2 for details). On this ground, the upper-intermediate L1 Thai learners of L2 English were selected since their interlanguage was assumed to be more systematic, compared to those with very limited English proficiency. Learners with limited English proficiency may not be able to perform this complex task, i.e., comprehending the English present tense verbs presented in an ERC, or may perform it at random, which may not be useful for the investigation. With regard to the L2 proficiency, comparing learners with different L2 proficiencies was beyond the scope

of the study since this research attempted to establish understanding of how individual differences in WM capacity affected the processing of L2 agreement during reading for comprehension. Advanced L2 learners were not included either as their interlanguage may have become near native-like in the use of the present tense agreement morphology, as several past findings showed (e.g., Thapthimhin & Pongpairoj, 2015), and this was not the focus of this investigation.

The participants with extensive experience in an English-speaking country for more than three consecutive months were excluded from the study as their L2 performance might not reflect L1 Thai learners of L2 English in general. This should suffice to maintain representative samples of adult Thai-speaking learners of L2 English. The criterion was based largely on the previous literature. For instance, Kaan et al. (2015) reported that the average amount of time the L2 participants, participating in their experiment had stayed in an English speaking country was 1.2 months, and Phoocharoensil (2009) excluded the participants who had spent more than three consecutive months staying in an English-speaking country.

The participants who were fluent in a third language were also excluded since transfer stemming from a third language or additional languages other than English may potentially confound the data, primarily based on the L1-L2 structural competition account (Austin et al., 2015; Kim & Christianson, 2017; Trenkic & Pongpairoj, 2013).

### 3.1.2.1 Lexical Test for Advanced Learners of English (LexTALE)

One crucial variable needing to be kept constant in the present investigation was the participants' L2 English proficiency. The primary aim of this research was based on individual differences in terms of WM capacity; accordingly, it was necessary that the participants' L2 proficiency be kept constant in order to gain efficiency in the observation of the WM capacity effects. In psycholinguistic investigations, how participants' L2 proficiency should be measured has long been discussed. Some previous research included self-ratings requiring the participants to rate themselves on a rating scale for their listening, speaking, reading, and writing skills (e.g., Kaan et al., 2015; Sagarra & Herschensohn, 2012), while other studies employed standardized English placement tests to supplement this requirement, e.g., the Oxford Placement Test or the Quick Placement Test (e.g., Trenkic et al., 2014; Trenkic & Pongpaibroj, 2013), or even locally available standardized tests (e.g., Wong, 2012).

However, the present study adopted the Lexical Test for Advanced Learners of English, or LexTALE, in the investigation for several reasons. LexTALE is an L2 proficiency measure which has been used as an indication of general L2 English proficiency in a number of L2 processing research studies (Lemhöfer & Broersma, 2012). LexTALE, a recently developed measure, as an indicator of general L2 English proficiency, has gained increasing popularity in L2 sentence processing research, especially in psycholinguistic experiments thanks to its validity and practicality (e.g., Hopp, 2017; Kaan et al., 2018; Rankin et al., 2019; Supasiraprapa, 2022). Even though the measure is based largely on lexical decisions, it does not only test the participants' lexical knowledge in L2 English. It can also be used as an indicator of

general L2 English proficiency since it was validated by making comparisons with L2 learners' performance on standardized tests of English. LexTALE has been found to correlate highly with standardized L2 English placement tests, such as the Quick Placement Test (Lemhöfer & Broersma, 2012), which could be used to provide approximate estimate for L2 English proficiency. Since there is a substantially high correlation between the participants' LexTALE scores and the Quick Placement Test ( $r = .63$ ), it is appropriate when used to discriminate the participants' general L2 English proficiency based on the Common European Framework of Reference for Languages (CEFR) (see APPENDIX D). The CEFR levels provide descriptions for L2 proficiency levels ranging from A1 and A2 (basic users) and B1 and B2 (independent users), to C1 and C2 (proficient users) (Lemhöfer & Broersma, 2012). In addition, its growing popularity in psycholinguistic research lies in the fact that it is an efficient measure that can be administered quickly, which suits most psycholinguistics research that usually takes a large amount of time.

LexTALE consists of 63 trials of a lexical decision task, three of which are for practice. The lexical items used consist of 40 words from different vocabulary frequency bands and 20 nonce words legally formed according to English phonotactic constraints. Its unbalanced proportion is justified by the fact that if high frequency words were used in an equal number, it would be likely that the test may not be able to discriminate the participants. This test was computerized and controlled by the participants at their own pace. On a computer screen, they were presented with a string of words, including nonce words, in the middle of the computer screen. In each trial, one word appeared with a "no" box in red and a "yes" box in green. The participants were instructed to make a decision whether the word they saw on the



screen was an actual word in English. They were instructed to respond “yes” if they knew the word or they thought the word existed despite not knowing the meaning of the word. They were supposed to respond “no” if they did not know the word nor think the word existed. The first three words were used as practice trials and were not counted. Below is a sample of the task presentation on a computer screen and the list of the lexical items used in LexTALE with the correct responses in parentheses (y = yes and n = no).

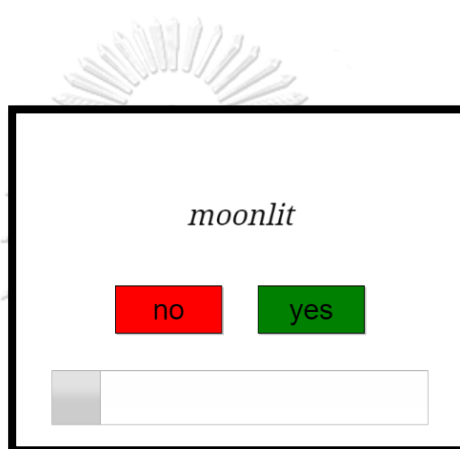


Figure 10: Illustration of the LexTALE task presentation

platory (practice item; n), denial (practice item; y), generic (practice item; y), mensible (n), scornful (y), stoutly (y), ablaze (y), kermshaw (n), moonlit (y), lofty (y), hurricane (y), flaw (y), alberation (n), unkempt (y), breeding (y), festivity (y), screech (y), savoury (y), plaudate (n), shin (y), fluid (y), spaunch (n), allied (y), slain (y), recipient (y), exprate (n), eloquence (y), cleanliness (y), dispatch (y), rebondicate (n), ingenious (y), bewitch (y), skave (n), plaintively (y), kilp (n), interfate (n), hasty (y), lengthy (y), fray (y), crumper (n), upkeep (y), majestic (y), magrity (n), nourishment (y), abergy (n), proom (n), turmoil (y), carbohydrate (y), scholar (y), turtle (y), fellick (n), destription (n), cylinder (y), censorship (y), celestial (y), rascal (y), purrage (n), pulsh (n), muddy (y), quirky (n), pudour (n), listless (y), wrought (y).

(Lemhöfer & Broersma, 2012, p. 339)

Points were given to the items that were correctly recognized as existing words. At the end of the session, the participants' scores were reported as percentages. In general, this task took about 5 minutes to complete. This L2 English proficiency

measure was administered to both the learners and NS participants. Once the scores were obtained, only the Thai participants who scored between 60% and 80% on the task were included in the present investigation. This range of percentage on the LexTALE is equivalent to B2 on the CEFR scale; therefore, the participants' general L2 English proficiency was at the upper-intermediate level. As for the English-speaking participants, this measure was also used so that the baseline in terms of English proficiency could be established. The native speakers' performance on this task was expected to be within the advanced range (80%-100%) as the past studies suggested (e.g., Kaan et al., 2018) Those whose performance was below the cut-off threshold, i.e., 80%, were excluded as there might be potential concerns with respect to their literacy, which might affect the data.

### **3.1.2.2 Language background questionnaire**

Since the present research placed an emphasis on L2 sentence processing, participants who were proficient in any language other than their L2 English were excluded from the study. This was to avoid crosslinguistic influence from other languages (Kim & Christianson, 2017). In the questionnaire, the questions relevant to the participants' L2 English background were regarding 1) age, 2) age of exposure to English, 3) number of years of English learning, 4) fluency in other languages, 5) experience using English in English-speaking countries, and 6) vision conditions since the experiments concerned reading sentences on a computer screen. This questionnaire was administered during a session break between the SPR task and the RSPAN task, and it took about five minutes to complete.

### 3.1.3 The measurement of the participants' WM capacity

According to Wen (2016), WM span tasks require a considerable amount of attention as well as memory demands. Past literature in L2 sentence processing inquiry concerning WM capacity employed various measures, e.g., the RSPAN task and the operation span task. These tasks were devised and adopted to reveal the participants' cognitive ability, reflecting individual differences (Conway et al., 2005; Daneman & Carpenter, 1980; Turner & Engle, 1989; Unsworth et al., 2005; Unsworth et al., 2009). The former was based on verbal information, whereas the latter involved some form of arithmetic calculations.

However, the most commonly used WM span task in the realm of L2 sentence processing tends to be the RSPAN task since it utilizes verbal information in sentence reading. The RSPAN task has been widely adopted in previous investigations of L2 sentence processing (e.g., Coughlin & Tremblay, 2013; Juffs, 2004; Kim & Christianson, 2017). Even though empirical evidence has shown that the operation span task is claimed to reflect the domain-generalty of WM and has high correlation with the RSPAN task (Turner & Engle, 1989), it has been argued that the RSPAN task and its variants, such as the listening span task, tend to be more closely associated with L2A, particularly in language processing (Wen, 2012). Therefore, the RSPAN task, as a measure of WM capacity, was adopted in the present study in order to determine WM spans of the learners and NSs of English. 3.1.3.1 details the characteristics, the materials design, the procedure, and the scoring method and analysis, involved in the RSPAN task.

### 3.1.3.1 The reading span task

The reading span (RSPAN) task has been ubiquitously adopted in the field of psycholinguistics as a measure that is assumed to tap into the participants' cognitive resources, or WM capacity. Similar to other WM span tasks, the RSPAN task is assumed to measure two major components of an individual's WM capacity, the processing and the temporary storage of verbal information. It measures the participants' ability to process sentences while holding other bits of information, such as letters, or words, in their memory. This task, which was first developed by Daneman and Carpenter (1980), requires the participants to read a series of sentences ranging from three to six sentences and recall the last words of each sentence. However, there tended to be some limitations of this original version as the task might not assure that the participants actually process the given sentences. Subsequent variants of the RSPAN task have been introduced (Unsworth et al., 2009, for an automated version; Waters & Caplan, 1996, for processing component). Waters and Caplan (1996) incorporated an additional aspect to ensure the inclusion of the processing component of the task, i.e., sentence judgment. Most previous studies manipulated this processing component such that the reading sentences became semantically plausible or implausible, which was assumed to ensure the sentences were actually processed. Unsworth et al. (2005) and Unsworth et al. (2009) introduced an automated version of the task to reduce the effects of the intervention of the experimenter and facilitate the scoring processes. Therefore, the present study employed an automated version of the RSPAN task (Redick et al., 2012; Unsworth et al., 2005; Unsworth et al., 2009), which was written using the E-Prime 3.0 software package (Spapé et al., 2014).

Next, the characteristics of the RSPAN task are described. Firstly, in the processing component of the RSPAN, the participants were instructed to read a series of sentences in different set sizes. After reading each sentence, they were instructed to judge whether the sentence they had read was semantically plausible (Waters & Caplan, 1996). In this regard, semantic plausibility is usually manipulated by the animacy of the subject or the object argument required by the verb in the sentence (Coughlin & Tremblay, 2013; Waters & Caplan, 1996) or by simply replacing one word in that sentence so as to make it semantically implausible (Redick et al., 2012; Unsworth et al., 2009). Here is an example of a sentence with semantic plausibility and an example of one with semantic implausibility.

(33) a. Semantic plausibility

“People in our town are more giving and cheerful at Christmas time.”

b. Semantic implausibility

“The prosecutor’s *dish* was lost because it was not based on fact.”

(Redick et al., 2012)

As shown by (33a), a sentence with semantic plausibility is complete and sensible, whereas (33b) becomes semantically anomalous as the original word “case” in the subject position of the sentence is replaced with “dish”. As revealed by previous literature, in this subtask, the participants usually performed at ceiling because the manipulated semantic plausibility was not intended to be exceedingly complex. Instead, it was made so simple and obvious that the anomaly was unacceptable and could be detected. This served to ensure that the participants processed the sentences and attended to the sentence comprehension to reflect their

processing rather than strategically try to concentrate on the to-be-remembered alphabetical letters, i.e., the recall stimuli.

Secondly, in the temporary storage component of the RSPAN task, the participants were instructed to remember a recall alphabet letter after each semantic plausibility judgment. To illustrate, after a sentence within a specific set size was read and judged in terms of semantic plausibility, the participants were presented with an isolated alphabet letter in the middle of the screen. They were instructed to remember the letter. The presentation of each of the recall stimuli was equally timed at 1000 ms to prevent them from trying to strategically rehearse the recall stimuli by using other techniques, such as forming a word out of the alphabet letters to facilitate their memorization. Upon completing one set size of the reading sentences, they were asked to supply the recall stimuli in the order in which they had appeared. It has been suggested that an RSPAN task be developed in the participants' native language to avoid L2 proficiency confounds. Previous literature has shown that the participants' performance on the RSPAN task in their L2 appeared to be lower than that in their L1 (Harrington & Sawyer, 1992; Osaka & Osaka, 1992). This suggested that the processing components, sentence reading and judgments, tend to correlate with the participants' L2 proficiency, especially when the RSPAN task is in the participants' L2 (Coughlin & Tremblay, 2013). It is also worth acknowledging that recent research has shown crosslinguistic differences in WM capacity (cf. Mattys et al., 2018), and the data analyses were thus performed separately for NSs and NNSs using within-group analyses.

In this regard, the RSPAN task in the present study was therefore chosen to be in the participants' native language, assuming that WM is language-independent (Osaka & Osaka, 1992) (see 2.1.1.2 for more details discussed). Therefore, the present research utilized the English version of the RSPAN task created by Unsworth et al. (2005) and Unsworth et al. (2009) for the L1 English participants and a translated version of the RSPAN task for the L1 Thai participants (Redick et al., 2012; Unsworth et al., 2005; Unsworth et al., 2009); the RSPAN task has been translated into different languages for research purposes, such as German, Chinese, Korean, Arabic, Portuguese, and Spanish. Since the automated task format in the Thai language was emulated from the RSPAN task provided by Unsworth et al. (2005) and Unsworth et al. (2009), written permission was obtained from the Attention & Working Memory Lab, School of Psychology, Georgia Institute of Technology, USA, for this research purpose.

#### **3.1.3.1.1 Materials design and procedure**

This section details the RSPAN task adopted to measure the participants' cognitive resources, or WM capacity. The automated version of the RSPAN task, used in the present study, was proposed and developed by Unsworth et al. (2005) and Unsworth et al. (2009). This task is divided into practice trials and actual trials. In the practice session, there were three parts which functioned to familiarize the participants with the task and its subtasks. Moreover, it essentially allowed the collection and calculation of the individualized time each participant would need to perform the task in the actual trial blocks. It started with a simple letter span, i.e., a single unrelated English alphabetical character or a Thai alphabet character for the Thai translated version. The participants were instructed to recall the

letters, which were presented in the middle of the computer screen in a strict order. This was done by clicking on the appropriate boxes adjacent to the letters, corresponding to their recall order, on the recall screen. During recall, when the box adjacent to the recall letter was clicked, the screen showed a number, e.g., 1, 2, and 3 for a set size of three trials, in order to provide the participants with traceability of the answers. Feedback was given on their recall accuracy. In the second part of the practice trials, the participants were instructed to read a series of sentences as quickly as possible and judge whether they were sensible or nonsensical by clicking on the “TRUE” “จริง” /teɪŋ/ or the “FALSE” “เท็จ” /tʰét/ box. The final part of the practice session was the combination of both subtasks consisting of 15 sentences, eight of which were semantically implausible. This allowed task familiarization and provided the average RT an individual participant would be allowed in the actual trials. The individualized time allowed for each individual participant to read and judge the semantic plausibility of a given sentence was the average time spent during the practice trials plus 2.5 *SD*. If the participants exceeded the time limit for a particular item, it would be considered as a speed error, resulting in less accuracy in their overall processing performance.

In the real trials, there were different set sizes ranging from three to seven sentences and recall letter stimuli. The sentence length was between 10 and 15 words. Each set size had three trials in order to maximize the span reliability (Friedman & Miyake, 2005; Redick et al., 2012), yielding 75 sentences in the entire RSPAN task. The set sizes were not necessarily incrementally ascending. This means the set sizes were randomized to avoid potential confounds from participants who had strategic knowledge of and could predict the memory span size (Conway et al., 2005). Half of



the sentences were semantically plausible, whereas the other half were not. Such semantic anomalies were made by substituting one word in the sentence in order to make it nonsensical. The position of the word making the sentence nonsensical was manipulated in different positions of the sentences. This served to prevent a strategic individual from stopping reading when the nonsense word was detected earlier in the sentence and devoting their time to rehearsing the recall stimuli.

The RSPAN task employed in the present investigation was a Thai translated version of the automated RSPAN task developed by Unsworth et al. (2005) and Unsworth et al. (2009). As far as the translation of the task was concerned, all of the task instructions and reading sentences were translated by a translator who was a native Thai speaker proficient in English. Once all the instructions and sentences were translated, they were reviewed again by an expert in Thai-English translation. They were instructed to preserve the original meaning while adapting it to the Thai context when it came to differences in cultural references, such as proper names. In addition, the nonsense words needed to be strictly preserved in the original positions in order to prevent some participants from strategically stopping reading and instead devoting their time to rehearsing the recall letter stimuli. The researcher liaised with the translator and the reviewer on the matter of the in-sentence locations of the nonsense words. They were informed that they needed to preserve the nonsense word locations as strictly as possible. Examples (34a) and (34b) show how a nonsense word was placed earlier and later in the sentences, respectively. Finally, the researcher verified and finalized the task, identifying any discrepancies in the translations.

(34) a. The *lemonade* players decided to play two out of three sets.

(Unsworth et al., 2005)

Translated version: “นักกีฬาน้ำมะนาวตัดสินใจที่จะเล่นแบบสองในสามเซต”

b. My mother has always told me that it is not polite to *shine*.

(Unsworth et al., 2005)

Translated version: “คุณแม่มักคอยเตือนฉันอยู่เสมอว่ามันไม่สุภาพที่จะส่องแสง”

As regards the recall prompts, the RSPAN task in the present study used the following set of unrelated Thai characters: พ, ศ, จ, ก, ย, ร, ท, ม, ต, ฉ, ห, and ว. These isolated Thai alphabet characters appeared in a 4 x 3 grid on the computer screen for the participants to recall in a strict given order. They were selected based on their distinctive phonemic properties since Thai is known for having various letters for the same sounds; for instance, the /s/ phoneme in Thai can be orthographically represented by <ศ>, <ส>, and <ษ>. The uses of isolated characters for the memory targets are preferred as they are assumed to reduce latencies from lexical knowledge in the case of using words as the memory targets (Conway et al., 2005; Turner & Engle, 1989; Unsworth et al., 2005).

The entire task was mouse-driven, computerized, and administered to each participant individually. The experimental environment was kept constantly quiet to prevent any distractions during the reading, which could affect their performance on the task. The experiment began with the practice trial sessions followed by the actual trials. The participants were asked to carefully read the instructions written in their

native language, and they were allowed to ask any questions they might have. In the actual trials, they were instructed to read a series of Thai sentences presented in the middle of the screen as quickly as possible and judge the semantic plausibility of the sentences as accurately as possible, as shown in Figure 11.

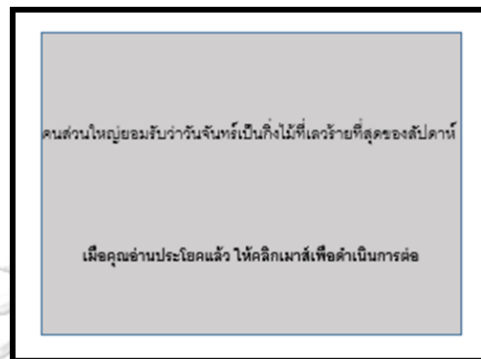


Figure 11: Illustration of the reading sentence in the reading span task

Once they finished reading each sentence, they were instructed to advance to the next screen, where they were asked whether the sentence they read was sensible. In this processing component subtask, they were asked to judge the semantic plausibility of the sentence by clicking the “TRUE” “จริง” /teɯŋ/ or the “FALSE” “เท็จ” /tʰét/ box, depending on their response, as shown in Figure 12.

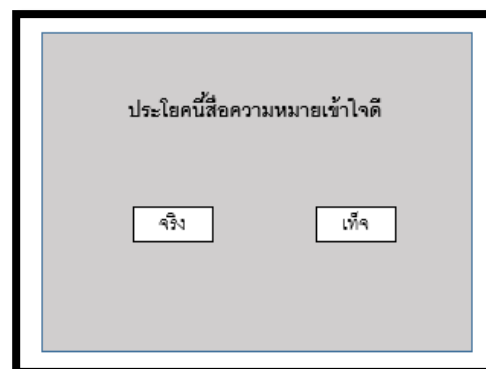


Figure 12: Illustration of the semantic plausibility judgment instruction

Immediately after the participants clicked on either of the boxes, a recall stimulus appeared in the middle of the next screen. They were instructed to memorize the recall stimulus, which remained on the screen for 1000 ms, as shown in Figure 13.

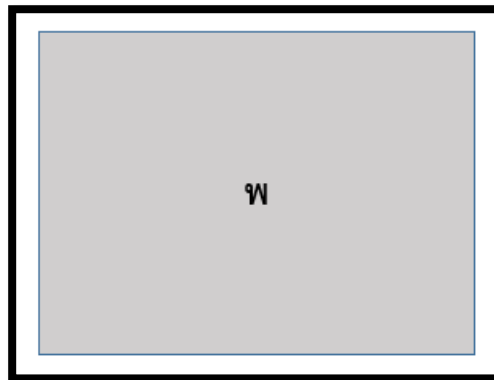


Figure 13: Illustration of the recall stimulus presentation

Once the participants completed one set size, they were automatically moved on to the next screen where they were presented with 12 isolated Thai characters adjacent to a click box. On this recall screen, there was no time limitation for them to recall the stimuli. To elaborate, the participants supplied their recall items in a strict order. Numbers appeared in order after they clicked each box next to the letter to help them keep track of the sequence of the items they could recall. They could opt to click a “blank” “ว่าง” /wâ:ŋ/ button if they were unable to recall any recall stimulus in a given position. For example, in a set size of three items with ฮ, อ, and ฎ, if the participants forgot the first position, they could choose to click the “blank” “ว่าง” /wâ:ŋ/ button followed by the other two letters, e.g., “-, อ, ฎ”. If they made a mistake in selecting their recall items, they could rearrange them again, using the “CLEAR” “ล้าง” /lá:ŋ/ box. Once all the recall items were supplied, the participants proceeded to

the next screen by clicking the “ENTER” “ป้อน” /pôn/ box at the bottom of the screen, as shown in Figure 14.

เลือกตัวอักษรตามลำดับที่แสดง โดยใช้ปุ่ม “ว่าง” กรอกตัวอักษรที่ลืม

<input type="text"/>	ท	<input type="text"/>	ธ	<input type="text"/>	จ
<input type="text"/>	ค	<input type="text"/>	ย	<input type="text"/>	ร
<input type="text"/>	ท	<input type="text"/>	น	<input type="text"/>	ด
<input type="text"/>	ล	<input type="text"/>	ท	<input type="text"/>	ว

ว่าง

ถึง ป้อน

Figure 14: Illustration of the recall screen

On the feedback screen, they were presented with a cumulative percentage on their processing accuracy on the sentence judgments on the top right of the screen. Feedback on their judgment and recall performance of the current trial was also provided on the same screen as illustrated in Figure 15.

92%

คุณจำตัวอักษรได้ถูกต้อง 3 ตัว จากทั้งหมด 6 ตัว

คุณตอบข้อคำถามผิด 1 ประโยค ในการฝึกทำแบบทดสอบชุดนี้

Figure 15: Illustration of the feedback screen

The feedback remained on the screen for 2000 ms before the task moved to the next randomized set size. The feedback was provided to ensure the participants paid

attention to both their processing and memory storage performance. When the last set size was reached, the screen prompted the participants to inform the experimenter. This task was administered last and took approximately 20 minutes to complete.

### 3.1.3.1.2 Scoring and analysis

Two widely employed approaches to scoring WM capacity in complex span tasks are 1) an absolute or all-or-nothing scoring method and 2) a partial-credit scoring method. Each of the scoring approaches is discussed in turn.

In comparison to the absolute scoring method, the partial-credit scoring method takes into account all of the correct recall stimuli in the correct positions, irrespective of whether a participant can correctly recall the stimuli for the entire set size. For instance, if a participant could recall four letters in a set size of four items, three letters in a set size of three items, and two letters in a set size of four items, the score would be 9 ( $4+3+2$ ) out of 11. However, in the absolute scoring method, it is obligatory that a participant successfully recall all of the recall stimuli in a given set size so that they could gain the scores. If an absolute-scoring method was employed, in the same situation, the participant's score would be 7 ( $4+3+0$ ) out of 11. This means the score is given only when the entire set size is correctly recalled.

Past research showed that scores based on partial-credit scoring indicated higher correlations with reading comprehension (Friedman & Miyake, 2005). Moreover, such scores revealed better psychometric properties and seemed to have higher internal consistencies when compared with those offered by the absolute-scoring method (Conway et al., 2005; Redick et al., 2012). According to literature on

measurement of WM capacity (Conway et al., 2005), partial-credit scoring is generally considered better as it appears to provide the measure of cognitive ability more exhaustively. Thus, in this research, the possible score range was between 0 and 75 points. Most importantly, since WM is assumed to mainly consist of both active processing and storage components, it was essential that the participants' sentence judgments be at 85% or above (Conway et al., 2005; Unsworth et al., 2009); otherwise, they were excluded from the investigation. In terms of sentence judgment accuracy, any incorrectly judged sentences were regarded as accuracy errors. In addition, if the participants failed to process and judge a sentence within the time allowed, it would be categorized as a speed error. Therefore, WM capacity in the present study was based on the total sum of the recall items in the entire task as in the partial-credit scoring method. The complete list of the RSPAN task sentences is provided in APPENDIX B.

### **3.2 Experimental study: Self-paced reading task**

A self-paced reading (SPR) paradigm is a time-sensitive, computer-based task widely adopted in psycholinguistic research (Just et al., 1982). This SPR technique resembles the natural movement of reading and has been widely adopted to tap into moment-by-moment processing during sentence comprehension (Roberts, 2016; Sagarra & Herschensohn, 2010). This online processing task was developed primarily to investigate underlying processes and mechanisms in language comprehension in real time in cognitive psychology. It has also served as one of the most fundamental experimental research instruments in L2 processing, which is particularly useful for investigations at the sentence level or beyond (Jegerski, 2014). In L2A, this data collection technique was first used in the competence-performance debate under the

generative approaches to L2A (Juffs & Harrington, 1995). It was used as a complement for grammaticality judgments in order to argue that adult late L2 learners' performance divergent from that of native speakers may be ascribed to processing constraints, rather than to representational deficit in their L2 linguistic competence.

The SPR task has been previously employed to investigate various linguistic phenomena in psycholinguistic studies (Brehm et al., 2019, for agreement attraction; Coughlin & Tremblay, 2013, for number agreement; Juffs, 2004, for garden-path sentences; Just & Carpenter, 1992, for relative clauses; Kaan et al., 2015, for number agreement; Kim & Christianson, 2017, for relative clause attachment). In the present study, this online sentence processing data collection technique was selected to collect behavioral data on the participants' RTs as a dependent variable observable from the participants' sentence reading at their own pace. Details of the material manipulation and design, procedure, predictions, and scoring and analyses are described in 3.2.1.

### **3.2.1 Materials design and procedure**

Since this research was aimed at investigating the effects of WM capacity and distance-based complexity on L2 agreement processing in complex sentences, the main experimental stimuli included ERC constructions with English present tense verb agreement inflections in the matrix clause as the target morphosyntactic processing.

Previous literature suggested that, in order to observe the effects of WM, complex sentence structures should be used as the experimental stimuli. Hyun and Lee (2018) found correlations between WM effects and the high cognitive demand



task. That is, WM effects can be efficiently observed when the task is complex. In addition, Just and Carpenter (1992) found support for effects of WM capacity, which could be observed when comparing the processing of English SRCs and ORCs (Liu & Wang, 2019). On this ground, use of ERC constructions is justified due to their potential syntactic complexity and differences in terms of the linear distance between the filler and the gap, which is different between SRCs and ORCs. Thus, they are appropriate as an explanatory variable concerning linguistic complexity in the L2 processing investigation under the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013).

In SPR experiments, sentences are teased apart depending on the purpose of the study. That is, some studies may adopt a phrase-by-phrase presentation while others may use a word-by-word method. In the present research, the word-by-word SPR is favored since the target English 3S agreement morphology *-s* is inflected to a single verb. In the word-by-word moving-window SPR task, each appearing word or region is to be observed in a millisecond (ms). The target region being investigated is referred to as a critical region, i.e., matrix verbs (henceforth “critical region”) and the following word for spillover effects (henceforth “spillover region”), while the other words in a given sentence are referred to as non-critical regions.

It is crucial that other non-critical regions be kept constant. Since RTs are measured in SPR, it is suggested that the critical regions, which provided crucial information for the study, be the exact same words or form minimal pairs. Introducing different words may act as confounding factors in the design (Marinis, 2010). In this regard, all of the critical regions in the experimental sentences were identical with

respect to both the lexical uses and position, i.e., the seventh region and eighth region for spillover, to prevent confounds relevant to speeds of lexical access as well as the effects of distance (Just & Carpenter, 1992). The critical regions to be observed were the (un)grammaticality of the finite verbs in the matrix clauses, which were manipulated in terms of number and person features of the English present tense morphology. This was to observe the effects of distance intervening the agreement controllers (i.e., the subject head NPs) and the finite verbs of the matrix clauses (see Table 4 and Table 5 for an illustration), on the processing of the English 3S present tense morphology.

