การประมวลผลการเกาะเกี่ยวหน่วยหลักของคุณานุประโยคในภาษาไทยและบทบาทของประสบการณ์ในการประมวลผลประโยค

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THE PROCESSING OF RELATIVE CLAUSE ATTACHMENT IN THAI AND THE ROLE OF EXPERIENCE IN SENTENCE PROCESSING

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วิทยานิพนธ์นี้ศึกษาการประมวลผลการเกาะเกี่ยวหน่วยหลักของคุณานุประโยคในภาษาไทยที่สามารถขยายคำนามที่อยู่ใกล้หรืออยู่ห่างออกไป (เช่น “โค้ชของนักวิ่งที่วาดรูปสวย”) โดยใช้วิธีการศึกษาตามทฤษฎีประสบการณ์นิยมเพื่อทำความเข้าใจว่าประสบการณ์มีผลต่อการประมวลผลประโยคอย่างไร ประเด็นที่ศึกษาในวิทยานิพนธ์นี้ได้แก่ 1) ศึกษาว่าประสบการณ์ที่ผู้ร่วมการทดลองมีต่ออนุประโยคเติมเต็มนามซึ่งเป็นโครงสร้างที่คล้ายคลึงกับคุณานุประโยคในด้านลำดับคำมีผลต่อการประมวลผลคุณานุประโยคหรือไม่ และ 2) ศึกษาว่าบทบาทของประสบการณ์ต่อการประมวลผลสะท้อนให้เห็นถึงการเรียนรู้ที่จะเปลี่ยนแปลงความนิยมในการเกาะเกี่ยวความโดยทั่วไป หรือสะท้อนเพียงการเรียนรู้กลวิธีที่ทำให้ผู้ร่วมการทดลองประมวลผลประโยคในสถานการณ์จำเพาะได้ดีขึ้นเท่านั้น

จากการวิเคราะห์คลังข้อมูลพบว่าการเกาะเกี่ยวคุณานุประโยคกับคำนามที่อยู่ใกล้ (เช่น “นักวิ่ง”) มีความถี่สูงกว่าการเกาะเกี่ยวคุณานุประโยคกับคำนามที่อยู่ไกล (เช่น “โค้ช”) อย่างไรก็ตาม การศึกษาครั้งนี้พบว่าบริบทก็สามารถส่งผลต่อการเกาะเกี่ยวความโดยทำให้ความถี่ในการเกาะเกี่ยวคุณานุประโยคกับคำนามที่อยู่ใกล้ลดลง

ผลจากการทดลอง 3 การทดลองพบว่า 1) เมื่อคุมปัจจัยด้านบริบทและด้านการตัดแบ่งประโยค ผู้ร่วมการทดลองนิยมให้คุณานุประโยคขยายคำนามที่อยู่ใกล้ ผลการทดลองนี้ยืนยันว่าผลในการศึกษาก่อนหน้าที่พบว่าผู้พูดภาษาไทยนิยมให้คุณานุประโยคขยายคำนามที่อยู่ไกลเป็นผลมาจากอิทธิพลของบริบทและการตัดแบ่งประโยค 2) ประสบการณ์ที่ผู้ร่วมการทดลองมีต่อโครงสร้างหนึ่งสามารถส่งผลกระทบต่อการประมวลผลโครงสร้างเดียวกันได้ ผลนี้เป็นไปตามที่การศึกษาวิจัยก่อนหน้าได้ค้นพบและสนับสนุนแนวคิดทฤษฎีประสบการณ์นิยม 3) ผลจากการทดลองในวิทยานิพนธ์นี้ได้แสดงให้เห็นเพิ่มเติมจากงานวิจัยก่อนหน้าว่าผู้ร่วมการทดลองมีความไวต่อประสบการณ์ที่ได้รับจากการทดลองแม้ว่าประสบการณ์ที่ได้จากสถานการณ์การทดลองนั้นจะแตกต่างจากประสบการณ์ในชีวิตประจำวันเพียงเล็กน้อย

ข้อค้นพบสำคัญในวิทยานิพนธ์นี้มี 2 ประเด็น คือ 1) ประสบการณ์ที่ได้รับจากการประมวลผลในสถานการณ์หนึ่งสามารถถ่ายโอนไปยังการประมวลผลในสถานการณ์ที่แตกต่างออกไปได้ ผลการทดลองนี้ชี้ให้เห็นว่าผู้ร่วมการทดลองสามารถเรียนรู้จากประสบการณ์และสามารถประยุกต์ใช้ประสบการณ์นั้นได้ 2) ประสบการณ์ที่ผู้ร่วมการทดลองมีต่ออนุประโยคเติมเต็มนามไม่ส่งผลต่อการประมวลผลการเกาะเกี่ยวหน่วยหลักของคุณานุประโยค ผลการทดลองนี้อาจขัดแย้งกับแนวคิดที่เชื่อว่าความคล้ายคลึงกันทางโครงสร้างสามารถส่งผลต่อการประมวลผลได้ ทั้งนี้เนื่องจากผลการทดลองชี้ให้เห็นว่าความคล้ายคลึงกันทางด้านลำดับคำเพียงอย่างเดียวไม่สามารถทำให้ประสบการณ์ที่มีต่อโครงสร้างหนึ่งถ่ายโอนไปยังการประมวลผลอีกโครงสร้างหนึ่งได้

ภาควิชา	ภาษาศาสตร์	ลายมือชื่อนิสิต	....
สาขาวิชา	ภาษาศาสตร์	ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
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KEYWORDS: RELATIVE CLAUSE ATTACHMENT / EXPERIENCE / PROCESSING TRANSFER / SIMILARITIES BETWEEN CONSTRUCTIONS

TEERANOOT SIRIWITTAYAKORN: THE PROCESSING OF RELATIVE CLAUSE ATTACHMENT IN THAI AND THE ROLE OF EXPERIENCE IN SENTENCE PROCESSING. ADVISOR: ASST. PROF. THEERAPORN RATITAMKUL, Ph.D., CO-ADVISOR: ASSOC. PROF. EDSON T. MIYAMOTO, Ph.D., 319 pp.

We adopt experience-based accounts' techniques in investigating the processing of relative clauses that can modify either of two nouns in Thai (e.g., "the coach of the runner that is good at drawing") with the aim to understand the nature of experience in sentence comprehension. Two issues are addressed. Firstly, we investigate whether experience with a construction with identical surface word order, namely nominal sentential complements, can affect the processing of relative clauses. Secondly, we investigate whether previously-reported effects of experience in sentence processing reflect general learning that can change participants' preferences or whether it only reflects strategic learning that helps participants perform better in a specific situation.