In the present study, there were two experiments. Experiment 1 focused on agreement processing with an omission of the 3S agreement marker, and Experiment 2 investigated the agreement processing with an overuse of the agreement marker. In each experiment, four lists of 20 experimental items were created. Distance and grammaticality were crossed in a 2 x 2 design. The short-distance condition was based on the English SRC and the long-distance one was based on the English ORC constructions. Grammaticality manipulations were created according to the use of the English 3S agreement morpheme *-s*. In each experimental list, there were 10 grammatical sentence stimuli and 10 ungrammatical sentence stimuli. Table 4 and Table 5 depict each experimental quadruplet in Experiment 1 and Experiment 2.

Table 4 Experimental stimuli in Experiment 1

Experiment 1	Grammatical (G)	Ungrammatical (UG)
Short-distance (SRC)	The guy [that __knows the driver] wants to buy a new car.	*The guy [that __knows the driver] want to buy a new car.
Long-distance (ORC)	The guy [that the driver knows __] wants to buy a new car.	*The guy [that the driver knows __] want to buy a new car.

Table 5 Experimental stimuli in Experiment 2

Experiment 2	Grammatical (G)	Ungrammatical (UG)
Short-distance (SRC)	The guys [that __know the driver] want to buy a new car.	*The guys [that __know the driver] wants to buy a new car.
Long-distance (ORC)	The guys [that the driver knows __] want to buy a new car.	*The guys [that the driver knows __] wants to buy a new car.

This section provides the descriptions of the target sentences shown in Table 4 and Table 5, followed by the justification for the experimental manipulations of the materials. As seen above, in each type of ERC, i.e., subject-extracted and object-extracted ERCs, the sentences were manipulated by (un)grammaticality. To avoid plausibility effects (Thornton & MacDonald, 2003), the subject or object position contained all animate NPs with definite descriptions, i.e., “the guy(s)” and “the driver”. The subjects of the matrix clauses were of two types, i.e., 1) third-person singular definite NP in Experiment 1 and 2) third-person plural definite NP in Experiment 2. This research project was divided into two experiments so as to avoid repetition effects or priming effects introduced by reading more than one version of the same lexical item (Keating & Jegerski, 2015).

In the short-distance SRC conditions, the verb residing in the subordinate clause always agrees in terms of number and person features with the head NP agreement controller of the main clause. The object NPs in the RCs were always a singular NP in both experiments to avoid agreement attraction effects (Bock & Cutting, 1992; Bock & Miller, 1991; Lim & Christianson, 2015; Wagers et al., 2009). The critical region observed for the participants’ RTs was the agreement inflection of

the verb in the matrix clause, i.e., the verb “want(s)”, and the RTs in the immediate postcritical region were recorded for spillover effects (henceforth “spillover region”) (Marsden et al., 2018).

Similarly, in the long-distance ORC conditions, the finite verb in a given subordinate clause always agreed in terms of number and person features with the subject of the clause, i.e., the singular subject NP “the driver” and the verb “knows”. The NPs used in the RCs were always third-person singular definite NPs. The verbs in the matrix clauses were manipulated so as to have number mismatches between the subject agreement controller and the verb of a given matrix clause.

The intervening ERCs were always grammatically well-formed in terms of person and number agreement because they served two main purposes in the SPR experiments. Firstly, the grammaticality of the verbs within an ERC functioned to provide a present tense context. Using different time markers or adverbs of frequency manipulations may draw the participants’ attention to the experimental manipulations, and it may impose confounds since different types of adverbs of frequency were found to differently influence L2 participants’ agreement processing (see 3.2.2 for discussions). Secondly, the subordinate clauses, i.e., the ERCs, were kept constant in terms of grammaticality because they solely served to impose different distance-based complexity. Therefore, it was necessary that these intervening materials be always grammatical, keeping only one difference based on the distance. For instance, in the short-distance SRCs shown in “The guy that knows...” and “The guys that know...”, the main verb “know(s)” always agrees with the subject head NP, “The guy(s)”.

As regards the target L2 English 3S agreement morphology, the manipulations followed the L1-L2 structural competition account of processing functional morphology licensed differently by L1 and L2 systems (Austin et al., 2015; Trenkic & Pongpairoj, 2013). That is, the L1-based grammatical feature was assumed to be better established, thus competing with the attempted use of the novel L2-licensed counterpart being attempted during online processing. Apart from the grammatical verbs within an ERC, two incorrectly inflected versions of the verbs with a 3S morpheme *-s* were manipulated, e.g., “\*The guy [SRC/ORC] want...” and “\*The guys [SRC/ORC] wants...”. The former example shows a grammatical mismatch with omission of L2 English 3S inflection (L1-based feature), whereas the latter shows a mismatch with overuse of the morpheme (L2-based feature). See the descriptions of the detailed predictions relevant to the L1-L2 structural competition of the target 3S agreement morphology in 3.2.3.

Each experiment, therefore, consisted of 20 experimental items, and each of the items had four versions. The lexical items used in both experiments were identical. In each experiment, four lists of the 20 items were created using a Latin Square design so that no two versions of an item appeared on the same list to avoid repetition and priming effects. That is, each participant read only one of the four versions of the 20 experimental items. In addition, the 20 experimental items were pseudorandomized with 40 distractors, yielding a total of 60 sentences for one participant to read. In addition, the stimuli were pseudorandomized with the distractors so that no two sentences of the same grammatical condition appeared in the same sequence to avoid ordering effects. Ten practice trials were also included to familiarize the participants with the task.

The two types of distractor sentences used were complex sentences in English. Using complex sentences consisting of two clauses, one main clause and one subordinate clause, was intended to make the overall task consistent with the experimental sentences based on the number and types of clauses, while drawing the participants' attention away from the experimental manipulations. The distractors were 40 complex sentences: conditional sentences and sentences with “because”, “when”, “while”, “before”, or “after” as a subordinating conjunction. Examples of each type of distractors are shown below.

(35) a. Conditional sentences:

“If you have time, you should go shopping on the way home.”

b. Complex sentences with a subordinate conjunction:

“We should stop here for a while because the tourists are very tired.”

“When the phone rang, he was just getting into the bath.”

“My dad gained a lot of weight while he was on holiday last month.”

“They must take the dogs indoors before they bite somebody.”

“They usually get together on Fridays after they finish work.”

In order to ensure the participants attended to comprehension of the sentence reading as the task was intended, it was important that an SPR item be followed by a comprehension subtask that probed their comprehension (Just & Carpenter, 1992). In this regard, the present study adopted a sentence statement verification subtask for this purpose. To illustrate, after the participants read each sentence both in experimental sentences and distractor sentences, there was a statement and dichotomous “true” and “false” answers appearing on the next screen. Following Kaan et al. (2015), the statement verification probed the subject and object positions

of the target experimental sentences based on their thematic roles. For instance, based on the example from the short-distance SRC condition in Table 4, “The guy that knows the driver wants to buy a new car.” could have either “The guy wants to buy a new car.” or “The driver wants to buy a new car.” as its final statement verification task. If the answer was true, the participant was instructed to press the green color-coded key (L key) on the keyboard. If the answer was false, the participant was supposed to press the red color-coded key (D key). In the long-distance ORC condition, the same concept of the sentence statement verification subtask was applied. The two types of questions were equal in number. Half of the answers to the true/false statements were true. To ensure the participants were attentive to the meaning comprehension, as the task intended, only the RTs from the experimental items that were correctly comprehended were taken for further analyses (Coughlin & Tremblay, 2013).

The SPR task was administered to an individual participant in a quiet environment. In this task, the participants started by reading the instructions and were familiarized with the tasks through the 10 practice trials. They were allowed to ask any questions they might have before the actual experiment began. The experimenter was present only during the practice session to ensure the participants understood how to perform the task and refrained from intervening during the actual trials. The task instructions were written in simple language in English. Since the main emphasis of the study was placed on L1-L2 structural competition, all the task instructions were in English in order to avoid the occurrence of L1-L2 co-activation, which may heighten L1 activation in the L2 participants during the experiment.

In this SPR task, individual participants read a sentence presented in a non-cumulative word-by-word moving-window paradigm. In this linear non-cumulative SPR task, each participant was asked to read each region of the sentence on a word-by-word basis (Jegerski, 2014; Jiang, 2012). Figure 16 illustrates an example of an experimental sentence presented using a non-cumulative moving-window method in the SPR task. Each line represents each region appearing at the center of a computer screen.

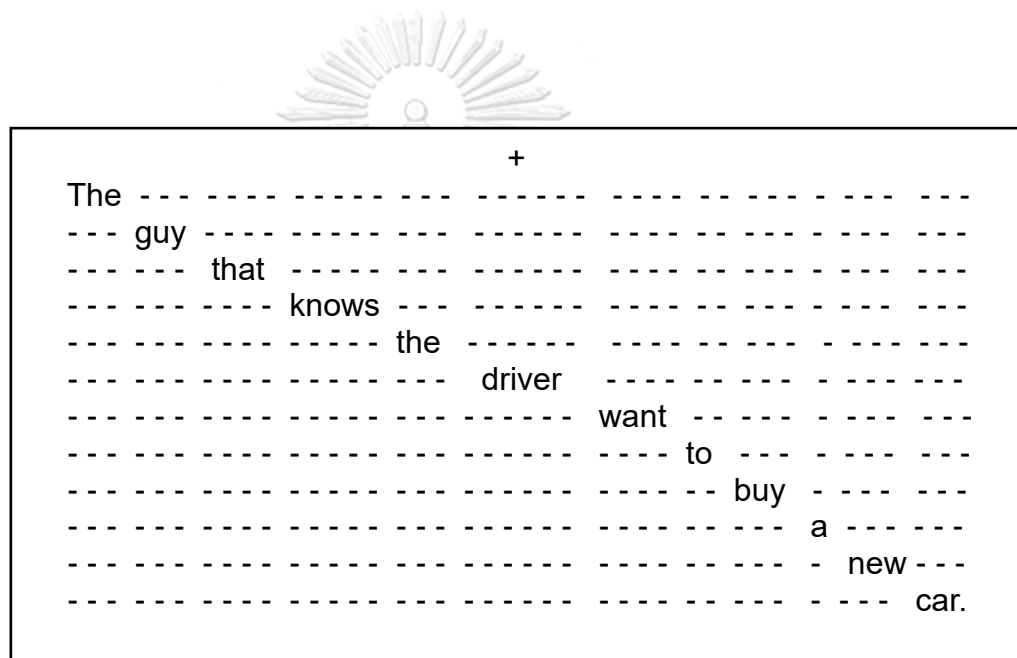


Figure 16: Illustration of the self-paced reading task  
(Jegerski, 2014, p. 23)

Following Sagarra and Herschensohn (2010), each sentence in the SPR task began with a '+' fixation marker for 500 ms to prepare the participants for the coming item. Each sentence was masked with dashes and presented at the center of the computer screen with no line breaks. Manipulated by the participants, each word appeared to the right of the computer screen. The appearing region replaced a set of dashes equivalent to the total number of masked characters and word boundaries, and the previous word simultaneously disappeared as the participants pressed the spacebar



key on the computer keyboard to advance their reading. They were advised to use their index fingers to advance their reading. The process was repeated until the participants reached the end of the sentence, which meant the participants could not go back to read the previous regions again. After the last region appeared, pressing the spacebar again would prompt the final sentence statement verification task. On verification, the participants read the sentence and responded to it by pressing the green (true) or red (false) color-coded button on the keyboard. There was no time constraint during the statement verification task. In this task, while the participants were reading each region, their RTs in each of the regions were recorded in ms. Longer RTs or reading slowdowns at the target matrix verbs were taken as an index of their sensitivity to agreement violation of the English present tense agreement morphology. It could then be considered whether the likelihood of mental operations being used in their L2 morphosyntactic processing was similar to that of the native speaker controls (see APPENDIX C for the list of experimental sentences of the SPR task).

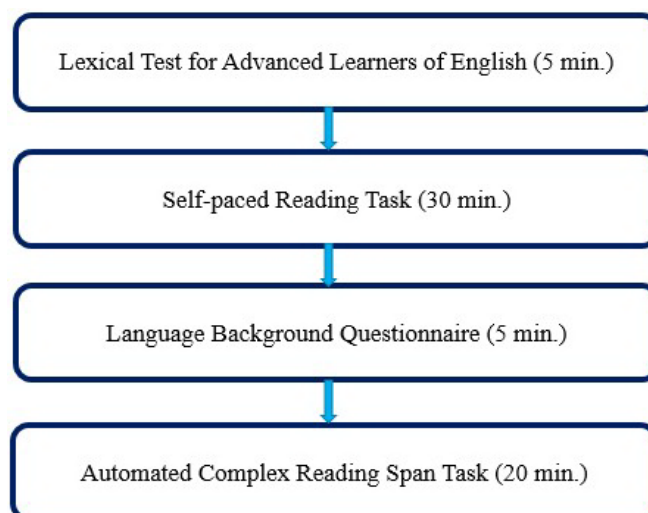


Figure 17: Illustration of the sequence of the tasks

Figure 17 illustrates an overview of the sequence of the tasks. The SPR task took approximately 30 minutes and was administered after the LexTALE, which took approximately five minutes. Upon the completion of this SPR task, the participants were asked to complete a language background questionnaire, which took about five minutes, followed by the RSPAN task, which took about 20 minutes to complete.

### 3.2.2 Variable manipulations

Sentence manipulations were taken into account to assess the potential effects of various factors which could be controlled for to avoid potential confounds, namely types of verbs, animacy, types of RCs and relative markers, plausibility, and lexical frequency. The sections below discuss several considerations for the manipulations of the experimental sentences in the present investigation.

Firstly, the verb types included in the experimental items were kept constant, using stative verbs. English is a tense language and its verbs are usually concerned

with time and aspect of a given situation. Different types of verbs may appear in different verbal aspects in relation to time, which may have an influence on participants' processing. Both tense and aspect in English are morphologically marked. In this regard, finite English verbs are overtly marked with the present tense marking *-s* when the subject argument is a third-person singular. However, some verb types may be prone to occur to a particular tense and aspect. Take stative verb and activity verbs for example. Shirai (2002, p. 455) defines the use of statives, e.g., "love", as a way to describe a situation that continues to exist if not otherwise changed by other outside situations, whereas activity verbs, e.g., "walk", are used to describe a dynamic and durative situation which is subject to an endpoint at any time. Unlike activity verbs, dynamic verbs have neither a beginning point nor an endpoint. For instance, according to Collins (2002, pp. 57-58), stative verbs are likely to occur in the present tense while activity verbs tend to occur to the progressive aspect. That is, statives appear to be more prototypical in the present tense, e.g., "She likes pizza.", but not "\*She is liking pizza." This tendency is in line with the prediction of the acquisition of tense-aspect systems at an early stage in both L1 and L2, i.e., the Aspect Hypothesis<sup>7</sup> (Anderson & Shirai, 1994; Bardovi-Harlig, 1994). Due to the prototypical use in the present tense, statives had to be appropriate and justified in the present experiment. In addition, alongside the matrix verbs which were the target

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<sup>7</sup> The Aspect Hypothesis assumes that the acquisition of verbal morphology is constrained by certain classes of verbs, which is according to their aspectual properties. Based on the Aspect Hypothesis, Anderson and Shirai (1994, p. 133) state that "first and second language learners will initially be influenced by the inherent semantic aspect of verbs or predicates in the acquisition of tense and aspect markers associated with or affixed to these verbs." That is, the prototypical uses of certain classes of verbs may restrict how the verbal markings in relation to the tense-aspect system are used and acquired at early stages of learning. For instance, in the earliest stage of L1 learning, L1 learners whose language has tense-aspect markings tend to restrict the use of progressive inflections mainly to activities (a verb class depicting a durative situation that requires a form of energy in order for the situation to take place, the beginning and end points of which are arbitrary), such as in "run", in such a way that progressive marking is rarely overextended to statives (Anderson & Shirai, 1994, p. 135).

regions of this investigation, a correct use of subject-verb agreement appearing earlier in the intervening RCs was expected to adequately provide the present tense contexts adequately for the participants to conceive of the present tense. In this regard, the experimental sentences involved 20 different English stative verbs in the critical region. They were chosen from the 2,500 most frequently occurring words offered by the new general service list (new-GSL) (Brezina & Gablasova, 2015).

Secondly, given that past agreement studies showed that the auxiliary/copula “be” tended to be easier to acquire (Ionin & Wexler, 2002; Lardiere, 1998), agreement processing in this study was studied through the less salient but more complex agreement inflection *-s* to provide more insights into how L2 agreement was processed. The selected verbs are all thematic verbs which take the English 3S morpheme *-s* to agree with the head nouns in person and number. Unlike the variant forms of copula “be”, e.g., “is”, “are”, “was”, and “were”, or “have”, i.e., “have”, “has”, which appear to contain number and person features and have been widely studied (e.g., Jiang, 2004; Kaan et al., 2015), a thematic verb in its bare form does not have such features. Accordingly, they are assumed to be more difficult to process due to the involvement of the 3S morpheme inflections. This investigation, accordingly, aimed to add to and extend the knowledge of the underlying mechanisms involved in the processing of the subject-verb number agreement suffix *-s* in thematic verbs. Thus, it was appropriate that English thematic verbs were selected to investigate the subject-verb number agreement inflectional morphology in the present experiment.

Thirdly, animacy of the NPs used was taken into consideration. O'Grady (2011) pointed out that processing cost differences between SRCs and ORCs may not

be as simplistic as the past findings showed. It has long been agreed that SRCs are easier to process (Baddeley, 2012; Gibson, 1998, 2000; Just & Carpenter, 1992; Suda, 2015); nevertheless, this notion has been challenged by empirical evidence that such processing asymmetry may be due to the role of the animacy of the head NP. That is, when the direct object RC modifies an inanimate head NP, the difficulties between the two types tended to be neutralized. In addition, the processing of ORCs tends to be facilitated when the RC involves pronominal animate subjects, such as in the following example from O'Grady (2011): "The apple that you ate was green." It is well established that animacy seems to play a crucial role in subject and object ERC processing (O'Grady, 2011), thus potentially affecting the 3S morphology manipulated in the experimental sentences. However, in the present study, it is assumable that SRCs are usually easier to process (Baek, 2012; Gibson, 1998, 2000; Just & Carpenter, 1992; Suda, 2015). To keep the non-critical regions constant between the two types of ERCs, it seems impossible to use inanimate head NPs in the manipulation due to thematic relations. That is, they are semantically non-reversible. For instance, the inanimate direct object of an ORC cannot be reverted to the subject of an SRC; it would become semantically anomalous. Consider "The book that the girl likes..." and "\*The book that likes the girl...", for example. It is, thus, appropriate to manipulate and include only animate subject and object head NPs in the experimental sentences.

In addition to the role of animacy, the selection of the English relative markers was taken into account in the linguistic manipulations. English restrictive relative clauses allow the use of "who", as a relative marker, in either in SRCs or ORCs with animate head NPs. The fact that the relative marker "who" may be used

interchangeably with “whom” in an ORC might variably increase processing cost if they were not kept constant. Since this study deals with both SRCs and ORCs, it was important to control the use of the relative marker. According to Biber et al. (1999), the relative marker “that”, which covers both animate and inanimate entities, appears to be commonly used across registers. Since the ERC constructions used in the experiment were all restrictive relative clauses, it was appropriate that only the relative marker “that” was used to introduce an ERC in all experimental sentences. The fact that the relative marker “that” is more common (Biber et al., 1999) than “who” and “whom” and can be used interchangeably to modify both subject-extracted and object-extracted ERCs, be they with animate or inanimate head NPs, as well as its consistency throughout the task, justifies its adoption in the present study.

Another linguistic factor controlled for was the complexity of the NPs, which was explained in relation to the uses of SRCs and ORCs. The NPs involved in the manipulations of the experimental sentences were kept constant based on their complexity. The complexity of the ERCs was carefully manipulated to filter out potential confounds other than the differences in filler-gap dependencies of the SRCs and ORCs. In this regard, the manipulations of the ERCs followed the dependency locality theory (DLT) (Gibson, 2000). That is, the notion of DLT assumes computational resources are differently consumed depending on the number of new discourse referents intervening in the integration. (Gibson, 2000, p. 103) defines a discourse referent as “an entity that has a spatiotemporal location so that it can later be referred to with an anaphoric expression.” To elaborate, processing a head noun of a given NP that introduces a new discourse referent, such as a proper name, e.g., “John”, or definite descriptions (Warren & Gibson, 2002), e.g., “the man”, tends to

consume cognitive resources more substantially than a more accessible entity, such as a pronominal subject (Warren & Gibson, 2002), e.g., “you”. Therefore, all the subject NPs were all definite descriptions, e.g., “the guy(s)”, and overtly marked with plural marking -s in the case of the plural subject NP conditions to keep the levels of complexity of the NPs constant.

Furthermore, plausibility of the semantically reversible ERCs was carefully controlled for as it might affect the participants’ comprehension accuracy in the statement verification subtask, which might lead to unnecessary exclusion of the data points. To prevent excluding data points from items inaccurately responded to, the items for the comprehension question subtask were normed. A small-scale plausibility norming survey was conducted to examine potential plausibility differences (Gibson & Warren, 2004). Participants were instructed to read and rate plausibility on a scale of 1 (not very) to 7 (very much). Two lists were created, each containing 20 target sentences interspersed with 40 distractors. The sentences were simplified using simple sentence structure while the role of the subject and the object was alternated, as shown in (36).

- (36) a. The guy knows the driver.  
 b. The driver knows the guy.

In total, 16 native speakers of American English at University of Illinois at Urbana-Champaign, who did not participate in the SPR experiments, were assigned randomly to one of the two lists to rate the plausibility of the items on one of the two lists according to a 7-point rating scale. This means each participant saw only one

version of the sentences. In the norming survey, they were asked to judge the naturalness of the sentences—how likely the situation was to occur in the real world. The results revealed that the experimental items had relatively high plausibility rating scores with mean scores ranging from 5.13 to 7. An Independent-Samples Mann-Whitney U Test was performed to analyze the plausibility differences in the norming data. In all 20 pairs of target sentences, the norming survey results showed that there were no significant differences in terms of plausibility found ( $p > .05$ ), indicating that the plausibility effects should be considered minimal and should not affect the comprehension accuracy. Mean scores, standard deviation, median, U and  $p$ -value of each pair are reported in APPENDIX F.

In addition, an intervening adverb tended to influence the processing of the subject-verb agreement morphology. Moreover, it was found that sentences with longer adverbs, i.e., “sometimes” and “usually”, had higher omission rates than the shorter ones, i.e., “often” and “always” (Wakabayashi et al., 2006, p. 241, as cited in Shibuya & Wakabayashi, 2008). Since using adverbs appears to variably modulate the processing of the 3S morpheme *-s*, it was decided no adverbs would be used as part of the experimental sentences. It could be argued that without sufficient contexts or time markers, such as “every day”, or adverbs of frequency, such as “always” and “usually”, multiple considerations when interpreting the verb tenses may be possible and may not precisely reflect the present tense morphology. However, the present study chose not to include such markers in order to avoid their effects on the processing of the verbs. In doing so, it should also make the purpose of the study unknown to the participants. To address the accuracy and validity concerns of the measure, all the finite verbs in the embedded ERCs were manipulated to provide a



present tense context. This RC would be encountered first during the reading. Recall that all subordinate clauses, the ERCs per se, were always grammatically correct. While such manipulation functioned to constrain the possibility of the critical verb interpretation to the present tense, the initial encounter with the present tense verb in a particular stimulus should provide sufficient context of the present tense for the participants.

Finally, frequency effects were addressed in the experimental task materials. In L2 sentence processing and L2A experimental studies, it is essential that frequency of lexical items selected for experimental materials be controlled for. Although all the participants were at the upper-intermediate level of L2 English proficiency, lacking L2 lexical knowledge might impose L2 proficiency-related confounds in the data. This consideration was aimed at avoiding potential confounds between L2 lexical knowledge and L2 grammatical knowledge, which may arise as a result of unfamiliar L2 vocabulary. To this end, the sentences were devised based on a word frequency list offered by an analysis of instances from various corpora (Marsden et al., 2018; Pratt, 2016). In this study, the target nouns, adjectives, and verbs selected to construct the experimental sentences were largely based on the 2,500 most frequently occurring English words. The list is provided by the new general service list (new-GSL) (Brezina & Gablasova, 2015), which is derived from four corpora with a total size of over 12 billion running words. In addition, the words were verified on the vocabulary profile offered by English Vocabulary Profile (Cambridge University Press, 2013) to ensure that the lexical items chosen from the frequency list in order to manipulate the sentences were appropriate. English Vocabulary Profile offers an analysis of vocabulary level in accordance with the CEFR (see APPENDIX D). The uses of

vocabulary, based on the CEFR, can be broadly classified into six levels: A1 and A2 (basic users), B1 and B2 (independent users), C1 and C2 (proficient users). Accordingly, to keep the lexical variables constant and to minimize the effects of the selected lexical items, the vocabulary encompassed in the experimental sentences were drawn from the list of the most frequently occurring words and ranged from A1 to B1 levels. With such a manipulation, the range of lexical items used in the experimental sentences should suffice to reduce latency associated with lexical knowledge of L2 English. In relation to the contexts of L1 Thai learners of L2 English, these criteria were in line with the recent findings on Thai undergraduates' vocabulary size (Mungkonwong & Wudthayagorn, 2017), indicating that Thai learners of L2 English, by large, possessed approximately 4,200 word families. It was suggested that such a vocabulary size would be adequate for them to perform basic language skills in L2 English at the university level. Therefore, confounds related to vocabulary unfamiliarity were expected to be minimal when constructing experimental sentences based on the 2,500 most frequent English words (Brezina & Gablasova, 2015). See APPENDIX C for a list of the experimental stimuli.

### 3.2.3 Predictions

Two main arguments were made in the present study. One assumption was that WM capacity varying across individuals would constrain the extent to which L1 Thai learners of L2 English were able to process an L2-appropriate morphosyntactic feature, the English present tense inflectional agreement morphology in complex sentences, in real-time processing. The other was that the complexity of the L2 structures manipulated was based on the distance of the two types of filler-gap dependencies in ERC extractions. They served as explanatory variables depicting how

the learners' cognitive resources were differently demanded during the processing of the agreement morphology during the attempt to comprehend syntactically complex structures of ERCs. Such a relationship could be established in an investigation of real-time morphosyntactic processing. The argument in support of this view was posited by the L1-L2 structural competition account, which showed L1-appropriate forms and L2-appropriate forms were competing for selection at the time of processing an L2 grammatical feature, during which cognitive resources were highly demanded by the task, especially when the processing involved complex constructions (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairroj, 2013).

Distance-based complexity based on ERC extraction types was predicted to differently affect how L1 Thai learners of L2 English with different WM capacity would process the English present tense inflectional agreement morphology. Specifically, the long-distance ORCs were predicted to be perceptually more difficult than the short-distance SRCs to process (Baek, 2012; Gibson, 1998, 2000; Just & Carpenter, 1992; Suda, 2015). Consequently, it was assumed such intervening complex constructions would pose substantial difficulty in the agreement processing as the integration of the subject and the verb of the matrix clause was non-adjacent and interrupted by the processing of the two types of ERCs. Specific predictions as to the present investigations are presented as follows.

As regards the WM effects, it was predicted that L1 Thai learners of L2 English who possessed higher WM capacity would be more sensitive to subject-verb number agreement grammatical violations. Therefore, RTs in the critical and spillover regions were expected to be longer in ungrammatical conditions than grammatical

conditions since the main verbs of the matrix clauses in both short-distance SRCs and long-distance ORCs usually take longer to process as a result of syntactic complexity. More specifically, the ORC matrix verbs have been found to take longer for one to process than the matrix verbs in SRCs (Just & Carpenter, 1992). In this regard, equivalent grammatical ERC constructions corresponding to each condition were used as a baseline to prove that an increase in the RTs was from the participants' sensitivity to the grammatical violations, rather than merely from the processing of the verbs residing in the ERCs per se (see Table 4 and Table 5).

Asymmetric processing patterns of the English present tense agreement morphology may be generated by two different types of distance-based complexity in relation to the availability of cognitive resources in agreement computations. To examine the effects of distance-based complexity and WM capacity on the L1-L2 structural competition, the critical and spillover regions of each experimental stimulus included the L2 English present tense verb inflections being omitted (L1-based) or incorrectly inflected (L2-based). The participants' sensitivity to agreement violations was indexed by longer RTs. To explain, if they showed sensitivity to grammatical violations in all distance conditions through reading slowdowns, it was probable that they had L2 competence and could put it into use in real-time comprehension, which was necessary for parsing L2 grammatical features in syntactically complex sentences in real-time processing. On the other hand, if the participants did not show sensitivity to grammatical violations, i.e., lacking sensitivity to 3S morpheme omissions or incorrect inflections, through a lack reading slowdowns in the critical or spillover regions, it was appropriate that the L1-L2 structural competition account could be accounted for. That is, the better established L1 grammatical forms may get co-

activated during the L2 agreement processing, thus winning out over its counterpart in L2 English, whereby cognitive resources are consumed more in the more complex environment, resulting in greater processing difficulties and suffering from crosslinguistic competition (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpaiboj, 2013).

### **3.2.4 Scoring and analysis**

The dependent variable observed in the SPR experiments was the RTs collected from the critical region, i.e., the main verbs of the matrix clauses, and the spillover region, i.e., one word immediately following the critical region. The explanatory variables included WM capacity scores and types of distance based on the short-distance SRC and long-distance ORC constructions.