We report a corpus count showing that local attachment (e.g., attaching the relative clause to "the runner") is more frequent than non-local attachment (e.g., attaching the relative clause to "the coach") but context can obscure such a local-attachment preference.

With contextual effects and segmentation kept under control, three reading experiments demonstrate that in comprehension, native Thai speakers prefer attaching relative clauses to the local noun. The results confirm that a previous report of a non-local attachment preference in Thai was likely to have been tainted by contextual and segmentation factors. As in previous studies, the results of this dissertation support the claim of experience-based accounts as they show that experience with the target construction can affect its later processing. However, we expand previous findings by showing that participants are sensitive to experience manipulation in experiments even when the distributions used in the experiment diverge minimally from their daily experience.

Crucially, we find that the effect of experience can be transferred to a different situation, indicating that participants can learn from their experience and generalize it. Moreover, the results of this dissertation pose a challenge to similarity proposal as in all three experiments, experience with nominal sentential complements do not affect processing of relative clause attachment. This suggests that superficial similarity in terms of word order is not a sufficient condition to cause a processing transfer.

Department:	Linguistics	Student's Signature	....
Field of Study:	Linguistics	Advisor's Signature	....
Academic Year:	2015	Co-Advisor's Signature	....

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List of abbreviations and symbols

1. ∈ = element of
2. ∞ = infinity
3. ANOVA = analysis of variance
4. attach = attachment
5. df = degree of freedom
6. L = logit
7. logSorder = log-transformed stimulus order
8. MV = main verb
9. N = noun
10. NP = noun phrase
11. Ø = an extraction position or a zero pronoun
12. OSV = object-subject-verb
13. P, p = probability
14. r = coefficient of correlation
15. RC = relative clause
16. RRT = residual reading time
17. RT = reading time
18. SC = nominal sentential complement

19. SD = standard deviation

20. SE = standard error

21. Sorder = trial number

22. SVO = subject-verb-object

23. t = “the calculated difference represented in units of standard error” (Runkel, 2015)

24. TIorder = test item order

25. V = “the sum of the positive ranks” (Dalgaard, 2011)

26. Z = z score which is “the number of standard deviations away from the average value of the reference group” (Ott, 2011)

27. $\chi2$ = chi-square

Chapter 1
Introduction

1.1. Background of the dissertation

Two major themes in psycholinguistics are language acquisition and language processing. In the field of language acquisition, there has been a debate as to whether language acquisition is driven by nature or by nurture. Behaviorists such as Skinner (1957) proposed that speakers learn language by exposure. On the other hand, scholars such as Chomsky (1957, 1959) and Lenneberg (1967) argued that only exposure is not enough for speakers to learn a language (see Chomsky, 1980, for discussion on stimulus poverty). Rather, humans are born with a biological endowment for learning languages, and the role of experience is to specify the details that are allowed to vary (Chomsky, 1957, 1959). Regardless of whether there is an innate mechanism for learning language or not, it is inevitable to say that experience plays a role in learning. Independent of acquisition, many processing accounts (e.g., *garden path models*, Frazier, 1978; *modifier straddling hypothesis*, Cuetos & Mitchell, 1988*; Construal theory*, Frazier & Clifton, 1996) focus on how knowledge about language that has already been acquired affects processing. However, the view of experience-based accounts on sentence processing is different. Experience-based accounts are intriguing in that they are trying to bridge the gap between language acquisition and language processing. According to Wells and colleagues (Wells, Christiansen, Race, Acheson, & MacDonald, 2009), processing is dynamic in that it can change all the time as a result of learning. Fine and colleagues (Fine, Jaeger, Farmer, & Qian, 2013) added that every time a new sentence is processed, it is regarded as new experience. From this point of view, experience, learning, and processing are closely connected. Speakers learn from experience. What they learn affects their processing. What they process gives them experience for learning. By investigating how experience affects processing, learning mechanisms bridging experience and processing can be determined (i.e., how speakers learn from experience to process languages; Fine et al., 2013; Wells et al., 2009), and the nature of such mechanisms may shed light on whether language acquisition is driven by nature or nurture. In this dissertation, we take the first step to the nature-nurture debate by trying to understand the nature of experience on sentence processing. Specifically, we study the processing of relative clauses (RCs) attachment in Thai to investigate the claims made by experience-based accounts.

To explain how readers process sentences (e.g., to explain why readers prefer one interpretation in ambiguous constructions), experience-based accounts propose that readers' past experience guides the way they process sentences. That is, readers interpret sentences based on how past ambgiguities they encountered were resolved. Some experience-based accounts suggest that both experience with target constructions and experience with similar constructions can affect processing of the target construction (MacDonald & Christiansen, 2002; also Kaschak & Glenberg, 2004). For example, in English subject-extracted RCs (e.g., *the reporter that attacked the senator…*) were reported to be easier to process than object-extracted RCs (e.g., *the reporter that the senator attacked…*). MacDonald and Christiansen (2002) explained such results by proposing that subject-extracted RCs are similar to simple sentences in terms of word order (i.e., subject-verb-object, or SVO). Therefore, processing of subject-extracted RCs is facilitated by readers' experience with both subject-extracted RCs and simple sentences. Object extracted RCs are harder to process because they contain a rare word order (i.e., object-subject-verb, or OSV). Therefore, processing of object-extracted RCs is facilitated only by experience with object-extracted RCs themselves (see also Gennari & MacDonald, 2008, 2009 for possible effects of thematic role assignment on object-extracted RCs processing). One problem with similarity proposals is that the extent to which constructions have to be similar in order for processing transfer to take place is left unspecified. Word order of subject-extracted RCs is not identical to that of simple sentences because an RC marker intervenes between the head noun and the RC verb. If such word-order similarity is enough to cause processing transfer, the question is whether it implies that any constructions that share identical word order can cause processing transfer.

In Thai, RCs and nominal sentential complements (SCs) are similar. That is, both types of clauses follow the noun they modify or complete its meaning. RCs and SCs can be introduced by the marker *thi*: (Kullavanijaya, 2010). It is possible to find a zero pronoun in SCs when the interpretation of a noun can be inferred from the context, and this zero pronoun is similar to the extraction position in RCs (see Comrie, 1996, 1998; for related discussion on similarities between extraction positions and zero pronouns). See (1) for an RC example and (2) for an SC example.