In the data trimming process to exclude potential outliers which may confound the results, the following criteria were applied. Firstly, only the RTs from trials correctly comprehended were included for further analyses (Coughlin & Tremblay, 2013). This was to ensure that the participants comprehended the embedded RCs serving as two types of distance-based complexity, which may affect the L2 processing involving long-distance agreement dependencies. Secondly, consistent with the SPR methodology, predetermined cutoff ranges were applied. That is, RTs shorter than 100 ms or exceeding 2000 ms were removed from the analyses since such reading speeds would suggest unnatural reading or might reflect the participants' lack of attention. According to previous research (Miralpeix & Meara, 2014), the mean RTs of native speakers of English, in general, were reported to be around 250 ms per word. Finally, participants whose comprehension accuracy rates of the experimental

items were below 80% were excluded and replaced as such rates might reflect their lack of attention to or their inability to comprehend the stimuli.

After the data trimming processes, the RT data were then fitted in a series of Linear Mixed-Effects (LMEs) models separately (Baayen et al., 2008), using IBM SPSS Statistics (version 25). LMEs are statistical models used to describe the relationships between the response variable (RTs) and the three explanatory variables (WM capacity, distance, and grammaticality). LMEs regression analysis was preferred to analysis of variance for several reasons. Firstly, LMEs models allowed for inclusion of several variables, such as WM capacity, distance types, and grammaticality, to be considered simultaneously (Baayen et al., 2008; Christianson, 2017). Secondly, the LMEs regression analysis could account for individual differences between participants and the research stimuli, and thus was appropriate for analyzing the RT data in the present experiments, which were considered non-independent or hierarchical data since the RTs of each participant were observed in different conditions of the same items by each participant. In addition, LMEs modeling also allowed for the assumption that the sample group had been randomly sampled from the population, accounting for individual differences which might appear to be more influential than differences in terms of crosslinguistic influence (Christianson, 2017; Tanner, 2013).

LMEs models are statistical models which contain both fixed effects and random effects. In structuring the RT data in the LMEs models, *WM capacity* (RSPAN scores), *distance* (short-distance SRCs vs. long-distance ORCs), and *grammaticality* (grammatical vs. ungrammatical) were included as fixed effects, and

*participants* and *items* were included as random effects. The equation of the LMEs models used in the present study can be represented as follows:

$$Y_i = \beta_0 + \beta_1 (\text{WM}) + \beta_2 (\text{DISTANCE}) + \beta_3 (\text{GRAMMATICALITY}) + \\ \beta_4 (\text{WM} \times \text{DISTANCE}) + \beta_5 (\text{WM} \times \text{GRAMMATICALITY}) + \beta_6 (\text{DISTANCE} \times \\ \text{GRAMMATICALITY}) + \beta_7 (\text{WM} \times \text{DISTANCE} \times \text{GRAMMATICALITY}) + \epsilon_i$$

To elaborate,  $Y_i$  is a vector of continuous responses (the RT observations) for the  $i^{\text{th}}$  participant, and  $\beta$  is a vector of regression coefficients for the fixed effects. In SPSS Statistics, the participants' WM capacity, or the RSPAN scores, were entered into the models as a continuous variable with a possible range between 0 and 75. The other two explanatory variables concerning the manipulations of the stimuli, i.e., distance and grammaticality, were entered into the models as categorical variables. In the analyses of both Experiment 1 and Experiment 2, the short-distance SRC condition was coded as 0, and the long-distance ORC condition was coded as 1. As regards the grammaticality of the stimuli, the grammatical condition was coded as 0, and the ungrammatical condition was coded as 1. The error term is denoted by  $\epsilon_i$ , which is an error vector representing the deviations that could not be explained or controlled experimentally.

The possible main effects may include 1) the main effects of WM capacity on the RTs, 2) the main effects of distance on the RTs, and 3) the main effects of grammaticality of the agreement morphology on the RTs. The relationships among the explanatory variables, i.e., WM capacity, distance, and grammaticality, might also

influence the response variable, i.e., the RTs, and the possible interaction effects may include 1) the interaction between WM capacity and distance, 2) the interaction between WM and grammaticality, 3) the interaction between distance and grammaticality, and 4) the interaction among the three explanatory variables, i.e., WM, distance, and grammaticality. In both Experiment 1 and Experiment 2, the main effects and interaction effects that reached significance ( $p < .05$ ) were retained in the final fitted LMEs models of the RT data.

### 3.2.5 Validity

The index of item-objective congruence (IOC) (Rovinelli & Hambleton, 1977) was employed to evaluate the validity of the experimental stimuli in the SPR task. The validity can be defined as the degree to which the task contents represent the sample of the contents the test claims to measure (Brown, 2005). It is advisable that experimental sentences in the SPR task be checked for perceived naturalness by native speakers, especially when a study attempts to make a comparison between an L2 population and a native speaker population. This is because RTs may be affected by unnatural language despite the grammaticality of the sentences (Marsden et al., 2018). In this regard, since the experimental sentences were not authentic instances drawn directly from English corpora, three native speakers of English were asked to verify whether the experimental sentences served as an appropriate representative sample of the content which the SPR task of the present study was devised to measure.

To obtain the data on validity of the experimental stimuli, three experts in psycholinguistics and English language studies were asked to provide their judgment and opinion on the validity of each experimental stimulus through an index of IOC.



The IOC rating form included the objectives of the measurement and the descriptions of the stimuli of the SPR task. On the rating scale, they were instructed to indicate their agreement according to the scale, where +1 means they were certain that the stimulus was congruent with the objectives, 0 means they were uncertain that the stimulus was congruent with the objectives, and -1 means that they were certain that the stimulus was not congruent with the objectives. It was required that they provide comments or suggested revisions if any item was rated -1. Stimuli which received an average score of lower than 0.67 were adjusted based on the experts' comments and suggestions. After the IOC results were taken into consideration, adjustments were made to the experimental stimuli accordingly. All of the experimental stimuli received an average IOC score equal to or higher than 0.67 and were thus retained for use in the actual experiments. The IOC results are reported in APPENDIX C.

### **3.3 Pilot study**

Prior to the actual experiments, a small-scale pilot study was conducted to ensure that the experimental tasks and data collection procedure were appropriate for the investigation.

#### **3.3.1 Objective of the pilot study**

The primary goal of the pilot study was to gain better understanding of the experimental design and research procedure prior to the implementation in the actual data collection. This was also to prevent any unprecedented occurrences which may arise in the actual data collection.

#### **3.3.2 The present pilot study**

The pilot study was implemented with a similar group of participants, L1 Thai learners of L2 English at the undergraduate level. In this regard, a total of 10 L1

Thai learners of L2 English at the undergraduate level and a group of 10 native speakers of English participated in the pilot study. They were not part of the actual experiments. The tasks and the research procedure resembled the actual data collection.

### **3.3.3 The summary of the pilot study**

The pilot study primarily helped improve the research procedure regarding task administration. First, it was essential to ensure that the participants understood the task instructions. In addition to the description of the instructions provided for each task, they were allowed to ask any questions upon completing the practice trials. Second, the environment during the experimental session might affect the obtained data; therefore, it was crucial that the experimental areas be quiet. In addition, in the pilot study, there was one native speaker participant stopping during the session to ask what she should do as she had noticed some grammatical mistakes, which might be from the distractors or experimental stimuli. This was taken into consideration because the occurrence was not expected. To prevent this from happening in the actual experiments, each participant was instructed to try their best to answer the comprehension questions no matter what sentences were presented on the screen. Finally, for the sake of consistency of the RT data, the experimenter emphasized that each participant should use both of their index fingers to perform the SPR task.

### **3.4 Information about research ethics for research involving human subjects**

Prior to the experiments, every participant read the research information sheet and signed a consent form written in their native language in order to participate in the experiments and allow the use data collected from their performance for further

analyses and discussion. As regards research ethics in human subjects, this research proposal and its procedure had been 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. 080/62, see APPENDIX G) and the Office for the Protection of Research Subjects, the Institutional Review Board (IRB), University of Illinois at Urbana-Champaign (IRB Protocol No. 20285, see APPENDIX H) prior to data collection. The entire session of data collection took up to one hour, and the Thai participants were remunerated with 200 Baht for their time spent and traveling expenses. For the English native speaker participants recruited at University of Illinois at Urbana-Champaign, USA they could choose to receive either 7 USD or a course credit for their participation. This was based on a guideline provided by the Educational Psychology Psycholinguistics Lab, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, USA. This extra course credit was optional, depending on the course requirements the native speaker participants had in each semester. That is, this experiment along with many other experiments were available for the University of Illinois at Urbana-Champaign students to choose to participate in if they needed this extra credit. Regarding the native speaker participation, equal opportunities to earn extra credits for any courses on campus was ensured by the course instructors, which meant there were various means to earn extra credits through different assignments and activities, which depended on the students' preferences.

The research participants, both Thai and native speakers, were accessed through faculty members at the departments at which the students studied. The faculty

members only provided the contact information and refrained from joining any research activities so as to avoid any influences from their presence. The research participants had to be at least 18 years of age at the time of participation. The participation in the experiment was entirely voluntary. This means, upon voluntarily agreeing to participate in this research, each participant was informed that they could choose to withdraw at any time if they felt uncomfortable, without any negative consequences on them, their future study or work. The participants' personal information was protected, treated as confidential and deleted upon the completion of the research project. The research results were only reported in aggregate, and all collected data were coded so that there was no identifying information associated with the participants' responses. That is, no information in the research report would lead to identifying the participants as individuals unless they consented.

## **CHAPTER IV**

### **FINDINGS AND DISCUSSION**

This chapter reports on the findings from Experiment 1 and Experiment 2. Each is followed by discussions in relation to the related concepts and the previous research findings on the two primary variables of interest: WM capacity and distance-based complexity. 4.1 reports on the findings from Experiment 1, which examined sensitivity to L1-based L2 agreement violation by L1 Thai learners of English, where the experimental sentences each contained a singular agreement controller and an omission of the English 3S morpheme *-s*. 4.2 reports on the results obtained from Experiment 2, which placed an emphasis on investigating sensitivity to L2-based violation in the agreement processing with two unique-to-L2 morphological features: *-s* plural marking at the agreement controller and an overuse of *-s* agreement marking. Finally, 4.3 deals with a general discussion of the present experiment.

#### **4.1 Experiment 1**

The objective of Experiment 1 was to investigate the extent to which WM capacity and distance-based complexity (Gibson, 1998, 2000) affected the processing of English subject-verb agreement by L1 Thai learners of L2 English and NSs of English. The primary distinction between Experiment 1 and Experiment 2 lies in the manipulations of the subject NPs. According to the notion of between-language competition and within-language competition (Marian & Spivey, 2003), all manipulated subject NPs in Experiment 1 were L1-analogous singular agreement controllers with grammatical mismatch manipulated in the target verb regions, i.e., an omission of the *-s* agreement marker, an agreement violation based on an L1-feature as Thai lacks verbal agreement morphology. The findings are discussed in light of the

L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpaibroj, 2013).

#### 4.1.1 Participants

The participants were 40 native speakers of English (NSs) and 40 L1-Thai L2-English learners. The NSs were undergraduate and graduate students from various study disciplines, recruited at University of Illinois at Urbana-Champaign, USA. The participation was voluntary and the NS participants received either one extra course credit or monetary benefit of 7 US dollars in exchange for their participation. The L2 learners (nonnative speakers, NNSs) were undergraduates majoring in English for Communication, and recruited at Rajamangala University of Technology Suvarnabhumi, Thailand. The participation was voluntary, and the participants were remunerated with 200 Thai baht for their participation. The participants were naive to the purpose of the study. The participants whose comprehension accuracy rates of the experimental items were below 80% in the comprehension subtask were excluded and replaced (1 NSs and 3 NNSs were replaced). The demographical data of the NS and NNS participants in Experiment 1 are provided in Table 6 below.

Table 6 Demographical data on the NS and NNS participants in Experiment 1

	<i>n</i>	Residence	Age (yrs)	Gender (M, F, X)	WM Score (max=75)	LexTALE (max=100)
Native speakers	40	US	21 (18-31)	M=10, F=30	60.05 (39-75)	95.94 (90-100)
Nonnative speakers	40	Thailand	20 (18-24)	M=12, F=27, X=1	53.80 (32-74)	68 (60-78.75)

At the time this research was conducted, the 40 L1-Thai NNSs of English were those who resided in their home country, Thailand, and the 40 L1-English NSs were those who resided in the USA. Among the NNSs, 27 of them were females and 12 of them were males while there was one participant identifying their gender as a non-binary third gender (mean age = 20 years old). The NSs were homogeneous in comparison with the NNS group in terms of their age (mean age = 21 years old). The majority of them were also females. In total, 30 of them were females and 10 of them were male participants. All participants' WM span was measured by an RSPAN task in their L1. Following the partial-credit scoring procedure (Conway et al., 2005), it showed that the NNSs' WM spans ranged from 32-74 (mean WM span = 53.80), whereas the NSs' WM spans were between 39 and 75 (mean WM span = 60.05). The NNSs' English proficiency was at an upper-intermediate level (between 60% and 80%) as measured by LexTALE (Lemhöfer & Broersma, 2012). Their LexTALE scores were in a range between 60% and 78.75% (mean LexTALE score = 68%). The NSs performed at ceiling and were placed at the advanced level (above 80% threshold). Their LexTALE scores ranged from 90% to 100% (mean LexTALE score = 95.94%). All the participants were naive to the purpose of the study and reported having normal or corrected to normal vision.

#### **4.1.2 Stimuli**

In Experiment 1, the experimental stimuli were manipulated to have a third-person singular subject NP as the agreement source at the agreement controller. The agreement target verbs were either grammatical (L2-based, correct use of the -s agreement marker, such as “The guy...wants...”) or ungrammatical (L1-based violation, absence of the -s agreement marker, such as “The guy...want...”). These

manipulations were based on the notion of between-language competition between the learners' L1 and their L2 (Marian & Spivey, 2003). That is, if a diverging processing pattern was found when the agreement violation involved omission of *-s* agreement marking, it would mean that the two groups of participants processed the target verbs differently and that it would be ascribed to crosslinguistic influence. Table 7 illustrates each experimental condition in Experiment 1.

Table 7 Sample experimental items in Experiment 1

Experiment 1 stimuli	Condition
a. The <i>guy</i> that_knows the driver <i>wants</i> to buy a new car.	SRC-G
b. The <i>guy</i> that_knows the driver <i>want</i> to buy a new car.	SRC-UG
c. The <i>guy</i> that the driver knows_wants to buy a new car.	ORC-G
d. The <i>guy</i> that the driver knows_want to buy a new car.	ORC-UG

Note: SRC, subject-extracted relative clause; ORC, object-extracted relative clause; G, grammatical; and UG, ungrammatical.

The RTs were observed in two regions of interest, the matrix verb and the following word as illustrated below (with the seventh word as a critical region and the eighth word as a spillover region).

(37) SRC: \*The | guy | that | knows | the | driver | *want* | *to* | buy | a |  
new | car.

ORC: \*The | guy | that | the | driver | knows | *want* | *to* | buy | a |  
new | car.

There were 20 experimental sentences; half of them were grammatical and the other half were ungrammatical. A total of 40 fillers were interspersed across the four



lists. All 60 sentences were pseudorandomized so that no two experimental sentences appeared in succession. Four lists were created in a 2 x 2 Latin Square design, crossing distance (short-distance SRC and long-distance ORC) and grammaticality.

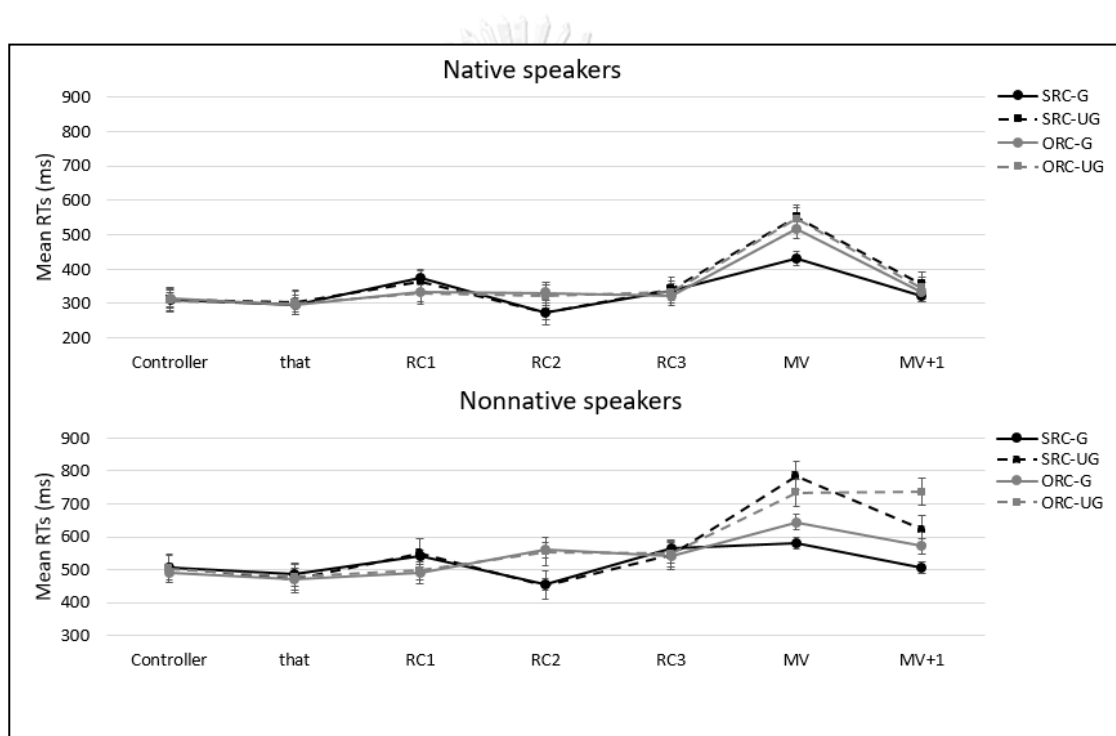
#### **4.1.3 Procedure and data analyses**

In Experiment 1, each participant voluntarily participated in the study. The participants were instructed to perform the computerized LexTALE as a measure of their L2 English proficiency. They responded to each of the 60 words appearing on the computer screen, judging whether the words existed in English. Then, each participant was instructed to do the SPR task, reading sentences word-by-word on a computer screen, and give their responses to the comprehension questions that followed. Then, a questionnaire on the participants' demographical information as well as their language background was administered. Finally, they performed a computerized RSPAN task, which examined their WM capacity. In this task, they were instructed to read sentences in their L1 and judge their semantic plausibility. Once each judgment had been made, they were instructed to try to remember the letter stimuli in each set size and recall them in the correct order. In the analysis, only the RTs from items that were correctly comprehended were included for further analyses. In addition, The RT data were then trimmed to exclude items acting as potential outliers. Consistent with SPR methodology, predetermined cutoff ranges were applied. RTs shorter than 100 ms or exceeding 2000 ms were removed from the analyses since such reading speeds suggest unnatural reading or may reflect the participants' lack of attention. In Experiment 1, the data cleaning process affected 4.25% of the trials for NSs and 9.19% of the trials for NNSs. The experiment was conducted in a quiet environment.

#### 4.1.4 Results

After the data cleaning processes, the RTs were then analyzed using descriptive statistical analyses to determine the mean scores and standard deviation. The RTs in each region of the experimental sentences are illustrated in Figure 18 below.

Figure 18: Mean RTs in critical regions and spillover regions for NSs and NNSs in Experiment 1



As seen in Figure 18, the overall results showed that, in both NS and NNS groups, the matrix verbs (MV) as well as the spillover region (MV+1) in the short-distance SRC condition were read faster than in the long-distance ORC condition, given other factors. This may be attributed primarily to the effects of distance-based complexity on the matrix verb RT results overall (Gibson, 1998, 2000). This processing difficulty could well serve as a baseline of the different distance effects in relation to cognitive resources necessitated in the processes (Baek,

2012; Just & Carpenter, 1992; Suda, 2015). In addition, the ungrammatical conditions took the participants in both groups longer to read overall. The reading slowdowns suggested that both NSs and NNSs at an upper-intermediate L2 English proficiency were able to show sensitivity to agreement violations with a singular subject NP controller and the less salient *-s* agreement inflection; however, their sensitivity was modulated by individual differences in terms of WM capacity. The linguistic variable manipulated in terms of distance-based complexity also played an important role in reduced sensitivity to agreement violation in both groups. The results were reported and discussed in line with the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013).

#### 4.1.4.1 Reading times in the critical region

In Table 8, the mean RTs and standard deviations in the critical regions, i.e., the matrix verbs, are reported based on types of distance and grammaticality for the NS and NNS participants in Experiment 1.

Table 8 Mean (*SD*) RTs in milliseconds in the critical region for native and nonnative speakers in Experiment 1

Condition	NS		NNS	
	SRC	ORC	SRC	ORC
Grammatical	430(132)	517(131)	581(185)	645(276)
Ungrammatical	552(160)	546(148)	785(394)	733(291)

Overall, different degrees of distance-based complexity between SRCs and ORCs contributed to the processing time course in both NSs and NNSs. The NSs' processing patterns showed longer RTs being observed in the critical regions in the ORC-G condition ( $M = 517$ ,  $SD = 131$ ) than in the SRC-G condition ( $M = 430$ ,  $SD = 132$ ). Sensitivity to agreement violation as indexed by the reading slowdowns of the

NSs was found in both SRC and ORC conditions; however, they read more slowly in the SRC-UG condition ( $M = 552$ ,  $SD = 160$ ) than in the ORC-UG condition ( $M = 546$ ,  $SD = 148$ ). From the mean RTs with respect to different types of distance manipulations, it can be seen that the NSs seemed to exhibit longer RTs in the SRC-UG condition than in the ORC-UG condition.

In a similar vein, the effect of distance-based complexity was also evident in the NNSs' processing patterns. In reading the matrix verbs, they took longer to read in the ORC-G condition ( $M = 645$ ,  $SD = 276$ ) in comparison with the SRC-G condition ( $M = 581$ ,  $SD = 185$ ). However, in the ORC-UG condition ( $M = 733$ ,  $SD = 291$ ), shorter RTs were observed when compared with those in the SRC-UG condition ( $M = 785$ ,  $SD = 394$ ).

As the RT data in Experiment 1 showed, similar processing patterns were observed between the NSs and NNSs. Both groups' processing times tended to be affected by distance, based on the DLT (Gibson, 1998, 2000), and hence their ability to show sensitivity to ungrammaticality was evidently affected by the longer distance of the intervening materials, the long-distance ORCs, thus leading to a decline in their sensitivity to agreement violation when encountering the matrix verbs in the ORC-UG condition.

Effects of each predictor on the RTs of NS and NNS participants were estimated using Linear Mixed-Effects (LMEs) modeling (Baayen et al., 2008). The RT data were then fitted in a series of LMEs models, using IBM SPSS Statistics (version 25), with WM (RSPAN scores), distance, and grammaticality as fixed effects, and participants and items included as random effects. Table 9 and Table 10

show the results from the LMEs modeling of the RTs of NS and NNS participants in the critical region.

Table 9 Fixed effects in the LMEs model of RTs in the critical region for native speakers in Experiment 1

**Linear Mixed Effects Model of Reading Times**

Predictor	Coefficient	SE	df	t	p
Intercept	590.89	72.01	51.23	8.21	.000
WM	-2.65	1.18	50.48	-2.25	.029
Distance	217.50	53.91	719.45	4.04	.000
Grammaticality	122.63	12.45	719.27	9.85	.000
WM x Distance	-2.20	.87	719.47	-2.51	.012
Distance x Grammaticality	-95.80	17.74	719.37	-5.40	.000

Adjusted R-squared: 0.293

Table 10 Fixed effects in the LMEs model of RTs in the critical region for nonnative speakers in Experiment 1

**Linear Mixed Effects Model of Reading Times**

Predictor	Coefficient	SE	df	t	p
Intercept	590.49	37.77	48.20	15.64	.000
Distance	196.52	68.73	712.16	2.86	.004
WM x Distance	-2.55	1.21	715.66	-2.11	.035
WM x Grammaticality	3.68	.37	684.77	9.98	.000
Distance x Grammaticality	-109.69	29.34	682.46	-3.74	.000

Adjusted R-squared = 0.451

In the critical region, in the NS group, a main effect of WM was observed ( $\beta = -2.65$ ,  $t(50.48) = -2.25$ ,  $p < .05$ ), suggesting that as the participants' WM capacity increased, they tended to take a shorter time to read the matrix verbs. Distance was also found to be a main effect, indicating NSs had a tendency to show longer RTs

when encountering the matrix verbs in the ORC condition ( $\beta = 217.50, t(719.45) = 4.04, p < .001$ ). In addition, a main effect of grammaticality was also observed ( $\beta = 122.63, t(719.27) = 9.85, p < .001$ ). This indicated that the participants showed sensitivity to ungrammaticality through their reading slowdowns when reading the ungrammatical verbs. There was a significant interaction between WM capacity and types of distance complexity between SRCs and ORCs ( $\beta = -2.20, t(719.47) = -2.51, p < .05$ ). It was found that the NSs exhibited shorter RTs in ORC conditions as their WM capacity increased (Gibson, 2000; Just & Carpenter, 1992). In addition, the effects of distance were manifested as it interacted with grammaticality ( $\beta = -95.80, t(719.37) = -5.40, p < .001$ ). The ORC-UG condition took the NSs a shorter time to read when compared to the SRC-UG condition, which could be due to influence from the distance complexity on the processing of agreement at the matrix verbs.

In the NNSs group, a main effect of distance was found ( $\beta = 196.52, t(712.16) = 2.86, p < .05$ ), suggesting that the effect of distance contributed to the longer RTs in the more distant agreement dependency with an ORC as an intervening material compared with those in an agreement dependency with an SRC. The NNS participants took longer to read the matrix verbs in the long-distance ORC condition than in the short-distance SRC condition. Similar to the NSs, the NNS group showed shorter RTs in ORC conditions as their WM capacity increased, as shown by the significant interaction between WM and distance ( $\beta = -2.55, t(715.66) = -2.11, p < .05$ ). This phenomenon indicated that the NNSs' capability of dealing with linguistically complex structures may be modulated by their cognitive capacity constraint (Just &

Carpenter, 1992). In addition, WM capacity was found to interact with grammaticality, as shown by the reading slowdowns in ungrammatical conditions as their WM capacity increased ( $\beta = 3.68, t(684.77) = 9.98, p < .001$ ). This suggested that the NNSs whose WM spans were larger were generally abler to maintain sensitivity to agreement violations. Finally, there was also a significant interaction between distance and grammaticality displayed by shorter RTs in the ORC-UG condition ( $\beta = -109.69, t(682.46) = -3.74, p < .001$ ). This indicated that the NNSs' ability to show sensitivity to agreement violation was also modulated by distance-based complexity. The reading slowdowns at an ungrammaticality were not evident in the more distant ORC condition as compared to the less distant SRC condition in the critical region of matrix verbs.

#### 4.1.4.2 Reading times in the spillover region

In Table 11, the mean RTs and standard deviations in the spillover regions are reported based on types of distance and grammaticality for the NSs and NNSs in Experiment 1.

Table 11 Mean (*SD*) RTs in milliseconds in the spillover region for native and nonnative speakers in Experiment 1

Condition	NS		NNS	
	SRC	ORC	SRC	ORC
Grammatical	324(98)	333(82)	505(197)	571(237)
Ungrammatical	356(125)	346(114)	622(261)	736(372)

The overall RT data showed that similar processing patterns were evident between SRC and ORC grammatical conditions. That is, the longer the distance, the longer RTs required. This held true in the grammatical condition for NSs and NNSs. To elaborate, the NSs' RTs were found to be longer in the ORC-G condition ( $M =$

333,  $SD = 82$ ) than in the SRC-G condition ( $M = 324$ ,  $SD = 98$ ). In comparison, the NS participants' RTs in the ORC-UG condition ( $M = 346$ ,  $SD = 114$ ) were slightly shorter when compared with the RTs in the SRC-UG condition ( $M = 356$ ,  $SD = 125$ ).

Given the distance differences between SRCs and ORCs, the NNSs also found the more distant dependency ORCs more difficult to process, reading longer in the ORC condition than in the SRC condition. They were found to read longer in the ORC-G condition ( $M = 571$ ,  $SD = 237$ ) in comparison with the SRC-G condition ( $M = 505$ ,  $SD = 197$ ). Unlike the NSs, the NNSs had a tendency to show longer RTs when reading the spillover region in the ORC-UG condition ( $M = 736$ ,  $SD = 372$ ), whereas the RTs in the SRC-UG condition were shorter ( $M = 622$ ,  $SD = 261$ ).

As shown above, differences in the RT data were observed in the spillover region despite similar processing patterns being found in the critical region. From the RT data in the spillover region in Experiment 1, both groups of the participants showed sensitivity to agreement violation in the SRC condition. In particular, the delayed effects of ungrammaticality were captured in the spillover region, indicating NNSs' sensitivity to agreement violation indexed by reading slowdowns, particularly in the ORC-UG condition.

The results from LMEs modeling, showing the effects of each predictor on the RTs in the spillover regions for both NSs and NNSs, are demonstrated in Table 12 and Table 13.



Table 12 Fixed effects in the LMEs model of RTs in the spillover region for native speakers in Experiment 1

**Linear Mixed Effects Model of Reading Times**

Predictor	Coefficient	SE	df	t	p
Intercept	327.46	9.17	5.94	35.73	.000
Grammaticality	107.81	38.06	662.61	2.83	.005
WM x Grammaticality	-1.41	.62	652.37	-2.25	.025

Adjusted R-squared: 0.115

Table 13 Fixed effects in the LMEs model of RTs in the spillover region for nonnative speakers in Experiment 1

**Linear Mixed Effects Model of Reading Times**

Predictor	Coefficient	SE	df	t	p
Intercept	509.27	33.11	51.74	15.38	.000
Distance	65.90	20.20	687.67	3.26	.001
Grammaticality	113.27	19.94	687.67	5.68	.000
WM x Distance x Grammaticality	1.07	.51	689.67	2.09	.037

Adjusted R-squared: 0.268

In Table 12, in the spillover region, a main effect of grammaticality was found ( $\beta = 107.81, t(662.61) = 2.83, p < .05$ ), indicating NSs had a tendency to show sensitivity to agreement violation by reading longer in ungrammatical conditions. In addition, a significant interaction between WM capacity and grammaticality showed that NSs tended to read longer in ungrammatical conditions overall; however, it did not seem to take NSs with higher WM capacity longer to read in ungrammatical conditions ( $\beta = -1.41, t(652.37) = -2.25, p < .05$ ). Despite the main effect of grammaticality in aggregate, as the mean RT shows in Table 11, this negative association between WM capacity and grammaticality indicated that as the NSs' WM

capacity increased, they did not need longer RTs to read in the ungrammatical conditions in the spillover region, while the participants with lower WM capacity tended to take longer to read the ungrammatical conditions. This showed that NSs were sensitive to agreement violations, but their WM may probably operate in a different manner when compared to the NNSs.

As Table 13 shows, distance was found to yield a main effect, suggesting that the NNS participants took longer to read in the long-distance ORC condition than in the short-distance SRC condition ( $\beta = 65.90, t(687.67) = 3.26, p < .05$ ). In addition, a main effect of grammaticality was observed ( $\beta = 113.27, t(687.67) = 5.68, p < .001$ ). This indicated that the NNSs took longer to read in the ungrammatical conditions. Finally, interactions among WM, distance, and grammaticality reached significance in the spillover region ( $\beta = 1.07, t(689.67) = 2.09, p < .05$ ). This phenomenon was not found in the critical region, but it was later found in the spillover region, suggesting that both the effects of WM and distance modulated the NNSs' ability to maintain sensitivity to L2 agreement violation during the processing for comprehension. That is, their sensitivity to agreement violation tended to reduce on the condition that the agreement dependencies were more distant, and their cognitive resources were left insufficient for computations.

#### **4.1.5 Discussion: Experiment 1**

The integral question this study aimed to answer concerned how L2 learners used their newly-established L2 morphosyntactic information during online processing. More specifically, it asked whether and to what extent cognitive resources and distance-based complexity influenced their morphosyntactic processing in L2. Experiment 1 specifically investigated L2 agreement violation involving an omission

type of the 3S morpheme *-s* in the English subject-verb agreement in online processing by L1 Thai learners of English and NSs of English. The research results, overall, indicated that the effects of locality of distance between the agreement source and agreement target in association with individual differences in terms of WM capacity modulated the ability to maintain sensitivity to agreement violation in both NS and NNS groups. Both NSs and NNSs were able to maintain sensitivity to agreement violations in both short- and long-distance conditions; the L2 learners experienced processing difficulties more evidently when the agreement dependencies were more distant and the grammaticality effects in relation to WM capacity and distance-based complexity were more pronounced in the spillover regions.

#### **4.1.5.1 The native speakers' agreement processing**

Overall, the NSs' RT data showed reading slowdowns, indicating they were sensitive to grammatical violations in both short- and long-distance agreement dependencies. The effects of distance-based complexity was evident in longer RTs in the ORC-G condition, compared with the SRC-G condition. In addition, the NSs' reduced sensitivity was observed in the processing of the linearly more distant agreement dependencies as indicated by their shorter RTs in the long-distance ORC condition. These findings corroborated the results from previous studies on distance effects in native language processing in that NSs might not always compute full syntactic analyses using their L1 information in real-time processing (Keating, 2010). One evident factor suggested by Keating (2010) was distance. He found that when the agreement was local, one word or four words apart, the NSs could maintain their sensitivity to agreement violation; however, that was not the case when the agreement dependencies were seven words apart. The findings were

explained in accordance with the Shallow Structure Hypothesis (Clahsen & Felser, 2006). This shallow processing hypothesis assumes that nonnative syntactic computations are less detailed when compared with those of the NSs, and the morphosyntactic processing by the NNSs is limited to local domains (i.e., closely adjacent agreement). This means that the NSs' full parsing is assumed to be guided by the grammar, but the NNSs' shallow parsing is guided, for example, by lexical- semantics and pragmatics. Nevertheless, Keating's (2010) findings suggested that the seven-word distance agreement processing could also induce shallow processing of a morphosyntactic feature among the NSs. Our findings built on this knowledge, revealing that when the intervening materials were equally distant (four words) when counting the raw number of words, such as in "The guy that knows the driver..." vs. "The guy that the driver knows...", the cost of integrating the information of the intervening materials had influence on the ability to show and maintain sensitivity to morphosyntactic violation in native language processing. This is in line with the locality effects of distance suggested by the dependency locality theory (Gibson, 1998, 2000), which assumed that differences in the number of new discourse referents (i.e., verbs and nouns) interrupting the integration of the filler and the gap in English RCs would lead to different processing difficulties. The more new discourse referents, the greater the computational difficulty, which thus consumed more cognitive resources. Therefore, in addition to the distance effects suggested by the raw number of words, the underlying integration and locality effects played an important role in the native language grammatical processing.

One surprising result in Experiment 1 was the negative association between WM capacity and grammaticality in NSs' processing. As hypothesized, they showed

sensitivity to agreement violation in both short- and long-distance conditions, and the underlying assumption of the study was accepted. However, when taking WM capacity into account, those high-span NSs were likely to process ungrammatical verbs in both conditions in a relatively quicker manner. With respect to NSs' WM capacity and their ability to show sensitivity to agreement violation in Experiment 1, it was initially assumed that the effects of WM among NSs may not be large, as it is generally accepted that routinized L1 sentence processing usually requires less cognitive resources than L2 sentence processing (Dussias & Piñar, 2010; Trenkic et al., 2014). However, contradicting with what we expected, the NSs were found to read faster in ungrammatical conditions as their WM capacity increased. It was speculated that such a negative association might be due to the effects of the availability of cognitive resources that guide the ease of recovery from processing difficulties in native language processing (Gibson, 1998, 2000; Just & Carpenter, 1992; Kim & Christianson, 2017; King & Just, 1991; MacDonald et al., 1992). The notion of recovery has often been cited in sentence processing inquiry concerning an initial misanalysis and reanalysis as a result of syntactic ambiguity, such as garden-path sentence effects (e.g., Ferreira et al., 2001; Frazier & Clifton, 1998; Hopp, 2015; Roberts & Felser, 2011). Even though the present study did not set out to specifically investigate recovery costs in morphosyntactic processing, our findings appeared to suggest that NSs' processing norm should be interpreted with caution, taking individual differences in terms of cognitive resources into consideration. In this case, some high-span NSs may be fast readers and thus read with speed, which might contribute to a quick recovery from processing difficulties when faced with grammatical mismatches (cf. Hopp, 2015; Just & Carpenter, 1992; Kaan et al., 2015;

Roberts & Felser, 2011). To elaborate, reading slowdowns at the ungrammaticality were observed in the NSs' RTs regardless of their WM capacity. Given the negative association between WM capacity and grammaticality in the NS group, there should be other causes that gave rise to this phenomenon. We proposed that individual differences in terms of cognitive resources played an essential role in this contradictory finding in the NSs' RT data. In view of the fact that L1 processing is routinized and automatized in tandem with a larger pool of cognitive resources, the lack of reading slowdowns among high-span NSs indicated their quick recovery and greater resilience to processing difficulties (Just & Carpenter, 1992). This capacity-based counterevidence may be taken as indicating that even NSs do not always process complex sentences in a similar manner (Keating, 2010) and WM capacity also plays an important role in one's native language processing (Just & Carpenter, 1992; Kim & Christianson, 2017; MacDonald et al., 1992). In this regard, Just and Carpenter (1992) pointed out the advantages of having higher WM capacity. They found that NSs with higher WM capacity were more resilient to syntactically more complex sentences in their online comprehension of RC sentences as they showed shorter RTs when the main verb followed an ORC compared to the NSs with a lower memory span. Consistent with the present findings, with cognitive resources available, there may also be a good possibility that some NSs became more resilient to morphosyntactic violations and were able to recover from processing difficulties as they encountered sentences containing manipulations of ungrammatical matrix verbs after a more distant agreement dependency with an ORC during online processing. Furthermore, since morphosyntactic processing in NSs is assumed to be routinized and automatized as NSs routinely process agreement in their L1, such a phenomenon

might also be accounted for by the fact that NSs' morphosyntactic processing is automatized in such a way that they were sensitive to grammatical violation but in a faster manner.

#### 4.1.5.2 The nonnative speakers' agreement processing

In Experiment 1, L1 Thai learners of L2 English overall read more slowly than the NSs, as shown by the mean RTs in Figure 18. Moreover, the results showed that their L2 agreement processing was influenced by the locality effects indexed by longer RTs in the long-distance agreement dependencies, ORCs. The NNSs whose WM span was larger tended to show greater sensitivity to agreement violation, where the agreement controller was a singular definite NP such as "The guy" and the verb was manipulated based on the omission of the 3S morpheme *-s* in the matrix verb region, such as in "know". The results could be in part explained by the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairroj, 2013).

The hypotheses of the present study, which were formulated based on the notion of L1-L2 structural competition, were borne out (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairroj, 2013). In particular, the NNSs' RT data showed a significant interaction between WM capacity, distance and grammaticality in the spillover region, indicating that both the effects of WM capacity and distance-based complexity of the intervening RCs modulated the NNSs' ability to show and maintain sensitivity to L2 morphosyntactic agreement violations during the processing for comprehension (Foote, 2011; Keating, 2009, 2010; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012). This delayed processing, captured in the spillover region, indicated that locality effects of the distance in tandem with the cognitive resources

required by the computationally demanding linguistic complexity effected the learners' sensitivity to morphosyntactic violation in their L2. The learners' reduced sensitivity to agreement violation may have been due to the L1-option, which is more entrenched, manifesting as part of their routine L1 processing (Chen et al., 2007; Hopp, 2010; Kaan et al., 2015; Rankin et al., 2019).

To elaborate, the heightened sensitivity indicated by increased RTs in the ORC-UG condition as the learners' WM capacity increased suggested that the NNSs with a greater WM span were more likely to be able to maintain sensitivity to L2 agreement violation during processing, while those with a smaller pool of cognitive resources tended to be less able to do so, especially when the agreement was linearly more distant. Based on the research hypothesis, the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013) may elucidate this phenomenon on the L2 learners' part. Two potential candidates here included the L1-appropriate form (bare verb form) and the L2-appropriate form (inflected verb form), which may be activated in parallel during online processing. The more entrenched L1-appropriate form may compete with the newly learned L2-appropriate alternative for selection. The account posits that when the cognitive resources were insufficient for computations, it is likely that the L1 option will win out over the L2 option, thus leading to variable performance, as succinctly shown in the findings from the learners with lower WM capacity (Austin et al., 2015; Hopp, 2010, 2017; Kaan et al., 2015; Trenkic & Pongpairoj, 2013). In order to successfully resolve the agreement dependencies, the learners had to simultaneously keep the structures in memory and at the same time keep track of the incomplete agreement dependencies. With the present linguistic manipulations, the long-distance ORC



constructions were assumed to use and tax more WM capacity, which could pose processing difficulties for the learners with limited pool of WM resources (Baek, 2012; Gibson, 1998, 2000; Just & Carpenter, 1992; King & Just, 1991; O'Grady, 2011; Reichle et al., 2016; Suda, 2015). This was particularly true when it came to agreement processing at the matrix verbs, where inhibition of the irrelevant L1-option must be operated (Austin et al., 2015; Kaan et al., 2015; Trenkic & Pongpairoj, 2013). Those L2 learners with limited WM capacity tended to suffer greater difficulties suppressing the non-target L1-competitors in their mental processes, thus resulting in reduced sensitivity to L2 agreement processing, especially when the processing was intervened by a linearly more distant syntactic structure, like ORCs. This is compatible with previous findings suggesting that allocation of cognitive resources in L2 processing was prominent for agreement computations (Hopp, 2010; Kaan et al., 2015; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012). Cognitive resources are needed in L2 processing in order to inhibit the learners' native language (Kaan et al., 2015; Trenkic & Pongpairoj, 2013). The present findings revealed that the higher-span learners appeared to show reading slowdowns in long-distance agreement dependency conditions, meaning they were abler to maintain sensitivity to agreement violations, which could be attributable to their larger pool of cognitive resources, consistent with previous research findings (Coughlin & Tremblay, 2013; Hopp, 2010; Indrarathne & Kormos, 2017; Kaan et al., 2015; Keating, 2010; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012; Suda, 2015; Zhou et al., 2017). See 4.3 for further general discussion.

## 4.2 Experiment 2

The objective of Experiment 2 was to examine L1-Thai L2-English participants' sensitivity to agreement violation. Experiment 2 differed from Experiment 1 in terms of the type of agreement violation. That is, while Experiment 1 mainly concerned L1-based agreement violation (an omission of the *-s* agreement marker), Experiment 2 focuses on agreement violation based on the L2-feature (an overuse of *-s* agreement marker). The former is referred to as between-language competition as the target verb agreement concerns a feature comparable to the learners' L1 system (i.e., bare form of verbs). However, the latter is regarded as within-language competition since the ungrammatically inflected target verb agreement involves a feature unique to the learners' L2 system (i.e., inflected form of verbs) and each agreement controller contains an L2 morphological feature, i.e., the *-s* plural morpheme. The results are discussed in accordance with the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairaj, 2013).

### 4.2.1 Participants

The participants recruited for Experiment 2 were also 40 L1 English speakers and 40 L1 Thai learners of English. The participants in Experiment 2 were not involved in Experiment 1. The NS group was also recruited at University of Illinois at Urbana-Champaign. They were undergraduate and graduate students who participated in this study either for one extra course credit or a monetary benefit of 7 US dollars. The NNS group involved L1 Thai learners of L2 English, majoring in English for Communication at Rajamangala University of Technology Suvarnabhumi, Thailand. They received 200 Thai baht in compensation for their participation. The

participants were naive to the purpose of the study. Participants whose comprehension accuracy rates of the experimental items were below 80% in the comprehension subtask were excluded and replaced (2 NSs and 5 NNSs were replaced). The demographical data of the participants in Experiment 2 are presented in Table 14.

Table 14 Demographical data on the NS and NNS participants in Experiment 2

	<i>n</i>	Residence	Age (yrs)	Gender (M, F, X)	WM Score (max=75)	LexTALE (max=100)
Native speakers	40	US	22 (18-36)	M=5, F=35	59.75 (35-73)	94.69 (87.5-100)
Nonnative speakers	40	Thailand	20 (18-24)	M=6, F=34	54.40 (33-75)	66.72 (61.25-78.75)

The 40 NSs of English, residing in the USA at the time of data collection, participated in Experiment 2, and the 40 L1-Thai NNSs of English were in Thailand at the time this research was carried out. Similar to Experiment 1, the majority of the participants in both groups were females. In the NNS group, there were 34 females and 6 males participating in Experiment 2 (mean age 20 years old). Among the NS participants, 35 were female, and five were male (mean age 22 years old). Their WM span scores were measured by an RSPAN task in their L1. A partial-credit scoring method was also used in Experiment 2 for the WM span scores (Conway et al., 2005). The NNSs' WM spans were between 33 and 75 (mean WM span = 54.40), while the NSs' WM spans were between 35 and 73 (mean WM span = 59.75). LexTALE, as a measure of L2 English proficiency, revealed that the NNSs were at an upper-intermediate level (between 60% and 80%). Their LexTALE mean scores ranged from 61.25 to 78.75 (mean LexTALE score = 66.72), whereas the NS group was placed at an advanced level, performing at ceiling with a range from 87.5 to 100

(mean LexTALE score = 94.69). They were also naive to the purpose of the study and reported having normal or corrected to normal vision.

#### 4.2.2 Stimuli

Based on the notion of within-language competition (Marian & Spivey, 2003), experimental stimuli in Experiment 2 involved manipulations of third-person plural subject NPs marked by a plural marker *-s* in the agreement controller region in conjunction with an overuse of the 3S morpheme *-s* inflection as agreement violation (see Table 15). Both of them are grammatical features unique to the learners' L2 English. That is, these two grammatical features are not instantiated in the learners' L1 Thai, thus appropriate for investigating within-language competition in a second language. If a different processing pattern was found between the NSs and L1 Thai participants, it would reveal the effects of morphological complexity of the agreement controller processed alongside the verbal agreement morphology. The role of crosslinguistic influence may be accounted for as a result of insufficiency in cognitive resources and distance-based complexity. The experimental stimuli employed in Experiment 2 are shown in Table 15.

Table 15 Sample experimental items in Experiment 2

Experiment 2 stimuli	Condition
a. The <i>guys</i> that <sub>know</sub> the driver <i>want</i> to buy a new car.	SRC-G
b. The <i>guys</i> that <sub>know</sub> the driver <i>wants</i> to buy a new car.	SRC-UG
c. The <i>guys</i> that the driver knows <sub>want</sub> to buy a new car.	ORC-G
d. The <i>guys</i> that the driver knows <sub>wants</sub> to buy a new car.	ORC-UG

Note: SRC, subject-extracted relative clause; ORC, object-extracted relative clause; G, grammatical; and UG, ungrammatical

Similar to Experiment 1, the RTs were observed in two regions of interest, i.e., the matrix verb and the following word, as illustrated below (with the seventh word as a critical region and the eighth word as a spillover region).

(38) SRC: \*The | guys | that | know | the | driver | *wants* | *to* | buy | a | new | car.

ORC: \*The | guys | that | the | driver | knows | *wants* | *to* | buy | a | new | car.

Similar to Experiment 1, there were 20 experimental sentences: half grammatical and the other half ungrammatical. A set of 40 fillers were interspersed across the four lists. All 60 sentences were pseudorandomized so that no two experimental sentences were consecutively presented. Four lists were created in a 2 x 2 Latin Square design, crossing distance (short-distance SRC and long-distance ORC) and grammaticality.

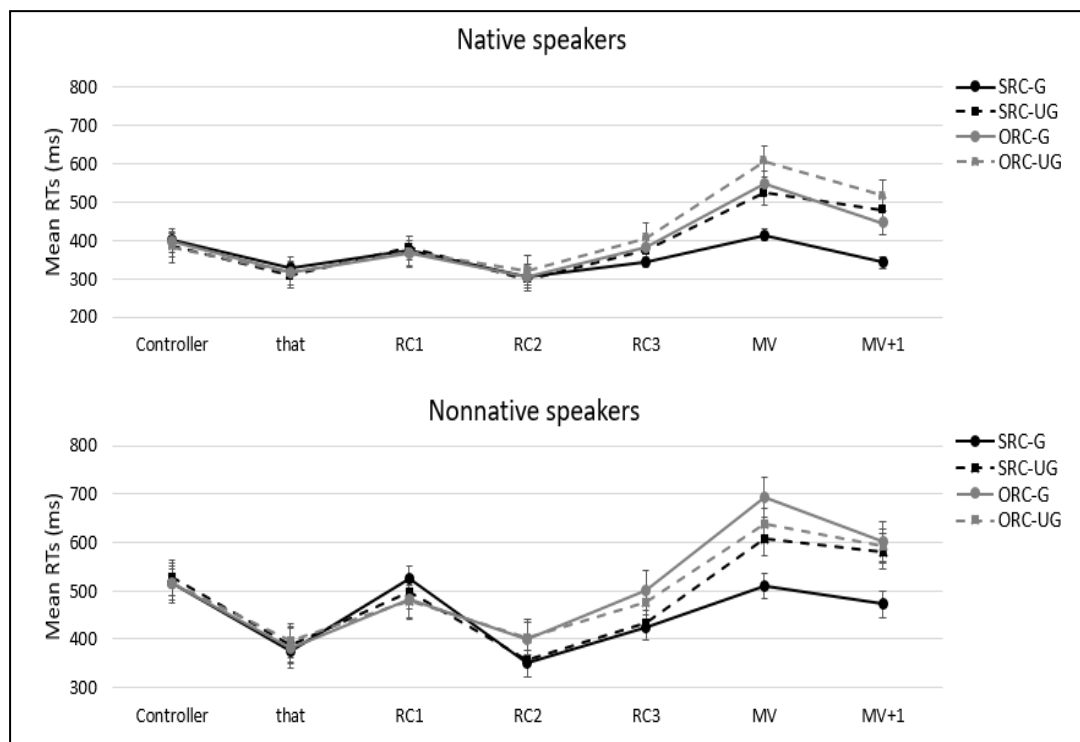
### 4.2.3 Procedure and data analyses

Experiment 2 followed the same research procedure as described in Experiment 1. Each participant voluntarily participated in the study. The tasks were administered to them individually in a quiet environment. They participated in the LexTALE, followed by the SPR task. After that, a questionnaire on their demographical data and language background was administered. Finally, they sat the RSPAN task as a measure of their WM capacity. The same criteria for data analyses as described in Experiment 1 were applied. The RT data were trimmed to exclude the items that were incorrectly comprehended as well as those RTs that exceeded 2000 ms or were lower than 100 ms. This data cleaning process resulted in an exclusion of 3.94% of the trials for NSs and 9% of the trials for NNSs.

### 4.2.4 Results

Similar to Experiment 1, after the data cleaning process, the RTs were then analyzed using descriptive statistical analyses to determine the mean scores and standard deviations. The RTs in each region of the experimental sentences are shown in Figure 19 below.

Figure 19: Mean RTs in critical regions and spillover regions for NSs and NNSs in Experiment 2



In Experiment 2, the experimental stimuli were similar to those of Experiment 1, except for the agreement source (the subject NP controller), which was marked with a plural marker *-s*. The agreement verb target (the matrix verbs) was either grammatical or ungrammatical with the manipulations of the English 3S agreement marker *-s*. As illustrated in Figure 19, the overall results showed that NNSs took longer to process the agreement than the NSs and that, in both groups, the matrix verbs ORCs took longer to process, given other factors (Baek, 2012; Just & Carpenter, 1992; Suda, 2015; Traxler et al., 2002). This may be due to the locality effects of linear distance intervening the agreement concord on the RT results overall (Gibson, 1998, 2000; Just & Carpenter, 1992). The matrix verbs after ORCs tended to require more processing cost, thus more time to process. However, unlike the results

shown in Experiment 1, when taking grammaticality of the verbal agreement into consideration, there was a qualitative difference in the processing patterns between the two groups. That is, while the NSs showed reading slowdowns at both short- and long-agreement dependency relations, the NNSs seemed unable to maintain their sensitivity to L2 agreement violation, particularly in the long-distance ORC conditions, which could be in part explained by insufficiency in cognitive resources necessitated by the cognitively demanding processing in the more distant conditions. The present findings are discussed in light of the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongparoj, 2013).

#### 4.2.4.1 Reading times in the critical region

Table 16 shows the mean RTs and standard deviations in the critical regions in Experiment 2 for NSs and NNSs, which were calculated based on types of distance and grammaticality across the four experimental conditions.

Table 16 Mean (*SD*) RTs in milliseconds in the critical region for native and nonnative speakers in Experiment 2

Condition	NS		NNS	
	SRC	ORC	SRC	ORC
Grammatical	414(201)	549(227)	510(177)	692(229)
Ungrammatical	524(216)	608(289)	607(210)	637(187)

Table 16 reports mean RTs in the critical regions for NSs and NNSs in Experiment 2. The RTs, overall, showed that both NSs and NNSs spent more time reading the matrix verbs in the long-distance ORC conditions. In NSs, longer RTs were observed in the critical regions in the ORC-G condition ( $M = 549$ ,  $SD = 227$ ) than in the SRC-G condition ( $M = 414$ ,  $SD = 201$ ). Similarly, they also read more



slowly in the ORC-UG condition ( $M = 608$ ,  $SD = 289$ ) than in the SRC-UG condition ( $M = 524$ ,  $SD = 216$ ). It was evident that, irrespective of whether the stimulus sentences were grammatical, RTs in the ORC condition tended to be longer.

Similar to NSs, NNSs also experienced distance-based processing difficulties, as indicated by their longer RTs taken to read the matrix verbs in the ORC condition. In the ORC-G condition, they read longer at the matrix verbs ( $M = 692$ ,  $SD = 229$ ), when compared with the SRC-G condition ( $M = 510$ ,  $SD = 177$ ). The RTs in the ORC-UG condition ( $M = 637$ ,  $SD = 187$ ) were also longer than in the SRC-UG condition ( $M = 607$ ,  $SD = 210$ ).

As regards the grammaticality, while NSs showed their sensitivity to agreement violations through slowdowns in both SRC-UG and ORC-UG conditions, the NNSs, however, showed reading slowdowns only in the SRC condition. In the ORC-UG condition, the RTs were slightly shorter when compared to those in the ORC-G condition, suggesting a lack of sensitivity to agreement violation among NNSs in the long-distance condition. Estimated effects of each predictor on RTs of NSs and NNSs in the critical region are reported below, using linear mixed-effects regression.

Table 17 Fixed effects in the LMEs model of RTs in the critical region for native speakers in Experiment 2

<b>Linear Mixed Effects Model of Reading Times</b>					
Predictor	Coefficient	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	847.76	158.00	41.57	5.37	.000
WM	-7.21	2.60	41.35	-2.77	.008
Distance	380.33	71.11	719.60	5.35	.000
Grammaticality	115.02	16.31	719.66	7.05	.000
WM x Distance	-4.10	1.16	719.60	-3.54	.000
Distance x Grammaticality	-63.84	23.20	719.72	-2.75	.006

Adjusted R-squared = 0.399

Table 18 Fixed effects in the LMEs model of RTs in the critical region for nonnative speakers in Experiment 2

<b>Linear Mixed Effects Model of Reading Times</b>					
Predictor	Coefficient	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	608.48	94.36	68.02	6.45	.000
Distance	308.70	68.96	677.81	4.48	.000
Grammaticality	-145.58	68.48	677.86	-2.13	.034
WM x Grammaticality	4.50	1.21	677.95	3.72	.000
Distance x Grammaticality	-154.77	26.42	677.63	-5.86	.000

Adjusted R-squared = 0.273

Table 17 presents the significant effects each predictor had on the RTs of NSs at the matrix verbs, according to the LMEs model. In the critical region, the NSs were found to show a main effect of WM. That is, as their WM capacity increased, their RTs in the critical regions tended to decrease ( $\beta = -7.21$ ,  $t(41.35) = -2.77$ ,  $p < .05$ ). It indicated that if the cognitive resources were abundant, the NSs were likely to require

less time to process the verbal agreement given the other variables. A main effect of distance was also observed. The NSs tended to show longer RTs when they read the matrix verbs in the ORC condition ( $\beta = 380.33, t(719.60) = 5.35, p < .001$ ). In addition, a main effect of grammaticality shows that overall RTs in ungrammatical conditions were found to be longer than in grammatical conditions ( $\beta = 115.02, t(719.66) = 7.05, p < .001$ ). Two significant interactions were found. WM was found to interact with distance, indicating that as the NSs' WM capacity increased, their RTs tended to decline in the ORC condition ( $\beta = -4.10, t(719.60) = -3.54, p < .001$ ). This means they did not seem to take long to process the matrix verbs in the more complex long-distance condition, which could be due mainly to their having sufficient cognitive resources available for such computation. Finally, a significant interaction between distance and grammaticality shows that when the NSs encountered the matrix verbs in the ORC-UG condition, their RTs tended to decrease ( $\beta = -63.84, t(719.72) = -2.75, p < .05$ ). Their sensitivity tended to be reduced in the attempt to maintain sensitivity to agreement violation when experiencing distance effects present between the agreement source and agreement target.

Table 18 shows how the effects of each predictor contributed to the response variables, the RTs of NNSs at the matrix verbs. At the critical region matrix verbs, the NNSs showed the significant main effect of distance, which suggested that they read the matrix verbs longer in the ORC condition than in the SRC condition ( $\beta = 308.70, t(677.81) = 4.48, p < .001$ ). In addition, the main effect of grammaticality was observed, indicating longer RTs in the ungrammatical conditions ( $\beta = -145.58, t(677.86) = -2.13, p < .05$ ). The analyses also yielded two significant

interaction effects. WM was found to interact with grammaticality, suggesting that as the NNSs' WM capacity increased, there was a tendency for them to show longer RTs in ungrammatical conditions ( $\beta = 4.50, t(677.95) = 3.72, p < .001$ ) irrespective of the distance types. In addition, a significant interaction between distance and grammaticality was also found, indicating a tendency for ORC-UG conditions to yield shorter RTs ( $\beta = -154.77, t(677.63) = -5.86, p < .001$ ). This tendency was similar to the NSs. The learners' ability to maintain sensitivity to agreement violation in a long-distance condition appeared to be influenced by the effects of distance.

#### 4.2.4.2 Reading times in the spillover region

The mean RTs and standard deviations in the spillover regions based on types of distance and grammaticality for NS and NNS participants in Experiment 2 are presented in Table 19.