(1) คุณครูที่สอนวิชาภาษาไทย

khunkhru: thî: ø sɔ̌:n wíʔcha: pha:sǎ:thaj

teacher that ø teach subject Thai language

“the teacher that teaches Thai”

(Siriwittayakorn, Miyamoto, Ratitamkul, & Cho, 2014)

(2) ความพยายามที่จะเป็นอิสระจากอิทธิพลของผู้ให้กำเนิด

khwā:mphājā:jā:m thî: ø càʔ pēn ʔìtsàràʔ cà:k ìttíʔphōn khɔ̌ŋ

attempt that ø MODAL be free from influence of

phûhâjkāmnə̀t

parent

lit: attempt that is going to be free from influence of parent

“the attempt to be free from parent’s influence”

(Thai National Corpus, TNC; Aroonmanakun, Tansiri, & Nittayanuparp, 2009)

In (1) and (2), the ø represents either an extraction position (as in (1)) or a zero pronoun (as in (2)). It can be seen that with similarities described above, word-order configurations of the two clauses are identical (schematically *N thî: ø predicate*). The similarities between RCs and SCs allow us to use Thai to investigate the effect of experience with similar constructions on the processing of a given target construction.

To investigate effects of similar constructions on sentence processing, this dissertation reports corpus counts and reading experiments. The focus of the dissertation is on the processing of RC attachment, a construction in which an RC can modify one of the two nouns in a complex noun phrase (i.e., the target construction). An example is given in (3).

(3) โค้ชของนักวิ่งที่วาดรูปสวย

khó:t khɔ̌:ŋ nákwîŋ thî: wâ:t rû:p sǔaj

coach of runner that draw picture beautifully

"the coach of the runner that is good at drawing"

In (3), the two head nouns (*khó:t* "coach" and *nákwîŋ* "runner") are joined by the preposition *khɔ̌:ŋ* "of". The underlined part is the RC introduced by the marker *thî:*, which is comparable to *that* in English. The RC can be attached to either the non-local noun (N1, "coach") or the local noun (the noun closest to the RC, i.e., N2, "runner"). In other words, it can be either the coach or the runner that is good at drawing. From (3), it can be said that the word-order configuration of the target construction is *N1 khɔ̌:ŋ N2 thî: RC*. In this dissertation, we test which of the nouns (i.e., N1 or N2) native Thai speakers prefer as an attachment site for the RC. In other words, we test whether native Thai speakers prefer interpreting (3) as "the coach is good at drawing" or "the runner is good at drawing".

Since similarities between RCs and SCs make their word-order configuration the same, this dissertation employs SCs (schematically, *N1 khɔ̌:ŋ N2 thî: SC*; see

Chapter 3, Section 3.2.2, for a detailed discussion on SCs) to test whether experience with RCs and experience with SCs can affect RC-attachment preferences.

There are many ways for providing evidence that experience affects processing. One straightforward way is to take production data, specifically corpus data, as representative of readers' past experience and show that structures frequently encountered in the corpus are also favored in behavioral experiments (e.g., Mitchell, Cuetos, & Corley, 1992). Another way is to expose participants to sentences with a particular interpretation, and test whether their preference changes after exposure. Following the second method, recent studies have found that participants change their preference after receiving extra experience (Kamide, 2012; Wells et al., 2009).

Apart from the effect of experience manipulation (e.g., Kamide, 2012; Wells et al., 2009), a more recent study (Fine et al., 2013) suggests that experimental designs can have unintended effects. Previous sentence processing studies often asked participants to read test sentences in which two interpretations (e.g., subject-extracted RCs and object-extracted RCs) were shown in equal proportion and tested which interpretation was read faster, as a measure of readers' preference. In previous studies, statistical tests such as analysis of variance (ANOVA) were often used for analyzing the data. This kind of tests assumes that any effects in experiments are constant across the session (e.g., participants' preference does not change over the course of an experiment). However, reading test sentences in an experiment is also a kind of experience and such experience can also affect processing (Fine et al. 2013). By adopting a more sophisticated statistical test (i.e., mixed effect models), Fine et al. (2013) found that, participants' preference (i.e., the reading-time patterns of the two interpretations) changed over the course of the experiment.

From the results showing changes in preference (e.g., Fine et al., 2013; Kamide, 2012; Wells et al., 2009), previous studies claimed that participants kept track of the probability of each interpretation occuring in the experiment and changed their preferences accordingly (Wells et al., 2009; Fine et al., 2013). However, those previous studies tested the effect of experience only in a situation in which participants' freedom was restricted. That is, in those experiments, sentences shown to participants could be interpreted only in one way. Participants had no choice but to interpret sentences in the way researchers intended, and researchers only measured whether participants could read sentences with such interpretation faster. To claim for learning effects (i.e., change in preference), studies should show that the effect of experience in a low degree of freedom situation can be transferred to a situation in which participants have freedom to choose how to interpret sentences (see Schmidt & Bjork, 1992, for related discussion on learning effects). Since previous studies did not test the effect of experience in a higher degree of freedom situation, whether participants can change their preference after extra exposure cannot be drawn. It is possible that participants' actual preference in those previous studies did not change, and that they only adopted a temporary strategy that was convenient to complete the task in the experiment. That is, because the proportion of the two competing interpretations shown in experiments was different from what participants would encounter in daily life, participants might change their expectation on purpose, expecting the construction that was more frequent than usual so that they could perform better in the experimental setting. If this is the case, participants should not generalize what they did in such a freedom-restricted situation to a less-restricted situation. The absence of generalization will pose a challenge to experience-based accounts as it implies that only showing that there is a change in expectation after participants are exposed to more sentences with a particular interpretation is not enough to show that such experience changes their preference. This dissertation investigates whether effects of experience in one situation can be transferred to a different situation.

Based on a previous study on RC attachment in Thai, N1 attachment was preferred (Siriwittayakorn et al., 2014). However, there were a number of possible confounds (see Chapter 3, Section 3.5, for more details). This dissertation also addresses those confounds so that a more accurate conclusion on attachment preference in Thai can be drawn. With a more careful methodology controlling for possible confounds, this dissertation tests whether native Thai speakers prefer N1 attachment as reported in the previous study.