Table 19 Mean (*SD*) RTs in milliseconds in the spillover region for native and nonnative speakers in Experiment 2

Condition	NS		NNS	
	SRC	ORC	SRC	ORC
Grammatical	342(94)	446(171)	472(157)	602(252)
Ungrammatical	479(162)	517(216)	582(198)	592(195)

The results showed a similar tendency to that of the RTs in the critical regions. That is, the long-distance ORC condition also took the participants in both groups longer to read in the spillover region. The NSs took longer to read the spillover regions in the ORC-G condition ( $M = 446, SD = 171$ ) than in the SRC-G condition ( $M = 342, SD = 94$ ). In the ungrammatical conditions, similar processing patterns were found. The spillover regions in the ORC-UG condition ( $M = 517, SD = 216$ ) took the

NS participants longer to read in comparison to those in the SRC-UG condition ( $M = 479$ ,  $SD = 162$ ).

In comparison with the NSs, the NNSs showed similar processing patterns. The ORC condition yielded longer RTs in the spillover region; longer RTs were observed in the ORC-G condition ( $M = 602$ ,  $SD = 252$ ) when compared to the RTs in the SRC-G condition ( $M = 472$ ,  $SD = 157$ ). This phenomenon also held true in the ungrammatical conditions. The NNSs took longer to read the spillover region in the ORC-UG condition ( $M = 592$ ,  $SD = 195$ ) than that in the SRC-UG condition ( $M = 582$ ,  $SD = 198$ ).

With respect to grammaticality, it was evident that the NSs showed reading slowdowns at the ungrammaticality, reading longer in the ungrammatical conditions, SRC-UG and ORC-UG, when compared to the SRC-G and ORC-G conditions. Converging evidence in sensitivity to agreement violation was observed only when the NNSs showed reading slowdowns only in the SRC-UG condition, taking longer to read in the SRC-UG condition than in the SRC-G condition. The RT data showed that they did not show reading slowdowns when encountering the ORC-UG condition. The reverse results showed longer RTs in the ORC-G condition in lieu of the ORC-UG condition.

Below are the results from LMEs modeling, showing the effects each predictor had on the RTs for both NSs and NNSs.

Table 20 Fixed effects in the LMEs model of RTs in the spillover region for native speakers in Experiment 2

<b>Linear Mixed Effects Model of Reading Times</b>					
Predictor	Coefficient	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	529.11	73.19	88.02	7.23	.000
WM	-3.28	1.20	85.90	-2.74	.008
Distance	334.36	61.72	727.51	5.42	.000
Grammaticality	352.48	61.64	727.58	5.72	.000
WM x Distance	-3.86	1.00	727.52	-3.85	.000
WM x Grammaticality	-3.62	1.00	727.62	-3.60	.000
Distance x Grammaticality	-68.62	20.06	727.74	-3.42	.001

Adjusted R-squared: 0.395

Table 21 Fixed effects in the LMEs model of RTs in the spillover region for nonnative speakers in Experiment 2

<b>Linear Mixed Effects Model of Reading Times</b>					
Predictor	Coefficient	<i>SE</i>	<i>df</i>	<i>t</i>	<i>p</i>
Intercept	666.81	87.22	78.11	7.65	.000
WM	-3.78	1.56	76.36	-2.43	.018
Distance	191.13	71.00	689.72	2.69	.007
WM x Grammaticality	3.61	1.25	690.03	2.89	.004
Distance x Grammaticality	-120.43	27.25	689.82	-4.42	.000

Adjusted R-squared: 0.222

Table 20 shows the effect the three explanatory variables, namely WM, distance, and grammaticality, had on the RT data in the spillover region for NSs according to LMEs modeling. Main effects were found in each of the three variables.

The main effect of WM indicated that as the NSs' WM capacity increased, their RTs had a tendency to be shorter ( $\beta = -3.28, t(85.90) = -2.74, p < .05$ ). The RT data also showed the main effect of distance. That is, the more distant ORC condition took the NSs longer to read ( $\beta = 334.36, t(727.51) = 5.42, p < .001$ ). In addition, grammaticality was also found to have a significant main effect on the RTs, suggesting that the ungrammatical conditions took the NS participants longer to read ( $\beta = 352.48, t(727.58) = 5.72, p < .001$ ). The analyses also showed three significant interactions among the three explanatory variables. There was a significant interaction between WM and distance. This indicated the effect of the participants' WM in association with distance. That is, as their WM capacity increased, they tended to require shorter RTs to read in the ORC condition as compared to the SRC condition ( $\beta = -3.86, t(727.52) = -3.85, p < .001$ ). Similar to the findings in Experiment 1, the findings in this experiment showed that the NSs' WM was also found to interact with grammaticality, suggesting that as the NS participants' WM capacity increased, the RTs at the ungrammaticality tended not to be longer ( $\beta = -3.62, t(727.62) = -3.60, p < .001$ ). Finally, the RT data yielded a significant interaction between distance and grammaticality, showing the distance affected the ability to show sensitivity to grammatical violation among the NSs. That is, when the NSs experienced the distance effects present in the ORC condition, they tended to lose the ability to show sensitivity to agreement violation as suggested by decreased RTs in the ORC-UG condition ( $\beta = -68.62, t(727.74) = -3.42, p < .05$ ).

Table 21 shows the effects each of the explanatory variables had on the RT data when the NNS participants read the spillover regions. Like the results of the NSs'

RT data, the results of the NNSs' RT data also showed the main effect of WM. This indicated that as the participants' WM capacity increased, they had a tendency to read faster in both SRC and ORC conditions ( $\beta = -3.78, t(76.36) = -2.43, p < .05$ ). There was also a main effect of distance, showing that the ORC condition took the participants longer to read ( $\beta = 191.13, t(689.72) = 2.69, p < .05$ ). Furthermore, a significant interaction between WM and grammaticality indicated that, unlike the NSs, the NNSs whose WM was higher showed their sensitivity to agreement violation through their increased RTs ( $\beta = 3.61, t(690.03) = 2.89, p < .05$ ). Lastly, similar to the NSs, the NNSs were also affected by the distance effect of the ORC condition interacting with grammaticality, resulting in reduced RTs as they encountered the ORC-UG condition ( $\beta = -120.43, t(689.82) = -4.42, p < .001$ ).

#### 4.2.5 Discussion: Experiment 2

The present findings overall indicated that the NSs exhibited sensitivity to agreement violation by showing reading slowdowns in both short- and long-distance agreement dependencies. Their processing was affected by the effects of distance as well as WM capacity. In comparison, a qualitative difference between the NSs' and NNSs' processing patterns was observed. The NNSs' findings suggested that the effects of linear distance between the agreement source and target in tandem with WM capacity modulated the learners' ability to maintain sensitivity to L2 agreement violation involving unique-to-L2 constructions. That is, in agreement computations involving grammatical violation of unique-to-L2 features (i.e., an overuse of the *-s* agreement marker), upper-intermediate Thai-speaking learners of L2 English were able to show sensitivity to such a grammatical mismatch on the condition that the distance of the intervening materials was shorter, as measured by



the number of new discourse referents introduced between the filler and the gap in SRC and ORC constructions (Gibson, 1998, 2000).

#### 4.2.5.1 The native speakers' agreement processing

In Experiment 2, the NSs overall read faster than the NNSs across the four conditions, as revealed by the mean RTs in Figure 19. Similar to the findings in Experiment 1 with an omission type of agreement violation, in Experiment 2, the NSs were able to detect the ungrammaticality in the agreement violation involving an overuse of the 3S morpheme *-s* through reading slowdowns in both short- and long-distance agreement dependencies. More specifically, in relation to the roles of WM capacity and the linguistic manipulations, the high-span NSs tended to have greater processing advantages when processing agreement dependencies in a linearly more distant condition, ORCs. The findings were consistent with the capacity-based constraint model of WM (Just & Carpenter, 1992; King & Just, 1991) and corroborated past findings in that processing difficulties in ORCs were greater than in SRCs, relative to cognitive resources available (Baek, 2012). The distance-based complexity, posited by the DLT (Gibson, 1998, 2000), played an important role in the NSs' ability to maintain their sensitivity to agreement violation in L1. Since the present findings showed that reduced RTs were observed in the long-distance ungrammatical ORC condition, it was indicated that the distance manipulations in the present study could serve to tackle the processing difficulties encountered by NSs and could be appropriate in the investigation of the locality effects on L2 agreement processing. In line with the previous findings, the effects of distance in L1 processing could be more pronounced when the length of agreement dependencies increased, and NSs' ability to maintain their sensitivity might dwindle or they might even exhibit a

lack of sensitivity to morphosyntactic violation (Keating, 2010).

Like Experiment 1, a negative association between RTs in ungrammatical conditions and WM capacity was also found in Experiment 2. That is, despite showing reading slowdowns in both SRC-UG and ORC-UG conditions, higher-span NSs tended not to take long to read the matrix verbs at an ungrammaticality. These findings were similar to those in Experiment 1 and support the notion that cognitive resources in L1 probably allowed for a quicker recovery from processing difficulties (Just & Carpenter, 1992; King & Just, 1991). It is probable that L1 processing could be less taxing on WM capacity, and thus routinized L1 sentence processing probably requires fewer cognitive resources than L2 sentence processing (Dussias & Piñar, 2010; Reichle et al., 2016; Trenkic et al., 2014). Adding to the results in Experiment 1, the similar processing results found in Experiment 2 indicated that the NSs were able to show and maintain sensitivity to agreement violation in their L1 regardless of the violation types. It was evident that, whether the violation involved more morphological complexity by processing the complex subject NPs with plural markings, their ability to detect the agreement violation of an overuse of the *-s* agreement marking was manifested. A similar explanation to that used to account for the phenomenon found in Experiment 1 would be the notion of processing recovery when processing syntactically complex sentence structures (e.g., Christianson et al., 2001; Frazier & Clifton, 1998; Hopp, 2015; Just & Carpenter, 1992; MacDonald et al., 1992; Roberts & Felser, 2011). According to Gibson (1998, 2000) and Just and Carpenter (1992) the effects of individual differences in cognitive resources on syntactic complexity probably facilitate the recovery from and enable greater resilience to processing difficulties when the NSs experience grammatical mismatches

during online comprehension. With reference to Just and Carpenter (1992), this capacity-based counterevidence may be taken as indicating that even NSs do not always process complex sentences in a similar manner (Keating, 2010), and individual differences in WM capacity could also play an important role in one's native language processing as well as in an L2 (Baek, 2012; Kim & Christianson, 2017; MacDonald et al., 1992; Suda, 2015). Furthermore, sufficient WM capacity allowed the NSs in the present study to process complex structures with fewer processing difficulties as the interaction between WM and distance reached significance. It was overall evident that the NS participants took longer to read the matrix verbs in the ORC condition. Reduced sensitivity was observed in the ORC-UG condition such that their RTs tended to decrease as the agreement dependencies increased (Keating, 2010), indicated by the interaction between distance and grammaticality. This showed that they were able to show and maintain sensitivity to agreement violation as a function of distance-based complexity and that locality effects of distance relative to WM capacity were found to be a key determinant in the processing. Therefore, these two predictors could be used to account for the NSs' ability to maintain sensitivity to agreement violation, consistent with the distance-based explanation of the DLT with respect to individual differences in WM capacity (Gibson, 1998, 2000).

#### **4.2.5.2 The nonnative speakers' agreement processing**

To return to the central questions Experiment 2 attempted to answer, on whether the adult L2 learners whose L1 lacks inflectional number agreement morphology were able to show and maintain sensitivity to agreement violation and how they used novel L2 knowledge in the incremental processes of

sentence comprehension, the present findings demonstrated that they could show and maintain sensitivity to agreement violation at least when the intervening materials were less complex. Effects of distance-based complexity and WM capacity had an influence on the learners' agreement processing. While increased agreement dependency lengths affected the learners' processing such that the long-distance ORC condition took more time to process, the higher-span learners were likely to show processing advantages, reading the complex constructions faster than those with lower memory spans. In addition, grammaticality effects were modulated as a function of distance; that is, L2 learners' sensitivity to agreement violation was more likely to diminish as distance increased. WM appeared to facilitate computations such that RTs at an ungrammaticality, regardless of distance type, tended to be longer as the learners' WM capacity increased. The main qualitative difference in the processing by NNSs, as compared to the NSs, was a lack of reading slowdowns in the long-distance ORC-UG condition, which is supported by the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013). The findings were discussed in turn in the following section.

To account for the computationally less efficient nonnative agreement processing, we suggested that the insensitivity found in the present research might stem from the learners' lack of ability to hold a morphologically complex construction in the agreement controller region while keeping track of the agreement dependencies, coupled with the processing across a long-distance filler-gap dependency in an ORC (Gibson, 1998, 2000). The filler-gap dependency in an ORC is more distant, thus more difficult to process and presumably consumes greater cognitive resources (Baek, 2012; Gibson, 1998, 2000; Just & Carpenter, 1992; King & Just, 1991; Suda, 2015;

Traxler et al., 2002). In consequence, maintaining multiple unique-to-L2 features in such linguistically complex contexts likely exceeded computational resources available (Austin et al., 2015). Past studies have shown mixed results in nonnative processing among L2 learners whose L1 lacks inflectional morphology. Shibuya and Wakabayashi (2008) suggested that the variable agreement processing of Japanese learners of English might stem from their inability to identify number features based on plural markings while Siriwittayakorn and Miyamoto (2019) found that Thai learners of English were able to process such complex constructions. Our findings add to this line of research, suggesting that the L2 learners' cognitive capacity could be depleted especially quickly while holding the morphologically complex subject NP constructions "the + NP inflected by the plural marker -s" in their minds (Austin et al., 2015; Warren & Gibson, 2002). In so doing, the agreement processing mechanisms may have become more taxing as the learners simultaneously kept track of the agreement dependencies while processing was interrupted by the long-distance ORCs, which was more cognitively demanding than interruption by the short-distance SRCs, in an attempt to comprehend the sentence. In this regard, cognitive resources may be left insufficient for computations upon encountering the agreeing matrix verbs, which may lead to L2 learners' inability to successfully integrate the agreement source into the agreement target during online processing (Coughlin & Tremblay, 2013; Hopp, 2010; Keating, 2010; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010, 2012). To support this finding, our supplementary cross-experiment independent *t*-test analyses showed that the upper-intermediate Thai-speaking learners of English were indeed able to process plural morphology in the subject NP agreement controller regions. It was found that they appeared to

demonstrate significant longer RTs ( $t(1465) = -2.356, p < .05$ ) while processing subject NPs suffixed by the plural marker *-s*, such as “the guys” ( $M = 519, SD = 146$ ), compared with uninflected singular subject NPs, such as “the guy” ( $M = 501, SD = 137$ ) (Rattanasak et al., 2020). In this regard, the results could not be well explained by the Shallow Structure Hypothesis (Clahsen & Felser, 2006, 2018), which claims that L2 learners may not compute full syntactic analyses, and the L2 processing system probably relies more on nongrammatical information, i.e., semantic and lexical-pragmatic information, during sentence comprehension. Our findings showed that the insensitivity was evident only in the long-distance condition. L2 morphosyntactic processing is therefore not restricted to local domains (i.e., to closely adjacent agreeing elements) as the Shallow Structure Hypothesis would predict.

In accordance with the non-selective perspectives, it was proposed that the asymmetric processing patterns found were associated with the learners’ L1. The insensitivity to agreement violations involving unique-to-L2 constructions may be alternatively explained by the consequence of the lack of ability to retrieve grammatical features in the agreement source relative to their insufficiency of cognitive resources (Brehm et al., 2019), distance-based complexity relative to WM capacity (Coughlin & Tremblay, 2013; Foote, 2011; Keating, 2010; Ocampo, 2013; Reichle et al., 2016; Sagarra, 2021), and crosslinguistic influence from the more established L1-specific experiences (Austin et al., 2015; Chen et al., 2007; Hopp, 2010, 2017; Kaan et al., 2015; Rankin et al., 2019; Sagarra, 2021; Trenkic & Pongpairoj, 2013). That is, when the learners’ computational resources were depleted upon resolving the filler-gap dependency in a long-distance ORC, they might have thus lost the ability to retrieve the number feature in the subject NPs due to their

capacity constraints (Just & Carpenter, 1992; Keating, 2010; Reichle et al., 2016). In this regard, they may have resorted to their L1 by incorrectly retrieving a bare form of the agreement controller based on their L1, thus processing the ungrammatical verbs with an overuse of the *-s* agreement marker as if it were grammatical although it is not. The pertinence of crosslinguistic competition to the present findings, here, lies in the fact that the NNSs might well have had to resort to their L1-based option (i.e., the bare subject NP) amid the competition as their cognitive resources were left insufficient to continue to incrementally process the matrix verbs. At this point, the crosslinguistic influence from L1 would have come into effect. Consequently, the stronger form-meaning association of the L1-based alternative of the agreement source, despite being absent from the experimental stimulus, may have indirectly induced their insensitivity.

The effects of WM, distance-based complexity, and crosslinguistic influence found in the investigation were consistent with the notion of the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpaibroj, 2013). The evidence that L2 learners' agreement processing patterns diverged from those of the NSs showed that language processing was non-selective. This means that two language systems in a bilingual's mind could not be completely separated. In favor of the crosslinguistic competition account, it was argued that both linguistic systems in the learners' minds might be activated simultaneously and compete for selection even when one language is being processed (Jegerski, 2018; Kaan et al., 2015; Kroll et al., 2015; McManus, 2022; Sharwood Smith, 2019). The findings thus far have suggested that the learners found L2 agreement processing too cognitively demanding in complex linguistic contexts since they showed no reading slowdowns in

the long-distance ORC-UG condition. In sentence comprehension, the L2 agreement computational mechanism may be interfered with by the learners' L1-appropriate option, which was assumed to be more entrenched and co-activated to a certain degree. It was assumed that the more entrenched L1-appropriate option, shaped by L1-specific linguistic experiences and routinely processed by the learners, would be reverted to and would win out over the newly learned L2-appropriate option (Chen et al., 2007; Hopp, 2010, 2017; Kaan et al., 2015; Rankin et al., 2019; Sagarra, 2021; Trenkic & Pongpaiboj, 2013). In this regard, L2 agreement processing appeared to be computationally less efficient. The L2 learners' ability to show sensitivity to such a violation became limited, particularly when multiple features unique to L2 were involved. L2 agreement processing may not be attained efficiently on the occasion that the grammaticalization of the agreement source is not L1-analogous (Goldin, 2021; Rattanasak et al., 2020). As a result, making form-meaning connections between the L2 number feature absent in the L1 in linguistically complex contexts could potentially be more cognitively taxing and therefore consume more cognitive resources (Austin et al., 2015; Sagarra, 2021; Warren & Gibson, 2002). Thus, keeping track of such a complex construction and holding it in the WM, while at the same time processing the intervening materials, may quickly deplete cognitive resources. In consequence, L2 language processors may fail to incrementally use their L2 morphosyntactic knowledge in agreement computations during online sentence comprehension. The following section provides a general discussion of the findings from Experiment 1 and Experiment 2.



### 4.3 General discussion

The present findings, overall, suggested that the locality effects of linear distance between the agreement source and target in tandem with WM capacity modulated the NSs and L2 learners' ability to show and maintain sensitivity to agreement violation both in Experiment 1 and Experiment 2. For ease of discussion, all of the LMEs models of the RT data are summarized below as Table 22 for Experiment 1 and Table 23 for Experiment 2.

Table 22 Summary of LMEs models of RTs in Experiment 1

	Predictor	Coefficient	SE	df	t	p
<i>Native speakers</i>						
Critical region ( $R^2 = 0.293$ )	Intercept	590.89	72.01	51.23	8.21	0.000
	WM	-2.65	1.18	50.48	-2.25	0.029
	Distance	217.50	53.91	719.45	4.04	0.000
	Grammaticality	122.63	12.45	719.27	9.85	0.000
	WM x Distance	-2.20	0.87	719.47	-2.51	0.012
	Distance x Grammaticality	-95.80	17.74	719.37	-5.40	0.000
Spillover region ( $R^2 = 0.115$ )	Intercept	327.46	9.17	5.94	35.73	0.000
	Grammaticality	107.81	38.06	662.61	2.83	0.005
	WM x Grammaticality	-1.41	0.62	652.37	-2.25	0.025
<i>Nonnative speakers</i>						
Critical region ( $R^2 = 0.451$ )	Intercept	590.49	37.77	48.20	15.64	0.000
	Distance	196.52	68.73	712.16	2.86	0.004
	WM x Distance	-2.55	1.21	715.66	-2.11	0.035
	WM x Grammaticality	3.68	0.37	684.77	9.98	0.000
	Distance x Grammaticality	-109.69	29.34	682.46	-3.74	0.000
Spillover region ( $R^2 = 0.268$ )	Intercept	509.27	33.11	51.74	15.38	0.000
	Distance	65.90	20.20	687.67	3.26	0.001
	Grammaticality	113.27	19.94	687.67	5.68	0.000
	WM x Distance x Grammaticality	1.07	0.51	689.67	2.09	0.037

In Experiment 1, natively like agreement computations involving grammatical violation based on an L1-option (absence of agreement marking -s) appeared attainable as the learners were able to show sensitivity to such L1-analogous

agreement violation in both short- and long-distance agreement dependencies as the findings in Experiment 1 revealed.

Table 23 Summary of LMEs models of RTs in Experiment 2

	Predictor	Coefficient	SE	df	t	p
<i>Native speakers</i>						
Critical region ( $R^2 = 0.399$ )	Intercept	847.76	158.00	41.57	5.37	0.000
	WM	-7.21	2.60	41.35	-2.77	0.008
	Distance	380.33	71.11	719.60	5.35	0.000
	Grammaticality	115.02	16.31	719.66	7.05	0.000
	WM x Distance	-4.10	1.16	719.60	-3.54	0.000
	Distance x Grammaticality	-63.84	23.20	719.72	-2.75	0.006
Spillover region ( $R^2 = 0.395$ )	Intercept	529.11	73.19	88.02	7.23	0.000
	WM	-3.28	1.20	85.90	-2.74	0.008
	Distance	334.36	61.72	727.51	5.42	0.000
	Grammaticality	352.48	61.64	727.58	5.72	0.000
	WM x Distance	-3.86	1.00	727.52	-3.85	0.000
	WM x Grammaticality	-3.62	1.00	727.62	-3.60	0.000
	Distance x Grammaticality	-68.62	20.06	727.74	-3.42	0.001
<i>Nonnative speakers</i>						
Critical region ( $R^2 = 0.273$ )	Intercept	608.48	94.36	68.02	6.45	0.000
	Distance	308.70	68.96	677.81	4.48	0.000
	Grammaticality	-145.58	68.48	677.86	-2.13	0.034
	WM x Grammaticality	4.50	1.21	677.95	3.72	0.000
	Distance x Grammaticality	-154.77	26.42	677.63	-5.86	0.000
Spillover region ( $R^2 = 0.222$ )	Intercept	666.81	87.22	78.11	7.65	0.000
	WM	-3.78	1.56	76.36	-2.43	0.018
	Distance	191.13	71.00	689.72	2.69	0.007
	WM x Grammaticality	3.61	1.25	690.03	2.89	0.004
	Distance x Grammaticality	-120.43	27.25	689.82	-4.42	0.000

However, in Experiment 2, which involved an L2-analogous type of violation (overuse of agreement marking *-s*), the learners showed nonnative processing, particularly in the long-distance agreement dependency. The findings were partly accounted for by the capacity constraints of WM capacity (Hopp, 2010; Just & Carpenter, 1992; McDonald, 2006; Reichle et al., 2016; Sagarra, 2021), which enabled the agreement computations relative to linguistic complexity manipulated

based on distance (Foote, 2011; Gibson, 1998, 2000; Keating, 2010).

The following sections provide a general discussion of the findings based on the notions of WM capacity, distance-based complexity, and the crosslinguistic competition account in turn (Austin et al., 2015; Jegerski, 2018; Kaan et al., 2015; Kroll et al., 2015; Sharwood Smith, 2019; Trenkic et al., 2014; Trenkic & Pongpaiboj, 2013).

#### **4.3.1 Working memory and L2 agreement processing**

Online L2 agreement processing was assumed to rely on cognitive resources as such L2 processing can be illustrated in relation to both the temporary storage and the processing component, in line with the multi-component model of WM, proposed by Baddeley and Hitch (1974) and Baddeley (2000). The present investigation adopted the view of the capacity-constraint model of WM proposed by Just and Carpenter (1992), which states that the amount of “activation” made available in order to be shared between the processing capacity and the storage capacity is limited. Individuals vary in the amount of activation required to meet the demands of the computation and storage, which is required for language comprehension. The capacity constraint model also predicted that the functions of temporary storage and computations would become inefficient when the task was computationally more demanding and the available cognitive resources were exceeded (Just & Carpenter, 1992; King & Just, 1991). In the present experiments, L2 agreement dependencies could be resolved when the WM mechanism was active to store and process the grammatical information. To elaborate, the relevance of WM capacity as a predictor of NNSs’ ability to show sensitivity to morphosyntactic violation lies in the fact that the learners must hold the first element along with its

features (i.e., person and number features of the subject NP agreement controller) in their WM and keep such processing active until it reaches the other agreeing element (i.e., the matrix verbs) in order to resolve the agreement dependency to fully comprehend the sentences (Reichle et al., 2016).

Taking these memory-based assumptions into consideration, the phenomenon found in the current research could be explained in relation to individual differences in terms of WM capacity. As the findings in Experiment 1 and Experiment 2 demonstrated, as the learners' WM capacity measured in their L1 increased, they tended to show longer RTs in ungrammatical conditions, exhibiting processing advantages and the ability to show sensitivity to L2 agreement violation. While cognitive resources were a key determinant in Experiment 1 because the learners with higher WM capacity showed heightened sensitivity, even in the processing of the more distant ORC-UG agreement dependency, this was less likely the case in Experiment 2, where successful resolution of agreement dependencies was observed only in the less distant SRC-UG agreement dependency condition. Essentially, in Experiment 2, maintaining multiple L2-based features required more cognitive resources and tended to pose more difficulties in agreement processing (Austin et al., 2015; Goldin, 2021; Warren & Gibson, 2002), which thus led to failure to incrementally utilize L2 morphosyntactic knowledge during online processing for comprehension, as evidenced by the L2 learners' lack of reading slowdowns in the long-distance ORC-UG condition in Experiment 2.

The present results were in line with previous research findings observing WM effects in L2 agreement processing. For instance, Keating (2010) investigated

the processing of noun-adjective gender agreement by L1 English speakers of L2 Spanish and found a correlation between cognitive capacity and native-like processing, particularly when the agreement dependencies were one word apart. Since the learners' could use syntactic information to process agreement in real time, the processing difficulties the learners experienced could be ascribed to the limited pool of cognitive resources rather than their L2 representational deficits, which was consistent with the present research findings. Furthermore, Sagarra and Herschensohn's (2010) SPR study on within-phrase or adjacent gender and number agreement processing showed that adult L1 English learners of L2 Spanish with a higher WM capacity showed greater sensitivity to gender agreement violation. Even though a weak effect was found, the findings suggested WM capacity in tandem with a certain level of intermediate L2 proficiency would lead to processing which was similar to that of the monolinguals. The findings of the WM effects of the present study were also in support of those in Coughlin and Tremblay (2013), showing that, in SPR, the effects of WM capacity on sensitivity to L2 number agreement violations in short- and long-agreement dependencies by L1 English learners of L2 French were observable. Unlike the results in Sagarra and Herschensohn (2010), those in this study showed that greater WM effects were found in the high-proficiency participants, asserting that WM capacity could serve as a reliable predictor in adult L2 learners' sensitivity to the agreement violation. The study suggested that WM capacity could serve as a predictor predicting near native-like processing of both short- and long-distance agreement dependencies. In addition, Sagarra (2021) provided evidence that L2 learners' online morphosyntactic sensitivity in the processing of adjacent subject-verb number agreement in L2 Spanish could be accounted for by individual

differences in WM capacity. She found that the higher-span learners tended to be more sensitive to agreement violations than the lower-span ones and WM affected both intermediate and advanced groups of L2 learners. Adding to this line of research was a more recent study employing a more fine-grained online measure, an event-related potential (ERP) measure. Reichle et al. (2016) found similar results in online processing observed in the learners' brain responses to a grammatical anomaly while processing L2 agreement morphology. It showed that L1 English learners of L2 French showed the effects of WM capacity measured in their L1 on their L2 subject-verb agreement processing. In the computation involving agreement dependencies, the ability to show sensitivity to subject-verb agreement violation may be modulated by access to cognitive resources.

Despite numerous past findings that showed the effects of WM capacity in L2 morphosyntactic processing (e.g., Coughlin & Tremblay, 2013; Hopp, 2010; Kaan et al., 2015; Keating, 2010; Reichle et al., 2016; Sagarra, 2021; Sagarra & Herschensohn, 2010), other studies, such as Foote (2011), did not find support for WM capacity effects during online L2 agreement processing, attributing the findings of reduced sensitivity to L2 agreement violation to the distance of the agreement dependency which was non-adjacent. The present study added to Foote's (2011) findings which showed that differences in the degree of complexity of the intervening materials, albeit non-adjacent, could yield different extents of sensitivity. To summarize thus far, based on the findings revealed in Experiment 1 and Experiment 2, the hypothesis that the L2 learners with higher WM capacity would be more likely to show and maintain sensitivity to agreement violation was by and large accepted. This relationship provided support for the facilitative role of WM capacity relative to

distance-based complexity in L2 morphology learning. The following section discusses distance-based complexity as a contributing factor predicting L2 learners' sensitivity to agreement violation.