To summarize, this dissertation contributes to the nature-nurture debate by investigating experience in sentence comprehension so that the power and limitations of learning mechanisms can be better specified. In this dissertation, the processing of RC attachment is investigated to test whether:

I) RC-attachment preference in production data as observed in a corpus count is compatible with the results of comprehension experiments;

II) experience with RCs and experience with a similar construction, namely SCs, can affect the processing of RC attachment; and

III) experience in a low degree of freedom situation is generalized and affects processing in a situation with a higher degree of freedom.

1.2. Objectives

The objectives of the study are to investigate

1. native Thai speakers' attachment preferences for *thî:*-marked RCs; and
2. the role of experience in the processing of *thî:*-marked RCs in Thai.

1.3. Hypotheses

1. In production, native Thai speakers prefer attaching a *thi:*-marked RC to N1.
2. In comprehension, native Thai speakers prefer attaching a *thi:*-marked RC to N1. This preference should correspond to the frequency pattern observed in corpus data.
3. Both experience with RCs and experience with SCs affect the processing of RC attachment. However, such effect does not necessarily extend to every situation.

1.4. Scope of the dissertation

There are many types of production data. However, to test the first hypothesis in this dissertation (see (1) in the hypotheses section), corpus data will be used to determine which type of RC attachment (N1 or N2) is more frequent. As common in this type of research (Desmet, De Baecke, Drieghe, Brysbaert, & Vonk, 2006), corpus frequency is assumed to provide a measure of native speakers' preferences in production.

The target construction in this dissertation involves an RC modifying one of two nouns in a complex noun phrase. In this dissertation, there are four restrictions in the target construction. The first two restrictions are for both corpus counts and reading experiments, but the last two restrictions are only for reading experiments.

Firstly, this dissertation focuses on RCs introduced by the marker *thî*: because this marker is the most commonly used in RCs in Thai and its stylistic restrictions are relatively few (Iwasaki & Ingkaphirom, 2009). Moreover, the other two RC markers available in Thai (*sɯ̂ŋ* and *ʔān*) cannot be used in SCs. Therefore, the focus on *thî:*-marked RCs allows us to test the effect of experience with a similar construction.

Secondly, the two head nouns are joined by the preposition *khɔ̌:ŋ* ("of"). This is because cross-linguistic difference in RC attachment is most clearly observed in this type of complex noun phrases where the preposition lacks semantic content as opposed to semantically-rich prepositions such as locatives (Felser, Roberts, & Marinis, 2003, and references therein); therefore, most studies in the literature have paid attention to this type of construction. By using *khɔ̌:ŋ*, the results of the dissertation can be compared to those of other languages. It should be noted that sometimes the preposition *khɔ̌:ŋ* in the construction *N1 khɔ̌:ŋ N2* can be omitted but only the instances that are overtly marked are investigated.

Thirdly, for the target construction in reading experiments reported in this dissertation, the two head nouns are animate-concrete nouns. This is because RCs with two animate-concrete heads are the most commonly investigated in RC attachment studies. Therefore, using two animate-concrete heads allows the results in Thai to be compared to those of other studies.

Lastly, extraction position is known to be a factor in RC comprehension (Gibson, 1998; Grodner & Gibson, 2005; King & Just, 1991; Kwon, Polinsky, &

Kluender, 2006; MacDonald & Christiansen, 2002; Mak, Vonk, & Schriefers, 2002; Miyamoto & Nakamura, 2003; Wells et al., 2009; but see Traxler, Williams, Blozis, & Morris, 2005 for effects related to animacy contrasts). Therefore, all RCs used in the reading experiments are subject extracted. This is to avoid possible confounds that may arise from the difficulty in processing object-extracted RCs.

As for the characteristics of SCs used in this dissertation, although SCs can be either verbal complements or nominal complements, this dissertation only covers nominal complements. To keep the construction similar to RC attachment, the SCs used are of the form *N1 khɔ̌ːŋ N2 thîː SC* only.

1.4 Benefits of the dissertation

This dissertation can be the basis for future studies involving

1. the processing of RC attachment in other languages;
2. the role of experience in sentence processing; and
3. the processing of other constructions in Thai from a psycholinguistic perspective.

The organization of the remained of this dissertation is as follows. Chapter 2 provides details about general methodology often adopted in conducting sentence-processing studies. Chapter 3 reviews literature that is relevant to the topic of this dissertation. Chapter 4 reports corpus counts and based on the results outlines predictions for the reading experiments reported in the later chapters. In Chapters 5 and

6, we test the effect of experience with RCs and experience with SCs on RC attachment given the corpus counts reported in Chapter 4. In Chapter 7, we employ another method in investigating the effect of experience with RCs and experience with SCs. More specifically, in Chapter 7, participants receive extra experience with RCs and SCs, and their preferences are tested before and after exposure to determine if there are any changes in their preferences. In Chapter 7, we also test whether experience can be transferred across different types of situations. Chapter 8 discusses the nature of experience in sentence processing and future directions given the results of this dissertation.

Chapter 2
General Methodology

One way to investigate how readers or listeners process sentences is to observe the types of interpretations they favor by conducting experiments. This chapter summarizes general issues involved in conducting experiments and analyzing data so as to familiarize readers with the terminology and the assumptions underlying the methodologies adopted in the remaining chapters. This chapter is divided into three sections. Section 2.1 discusses the types of stimulus sentences used. Section 2.2 describes methodologies used in measuring readers' preferences. Section 2.3 gives a brief overview of statistical analyses used for analyzing data.

Literature review concerning theoretical background and previous studies on sentence processing will be given in Chapter 3. The specific methodology used in each experiment is detailed in Chapters 5, 6 and 7.

2.1 Stimuli

2.1.1 Sentences used in experiments

In an experiment measuring participants' preferences while comprehending sentences, two types of sentences, namely test sentences and fillers, are used. The test sentences are used for measuring participants' behavior and are either ambiguous sentences or unambiguous sentences.

Ambiguous sentences allow more than one interpretation and the intended meaning remains unclear even after reaching the end of the sentence. This type of sentences is used to determine the interpretation participants favor. An example of ambiguous sentences is given in (1).

(1) Adverb attachment

แม่บอกว่าน้องร้องไห้เมื่อวาน

mɛ̂ː	bɔ̀ːk	wâː	nɔ́ːŋ	rɔ́ːŋhâːj	mɨ̂əwāːnníː
mom	say	COMP	younger-sibling	cry	yesterday

"Mom said that the younger sibling cried yesterday."

In (1), the sentence is ambiguous because *mɨ̂əwāːnníː* "yesterday" can be attached either to the verb *bɔ̀ːk* "say" or to the verb *rɔ́ːŋhâːj* "cry". In other words, it is unclear whether mom spoke yesterday or the younger sibling cried yesterday. Another example of ambiguous sentences is given in (2).

(2) RC attachment

มีคนยิงคนรับใช้ของดาราสาวที่ยืนอยู่บนระเบียง

mīː khōn jīŋ khōnrápchái khɔ́ːŋ dāːrāːsǎːw thîː

there-is person shoot servant of actress that

jīːn jùː bōn ráʔbīəŋ

stand at on balcony

"Someone shot the servant of the actress that was on the balcony."

(adapted from Cuetos & Mitchell, 1988)

In (2), the relative clause *thîːjīːnjùːbōnráʔbīəŋ* "that was on the balcony" is ambiguous as it can be either *khōnrápchái* "the servant" (N1) or *dāːrāːsǎːw* "the actress" (N2) who was on the balcony.

Even though sentences as in (1) and (2) are ambiguous, readers often prefer one interpretation over the other. By showing this kind of sentences to participants and asking for their judgments (e.g., asking them who cried yesterday, or who was on the balcony), researchers can determine their preference.

In experiments, ambiguous sentences are used for measuring a preference after reading sentences. However, it is known that readers interpret a sentence as they read it word by word (incremental parsing; Van Gompel, 2013; and references therein). To measure readers' preference during reading, the second type of test sentences namely unambiguous sentences that involve local ambiguity is used. For this type of sentences, there is a point at which the sentence has more than one interpretation, but crucially at a later point, the ambiguity is resolved and the intended interpretation is clear. The point at which the intended interpretation is made clear is called the *disambiguating point*. Usually, readers are not aware of such ambiguity. If the interpretation they favor matches the disambiguation information, they will have no problem in comprehending the sentence. However, if the interpretaiton they have in mind does not go with the disambiguation information, their reading speed is likely to decrease as they have to reanalyze the representation for the sentence. Researchers construct pairs of unambiguous sentences and present them to participants to determine which interpretation is processed more quickly. The assumption is that the interpretation that is processed more quickly indicates the interpretation that participants favor. An example of pairs of unambiguous sentences is given in (3).

(3) Extraction type

a. Subject-extracted RC

จอยเห็นโจรที่ยิงเจ้าของตลาด

cɔ̄ːj hěn cōːn thîː jīŋ jâwkhɔ̌ːŋ tàʔlàt

Joy see burglar that shoot owner market.

“Joy saw the burglar that shot the owner of the market.”

b. Object-extracted RC

จอยเห็นโจรที่เจ้าของตลาดยิง

cɔ̄ːj hěn cōːn thîː jâwkhɔ̌ːŋ tàʔlàt jīŋ

Joy see burglar that owner market shot.

"Joy saw the burglar that the owner of the market shot."

The local ambiguity in (3) relates to the extraction types of the RCs. It starts at the marker *thîː* as it is not clear whether the head noun *cōːn* "burglar" will continue as the subject or the object of the RC. Only when participants read the following word, which is either the verb *jīŋ* "shot" or the noun *jâwkhɔ̌ːŋ* "owner", do they know the function that the head noun has inside the RC. In other words, they can determine whether the embedded clause is a subject-extracted RC or an object-extracted RC only when they read the disambiguating word which comes after the marker *thîː*. If, for example, participants read the disambiguating word in (3b) slower than that in (3a), the researcher can conclude that the participants prefer the sentence to continue as a subject-extracted RC.

The example pair in (4) involves RC attachment as the example shown in (2), but while (2) is ambiguous, (4) is unambiguous.

(4) RC attachment

a. N1 attachment

ลุงของเด็กหญิงที่จะขี่มอเตอร์ไซค์เป็นคนฝรั่งเศส

lūŋ khɔ̌ːŋ dèkjǐŋ thîː càʔ khìː mɔ̄ːtə̄ːsāi pēn khōn fáʔràŋsèːt

uncle of girl that MODAL ride motorbike be person France

"The uncle of the girl that will ride the motorbike is French."

b. N2 attachment

ลุงของเด็กหญิงที่จะนั่งม้าหมุนเป็นคนฝรั่งเศส

lūŋ khɔ̌ːŋ dèkjǐŋ thîː càʔ nâŋ máːmǔn pēn khōn fáʔràŋsèːt

uncle of girl that MODAL sit carousel be person France

"The uncle of the girl that will ride the carousel is French."

(adapted from Kamide, 2012)

In (4), the ambiguity starts at the marker *thî*: as it is unknown whether the upcoming clause modifies *lūŋ* "the uncle" (N1), or *dèkjǐŋ* "the girl" (N2). The disambiguating point is the words *khìːmɔ̄ːtə̄ːsāi* ("ride the motorbike") or *nâŋmáːmǔn* ("ride the carousel") as these are the points where the intended interpretation becomes clear. That is, in (4a), it is N1 (i.e., "the uncle") that is modified by the RC as he is expected to be the one who rides the motorbike. In (4b), however, it is N2 (i.e., "the girl") that is expected to ride the carousel, and thus, N2 is modified by the RC. If sentences such as (4a) are read faster than those as in (4b), this would suggest that participants prefer N1 attachment to N2 attachment.

Regardless of the types of test items (i.e., ambiguous or unambiguous sentences), a rule of thumb is for experiments to have at least five items and ten participants per condition although the exact number may vary depending on the technique used (e.g., reading times may be nosier and may require more data points than questionnaires). In experiments using ambiguous sentences such as (1), there is only one condition but since there are two interpretations of interest, 10 or more items are commonly used. For experiments using pairs of unambiguous sentences such as (3), there are two conditions (e.g., subject-extracted RCs as in (3a) and object-extracted RCs as in (3b)); therefore, it is common to have at least 20 participants read 10 items. However, the number of items and the number of participants can vary depending on the purpose of the experiment. If experiments require complex analyses, more items or more participants may be needed. Moreover, depending on the robustness of the effect of the factor of interest, researchers may consider having more items or more participants. Since one purpose of this dissertation is to investigate the effect of experience along experiments, the number of test items and the number of participants are higher than what have been suggested by the rule of thumb so that the amount of data collected will be enough for running complex analyses and the effect of experience can be measured.