#### 4.3.2 Distance-based complexity in L2 agreement processing

The locality effects of linear distance between the agreement source and agreement target matrix verb were found to modulate L2 learners' sensitivity to agreement violation. The effects were observed as the distance increased in accordance with the processing difficulty assumption of the memory-based account, the dependency locality theory (Gibson, 1998, 2000) (see 2.1.2 for more details). That is, the longer the linear distance between the filler and the gap dependency of the embedded RC is, the more cognitively demanding the resulting processing will be. This was consistent with an earlier piece of work by Just and Carpenter (1992), stressing the essence of WM capacity in tackling the processing complexity. They showed that NSs found processing filler-gap dependency in ORCs more cognitively taxing than in SRCs, resulting in different RTs at the matrix verbs (e.g., “The reporter that the senator attacked *admitted* the error.” vs. “The reporter that attacked the senator *admitted* the error.”). They found that the RTs were longer at the matrix verb “admitted” as it required more time to process in the ORC condition and that L1 English speakers with greater cognitive capacity did not require as much time as the lower-span ones during online comprehension. The model was in favor of computational efficiency in language comprehension, consisting of two primary roles: the processing and the storage. There is processing cost as a result of increasing dependency length to WM capacity, which was viewed as a single pool of resources in Just and Carpenter's capacity-constraint model. In the present findings, it was

evident that the effects of distance suggested by the filler-gap dependency of semantically reversible ERCs could appropriately serve to test long-distance agreement dependencies since the overall research findings in both experiments showed longer RTs in the long-distance ORC condition. The role of WM capacity was more prominent, indexed by shorter RTs upon processing long-distance agreement dependencies, as the participants' WM capacity increased.

The present research revealed empirical findings indicating L2 sensitivity in agreement processing was modulated by locality effects of distance disrupting the two agreeing elements in two different distance conditions. The overall RT data showed that both NSs and NNSs exhibited reading slowdowns at the matrix verbs in the long-distance ORC condition. This holds true for the NNSs' RTs despite generally reading more slowly than the NSs in both SRC and ORC conditions. The findings in both the critical and spillover regions, overall, showed that both NS and NNS populations took longer to read the main verbs in the ORC condition than those in the SRC condition. To be precise, distance, assumed to influence WM load during online processing, was found to interact with grammaticality, indicating that both populations' ability to maintain sensitivity to agreement violation was modulated by the intervening materials (Gibson, 1998, 2000). These empirical findings contribute to understanding in L2 agreement literature by showing that the complexity based on distance in non-adjacent agreement processing, be it with the short- or long-distance agreement dependencies, would modulate the extent to which L2 learners could show and maintain their sensitivity during online morphosyntactic processing (Coughlin & Tremblay, 2013; Foote, 2011; Keating, 2009, 2010; Ocampo, 2013). By using a violation paradigm in grammatical processing inquiry, the present study showed that



longer RTs at the ungrammatical matrix verbs disrupted by the two types of ERCs could index the participants' sensitivity to grammatical processing, providing novel findings for the agreement literature, since, to the best of my knowledge, no previous research work had compared inflectional agreement processing intervened by these two types of ERCs.

The present findings were in part compatible with previous research pertinent to the notion of distance (i.e., non-adjacent agreement). Distance effects have lent support to and influenced L2 learners' sensitivity to agreement violation (Foote, 2011; Keating, 2009, 2010; Lim & Christianson, 2015; Siriwittayakorn & Miyamoto, 2019). For example, Keating (2009, 2010) found that noun-adjective gender agreement by L1 English speakers of L2 Spanish was attainable only in the closely adjacent agreement processing. That is, the L2 learners' sensitivity to gender agreement violation was observed only in the one-word distance condition. However, those findings lent partial support to the present findings in that distance affected both NSs' and NNSs' sensitivity to morphosyntactic violation. In line with Keating's (2009, 2010) findings, Foote (2011), in a SPR study, attributed L2 learners' modulated sensitivity to the effects of distance. Specifically, less sensitivity was found when there was intervening material existing in the L2 Spanish subject-verb number agreement concord. L2 learners showed sensitivity to morphosyntactic violation, but in relation to the distance of disagreement errors. Nevertheless, the study did not find support for WM capacity, which might be due to the less taxing processing of the experimental stimuli, which utilized a prepositional phrase, unlike the present study, which employed an embedded RC in order to create distance to examine short- and long-distance agreement processing. In contrast with Foote's (2011) work, the present

findings corroborated several past studies succeeding in demonstrating that L2 learners' sensitivity to non-adjacent agreement violation was attainable, attributing it to various sources of processing difficulties. For example, Coughlin and Tremblay (2013) found that L2 learners with high proficiency were able to show sensitivity to agreement violation in long-distance dependencies; however, it was suggested that the source of variable sensitivity to ungrammaticality was the learners' cognitive resources, which were insufficient for agreement computations in a more distant agreement process. Hence, WM capacity was considered one of the factors that predicted L2 learners' sensitivity to long-distance agreement dependencies during online processing. In addition, Siriwittayakorn and Miyamoto (2019) showed that L2 sensitivity to the English subject-verb number agreement violations by Thai-speaking learners of L2 English was possible, using non-adjacent agreement dependencies between the subjects and the verbs, which were separated by a prepositional phrase. It was found that the L2 learners showed reading slowdowns in the spillover regions in the ungrammatical condition, indicating native-like sensitivity to number agreement violations.

Some previous findings even revealed that learners showed sensitivity to agreement violation in simple adjacent agreement processing (e.g., Sagarra & Herschensohn, 2010; Shibuya & Wakabayashi, 2008). Sagarra and Herschensohn (2010) found that WM was one of the contributing factors even when there was no distance existing between the two agreeing elements, while Shibuya and Wakabayashi (2008) investigated the processing of an overuse of the English 3S morpheme *-s* marker by Japanese-speaking learners of English. The study demonstrated that sensitivity to L2 adjacent agreement violation was attainable, particularly when the

agreement source was expressed through a demonstrative and numeral quantifier (e.g., “These two secretaries”) and syntax-based constructions (e.g., “Tim and Paul”). However, they showed that when the subject NPs were morphologically marked for plurality with an -s inflectional plural marker, the learners were not found to show sensitivity, which could be ascribed to the learners’ ability to identify the number feature in the subject NPs. Their findings were in line with a more recent acceptability judgment and ERP study by Tanner and Bulkes (2015), which showed that heightened sensitivity was triggered by quantification at the subject NPs, which was very crucial in agreement processing mechanisms. That is, when the subject NP was doubly marked with a quantifier and a plural marker, compared with that singly marked with a plural marker in the subject NP (e.g., “Many/The cookies taste/\*tastes the best when dipped in milk.”), they found that English NSs showed greater sensitivity when the agreement was cued by overt quantification with the quantifiers “some” and “many”. They argued that it was not due to the lack of ability to identify the number feature (Shibuya & Wakabayashi, 2008) but could be explained by the important role of quantification at the agreement source. Such findings could be best accounted for by the predictive and retrieval quality offered by the cues.

Based on these previous findings, the present results, especially in Experiment 2, advanced our understanding of L2 morphosyntactic processing. It was found that the NNSs, similar to the NSs, were able to show sensitivity to agreement violation in their online processing, even when the manipulated subject NPs were marked for plurality by means of inflectional marking, at least when agreement violation was presented in the short-distance SRC condition. The results of the present study contrasted with those of previous investigations that showed L2 learners’ were

insensitive to morphosyntactic violation (e.g., Jiang, 2004, 2007; Sato & Felser, 2010). The present findings were partly inconsistent with those in Shibuya and Wakabayashi (2008) since, in Experiment 2, L1 Thai learners were able to process the plural inflectional morpheme *-s* and, as facilitated by their sufficient cognitive resources, could incrementally integrate this L2 knowledge in the short-distance agreement dependencies during online sentence comprehension. However, the present findings were in line with other previous findings (Lim & Christianson, 2015; Siriwittayakorn & Miyamoto, 2019). That is, despite the fact that NPs were morphologically marked for plurality with the less salient *-s* plural marker and that the processing was disrupted by a short-distance SRC construction, L2 learners were able to show their sensitivity to agreement violation.

In addition to the mentioned findings, the present research also added to the agreement literature by demonstrating that it was not just a matter of the agreement concord being adjacent or non-adjacent that may modulate or even constrain L2 learners' sensitivity to agreement violation. However, the processing cost from the intervening materials could serve as a predictor of how sensitivity to L2 agreement violation can be modulated. That is, sensitivity to L2 agreement violation during online processing tended to diminish as a function of the linear distance between the agreement source and agreement target, relative to cognitive resources available (Gibson, 1998, 2000; Keating, 2010).

#### **4.3.3 Native and nonnative sensitivity to L2 agreement violation**

In comparison with the NSs' agreement processing in relation to sensitivity to agreement violation during online processing, the present findings

showed that Thai-speaking learners of L2 English, whose L1 lacks inflectional systems, were similar to NSs when the processing involved a less complex definite singular default controller in Experiment 1. The processing patterns were, however, dissimilar to those of NSs when the processing involved a more complex definite plural NP controller, as evident in Experiment 2.

To explain, when comparing the matrix verb processing time course within the same distance condition, the ungrammatical conditions in both short-distance SRCs and long-distance ORCs took the NSs longer to read, suggesting that sensitivity to morphosyntactic violation could be manifested by NSs, serving as a baseline. Similar native-like processing was found in Experiment 1 (see Figure 18); however, in Experiment 2, the learners did so merely in the short-distance dependency relation, the SRC-UG condition, while the RTs in the ORC-UG condition showed a reverse pattern; that is, no reading slowdowns were observed when compared with the ORC-G condition (see Figure 19). It is worth noting that speed of lexical access should be canceled out as all lexical items used in the experiment were identical as we employed semantically reversible ERCs as distance differences in our experimental stimuli (e.g., “\*The guy *that\_knows the driver* want to buy a new car.” vs. “\*The guy *that the driver knows\_* want to buy a new car.”).

In that regard, processing multiple L2 features may be too taxing for L2 learners; their reduced sensitivity to agreement violation was observed in the lack of reading slowdowns in both critical and spillover regions in the long-distance ungrammatical condition. Unlike Experiment 1, where the learners showed sensitivity to agreement violation through longer RTs in both SRC and ORC conditions as a function of linear distance and WM capacity, Experiment 2 utilized the definite plural

subject NP as the agreement source, which is considered a morphologically complex construction (Austin et al., 2015; Warren & Gibson, 2002), and thus could be in part responsible for the processing difficulties. The construction was coupled with the processing of the filler-gap dependency within an RC, such that the filler-gap distance in the SRC was shorter, thus easier to process than the ORC (Baek, 2012; Traxler et al., 2002), as posited by the memory-based account, the DLT (Gibson, 1998, 2000; Just & Carpenter, 1992). In consequence, maintaining multiple features while having to keep track of the agreement dependency, which was disrupted by a linearly long distance of an ORC, may have probably exceeded the WM capacity available among the L2 learners. Accordingly, the processing may have become too cognitively taxing; therefore, in order to achieve the goals of the comprehension task at hand, the processing at this point may be interfered with by the learners' L1-option, which was assumed to be co-activated to a certain degree during online processing (Hopp, 2010; Kaan et al., 2015; McDonald, 2006; Reichle et al., 2016). This is consistent with the notion that language processing is nonselective: two language systems in a bilingual's mind cannot be completely separated; both may be activated simultaneously and compete for selection, even when only one language is processed (Austin et al., 2015; Jegerski, 2018; Kaan et al., 2015; Kroll et al., 2015; McManus, 2022; Sharwood Smith, 2019; Trenkic et al., 2014; Trenkic & Pongpaiboj, 2013).

#### **4.3.4 The L1-L2 structural competition in L2 agreement processing**

While the evidence based on the learners' sensitivity to agreement violation found in Experiment 1 could be in part explained by the L1-L2 structural competition account, the nonnative processing in Experiment 2 provided strong support for the account.

The fact that L2 agreement processing appeared to be computationally less efficient may be due to the interplay between cognitive resources relative to linguistic complexity, which led to crosslinguistic influence from the L1. L2 learners' ability to show sensitivity to such agreement violation in Experiment 2 became limited, particularly when two features unique to the L2 were involved, i.e., a subject NP morphologically marked for plurality and ungrammatical verb agreement with an overuse of the agreement marker *-s* (e.g., “\*The guys that the driver knows\_wants to buy a new car.”). L2 agreement processing may not be attained efficiently on the occasion that the grammaticalization of the subject NPs was not based on the L1. To explain, unlike Experiment 1, where the higher memory span learners were able to keep track of agreement processing of the agreement source with a singular default of the subject NP agreement controllers (i.e., “The guy” vs. “The guys”), in Experiment 2, making form-meaning connections between the L2 number feature, plurality (absent in L1), in the agreement source could potentially be more cognitively taxing, consuming more cognitive resources (Austin et al., 2015; Warren & Gibson, 2002). Consequently, the processing that involved keeping track of such a complex construction and holding it in the WM, while processing the subject-verb number agreement in the long-distance agreement dependencies in the ORC condition, may fast deplete cognitive resources. Thus, it was likely that failure to use their L2 morphosyntactic knowledge incrementally in agreement computations at the matrix verbs would result, and the processing would become computationally less efficient.

In accordance with the view that two linguistic systems represented in a bilingual's mind cannot be kept fully apart and that relevant grammatical features in both languages may be simultaneously activated to some degree, crosslinguistic

competition between L1 and L2 may result both in comprehension (Chen et al., 2007; Hopp, 2010; Kaan et al., 2015; Rankin et al., 2019; Trenkic et al., 2014) and production (Austin et al., 2015; Trenkic & Pongpairoj, 2013). The competing grammars here are regarded as nonselective, meaning even when one language is being processed, two languages are assumed to be activated in parallel (Austin et al., 2015; Jegerski, 2018; Kaan et al., 2015; Kroll et al., 2015; Sharwood Smith, 2019; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013). This account assumes that two relevant forms, L1-based and L2-based features, compete for selection. To successfully produce or comprehend a newly learned L2 grammatical feature, it is crucial that the relevant L1 counterpart need to be suppressed and that the ability to inhibit irrelevant grammatical features in there is assumed to be dependent on the cognitive resources (Austin et al., 2015; Kaan et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013).

The crosslinguistic account predicted that the relevant L1-option would compete with the L2-option being processed in real-time for selection, assuming that the more entrenched L1-option, shaped by L1-specific linguistic experiences (Chen et al., 2007; Hopp, 2010; Rankin et al., 2019) and routinely processed by the learners, would have recourse to and win out over the newly learned L2-option. That is, the form-meaning association of the L2 may be weaker when it comes to real-time processing, particularly in syntactically more complex structures where greater cognitive resources are required. This original prediction was particularly based on features absent in the learners' L1 but compulsory in the L2 being attempted. In support of the account, some previous findings were based on the omissions of articles in the studies of L2 oral production (Austin et al., 2015; Trenkic &



Pongpairoj, 2013). In comprehension, Trenkic et al. (2014) found that native-like processing could be possible even when the L2 features were not instantiated in the learners' L1. In an eye-tracking experiment, they found that L1 Mandarin-speaking learners of English could incrementally utilize L2 syntactic information about articles in their real-time processing. The present study differs from Trenkic et al. (2014) in that it employed a violation paradigm to explore L2 sensitivity in morphosyntactic processing, while that of Trenkic et al. (2014) used a non-violation paradigm. Processing grammatical features that are unique to L2 may not trigger crosslinguistic competition since there is nothing to transfer (their stimuli used were based on grammatically well-formed L2 constructions). In spite of the processing of the stimuli which were obviously based on L2 features, such as those in Experiment 2, one might argue that there is nothing to transfer from the L1 and that crosslinguistic competition should not be triggered. Nevertheless, in accordance with the non-selective perspectives in grammatical activation, it could be argued that the processing divergence found was not without recourse to the L1. Based on the differences in the manipulations of the linear distance, an alternative perspective is that when the learners' cognitive resources were depleted (i.e., upon resolving the filler-gap dependency in a long-distance ORC), they might have become unable to retrieve the number feature in the subject NPs due to morphological complexity of the subject NP agreement controllers (Goldin, 2021; Warren & Gibson, 2002). This view is in line with a recent study by Brehm et al. (2019), who attest, "Processing both nouns and verbs is likely to require lexical retrieval, but the representations that retrieval operates upon could differ" (p. 3). In this study, the lack of the ability to retrieve the number feature at the agreement source could be ascribed to the effects of long-

distance agreement dependencies. This may then influence their ability to suppress the L2-based form at the matrix verbs (Kaan et al., 2015; Trenkic & Pongpairaj, 2013). It was suggested that the insensitivity to agreement violation involving multiple unique-to-L2 features might be the consequence of the lack of ability to retrieve grammatical features in the agreement source relative to their insufficient cognitive resources and more established L1-specific experiences. The relevance of crosslinguistic competition, here, lies in the fact that the learners probably had to resort to their L1-based option (i.e., the bare subject NP) in the competition as their cognitive resources were insufficient to process the matrix verbs. At this point, the crosslinguistic influence from their L1 would come into effect. The stronger form-meaning association of the L1-based alternative of the agreement source (despite being absent from the experimental stimuli) may have indirectly led them to be unable to detect the morphosyntactic violation, accepting it as if it were grammatical when it was not during online processing.

Based on the present findings on insensitivity to L2 agreement violation in long-distance agreement dependencies, it seemed evident that multiple unique-to-L2 features coupled with distances yielded an adverse effect as no reading slowdowns were observed, particularly in the long-distance agreement dependency. It was further suggested based on the present findings that, despite the fact that linguistic manipulations such as those in Experiment 2 were based primarily on L2-options, competition may indeed occur, which could be additionally explained in relation to the insufficiency of cognitive resources. That is to say, the incremental processing cumulatively consumes the resources as the parsing progresses; consequently, competition across languages could take place at the points where resources were left

too insufficient for further L2 online morphosyntactic computations. In this regard, L2 learners would be, to some extent in the process, subject to competing grammars in their mind (Jegerski, 2018; Kaan et al., 2015; Rankin et al., 2018; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013), and the more entrenched L1-based feature would be resorted to in order to accomplish the task, i.e., sentence comprehension. This probably led to the learners' inability to detect morphosyntactic violation in real-time processing where agreement features were based on L2-options in the long-distance agreement dependency relations.

As discussed above, the results obtained here rule out the Shallow Structure Hypothesis (Clahsen & Felser, 2006, 2018). Furthermore, the asymmetry and interactions among the factors included in the present work suggest that more simplistic accounts relying on capacity constraint (Just & Carpenter, 1992), distance-based complexity (Gibson, 1998, 2000), or L1 interference (Hsieh, 2009; Jarvis & Pavlenko, 2008; Odlin & Yu, 2016) alone appear insufficient to explain the data here. Further work with other grammatical structures and different combinations of languages will be required to more definitively rule out the single-factor accounts, however. The expansion of this line of work to a wider typological sampling of languages will provide stronger evidence that the results here are due to the competition of specific L1 and L2 grammars (Thai and English, in this case) (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairoj, 2013), rather than to general characteristics of all L2 speakers as their L2 grammars develop.

## CHAPTER V

### CONCLUSION

This chapter aims at concluding the research findings of the present study. The conclusion in 5.1 provides an interpretation of the major research findings to advance fundamental understanding of the variables under investigation, i.e., WM capacity, distance-based complexity, and crosslinguistic influence in association with the crosslinguistic competition account, in online L2 agreement computations. In addition, 5.2 offers psycholinguistic and L2A theoretical implications, and 5.3 provides recommendations for the learning and teaching of L2 agreement morphology. Finally, in 5.4, the limitations are acknowledged and recommendations for future research directions are provided.

#### 5.1 Conclusion

This study was carried out to investigate L2 agreement processing by L1-Thai L2-English learners, whose L1 lacks agreement morphology, and NSs of English. More specifically, it examined the role of individual differences in terms of cognitive resources, i.e., WM capacity, relative to linear distance effects on the real-time resolution of non-adjacent agreement dependencies in L2 English subject-verb number agreement. The main goal was to examine how adult L2 learners process L2 grammatical information in real time. The L2 learners' (in)ability to show and maintain sensitivity to L2 English agreement violation was taken to infer the underlying mechanism operated during online sentence comprehension as compared to the NSs' processing. To this end, two moving-window self-paced reading experiments were conducted to investigate the time the participants took to read sentences with English subject-verb number agreement during sentence

comprehension. Two types of experimental conditions: short-distance SRCs and long-distance ORCs, where agreement anomalies were manipulated, were created. In each of the two experiments, 40 NSs of English and 40 L1 Thai learners of L2 English read the sentences word by word non-cumulatively and answered comprehension questions at the end of each trial. The RTs were observed at the matrix verbs and the immediately following word for spillover effects. The key findings from both Experiment 1 and Experiment 2 are summarized in Table 24.

Table 24 Summary of the key findings in Experiment 1 and Experiment 2

Experiment 1	Experiment 2
<p><i>NSs:</i></p> <p><i>Key findings:</i></p> <ul style="list-style-type: none"> <li>- Effects of distance modulated sensitivity to ungrammaticality.</li> <li>- Effects of WM capacity yielded processing advantages in the long-distance condition.</li> <li>- Effects of WM capacity influenced the ability to maintain sensitivity to ungrammaticality, interpreted as a processing advantage allowing for a quicker recovery from processing difficulties among high WM-span NSs.</li> </ul> <p><i>Summary:</i></p> <p>The NSs showed sensitivity to ungrammaticality in both distance conditions while their processing was influenced by distance and WM capacity. They were able to show and maintain their sensitivity to agreement violation involving <i>an omission of the 3S morpheme -s</i>.</p>	<p><i>NSs:</i></p> <p><i>Key findings:</i></p> <p><i>Summary:</i></p> <p>The NSs showed sensitivity to ungrammaticality in both distance conditions while their processing was influenced by distance and WM capacity. They were able to show and maintain their sensitivity to agreement violation involving <i>an overuse of the 3S morpheme -s</i>.</p>

*NNSs:*

*Key findings:*

- Effects of distance modulated sensitivity to ungrammaticality.
- Effects of WM capacity yielded processing advantages in the long-distance condition.
- Effects of WM capacity modulated sensitivity to ungrammaticality.
- The relationship between WM and distance effects was associated with the NNSs' ability to maintain sensitivity to ungrammaticality.

*Summary:*

The NNSs showed sensitivity to ungrammaticality as a function of WM capacity and locality effects of distance. When the agreement involved *an omission of the 3S morpheme -s*, heightened sensitivity to agreement violation was revealed through reading slowdowns but modulated by WM capacity and distance effects.

*NNSs:*

*Key findings:*

- Effects of distance modulated sensitivity to ungrammaticality.
- Effects of WM capacity modulated sensitivity to ungrammaticality.
- RT data showed a lack of reading slowdowns at ungrammaticality in the long-distance condition.

*Summary:*

The modulatory effects of distance and WM capacity were observed; however, the NNSs showed insensitivity to ungrammaticality by showing a lack of reading slowdowns in the long-distance condition. Showing sensitivity to agreement violation involving *an overuse of the 3S morpheme -s* appeared to be more difficult, given the long-distance agreement processing as related to cognitive resources available for computations.

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Experiment 1 demonstrated that the upper-intermediate L1 Thai learners of L2 English were able to show and maintain sensitivity to agreement violation. Locality effects indicated by increased dependency distance and cognitive resources available modulated both the NSs' and the L2 learners' sensitivity to agreement violations. As regards the lower efficiency found in L2 morphosyntactic processing, it may be

attributed to crosslinguistic influence, i.e., the influence of L1 co-activation, which came into play when there were too few cognitive resources left during the processing, especially by the L2 learners, whose L1 Thai does not grammatically mark agreement. On this ground, it was suggested that the L2 learners may labor under parallel activation during L2 agreement processing, whereby the more entrenched L1-appropriate forms played a role when WM was insufficient for agreement computations in a syntactically more complex linguistic environment, consistent in part with the L1-L2 structural competition account, adding to the literature of L2 agreement processing.

Experiment 2 provided evidence that asymmetries in the agreement processing patterns between the NSs of English and L1 Thai learners of L2 English can be predicted by cognitive resources in association with distance-based complexity, and crosslinguistic influence. The results of the SPR experiment revealed that, unlike Experiment 1, while the NSs were sensitive to agreement violations in both short-distance and long-distance conditions, the upper-intermediate L2 learners' ability to demonstrate morphosyntactic sensitivity appeared to dwindle as a function of increased dependency lengths, showing a lack of reading slowdowns in the ungrammatical long-distance agreement dependencies. The findings found thus far suggested that (in)sensitivity to L2 agreement violation during online processing could be commensurate with individual differences in their cognitive capacity, which in part affected retrieval of the number feature of the agreement source at the subject NP controller region. It was indicated that failing to integrate L2 knowledge incrementally during online processing may be the result of the processing exceeding cognitive resources. This may lead to insensitivity to L2 morphosyntactic processing

in sentence comprehension. The processing was associated with their limited pool of cognitive resources such that higher WM-span learners tended to show greater sensitivity to agreement violations. In addition, their decreased efficiency in agreement computations in long-distance agreement dependencies may be ascribed to the influence of L1 co-activation during online processing, presumably giving rise to crosslinguistic competition and thus interfering with the newly learned L2 grammatical knowledge.

Consistent with the notion of the L1-L2 structural competition account (Austin et al., 2015; Trenkic et al., 2014; Trenkic & Pongpairroj, 2013), essentially, this study highlights the interplay between WM capacity and distance-based complexity in L2 sentence comprehension. The findings suggest that L2 learners may experience parallel activation during processing, whereby reduced sensitivity to L2 morphosyntactic violations could be accounted for by cognitive resources that are rendered insufficient to resolve long-distance agreement dependencies in complex linguistic contexts.

## **5.2 Psycholinguistic and L2A theoretical implications**

This study contributed to our understanding of how L2 learners use their morphosyntactic knowledge in real-time processing during sentence comprehension. It provided empirical findings from two self-paced reading experiments showing the relationship between cognitive and linguistic variables in L2 agreement processing.

As regards the theoretical implications in relation to studies in psycholinguistics and L2A, the findings particularly provided evidence that L2 learners at the upper-intermediate level showed the ability to display and maintain



sensitivity to grammatical violations of verbal agreement morphology which is absent in the learners' L1. In addition, the locality effects based on distance posited by the dependency locality theory (Gibson, 1998, 2000) were successful in providing novel insights into long-distance agreement processing research, especially when the number of words and uses of lexical items in the intervening materials were kept constant. Such manipulations of the linguistic stimuli had the feasibility of revealing the effects of distance on agreement processing.

In addition, given that most of the past investigations concerning English subject-verb number agreement were studied through the processing of the copula “be”, the present findings suggested that utilizing the less salient but more complex inflectional 3S morpheme *-s* was possible among L2 learner populations whose L1 lacks inflectional morphology, thus providing deeper insights for the agreement processing literature.

Finally, this research showed that, among many variables, individual differences in terms of WM capacity measured in L1 in association with linguistic complexity contributed to and predicted how L2 agreement was processed. The findings advanced our understanding that not only the differences between L1 and L2 linguistic properties may lead to variable processing performance among L2 learners in comparison with the NSs, but it was also evident that dealing with complexity in an L2 during real-time processing may be dependent on the learners' cognitive resources available to tackle the complex L2 processing tasks.

### **5.3 Recommendations for the learning and teaching of L2 agreement morphology**

The present study has provided empirical findings relevant to factors influencing how Thai-speaking learners of L2 English, whose L1 lacks agreement morphology, processed the L2 English third-person singular morpheme *-s* in complex sentences during online comprehension.

Although this study could not provide direct pedagogical implications on L2 teaching and learning, the findings could help L2 instructors become more aware that both linguistic and non-linguistic factors may influence and lead to variable L2 processing performance among L2 learner populations whose L1 lacks or does not have rich verbal morphology. Based on the present findings, an L2 form-meaning connection could possibly be established and put into use given a certain level of L2 proficiency, i.e., the upper-intermediate level, and available cognitive resources to cope with the complexity in L2 processing tasks. Such a connection needs to be strengthened through the course of L2 development so that automatized processing can take place. Therefore, the learners' ability to establish such a connection in real-time processing plays an important role in L2 morphology learning. Since it was obvious that individual differences, such as L2 proficiency levels and the availability of cognitive resources in association with linguistic complexity, played a crucial role in L2 morphosyntactic processing, better understanding of these factors would help L2 instructors become aware of why and how variable performance occurs among L2 learners when it comes to L2 morphosyntactic processing.

Accordingly, planning lessons and designing tasks that better suit the learners would help foster L2 grammatical learning. Firstly, given the present findings,

processing L2 morphosyntactic features in syntactically more complex linguistic environments seems to be problematic but not insurmountable. In teaching L2 grammatical aspects which were absent in the learners' L1 system, such as agreement morphology, instructors may design instructional materials and tasks with form-focused instruction (Ellis, 2015). Involving explicit instructions on the problematic areas by helping L2 learners focus their attention on specific L2 properties would help them learn L2 grammars more effectively.

Secondly, the findings may be used as a guideline for sequencing orders of instructions based on the linguistic complexity of the grammatical structures where L2 agreement morphology is involved in complex sentences such as English relative clauses. More specifically, this research showed that non-adjacent agreement processing for real-time comprehension was possible when the linguistic environment was less syntactically complex. Therefore, L2 instructors may consider the order of instructions regarding types of English relative clauses as it is evidently known that production or comprehension of object-extracted relative clauses usually poses greater difficulties than that of subject-extracted relative clauses. The findings of the present study added to our knowledge that processing morphosyntactic features such as agreement morphology is not straightforward when multiple L2 features are involved in the processes. It is, therefore, essential to take the sequencing of instructional tasks into account in order to plan and deliver lessons concerning L2 morphology in complex sentences more effectively.

Furthermore, research evidence found thus far has shown that, in time-sensitive tasks such as self-paced reading, L1 Thai learners of L2 English showed

qualitative differences in agreement processing in complex linguistic environments, compared to native speakers. Thus, taking the present findings into consideration, L2 instructors may consider providing timed instructional activities which allow for language practice in real-time processing to foster automatization in L2 learning. For instance, L2 instructors may include L2A research methodologies, such as a timed/speeded grammaticality judgment task, in their explicit grammar teaching (cf. Gutiérrez, 2013, for task characteristics). In L2 instructional planning, it is therefore suggested that integrating L2A research methodologies into L2 instruction may help foster the learning of novel L2 features absent in the learners' L1 system. However, it is important that timed activities be implemented with careful consideration of individual variables such as the learners' L2 proficiency since they may result in extra pressure in the learning processes.