Although presenting test sentences is sufficient for investigating sentence processing, if experiments contain only test sentences, participants may notice what is being tested, and therefore, the results may not reflect their preference. To distract participants from the goal of the experiment, filler sentences are needed.

A good set of fillers should comprise of sentences that are similar to the test sentences in terms of structural complexity and types of words used such that participants cannot distinguish them from the test sentences. An experiment should have enough fillers so that participants will not be able to detect the objective of the experiment. However, there should not be too many as participants may get tired participating in the experiment. A rule of thumb is to have about twice as many fillers as test sentences. However, this can vary depending on the experiment.

2.1.2 Stimulus normings

Before running an experiment, all the sentences should be checked to make sure of the following points.

I) The sentences have the intended properties necessary to test the hypothesis in the experiment.

II) Irrelevant factors will not interfere with the testing of the hypothesis.

To this end, stimulus normings are often conducted.

For example, consider again the ambiguous sentence in (2) repeated below as (5).

(5) RC attachment

มีคนยิงคนรับใช้ของดาราสาวที่ยืนอยู่บนระเบียง

mīː khōn jīŋ khōnrápchái khɔ́ːŋ dāːrāːsǎːw thîː

there-is person shoot servant of actress that

jɨ̄ːn jùː bōn ráʔbīəŋ

stand at on balcony

"Someone shot the servant of the actress that was on the balcony."

(adapted from Cuetos & Mitchell, 1988)

To make sure that the two interpretations (e.g., for the servant to be on the balcony or for the actress to be on the balcony) of the test sentences are equally natural, a norming should be conducted to check the plausibility of each interpretation.

A different type of norming is for the unambiguous sentence pair in (4) which is repeated here as (6).

(6) RC attachment

a. N1 attachment

ลุงของเด็กหญิงที่จะขี่มอเตอร์ไซค์เป็นคนฝรั่งเศส

lūŋ khɔ̌ːŋ dèkjǐŋ thîː càʔ khìː mɔ̄ːtɤ̄ːsāi pēn khōn fáʔràŋsèːt

uncle of girl that MODAL ride motorbike be person France

"The uncle of the girl that will ride the motorbike is French."

b. N2 attachment

ลุงของเด็กหญิงที่จะนั่งม้าหมุนเป็นคนฝรั่งเศส

lūŋ khɔ̌ːŋ dèkjǐŋ thîː càʔ nâŋ máːmǔn pēn khōn fáʔràŋsèːt

uncle of girl that MODAL sit carousel be person France

"The uncle of the girl that will ride the carousel is French."

(adapted from Kamide, 2012)

For unambiguous sentences, a researcher has to make sure that the disambiguating region really makes clear what the intended interpretation is. In the sentences above, the disambiguating region (i.e., "ride the motorbike" in (6a) or "ride the carousel" in (6b)) should be equally clear in determining the noun being modified (i.e., N1, "uncle" for (6a) and N2, "girl" for (6b). Moreover, a researcher has to make sure that the unintended interpretations (e.g., for the girl to ride the motorbike, or for the uncle to ride the carousel) are equally implausible so that they are unlikely to compete with the intended interpretations. Therefore, such normings make sure that the plausibility manipulations are having the intended effects during the reading time experiment.

There are many ways of obtaining norming data. For example, researchers may create a questionnaire and ask participants to rate the plausibility of sentences (e.g., in (5), participants may be asked to rate the plausibility of the two interpretations: "the servant was on the balcony" and "the actress was on the balcony"). Crucially, the structure tested in the experiment (e.g., RCs) is not used in the norming, since the norming is meant to test the plausibility of the situation (e.g., how natural it is for a servant to be on the balcony). After obtaining the results of the norming, only sentences with the intended properties are used in the main experiment.

2.1.3 Stimulus presentation

Once the stimuli are ready, they need to be arranged before being presented in the experiment. If each sentence has more than one version, a Latin square design is needed. A Latin square design is commonly used in within-participant comparisons for distributing sentences into lists, so that each participant reads exactly one version of each sentence. For example, in an experiment with unambiguous sentences such as (6), each sentence has two versions (N1 attachment as in (6a) and N2 attachment as in (6b)). Therefore, two lists are needed. If there are six pairs of items in the experiment, the distribution according to a Latin Square design will be as illustrated in (7).

(7)

List 1: 1a, 2b, 3a, 4b, 5a, 6b

List 2: 1b, 2a, 3b, 4a, 5b, 6a

In (7), it can be seen that every item appears in each list but the two versions of a sentence never appear in the same list.

Regardless of how many versions of test sentences, once the test items and fillers are ready to be used in the experiment, they need to be intermixed. The order of the items is usually pseudo-random, rather than simply random, as an extra condition is usually imposed such that two test items are not shown consecutively.

2.2 Methodology

In order to measure language users' reactions to ambiguous and unambiguous sentences, two types of methodology namely off-line measure and on-line measure are used.

Off-line measures are used for measuring participants' reactions after reading sentences. Ambiguous sentences are commonly used with off-line measures because for those sentences, only final interpretation that participants favor is of interest. In particular, in off-line measures, after reading ambiguous sentences, participants can be asked about which interpretation they prefer. This type of measurement is usually in the form of paper-pencil questionnaires. One problem with this type of methodology is that participants can read the sentences and the questions in any order and as many times as they want. It is possible that they may read the question first and then read the sentence in order to answer the question. This type of strategy does not necessarily reflect what participants may do outside the laboratory, and participants may notice the point of the experiment. To avoid this type of problem, the whole-sentence presentation technique can be adopted. For this technique, the whole sentence is shown on a computer screen, and after reading the sentence, participants press a button and a question is shown on a new screen (see Appendix 1 for an example of instructions and graphic depictions of an experiment with whole-sentence presentation).

On-line measures, on the other hand, are used for measuring participants' reactions as they read each segment of a sentence. This type of measurement is commonly used with unambiguous sentences where preference during reading is of interest. An example of on-line measures, which is used in this dissertation, is self-paced reading.

In self-paced reading experiments, participants sit in front of a computer monitor and read sentences segment by segment at their own pace. Depending on the hypothesis tested, a segment may contain one single word or multiple words. There are different ways of presenting segments in self-paced reading experiments. In this dissertation, the non-cumulative moving-window self-paced presentation is adopted because it correlates well with natural reading (Just, Carpenter, & Woolley, 1982).