In sum, this study revealed problematic areas in L2 agreement morphology learning among L1 Thai learners of English. It was able to show that processing difficulties may have stemmed from various factors, such as linguistic complexity of the sentences and individual differences in cognitive resources. Therefore, based on the research results, the researcher recommends that the teaching of L2 English agreement morphology be facilitated by focusing on forms with explicit instruction, sequencing orders of instructions based on the linguistic complexity, and providing a variety of instructional tasks to foster automatization in the learning processes.

#### 5.4 Limitations and directions for future research

Some research limitations of the present study have been acknowledged. Firstly, since this study involved only L2 learners from an agreement-lacking L1 background, future research may incorporate L2 learner populations whose L1 instantiates inflectional agreement morphology. Including such participants in the comparison would help reveal the effects of crosslinguistic influence more comprehensively since L1s with typological differences in morphology may yield different results.

In addition, as one of the tenets of the L1-L2 structural competition account concerns learners' ability to suppress L1-competitors during real-time language processing, different measures of WM capacity, such as inhibition tasks (e.g., the n-back with lures task, cf. Hussey et al., 2015), may be taken into account to shed more light on the learners' ability to suppress irrelevant information during sentence comprehension.

Another aspect of individual differences that should be taken to consideration is the learners' L2 proficiency measurement. Since the present research involved only one L2 English proficiency measure, i.e., a lexical-decision based LexTALE (see 3.1.2.1, for task characteristics), including a measure that reveals the learners' L2 grammatical knowledge in future studies may help provide a better understanding of individual differences, especially when L2 proficiency is the focal concern of the research.

Finally, a more fine-grained measure, such as an eye-tracking technique, could be adopted to reveal different aspects of the processing and confirm the findings more

robustly. In particular, since eye-tracking allows reanalysis of the syntactic structures being read, using the technique would help confirm whether the reanalysis between the agreement controller and agreeing verbs occurs after the participants have detected the agreement violation during their reading for comprehension. With further research, our understanding of the effects of individual variables as well as linguistic variables on L2 morphosyntactic processing will continue to grow, as will our deeper knowledge of how L2 linguistic knowledge is put into use in real-time processing.



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**APPENDICES**

จุฬาลงกรณ์มหาวิทยาลัย  
**CHULALONGKORN UNIVERSITY**

## APPENDIX A

### Language Background Questionnaire

Please provide information about your language learning experience. Only group-level information from this questionnaire will be used for reporting. No identifiable information will be kept or reported in any published study.

**Directions:** Please put a tick (✓) in a circle (○) on the statement which best corresponds to you and provide the requested information.

- Gender:
- male
  - female
  - non-binary third gender
  - prefer not to say

Specify your age: \_\_\_\_\_

Which language(s) did you grow up with?

- Thai
- English
- Chinese
- Others (please specify) \_\_\_\_\_

Language you normally use with your friends/classmates:

- English
- Thai
- Others (please specify) \_\_\_\_\_

Specify your age when you start learning English: \_\_\_\_\_

How long have you studied English? \_\_\_\_\_

Education: Major of study: \_\_\_\_\_

- Year 1
- Year 2
- Year 3
- Year 4

Have you ever experienced using English in any English speaking country?

- No  
 Yes

If yes, specify the country and duration.

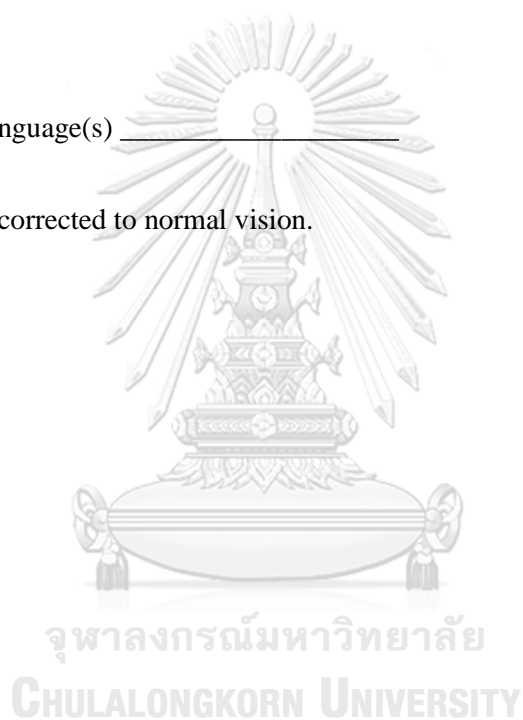
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| <input type="radio"/> the United Kingdom           | How long? _____ |
| <input type="radio"/> the United States of America | How long? _____ |
| <input type="radio"/> Others, please specify       | How long? _____ |

Can you use any language other than Thai and English?

- No  
 Yes

If yes, specify the language(s) \_\_\_\_\_

- I have normal or corrected to normal vision.



**APPENDIX B**  
**Experimental Sentences in Reading Span Task**

RSPAN practice trials

1	English	Andy was stopped by the policeman because he crossed the yellow <u>heaven</u> .	implausible
	Thai	ฉันถูกตำรวจเรียกให้หยุดเพราะเขาข้าม <u>สวรรค์</u> สีเหลือง	
2	English	During winter you can get a room at the beach for a very low rate.	plausible
	Thai	ช่วงฤดูหนาว คุณจะหาห้องพักริมชายหาดได้ในราคาถูกมาก	
3	English	People in our town are more giving and cheerful at Christmas time.	plausible
	Thai	คนที่เมืองเรามีน้ำใจและสุขใจกันมากขึ้นในช่วงคริสต์มาส	
4	English	During the week of final <u>spaghetti</u> , I felt like I was losing my mind.	implausible
	Thai	ช่วงสัปดาห์สุดท้ายของ <u>สปาเก็ตตี้</u> ฉันรู้สึกเหมือนตัวเองกำลังเป็นบ้า	
5	English	After final exams are over, we'll be able to take a well-deserved rest.	plausible
	Thai	หลังจากสอบปลายภาคเสร็จ เราจะได้พักผ่อนอย่างที่สมควร	
6	English	After a hard day at the office, Bill often stops at the club to relax.	plausible
	Thai	ภายหลังจากวันยุ่งยากที่สำนักงาน บิลล์มักจะแวะที่ <u>สโมสร</u> เพื่อผ่อนคลาย	
7	English	No matter how much we talk to him, he is never going to change.	plausible
	Thai	ไม่ว่าเราจะพูดกับเขาแค่ไหน เขาก็ไม่มีวันเปลี่ยนแปลง	
8	English	The prosecutor's <u>dish</u> was lost because it was not based on fact.	implausible
	Thai	<u>จาน</u> ของอัยการแพ้เพราะมันไม่ได้ตั้งอยู่บนข้อเท็จจริง	
9	English	Every now and then I catch myself swimming blankly at the <u>wall</u> .	implausible
	Thai	บางครั้ง ภารู้ตัวอีกที ฉันก็ว่ายน้ำอย่างงุนงงที่ <u>ฝาผนัง</u>	
10	English	We were fifty <u>lawns</u> out at sea before we lost sight of land.	implausible
	Thai	เราอยู่ที่ห้าสิบ <u>สนาม</u> กลางทะเลก่อนจะมองไม่เห็นแผ่นดิน	
11	English	Throughout the entire ordeal, the hostages never appeared to lose hope.	plausible
	Thai	ตลอดช่วงถูกทรมาณแสนสาหัส ตัวประกันไม่แสดงท่าทีหมดหวังเลย	
12	English	Paul is afraid of heights and refuses to fly on a plane.	plausible
	Thai	พลกลัวความสูงจึงปฏิเสธที่จะขึ้น โดยสารบนเครื่องบิน	
13	English	The young <u>pencil</u> kept his eyes closed until he was told to look.	implausible
	Thai	<u>ดินสอ</u> หนุ่มหลับตาของเขาไว้จนกระทั่งเขาถูกสั่งให้มองดูได้	
14	English	Most people who <u>laugh</u> are concerned about controlling their weight.	implausible
	Thai	คนส่วนใหญ่ที่ <u>ขำ</u> ต่างกังวลเรื่องควบคุมน้ำหนักตัวเอง	
15	English	When Lori shops she always looks for the lowest <u>flood</u> .	implausible
	Thai	เวลาสุภาพไปซื้อของ เธอมักจะหา <u>น้ำท่วม</u> ต่ำที่สุด	

## RSPAN experimental trials

1	English	When I get up in the morning, the first thing I do is feed my dog.	plausible
	Thai	เมื่อนั้นตื่นนอนในตอนเช้า สิ่งแรกที่ฉันทำก็คือให้อาหารสุนัข	
2	English	After yelling at the game, I knew I would have a <u>tall</u> voice.	implausible
	Thai	หลังจากร้องตะโกนคูกีฬา ฉันก็รู้ว่าฉันอาจมีเสียง <u>ขลุ่ย</u>	
3	English	Mary was asked to stop at the new mall to pick up several items.	plausible
	Thai	มาลีถูกขอให้แวะห้างสรรพสินค้าแห่งใหม่เพื่อไปรับสินค้าหลายรายการ	
4	English	When it is cold, my mother always makes me wear a cap on my head.	plausible
	Thai	เวลาอากาศเย็นๆ คุณแม่ของฉันมักจะสั่งให้ฉันสวมหมวกคลุมศีรษะ	
5	English	All parents hope their <u>list</u> will grow up to be intelligent.	implausible
	Thai	พ่อแม่ทุกคนหวังว่า <u>รายชื่อ</u> ของตัวเองจะเติบโตเป็นคนเฉลียวฉลาด	
6	English	When John and Amy moved to Canada, their <u>wish</u> had a huge garage sale.	implausible
	Thai	ตอนขรกับอนจันย้ายไปแคนาดา <u>คำอวยพร</u> เขามีการล้างขายของมือสองขนาดใหญ่	
7	English	In the fall, my <u>gift</u> and I love to work together in the yard.	implausible
	Thai	ในฤดูใบไม้ร่วง ฉันกับ <u>ของขวัญ</u> ของฉันชอบไปทำงานด้วยกันที่สนาม	
8	English	At church yesterday morning, Jim's daughter made a terrible <u>plum</u> .	implausible
	Thai	ที่โบสถ์เมื่อเช้านั้น ลูกสาวของจิมได้ <u>ทำเค้ก</u> ที่แย่มาก	
9	English	Unaware of the hunter, the deer wandered into his shotgun range.	plausible
	Thai	โดยไม่รู้ตัวได้สังเกตเห็นนายพราน กวางตัวนั้นจึงย่างเท้าเข้าสู่ระยะยิงปืนลูกซอง	
10	English	Since it was the last game, it was hard to cope with the loss.	plausible
	Thai	เนื่องจากนี่เป็นเกมสุดท้าย มันจึงเป็นเรื่องยากที่จะรับมือกับการพ่ายแพ้	
11	English	Because she gets to <u>knife</u> early, Amy usually gets a good parking spot.	implausible
	Thai	เพราะเธอมาถึง <u>มีด</u> ตั้งแต่เป็น ๆ เธอจึงมักจะได้ที่จอดรถดี ๆ	
12	English	The only furniture Steve had in his first <u>bow</u> was his waterbed.	implausible
	Thai	เครื่องเรือนเพียงชิ้นเดียวที่ <u>สตีฟ</u> มีใน <u>ขวาน</u> ใบแรกของเขาคือเตียงน้ำ	
13	English	Last year, Mike was given detention for running in the hall.	plausible
	Thai	เมื่อปีกลาย ฉัน <u>ได้ถูก</u> ควบคุมตัวไว้ที่ห้องปกครองเพราะวิ่งในหอประชุม	
14	English	The huge clouds covered the morning <u>slide</u> and the rain began to fall.	implausible
	Thai	เมฆกลุ่มใหญ่ปกคลุม <u>ลาน</u> หนึ่งยามเช้า แล้วฝนก็เริ่มโปรยปรายลงมา	
15	English	After one date I knew that Linda's sister simply was not my type.	plausible
	Thai	หลังจากออกเดทครั้งเดียวฉันก็รู้ว่าน้องสาวของลinda ไม่ใช่ <u>สเปค</u> ฉัน	
16	English	Jason broke his arm when he fell from the tree onto the ground.	plausible
	Thai	เจสันแขนหักตอนเขา <u>พลัด</u> ตกจากต้นไม้ลงมากะแทกกับพื้น	
17	English	Most people agree that Monday is the worst <u>stick</u> of the week.	implausible
	Thai	คนส่วนใหญ่ยอมรับว่าวันจันทร์เป็น <u>กิ่งไม้</u> ที่เลวร้ายที่สุดของสัปดาห์	
18	English	On warm sunny afternoons, I like to walk in the park.	plausible
	Thai	ในตอนบ่ายที่มีแดดอุ่น ๆ ฉันชอบไปเดินเล่นในสวนสาธารณะ	
19	English	With intense determination he overcame all obstacles and won the race.	plausible
	Thai	ด้วยความมุ่งมั่นอันแรงกล้า เขา <u>พิชิต</u> อุปสรรคทั้งปวงจนชนะการแข่งขัน	
20	English	A person should never be discriminated against based on his race.	plausible
	Thai	บุคคลไม่ควรถูกกระทำโดยการเลือกปฏิบัติด้วยเหตุแห่ง <u>เชื้อชาติ</u> ของตน	

21	English	My mother has always told me that it is not polite to <u>shine</u> .	implausible
	Thai	คุณแม่คอยเตือนฉันอยู่เสมอว่ามันไม่สุภาพที่จะ <u>ส่องแสง</u>	
22	English	The <u>lemonade</u> players decided to play two out of three sets.	implausible
	Thai	นักกีฬา <u>น้ำมะนาว</u> ตัดสินใจที่จะเล่นแบบสองในสามเซต	
23	English	Raising children requires a lot of <u>dust</u> and the ability to be firm.	implausible
	Thai	การเลี้ยงเด็กจำเป็นจะต้องใช้ <u>ฝุ่น</u> จำนวนมากและความสามารถในการทำให้ใจให้แน่วแน่	
24	English	The gathering crowd turned to look when they heard the gun shot.	plausible
	Thai	ฝูงชนที่มารวมกันต่างหันไปมองเมื่อได้ยินเสียงยิงปืน	
25	English	As soon as I get done taking this <u>envy</u> I am going to go home.	implausible
	Thai	ทันทีที่ฉันทำ <u>อิจฉา</u> นี้เสร็จเรียบร้อยแล้ว ฉันตั้งใจว่าจะกลับบ้านเลย	
26	English	Sue opened her purse and found she did not have any money.	plausible
	Thai	สุคาเปิดกระเป๋าสตางค์ของเธอจึงทราบว่าเธอไม่มีเงินเลย	
27	English	Jill wanted a garden in her backyard, but the soil was mostly clay.	plausible
	Thai	จิลอยากมีสวนที่ลานหลังบ้านของเธอ แต่ดินส่วนใหญ่เป็นดินเหนียว	
28	English	Stacey stopped dating the <u>light</u> when she found out he had a wife.	implausible
	Thai	สตาซีเลิกคบกับ <u>ความสว่าง</u> เมื่อเธอพบว่าเขามีภรรยาแล้ว	
29	English	I told the class that they would get a surprise if they were <u>orange</u> .	implausible
	Thai	ฉันได้บอกนักเรียนทั้งชั้นว่าจะได้รับของขวัญประทับใจถ้าพวกเขา <u>สีส้ม</u>	
30	English	Jim was so tired of studying, he could not read another page.	plausible
	Thai	ใจทบทวนคู่มือตำราเรียนเหนื่อยล้า อ่านต่ออีกหน้าก็อ่านไม่ไหว	
31	English	Although Joe is sarcastic at times, he can also be very sweet.	plausible
	Thai	ถึงแม้โจจะแสบคั้นบ้างบางครั้ง เขาก็พูดจาไพเราะได้มากเหมือนกัน	
32	English	Carol will ask her <u>sneaker</u> how much the flight to Mexico will cost.	implausible
	Thai	อัมพรจะสอบถาม <u>รองเท้าผ้าใบ</u> ของเธอว่าเที่ยวบินไปเม็กซิโกนั้นราคาเท่าไร	
33	English	The <u>sugar</u> could not believe he was being offered such a great deal.	implausible
	Thai	<u>ก้อนน้ำตาล</u> คนนั้นเชื่อไม่ลงเลยว่าเขากำลังได้รับข้อเสนอดียอดเยี่ยม	
34	English	I took my little <u>purple</u> to the ice cream store to get a cone.	implausible
	Thai	ฉันพา <u>สีม่วง</u> ตัวน้อยของฉันไปร้านไอศกรีมเพื่อหาซื้อไอศกรีมโคน	
35	English	Kristen dropped her parents off at the <u>love</u> for their annual vacation.	implausible
	Thai	กานดาไปส่งพ่อแม่ที่ <u>ความรัก</u> สำหรับวันหยุดพักผ่อนประจำปีของท่าน	
36	English	The firefighters <u>sour</u> the kitten that was trapped in the big oak tree.	implausible
	Thai	กลุ่มพนักงานดับเพลิง <u>เปรี้ยว</u> ลูกแมวที่ติดแหงกอยู่บนต้นโอ๊กใหญ่	
37	English	Peter and Jack ruined the family <u>carwash</u> when they burned the turkey.	implausible
	Thai	ปีติกับเจตน์ทำให้ <u>ล้างรถ</u> ของครอบครัวเสียตอนพวกเขาทำกังวลงใหม่	
38	English	Martha went to the concert, but <u>ate</u> to bring a thick sweater.	implausible
	Thai	มาร์ธาไปดูคอนเสิร์ต แต่ <u>กินน้ำ</u> เสียกันหนาวหนาว ๆ ติดไปด้วย	
39	English	Sara wanted her mother to read her <u>a window</u> before going to sleep.	implausible
	Thai	สุนิษฐ์อยากให้คุณแม่อ่าน <u>หน้าต่าง</u> ให้เธอฟังก่อนเข้านอน	
40	English	Our dog Sammy likes to greet new people by <u>joyful</u> on them.	implausible
	Thai	มอมแมมหมาของเราชอบทักทายคนมาใหม่ด้วย <u>สำราญใจ</u> ใส่มากเขา	
41	English	Wendy went to check her mail but all she received were <u>cats</u> .	implausible
	Thai	วันดีไปตรวจดูจดหมาย แต่สิ่งของที่เธอได้รับมีแต่ <u>แมวหลายตัว</u>	
42	English	Realizing that she was late, Julia rushed to pick up her child from	implausible



		<u>speaker</u> .	
	Thai	พอรู้ว่าสายแล้ว อู๋ก็รีบไปรับลูกของเธอจากลัมโบง	
43	English	Paul likes to <u>cry</u> long distances in the park near his house.	implausible
	Thai	ภักทรชอบวิ่งให้ระยะไกลในสวนสาธารณะใกล้ ๆ บ้านของเขา	
44	English	The sick boy had to stay home from school because he had a <u>phone</u> .	implausible
	Thai	เด็กชายที่ป่วยจำเป็นต้องอยู่บ้านนอกโรงเรียนเพราะเขาป่วยเป็นโทรศัพท์	
45	English	The judge gave the boy community <u>sweat</u> for stealing the candy bar.	implausible
	Thai	ผู้พิพากษาสั่งให้เด็กชายหนึ่งช้อนเพราะการขโมยขนมหวานแท่งเดียว	
46	English	Women fall in <u>jump</u> with their infants at first sight or even sooner.	implausible
	Thai	ผู้หญิงตกหลุมกระโดดลูกน้อยของตนเมื่อแรกพบหรือแม้แต่เร็วกว่านั้น	
47	English	Jason's family likes to visit him in Atlanta during <u>the cherry</u> every year.	implausible
	Thai	ครอบครัวของเจชชอบไปเยี่ยมเขาที่แอตแลนต้าในผลเชอร์รี่ทุกปี	
48	English	The doctor told my aunt that she would feel better after getting <u>happy</u> .	implausible
	Thai	หมอบอกป้าของฉันว่านางจะรู้สึกดีขึ้นหลังจากที่ได้รับสนุกสนาน	
49	English	The printer <u>sprinted</u> when he tried to print out his report last night.	implausible
	Thai	เครื่องพิมพ์วิ่งระยะสั้นตอนที่เขาพยายามจะพิมพ์รายงานของเขาเมื่อคืนนี้	
50	English	Nick's hockey team won their final game this past weekend at <u>the shoes</u> .	implausible
	Thai	ทีมสอกกีของนิกแข่งชนะในเกมสุดท้ายเมื่อสุดสัปดาห์ที่แล้วที่รองเท้า	
51	English	My mother and father have always wanted to live near <u>the cup</u> .	implausible
	Thai	ตลอดมาคุณพ่อคุณแม่ของฉันต้องการอาศัยอยู่ใกล้ ๆ ถ้วย	
52	English	The prom was only three days away, but neither girl had a dress yet.	plausible
	Thai	อีกเพียงสามวันจะถึงงานเลี้ยง แต่ยังไม่มียี่เด็กสาวคนไหนมีชุด	
53	English	The children entered in a talent contest to win a trip to Disney World.	plausible
	Thai	เด็กๆ เข้าร่วมประกวดการแสดงพรสวรรค์เพื่อชิงรางวัลไปเที่ยวที่สวนสนุกดิสนีย์เวิลด์	
54	English	They were worried that all of their luggage would not fit in the car.	plausible
	Thai	พวกเขาวิตกว่ากระเป๋าสัมภาระทุกใบจะใส่ในรถได้ไม่หมด	
55	English	The seventh graders had to build a volcano for their science class.	plausible
	Thai	เด็กนักเรียนชั้นมัธยมหนึ่งต้องประดิษฐ์ภูเขาไฟจำลองในวิชาวิทยาศาสตร์	
56	English	The college students went to New York in March and it snowed.	plausible
	Thai	นักศึกษามหาวิทยาลัยกลุ่มนั้นไปนิวยอร์กในเดือนมีนาคมซึ่งมีหิมะตก	
57	English	She had to cancel the appointment because she caught the flu yesterday.	plausible
	Thai	เธอจำเป็นต้องยกเลิกนัดครั้งนั้นเพราะเธอป่วยเป็นไข้หวัดเมื่อวานนี้	
58	English	Doug helped his family dig in their backyard for their new swimming pool.	plausible
	Thai	ดูจช่วยครอบครัวของเขาขุดสนามหลังบ้านเพื่อทำสระว่ายน้ำใหม่	
59	English	The dogs were very excited about going for a walk in the park.	plausible
	Thai	สุนัขตื่นเต้นกันใหญ่ที่จะได้ออกไปเดินเล่นในสวนสาธารณะ	
60	English	In the spring, the large birdfeeder outside my window attracts many birds.	plausible
	Thai	ที่ให้อาหารนกอันใหญ่ นอกหน้าต่างของฉันดึงดูดนกได้มากมายในฤดูใบไม้ผลิ	
61	English	Before Katie left for the city, she took a self-defense class at the gym.	plausible
	Thai	ก่อนที่วรัตนาจะย้ายเข้าเมือง เธอได้ไปเรียนวิชาป้องกันตัวที่โรงยิม	
62	English	Mary was excited about her new furniture that she had bought on sale.	plausible

	Thai	มาลีตื่นตื่นเรื่องเครื่องเรือนใหม่ที่เธอซื้อมาได้ตอนลดราคา	
63	English	The class did not think the professor's lecture on history was very interesting.	plausible
	Thai	ทั้งชั้นคิดว่าการบรรยายของอาจารย์เรื่องประวัติศาสตร์ไม่น่าสนใจเลย	
64	English	Jane forgot to bring her umbrella and got wet in the rain.	plausible
	Thai	เจ็บบลุ่มน้ำรมของเธอไปด้วยจึงเปียกปอนตอนฝนตก	
65	English	Dan walked around the streets posting signs and looking for his lost puppy.	plausible
	Thai	วิทย์เดินไปตามถนนเพื่อปิดใบประกาศและหาลูกสุนัขที่หายไป	
66	English	The couple decided that they wanted to have a picnic in the park.	plausible
	Thai	คู่รักคู่นั้นตกลงกันว่าทั้งสองอยากไปปิกนิกที่สวนสาธารณะ	
67	English	The girls were very excited about moving into their new house next week.	plausible
	Thai	พวกเด็กผู้หญิงตื่นตื่นกันนำดูเรื่องย้ายเข้าบ้านใหม่สัปดาห์หน้า	
68	English	Joseph told his mother that he was probably going to fail sixth grade math.	plausible
	Thai	ชายผู้กั้ลือบอกคุณแม่ว่าเขาอาจจะสอบวิชาคณิตศาสตร์ประถมหกไม่ผ่าน	
69	English	We like to eat eggs and bacon for breakfast in the morning.	plausible
	Thai	พวกเราชอบกินไข่และเบคอนเป็นมื้อเช้าในตอนเช้า	
70	English	Harry plans to play a lot of golf when he retires from his job.	plausible
	Thai	ฃรงศ์วางแผนว่าจะเล่นกอล์ฟเต็มทีเมื่อเขาปลดเกษียณจากงาน	
71	English	His stereo was playing so loud that he blew out the speakers.	plausible
	Thai	เครื่องเสียงสเตอริโอของเขาเล่นดังกระหึ่มจนลำโพงแตก	
72	English	It was a clear night, and we could see the stars in the sky.	plausible
	Thai	คั้งคืนนั้นอากาศปลอดโปร่งจนเราสามารถมองเห็นหมู่ดาวบนท้องฟ้าได้ชัด	
73	English	At the party, Randy got out the camera to take some pictures.	plausible
	Thai	ที่งานเลี้ยง รนซ์หยิบกล้องถ่ายรูปออกมาถ่ายหลายภาพ	
74	English	Catherine dressed up as a scary witch for the Halloween <u>pencil</u> on Friday.	implausible
	Thai	ปีทมาแต่งตัวเป็นแม่มดน่ากลัวสำหรับคืนฮาโลวีนเมื่อวันศุกร์	
75	English	Spring is her favorite time of year because flowers begin to bloom.	plausible
	Thai	ฤดูใบไม้ผลิเป็นช่วงเวลาที่ชอบไปรดของปีเพราะดอกไม้เริ่มเบ่งบาน	
76	English	John wants to be a football player when he gets older.	plausible
	Thai	ฃงรออยากเป็นนักกีฬาฟุตบอลเวลาที่เขาเติบโตขึ้น	
77	English	The boys knew they would have to hurry to make it to <u>the apple</u> on time.	implausible
	Thai	พวกเด็กผู้ชายรู้ว่าตัวเองจะต้องรีบเพื่อไปให้ถึงผลแอปเปิ้ลทันเวลา	
78	English	He wrecked his car because he was going too fast in the rain.	plausible
	Thai	เขาทำรถของตัวเองพังเสียหายนเพราะขับเร็วเกินไปตอนฝนตก	
79	English	The tornado came out of nowhere and destroyed our <u>raisin</u> .	implausible
	Thai	พายุทอร์นาโดเกิดขึ้นอย่างไม่มีเค้าและทำลายลูกกลุขของเรา	
80	English	After being ill, Suzy hoped to catch up on her work over the weekend.	plausible
	Thai	หลังจากล้มป่วย ปราณีหวังว่าจะสะสางงานของเธอให้ทันในช่วงสุดสัปดาห์	
81	English	Even though she was in trouble, she managed to go to the <u>dice</u> and shop.	implausible
	Thai	แม้ว่าเธอจะประสบปัญหา เธอก็ยังไปลูกเต๋าและซื้อของจนได้	

## APPENDIX C

## Experimental Stimuli in Self-paced Reading Task and the IOC Results

Item	Experimental sentences	Condition	Rater			Average
			1	2	3	
1a	The guy that knows the driver wants to buy a new car.	SRC-G	1	1	1	1
1b	The guy that knows the driver want to buy a new car.	SRC-UG	1	1	1	1
1c	The guy that the driver knows wants to buy a new car.	ORC-G	1	1	1	1
1d	The guy that the driver knows want to buy a new car.	ORC-UG	1	1	1	1
1a	The guys that know the driver want to buy a new car.	SRC-G	1	1	1	1
1b	The guys that know the driver wants to buy a new car.	SRC-UG	1	1	1	1
1c	The guys that the driver knows want to buy a new car.	ORC-G	1	1	1	1
1d	The guys that the driver knows wants to buy a new car.	ORC-UG	1	1	1	1
2a	The officer that follows the tourist seems to be very busy now.	SRC-G	1	1	1	1
2b	The officer that follows the tourist seem to be very busy now.	SRC-UG	1	1	1	1
2c	The officer that the tourist follows seems to be very busy now.	ORC-G	1	1	1	1
2d	The officer that the tourist follows seem to be very busy now.	ORC-UG	1	1	1	1
2a	The officers that follow the tourist seem to be very busy now.	SRC-G	1	1	1	1
2b	The officers that follow the tourist seems to be very busy now.	SRC-UG	1	1	1	1
2c	The officers that the tourist follows seem to be very busy now.	ORC-G	1	1	1	1
2d	The officers that the tourist follows seems to be very busy now.	ORC-UG	1	1	1	1
3a	The student that misses the teacher knows an interesting topic to discuss.	SRC-G	1	1	1	1
3b	The student that misses the teacher know an interesting topic to discuss.	SRC-UG	1	1	1	1
3c	The student that the teacher misses knows an interesting topic to discuss.	ORC-G	1	1	1	1
3d	The student that the teacher misses know an interesting topic to discuss.	ORC-UG	1	1	1	1