When a non-cumulative moving-window self-paced reading experiment is conducted, each sentence is initially shown masked with symbols such as dashes or underscores. After participants press a button, the first segment of the sentence appears. When they press the button again, the first segment is masked and the second segment appears on the screen. Participants keep on pressing the button until they read the entire sentence. The button-press latencies are recorded in lieu of reading times (RTs). After the data are collected, RTs are analyzed to determine which version of sentences requires longer RTs at or after the disambiguating segment (see Appendix 2 for an example of instructions and graphic depictions of a non-cumulative moving window-self-paced reading experiment).

When running an on-line experiment, to make sure that participants pay attention, a comprehension question is often asked at the end of each or some test sentences and fillers. Researchers often analyze response accuracy of the comprehension questions first. Participants with poor performance (i.e., low response accuracy) are eliminated from further analyses as this indicates that they were not paying attention to the experiment and that their data may contaminate the results of the study.

To conduct a self-paced reading experiment, programs such as Linger (D. Rohde, 2003), DMDX (Forster, 2002) and E-prime (Psychology Software Tools Inc., 2015) are available. In this dissertation, E-prime 2.0 was used because it guarantees millisecond (ms) accuracy (Psychology Software Tools Inc., 2015).

2.3 Statistical analyses

For experiments measuring participants' reaction to stimuli, researchers need to make sure that the results from their analyses are generalizable to other similar participants and items (see Clark, 1973, for the importance of by-items analyses). For statistical tests such as analysis of variance (ANOVA), t-test and Wilcoxon, analyses for participants and for items are run separately through by-participants and by-items analyses.

In order to run by-participants and by-items analyses, either means or medians based on participants or on items are used. That is, if the test is parametric (e.g., ANOVA), means are used. If the test is non-parametric (e.g., Wilcoxon), medians are used. Since means or medians are used in the analyses, in by-participants analyses, the variability in the items is ignored and in by-items analyses, variability in the participants is ignored.

Wilcoxon signed rank test is a non-parametric test used with paired samples (e.g., within-participants design). It is similar to a paired t-test except that it is used when the data are not normally distributed. For example, it is used for analyzing the norming data in which participants rate the plausibility of the interpretations of the test sentences.

ANOVA is another test that is often used in psycholinguistic research for analyzing continuous data such as RTs, and sometimes for analyzing categorical data such as data from a forced binary-choice question (e.g., the data from an experiment asking participants to choose an attachment site for ambiguous RCs as in (5) or the data from comprehension questions). However, since ANOVAs assume that the data follow a normal distribution, the use of ANOVAs with RTs is inappropriate because RTs do not typically follow a normal distribution. ANOVAs have also been criticized as unsuitable for categorical data (see Jaeger, 2008 for more detailed discussion). Moreover, because ANOVAs require means to be used in by-participants and by-items analyses, it is unsuitable for testing changes that are predicting from trial to trial.

More recently, mixed effects models have become more common and often replace ANOVAs. This is because they are not only able to address the aforementioned concerns with regards to the use of ANOVAs but also have numerous advantages. Importantly, because the original scores (e.g., raw RTs, rather than means) are used in the analyses, mixed models allow testing hypotheses that cannot be tested using

ANOVAs (e.g., the change in RTs over the course of an experiment). Additionally, in mixed effects models, by-participants and by-items analyses do not have to be run separately. Therefore, analyses do not lack statistical powers as do those performed by using ANOVA (see Baayen, Davidson, & Bates, 2008; Jaeger, 2008; and references therein for related discussion). In this dissertation, mixed effects models are used when simpler options such as ANOVAs cannot be used (e.g., to test for changes from trial to trial).

Hereon, mixed effects models will be used to refer to models used for the analyses of continuous data such as RTs. They can be used to determine, for example, whether RTs to two conditions (e.g., N1 and N2 RC attachments as in (6)) are significantly different (see Baayen, Davidson, & Bates, 2008; Winter, 2013, for a basic introduction to mixed effects models).

Mixed logit models are used for analyzing categorical data such as the data from a forced binary-choice question. To run the analyses, each data point is coded as 0 and 1 (see Agresti, 2002; Jaeger, 2008, for a basic introduction to mixed logit models). Hohenstein (2013) gave the following explanation on how to interpret results from mixed logit models.

> Probabilities range from zero to one, i.e., $P \in [0,1]$, whereas logits can be any real number (R, from minus infinity to infinity; $L \in (-\infty,\infty)$).
>
> A probability of 0.50 corresponds to a logit of 0. Negative logit values indicate probabilities smaller than 0.50, positive logits indicate probabilities greater than 0.50. The relationship is symmetrical: Logits of −0.2 and 0.2 correspond

to probabilities of 0.45 and 0.55, respectively. Note: The absolute distance to 0.5 is identical for both probabilities.

However, in some cases when there is very little difference between the data (e.g., when virtually no mistakes were made in comprehension questions), the mixed logit models cannot be conducted. In that case, Wilcoxon signed rank test is run as a backup.

Barr, Levy, Scheepers, and Tily (2013) proposed that when running mixed-effects models or mixed logit models, the models should include every fixed factor and interaction in the random effect structure (i.e., the structure that "encodes the assumptions that one makes about how sampling units (subjects and items) vary, and the structure of dependency that this variation creates in one's data"; Barr et al., 2013, p. 257). In other words, the models with maximal random structure should be used. However, when the data set is too small, the models with maximal random structure may not converge. Therefore, the models needs to be simplified in order to make it fit the amount of data collected (see Bates, Kliegl, Vasishth, & Baayen, 2015, for related discussion). To simplify models, in this dissertation, we adopt backward selection method following Bates et al. (2015).

For analyses specifically for RT data, another point that should be noted is that when raw RTs are analyzed, observed differences in RTs might be caused by the idiosyncrasy of each participants in relation to the differences between items such as the difference in terms of length (i.e., the number of characters). To factor out the theoretically irrelevant effects, residual reading times (RRTs) are used in analyses instead of raw RTs (see Ferreira & Clifton, 1986 for details about RRT calculation).

RRT values can be either positive or negative. Positive values indicate that participants read a particular item slower than what has been predicted. In contrast, negative values indicate that participants read faster than predicted.

In studies of sentence processing, apart from experiments, sometimes a corpus count is conducted so that a researcher can have an idea of production trends. In this case, chi-square goodness of fit test and exact binominal test are often used to test whether differences between conditions are reliable. For accounts such as experience-based accounts, these trends are compared to RTs with the assumption that patterns that are more frequent should also be favored in the experiments.