3a	The students that miss the teacher know an interesting topic to discuss.	SRC-G	1	1	1	1
3b	The students that miss the teacher knows an interesting topic to discuss.	SRC-UG	1	1	1	1
3c	The students that the teacher misses know an interesting topic to discuss.	ORC-G	1	1	1	1
3d	The students that the teacher misses knows an interesting topic to discuss.	ORC-UG	1	1	1	1
4a	The farmer that sees the brother loves to talk about the weather.	SRC-G	1	1	1	1
4b	The farmer that sees the brother love to talk about the weather.	SRC-UG	1	1	1	1
4c	The farmer that the brother sees loves to talk about the weather.	ORC-G	1	1	1	1
4d	The farmer that the brother sees love to talk about the weather.	ORC-UG	1	1	1	1
4a	The farmers that see the brother love to talk about the weather.	SRC-G	1	1	1	1
4b	The farmers that see the brother loves to talk about the weather.	SRC-UG	1	1	1	1
4c	The farmers that the brother sees love to talk about the weather.	ORC-G	1	1	1	1
4d	The farmers that the brother sees loves to talk about the weather.	ORC-UG	1	1	1	1
5a	The boy that likes the girl wishes to live in the city.	SRC-G	1	1	1	1
5b	The boy that likes the girl wish to live in the city.	SRC-UG	1	1	1	1
5c	The boy that the girl likes wishes to live in the city.	ORC-G	1	1	1	1
5d	The boy that the girl likes wish to live in the city.	ORC-UG	1	1	1	1
5a	The boys that like the girl wish to live in the city.	SRC-G	1	1	1	1
5b	The boys that like the girl wishes to live in the city.	SRC-UG	1	1	1	1
5c	The boys that the girl likes wish to live in the city.	ORC-G	1	1	1	1
5d	The boys that the girl likes wishes to live in the city.	ORC-UG	1	1	1	1
6a	The leader that thanks the member means to bring the team together.	SRC-G	1	1	1	1
6b	The leader that thanks the member mean to bring the team together.	SRC-UG	1	1	1	1
6c	The leader that the member thanks means to bring the team together.	ORC-G	1	1	1	1
6d	The leader that the member thanks mean to bring the team together.	ORC-UG	1	1	1	1
6a	The leaders that thank the member mean to bring the team together.	SRC-G	1	1	1	1
6b	The leaders that thank the member means to bring the team together.	SRC-UG	1	1	1	1

6c	The leaders that the member thanks mean to bring the team together.	ORC-G	1	1	1	1	1
6d	The leaders that the member thanks means to bring the team together.	ORC-UG	1	1	1	1	1
7a	The reader that meets the author believes in the power of love.	SRC-G	1	1	1	1	1
7b	The reader that meets the author believe in the power of love.	SRC-UG	1	1	1	1	1
7c	The reader that the author meets believes in the power of love.	ORC-G	1	1	1	1	1
7d	The reader that the author meets believe in the power of love.	ORC-UG	1	1	1	1	1
7a	The readers that meet the author believe in the power of love.	SRC-G	1	1	1	1	1
7b	The readers that meet the author believes in the power of love.	SRC-UG	1	1	1	1	1
7c	The readers that the author meets believe in the power of love.	ORC-G	1	1	1	1	1
7d	The readers that the author meets believes in the power of love.	ORC-UG	1	1	1	1	1
8a	The professor that advises the scientist remembers the first book on nature.	SRC-G	1	1	1	1	1
8b	The professor that advises the scientist remember the first book on nature.	SRC-UG	1	1	1	1	1
8c	The professor that the scientist advises remembers the first book on nature.	ORC-G	1	1	1	1	1
8d	The professor that the scientist advises remember the first book on nature.	ORC-UG	1	1	1	1	1
8a	The professors that advise the scientist remember the first book on nature.	SRC-G	1	1	1	1	1
8b	The professors that advise the scientist remembers the first book on nature.	SRC-UG	1	1	1	1	1
8c	The professors that the scientist advises remember the first book on nature.	ORC-G	1	1	1	1	1
8d	The professors that the scientist advises remembers the first book on nature.	ORC-UG	1	1	1	1	1
9a	The pilot that calls the expert forgets the work rules quite often.	SRC-G	0	1	1	1	0.67
9b	The pilot that calls the expert forget the work rules quite often.	SRC-UG	0	1	1	1	0.67
9c	The pilot that the expert calls forgets the work rules quite often.	ORC-G	0	1	1	1	0.67
9d	The pilot that the expert calls forget the work rules quite often.	ORC-UG	0	1	1	1	0.67
9a	The pilots that call the expert forget the work rules quite often.	SRC-G	0	1	1	1	0.67
9b	The pilots that call the expert forgets the work rules quite often.	SRC-UG	0	1	1	1	0.67
9c	The pilots that the expert calls forget the work rules quite often.	ORC-G	0	1	1	1	0.67
9d	The pilots that the expert calls forgets the work rules quite often.	ORC-UG	0	1	1	1	0.67

10a	The kid that pleases the parent appears to be good at music.	SRC-G	1	1	1	1
10b	The kid that pleases the parent appear to be good at music.	SRC-UG	1	1	1	1
10c	The kid that the parent pleases appears to be good at music.	ORC-G	1	1	1	1
10d	The kid that the parent pleases appear to be good at music.	ORC-UG	1	1	1	1
10a	The kids that please the parent appear to be good at music.	SRC-G	1	1	1	1
10b	The kids that please the parent appears to be good at music.	SRC-UG	1	1	1	1
10c	The kids that the parent pleases appear to be good at music.	ORC-G	1	1	1	1
10d	The kids that the parent pleases appears to be good at music.	ORC-UG	1	1	1	1
11a	The writer that invites the fan likes to go to the bar.	SRC-G	1	1	1	1
11b	The writer that invites the fan like to go to the bar.	SRC-UG	1	1	1	1
11c	The writer that the fan invites likes to go to the bar.	ORC-G	1	1	1	1
11d	The writer that the fan invites like to go to the bar.	ORC-UG	1	1	1	1
11a	The writers that invite the fan like to go to the bar.	SRC-G	1	1	1	1
11b	The writers that invite the fan likes to go to the bar.	SRC-UG	1	1	1	1
11c	The writers that the fan invites like to go to the bar.	ORC-G	1	1	1	1
11d	The writers that the fan invites likes to go to the bar.	ORC-UG	1	1	1	1
12a	The player that contacts the coach prefers to stay at the club.	SRC-G	1	1	1	1
12b	The player that contacts the coach prefer to stay at the club.	SRC-UG	1	1	1	1
12c	The player that the coach contacts prefers to stay at the club.	ORC-G	1	1	1	1
12d	The player that the coach contacts prefer to stay at the club.	ORC-UG	1	1	1	1
12a	The players that contact the coach prefer to stay at the club.	SRC-G	1	1	1	1
12b	The players that contact the coach prefers to stay at the club.	SRC-UG	1	1	1	1
12c	The players that the coach contacts prefer to stay at the club.	ORC-G	1	1	1	1
12d	The players that the coach contacts prefers to stay at the club.	ORC-UG	1	1	1	1
13a	The actor that avoids the director hates to work at the weekend.	SRC-G	1	1	1	1
13b	The actor that avoids the director hate to work at the weekend.	SRC-UG	1	1	1	1

13c	The actor that the director avoids hates to work at the weekend.	ORC-G	1	1	1	1	1
13d	The actor that the director avoids hate to work at the weekend.	ORC-UG	1	1	1	1	1
13a	The actors that avoid the director hate to work at the weekend.	SRC-G	1	1	1	1	1
13b	The actors that avoid the director hates to work at the weekend.	SRC-UG	1	1	1	1	1
13c	The actors that the director avoids hate to work at the weekend.	ORC-G	1	1	1	1	1
13d	The actors that the director avoids hates to work at the weekend.	ORC-UG	1	1	1	1	1
14a	The employee that warns the manager understands the problem with the product.	SRC-G	1	1	1	1	1
14b	The employee that warns the manager understand the problem with the product.	SRC-UG	1	1	1	1	1
14c	The employee that the manager warns understands the problem with the product.	ORC-G	1	1	1	1	1
14d	The employee that the manager warns understand the problem with the product.	ORC-UG	1	1	1	1	1
14a	The employees that warn the manager understand the problem with the product.	SRC-G	1	1	1	1	1
14b	The employees that warn the manager understands the problem with the product.	SRC-UG	1	1	1	1	1
14c	The employees that the manager warns understand the problem with the product.	ORC-G	1	1	1	1	1
14d	The employees that the manager warns understands the problem with the product.	ORC-UG	1	1	1	1	1
15a	The designer that supports the model promises to learn to use email.	SRC-G	1	1	1	1	1
15b	The designer that supports the model promise to learn to use email.	SRC-UG	1	1	1	1	1
15c	The designer that the model supports promises to learn to use email.	ORC-G	1	1	1	1	1
15d	The designer that the model supports promise to learn to use email.	ORC-UG	1	1	1	1	1
15a	The designers that support the model promise to learn to use email.	SRC-G	1	1	1	1	1
15b	The designers that support the model promises to learn to use email.	SRC-UG	1	1	1	1	1
15c	The designers that the model supports promise to learn to use email.	ORC-G	1	1	1	1	1
15d	The designers that the model supports promises to learn to use email.	ORC-UG	1	1	1	1	1
16a	The lady that loves the lawyer owns an excellent restaurant in town.	SRC-G	1	1	1	1	1
16b	The lady that loves the lawyer own an excellent restaurant in town.	SRC-UG	1	1	1	1	1
16c	The lady that the lawyer loves owns an excellent restaurant in town.	ORC-G	1	1	1	1	1
16d	The lady that the lawyer loves own an excellent restaurant in town.	ORC-UG	1	1	1	1	1

16a	The ladies that love the lawyer own an excellent restaurant in town.	SRC-G	1	1	1	1
16b	The ladies that love the lawyer owns an excellent restaurant in town.	SRC-UG	1	1	1	1
16c	The ladies that the lawyer loves own an excellent restaurant in town.	ORC-G	1	1	1	1
16d	The ladies that the lawyer loves owns an excellent restaurant in town.	ORC-UG	1	1	1	1
17a	The soldier that trains the guard deserves to win the top prize.	SRC-G	1	1	1	1
17b	The soldier that trains the guard deserve to win the top prize.	SRC-UG	1	1	1	1
17c	The soldier that the guard trains deserves to win the top prize.	ORC-G	1	1	1	1
17d	The soldier that the guard trains deserve to win the top prize.	ORC-UG	1	1	1	1
17a	The soldiers that train the guard deserve to win the top prize.	SRC-G	1	1	1	1
17b	The soldiers that train the guard deserves to win the top prize.	SRC-UG	1	1	1	1
17c	The soldiers that the guard trains deserve to win the top prize.	ORC-G	1	1	1	1
17d	The soldiers that the guard trains deserves to win the top prize.	ORC-UG	1	1	1	1
18a	The guide that helps the visitor agrees to reduce the tour price.	SRC-G	1	1	1	1
18b	The guide that helps the visitor agree to reduce the tour price.	SRC-UG	1	1	1	1
18c	The guide that the visitor helps agrees to reduce the tour price.	ORC-G	1	1	1	1
18d	The guide that the visitor helps agree to reduce the tour price.	ORC-UG	1	1	1	1
18a	The guides that help the visitor agree to reduce the tour price.	SRC-G	1	1	1	1
18b	The guides that help the visitor agrees to reduce the tour price.	SRC-UG	1	1	1	1
18c	The guides that the visitor helps agree to reduce the tour price.	ORC-G	1	1	1	1
18d	The guides that the visitor helps agrees to reduce the tour price.	ORC-UG	1	1	1	1
19a	The worker that trusts the boss sees the value of hard work.	SRC-G	1	1	1	1
19b	The worker that trusts the boss see the value of hard work.	SRC-UG	1	1	1	1
19c	The worker that the boss trusts sees the value of hard work.	ORC-G	1	1	1	1
19d	The worker that the boss trusts see the value of hard work.	ORC-UG	1	1	1	1
19a	The workers that trust the boss see the value of hard work.	SRC-G	1	1	1	1
19b	The workers that trust the boss sees the value of hard work.	SRC-UG	1	1	1	1



19c	The workers that the boss trusts see the value of hard work.	ORC-G	1	1	1	1	1
19d	The workers that the boss trusts sees the value of hard work.	ORC-UG	1	1	1	1	1
20a	The patient that visits the doctor needs to take a long rest.	SRC-G	1	1	1	1	1
20b	The patient that visits the doctor need to take a long rest.	SRC-UG	1	1	1	1	1
20c	The patient that the doctor visits needs to take a long rest.	ORC-G	1	1	1	1	1
20d	The patient that the doctor visits need to take a long rest.	ORC-UG	1	1	1	1	1
20a	The patients that visit the doctor need to take a long rest.	SRC-G	1	1	1	1	1
20b	The patients that visit the doctor needs to take a long rest.	SRC-UG	1	1	1	1	1
20c	The patients that the doctor visits need to take a long rest.	ORC-G	1	1	1	1	1
20d	The patients that the doctor visits needs to take a long rest.	ORC-UG	1	1	1	1	1



## APPENDIX D

### Common European Framework of Reference for Languages

Proficient user	C2	Can understand with ease virtually everything heard or read. Can summarise information from different spoken and written sources, reconstructing arguments and accounts in a coherent presentation. Can express him/herself spontaneously, very fluently and precisely, differentiating finer shades of meaning even in more complex situations.
	C1	Can understand a wide range of demanding, longer texts, and recognise implicit meaning. Can express him/herself fluently and spontaneously without much obvious searching for expressions. Can use language flexibly and effectively for social, academic and professional purposes. Can produce clear, well-structured, detailed text on complex subjects, showing controlled use of organisational patterns, connectors and cohesive devices.
Independent user	B2	Can understand the main ideas of complex text on both concrete and abstract topics, including technical discussions in his/her field of specialisation. Can interact with a degree of fluency and spontaneity that makes regular interaction with native speakers quite possible without strain for either party. Can produce clear, detailed text on a wide range of subjects and explain a viewpoint on a topical issue giving the advantages and disadvantages of various options.
	B1	Can understand the main points of clear standard input on familiar matters regularly encountered in work, school, leisure, etc. Can deal with most situations likely to arise whilst travelling in an area where the language is spoken. Can produce simple connected text on topics which are familiar or of personal interest. Can describe experiences and events, dreams, hopes & ambitions and briefly give reasons and explanations for opinions and plans.
Basic user	A2	Can understand sentences and frequently used expressions related to areas of most immediate relevance (e.g., very basic personal and family information, shopping, local geography, employment). Can communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters. Can describe in simple terms aspects of his/her background, immediate environment and matters in areas of immediate need.
	A1	Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herself and others and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly and is prepared to help.

**Communicative Language Competence Linguistic: Vocabulary Range**

C2	Has a good command of a very broad lexical repertoire including idiomatic expressions and colloquialisms; shows awareness of connotative levels of meaning.
C1	Has a good command of a broad lexical repertoire allowing gaps to be readily overcome with circumlocutions; little obvious searching for expressions or avoidance strategies. Good command of idiomatic expressions and colloquialisms.
B2	Has a good range of vocabulary for matters connected to his field and most general topics. Can vary formulation to avoid frequent repetition, but lexical gaps can still cause hesitation and circumlocution.
B1	Has a sufficient vocabulary to express him/herself with some circumlocutions on most topics pertinent to his everyday life such as family, hobbies and interests, work, travel, and current events.
A2	Has sufficient vocabulary to conduct routine, everyday transactions involving familiar situations and topics. Has a sufficient vocabulary for the expression of basic communicative needs. Has a sufficient vocabulary for coping with simple survival needs.
A1	Has a basic vocabulary repertoire of isolated words and phrases related to particular concrete situations.

## APPENDIX E

### Participants' Demographic Data, WM Scores, and LexTALE Scores

#### 1. Native speakers of English (Experiment 1, $n = 40$ )

Participant ID	Age	Gender	WM scores	LexTALE scores
NS001	21	F	60	93.75
NS002	19	F	71	91.25
NS003	19	F	67	100
NS004	21	M	60	93.75
NS005	21	F	59	100
NS006	23	M	75	91.25
NS007	18	F	69	97.5
NS008	20	F	72	91.25
NS009	21	F	64	95
NS010	20	F	73	92.5
NS011	20	M	52	100
NS012	21	F	55	100
NS013	18	F	48	90
NS014	18	M	74	92.5
NS015	22	F	66	90
NS016	22	M	39	100
NS017	20	F	59	98.75
NS018	20	F	48	100
NS019	20	F	63	93.75
NS020	22	F	43	93.75
NS021	18	F	73	97.5
NS022	21	M	53	100
NS023	18	F	58	90
NS024	20	M	73	93.75
NS025	19	F	42	95
NS026	24	F	68	98.75
NS027	20	F	56	100
NS028	19	F	47	91.25
NS029	19	F	60	95
NS030	19	F	42	97.5
NS031	20	F	52	95
NS032	28	M	53	95
NS033	19	F	63	97.5

NS034	25	M	48	100
NS035	23	F	69	97.5
NS036	21	F	57	100
NS037	31	F	73	100
NS038	21	M	61	98.75
NS039	24	F	68	92.5
NS040	20	F	69	97.5

2. Native speakers of English (Experiment 2,  $n = 40$ )

Participant ID	Age	Gender	WM scores (75)	LexTALE scores (100)
NS041	21	F	39	90
NS042	20	F	69	97.5
NS043	22	F	35	97.5
NS044	18	F	65	93.75
NS045	21	F	51	97.5
NS046	18	F	66	95
NS047	19	F	57	97.5
NS048	36	F	41	92.5
NS049	20	F	71	95
NS050	22	M	42	90
NS051	21	F	71	95
NS052	28	F	56	100
NS053	19	F	50	95
NS054	20	F	69	96.25
NS055	20	F	61	97.5
NS056	19	M	49	93.75
NS057	35	F	64	93.75
NS058	22	F	68	91.25
NS059	22	F	50	92.5
NS060	19	F	61	100
NS061	19	F	68	96.25
NS062	22	F	61	92.5
NS063	19	F	66	95
NS064	19	F	46	88.75
NS065	33	F	67	100
NS066	21	M	67	97.5
NS067	32	F	62	100
NS068	19	F	60	90
NS069	21	M	53	87.5

NS070	20	F	50	100
NS071	21	F	52	95
NS072	19	F	68	98.75
NS073	20	F	72	90
NS074	22	F	71	87.5
NS075	22	F	66	96.25
NS076	21	F	66	95
NS077	22	F	69	100
NS078	21	F	57	88.75
NS079	29	F	61	90
NS080	19	M	73	97.5

### 3. Thai learners of English (Experiment 1, $n = 40$ )

<b>Participant ID</b>	<b>Age</b>	<b>Gender</b>	<b>WM scores (75)</b>	<b>LexTALE scores (100)</b>
TH001	18	M	64	71.25
TH002	18	M	67	63.75
TH003	18	M	32	66.25
TH004	19	F	59	72.5
TH005	18	M	60	60
TH006	19	F	39	60
TH007	19	F	52	63.75
TH008	18	F	35	71.25
TH009	18	F	56	72.5
TH010	21	F	44	63.75
TH011	21	F	57	62.5
TH012	22	F	66	62.5
TH013	22	F	43	68.75
TH014	21	F	65	66.25
TH015	21	F	73	65
TH016	21	F	48	68.75
TH017	22	F	42	63.75
TH018	22	F	70	73.75
TH019	24	X	70	72.5
TH020	20	M	53	78.75
TH021	20	F	60	62.5
TH022	21	M	58	67.5
TH023	19	M	50	67.5
TH024	20	F	44	68.75
TH025	19	F	41	78.75

TH026	21	M	45	75
TH027	21	F	36	62.5
TH028	21	F	68	73.75
TH029	20	M	72	72.5
TH030	20	F	58	63.75
TH031	21	M	40	63.75
TH032	23	F	71	78.75
TH033	21	M	74	65
TH034	21	F	54	73.75
TH035	21	F	51	68.75
TH036	20	M	38	61.25
TH037	20	F	54	72.5
TH038	20	F	47	60
TH039	20	F	34	63.75
TH040	20	F	62	72.5

#### 4. Thai learners of English (Experiment 2, $n = 40$ )

<b>Participant ID</b>	<b>Age</b>	<b>Gender</b>	<b>WM scores (75)</b>	<b>LexTALE scores (100)</b>
TH041	20	F	52	61.25
TH042	19	F	66	66.25
TH043	20	F	60	65
TH044	20	F	71	63.75
TH045	21	F	56	61.25
TH046	20	F	43	68.75
TH047	22	M	54	65
TH048	20	F	52	71.25
TH049	20	F	59	72.5
TH050	21	F	43	61.25
TH051	24	F	45	70
TH052	22	F	55	66.25
TH053	22	F	47	77.5
TH054	22	F	53	65
TH055	18	F	38	61.25
TH056	18	F	36	65
TH057	22	F	44	62.5
TH058	19	F	50	62.5
TH059	18	F	65	63.75
TH060	18	F	66	78.75
TH061	19	M	71	62.5

TH062	19	M	49	62.5
TH063	20	F	68	72.5
TH064	20	F	67	61.25
TH065	20	F	49	65
TH066	21	F	61	62.5
TH067	21	F	54	76.25
TH068	21	F	43	61.25
TH069	20	M	33	66.25
TH070	21	F	62	68.75
TH071	20	M	45	65
TH072	21	F	58	75
TH073	19	F	67	68.75
TH074	19	F	42	66.25
TH075	20	F	75	63.75
TH076	21	F	61	71.25
TH077	20	M	34	68.75
TH078	19	F	54	65
TH079	19	F	59	76.25
TH080	22	F	69	61.25



## APPENDIX F

### Independent-Samples Mann-Whitney U Test Results on Plausibility Norming

No.	Items	<i>M</i>	<i>SD</i>	<i>Mdn</i>	<i>U</i>	<i>p</i>
1	a. The guy knows the driver.	6.88	0.35	7.00	28.00	0.72
	b. The driver knows the guy.	6.75	0.46	7.00		
2	a. The officer follows the tourist.	5.50	0.93	5.50	24.00	0.44
	b. The tourist follows the officer.	5.13	0.64	5.00		
3	a. The student misses the teacher.	6.50	0.76	7.00	28.50	0.72
	b. The teacher misses the student.	6.38	0.74	6.50		
4	a. The farmer sees the brother.	5.88	0.83	6.00	25.00	0.51
	b. The brother sees the farmer.	5.50	0.93	5.50		
5	a. The boy likes the girl.	7.00	0.00	7.00	28.00	0.72
	b. The girl likes the boy.	6.88	0.35	7.00		
6	a. The leader thanks the member.	6.13	0.64	6.00	25.00	0.51
	b. The member thanks the leader.	6.38	0.74	6.50		
7	a. The reader meets the author.	6.63	0.52	7.00	26.50	0.57
	b. The author meets the reader.	6.38	0.74	6.50		
8	a. The worker trusts the boss.	6.75	0.46	7.00	24.00	0.44
	b. The boss trusts the worker.	6.50	0.53	6.50		
9	a. The patient visits the doctor.	6.13	0.99	6.50	21.00	0.28
	b. The doctor visits the patient.	6.75	0.46	7.00		
10	a. The pilot calls the expert.	5.75	0.71	6.00	26.00	0.57
	b. The expert calls the pilot.	5.50	0.53	5.50		
11	a. The kid pleases the parent.	6.00	0.76	6.00	26.00	0.57
	b. The parent pleases the kid.	6.25	0.71	6.00		
12	a. The writer invites the fan.	6.38	0.74	6.50	21.50	0.28
	b. The fan invites the writer.	6.00	0.53	6.00		
13	a. The player contacts the coach.	6.38	0.74	6.50	30.00	0.88
	b. The coach contacts the player.	6.50	0.53	6.50		
14	a. The employee warns the manager.	5.88	0.64	6.00	19.50	0.20
	b. The manager warns the employee.	6.38	0.74	6.50		
15	a. The designer supports the model.	6.75	0.46	7.00	18.00	0.16
	b. The model supports the designer.	6.13	0.83	6.00		
16	a. The lady loves the lawyer.	6.00	0.76	6.00	32.00	1.00
	b. The lawyer loves the lady.	6.00	0.76	6.00		
17	a. The soldier trains the guard.	6.13	0.64	6.00	25.50	0.51
	b. The guard trains the soldier.	5.88	0.64	6.00		

18	a. The guide helps the visitor.	6.75	0.46	7.00	20.00	0.23
	b. The visitor helps the guide.	6.38	0.52	6.00		
19	a. The professor advises the scientist.	6.25	0.71	6.00	25.50	0.51
	b. The scientist advises the professor.	5.88	0.99	6.00		
20	a. The actor avoids the director.	6.38	0.74	6.50	30.00	0.88
	b. The director avoids the actor.	6.50	0.53	6.50		



## APPENDIX G

## IRB Approval (Chulalongkorn University)



Office of the Research Ethics Review Committee for Research Involving Human Subjects  
The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts  
Chanchuri 1 Building, Room 114, Phayathai Road, Wang Mai Sub-district,  
Pathum Wan District, Bangkok 10330  
Telephone number 0 2218 3210-11 E-mail curec2.ch1@chula.ac.th

COA No. 077/2562

## Certificate of Research Approval

**Research Project Number** 080/62 EFFECTS OF WORKING MEMORY ON STRUCTURAL  
COMPETITION IN PROCESSING ENGLISH PRESENT TENSE MORPHOLOGY BY L1 THAI LEARNERS

**Principal Researcher** Mr. Sonthaya Rattanasak

**Office** English as an International Language Program, Graduate School, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Subjects: The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts at Chulalongkorn University, based on Declaration of Helsinki, the Belmont report, CIOMS guidelines and the Principle of the international conference on harmonization – Good clinical practice (ICH-GCP) has approved the execution of the aforementioned research project.

Signature *Theraphan Luangthongkum* Signature *นงนุช รังปณสมร*  
(Emeritus Prof. Theraphan Luangthongkum, PhD.) (Asst. Prof. Nungnatai Rangponsumrit, PhD.)  
Chairman Secretary

**Research Project Review Categories:** Expedited Review

**Date of approval:** 22 October 2019

**Expiry date:** 21 October 2020

**Documents approved by the Committee**

1. The research proposal
2. The researcher CV
3. Document providing information for the research sampling population/participants
4. Informed consent document
5. Questionnaire and Reading Tasks

**Conditions**

1. The researcher has acknowledged that it is unethical if he/she collects information for the research before the application for an ethics review has been approved by the Research Ethics Review Committee
2. If the certificate of the research project expires, the research execution must come to a halt. If the researcher wishes to reapply for approval, he/she has to submit an application for a new certificate at least one month in advance, together with a research progress report
3. The researcher must conduct the research strictly in accordance with what is specified in the research project.
4. The researcher must only use documents that provide information for the research sampling population/participants, their letters of consent and the letters inviting them to take part in the research if any that have been endorsed with the seal of the Committee.
5. If any seriously untoward incident happens to the place where the research information, which has requested the approval of the Committee, is kept, the researcher must report this to the Committee within five working days.
6. If there is any change in the research procedure, the researcher must submit the change for review by the Committee before he/she can continue with his/her research.
7. For a research project of less than one year the researcher must submit a report of research termination (AF 03-11) and an abstract of the research outcome within thirty days of the research being completed. For a research project which is a thesis, the researcher must submit an abstract of the research outcome within thirty days of the research being completed. This is to be used as evidence of the termination of the project.
8. A research project which has passed the Exemption Review, must observe only the conditions in 1, 6 and 7.



Protocol No.	080/62
Date of Approval	22 OCT 2019
Approval Expiry Date	21 OCT 2020

## APPENDIX H

### IRB Approval (University of Illinois at Urbana-Champaign)



#### OFFICE OF THE VICE CHANCELLOR FOR RESEARCH

Office for the Protection of Research Subjects  
805 W. Pennsylvania Ave., MC-095  
Urbana, IL 61801-4822

#### Notice of Exempt Determination

October 21, 2019

Principal Investigator	Kiel Christianson
CC	Sonthaya Rattanasak
Protocol Title	<i>Effects Of Working Memory On Structural Competition In Processing English Present Tense Morphology By L1 Thai Learners</i>
Protocol Number	20285
Funding Source	Unfunded
Review Category	Exempt 2 (i)
Determination Date	October 21, 2019
Closure Date	October 20, 2024

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Office for the Protection of Research Subjects (OPRS) has reviewed your application and determined the criteria for exemption have been met.

The Principal Investigator of this study is responsible for:

- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Requesting approval from the IRB prior to implementing major modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

Changes to an exempt protocol are only required if substantive modifications are requested and/or the changes requested may affect the exempt status.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

IORG0000014 • FWA #00008584  
217.333.2670 • irb@illinois.edu • oprs.research.illinois.edu

## VITA

**NAME** Sonthaya Rattanasak

**DATE OF BIRTH** 12 April 1987

**PLACE OF BIRTH** Bangkok, Thailand

**INSTITUTIONS ATTENDED** BA - English, Phranakhon Si Ayutthaya Rajabhat University  
MA - English for Careers, Thammasat University  
PhD- English as an International Language, Chulalongkorn University

**HOME ADDRESS** Phra Nakhon Si Ayutthaya, Thailand

**AWARD RECEIVED** The Royal Golden Jubilee Ph.D. Program, National Research Council of Thailand (NRCT): NRCT5-RGJ63001-022, Ministry of Higher Education, Science, Research and Innovation, Thailand

The 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund)

Junior Research Scholarship, Thailand-United States Educational Foundation (Fulbright Thailand)

Overseas Research Experience Scholarship for Graduate Students, Graduate School Chulalongkorn University