Chi-square goodness of fit test, and exact binominal test are non-parametric tests used with frequency data such as corpus frequency to test whether the observed frequencies are different from the expected one. For example, the two tests can be used to determine whether of all N1 and N2 RC-attachment instances extracted from a corpus, the frequency of N1 attachment is higher than 50%. To perform analyses, if more than 20% of the cells contain frequencies that are less than five, the exact binominal test is used, otherwise the chi-square goodness of fit test is used.

Table 2.1 summarizes the statistical tests used in this dissertation and the software for conducting them.

Table 2.1 Statistical tests and references

Statistical tests	Type of data	Software		
		Program	Function	Package
Exact Binominal Test	Discrete: frequency	R version 3.2.3 (R Core Team, 2015)	binom.test	*stats* version 3.2.3 (R Core Team, 2015)
Chi-square Goodness of Fit Test			chisq.test	
Wilcoxon signed rank test	Discrete: plausibility rating scores		wilcox.test	
Mixed effects models	continuous: RTs		• *lmer* (for the mixed-effects models)	• *lmerTest* version 2.0-29 (Kuznetsova, Per, & Rune, 2015)
Mixed logit models	Discrete: forced binary-choice		• *glmer* (for the mixed logit models) • *Anova* (for p value, calculated by Wald Chi-square)	• *car* version 2.1.1 (Fox & Weisberg, 2011)

Statistical tests	Type of data	Software		
		Program	Function	Package
			• *anova* (for backward selection) • *lsmeans* (for pairwise comparison)	• *stats* version 3.2.3 (R Core Team, 2015) • *lsmeans* version 2.21.1 (Lenth, 2015)

Chapter 3
Literature review

Readers (or listeners) process sentences in an incremental fashion (Van Gompel, 2013). They start building an interpretation as soon as the first word of the sentence is perceived. There is no delay as each new word read (or heard) is immediately added to the interpretation being built. In this chapter, literature relevant for the discussion of this dissertation is summarized. Firstly, experience-based accounts that are of central interest in this dissertation will be reviewed. Secondly, basic knowledge about Thai will be given to show that RC attachment in this language provides an opportunity for investigating experience-based accounts. Thirdly, accounts on language processing other than experience-based accounts will be reviewed with a particular focus on the processing of RC attachment. In order for a study to obtain accurate results, it is important to control for any possible effects that might contaminate the results of the study. Therefore, fourthly, several factors that might affect the study of RC attachment will be discussed. Finally, the last section summarizes a previous study on RC attachment in Thai, pointing out the need for the study to be re-done.

3.1 Experience-based accounts

Experience-based accounts assume that readers process sentences based on their past experience. For these accounts, readers' experience is usually measured using data from corpora. One way of testing experience-based accounts is to conduct experiments showing that frequent constructions in corpora are favored in behavioral experiments. Another way is to expose participants to a particular construction or interpretation and investigate whether their preference changes. Some of relevant proposals are summarized and discussed in this section.

3.1.1 Experience-based accounts and previous studies

Tuning hypothesis

One early experience-based type of account is the *tuning hypothesis* proposed by Mitchell and colleagues (Cuetos, Mitchell, & Corley, 1996; Mitchell & Cuetos, 1991; Mitchell, Cuetos, Corley, & Brysbaert, 1995). It assumes a direct relation between frequencies of the structures under investigation and ease of comprehension. It is proposed that readers keep record of sentences they have processed and when they are faced with an ambiguous sentence, they resolve it towards the interpretation they have encountered most frequently in the past. Mitchell et al. (1995) suggested that frequencies readers store and use for resolving ambiguity are tallied based only on syntactic structures built based on parts of speech. They argued that records that keep information other than parts of speech such as lexical information are too detailed and are unlikely to be consulted during processing.

To support the tuning hypothesis, studies reported corpus counts tallying frequency of each interpretation based only on syntactic structure built based on parts of speech. Those studies showed that the corpus counts correlated with preferences in comprehension. An example of evidence is from the study of RC attachment as in (1).

(1) Someone shot the servant of the actress who was on the balcony.

(Cuetos & Mitchell, 1988)

Mitchell and colleagues conducted a corpus count in Spanish and in English. They found that in Spanish, the frequency of N1 attachment was higher than that of N2 attachment; but in English, the opposite pattern was observed (Mitchell, Cuetos, & Corley, 1992). The results of the corpus counts were compatible with the comprehension data reported in Cuetos and Mitchell (1988) according to which Spanish readers preferred N1 attachment and English readers preferred N2 attachment. Given these results, Mitchell and colleagues (1992) proposed that the difference in attachment preference is due to the difference in participants' experience.

One evidence against the claim of the tuning hypothesis is of Kamide (2012). The study demonstrates that not only frequencies that are tallied based only on syntactic structures built based on parts of speech but also other types of information are taken into consideration when readers (or listeners) process sentences. In Kamide's (2012) study, participants used experience they had with particular speakers in processing sentences. The experiment was divided into two sessions, the exposure session and the test session. In the exposure session, participants heard sentences in which RCs were attached to either of the two head nouns as in (2) from three different speakers.

(2)

a. N1 attachment

The uncle of the girl who will taste the beer is from France.

b. N2 attachment

The uncle of the girl who will taste the sweets is from France.

The first speaker always attached RCs to N1. The second speaker always attached RCs to N2. For the last speakers, the proportion for her to produce N1 RC-attachment and N2 RC-attachment was 50-50. In the test session, it was found that participants' expectation for a particular attachment pattern to be heard aligned with speakers' identity. That is, when they heard the first speaker, they expected N1 attachment. When the second speaker spoke, N2 attachment was expected. When the third speaker spoke, the number of times participants expected N1 and N2 attachment was not different. The results suggest that speakers' identity is one of the information that readers (or listeners) use in processing.

Surprisal theory

Another type of experience-based accounts is *surprisal theory* (Hale, 2001; Levy, 2008; 2013). It uses probability for each construction to occur in a particular context (i.e., the sentence segment processed so far) as an indicator for readers' expectation (see Levy, 2013, for details). The higher the probability for a particular construction is, the more it is expected. The theory predicts that processing difficulty will occur when there are large changes in the expectations that readers have in relation to the sentence being read. For example, the more the expectation is put on one construction, the larger effort readers have to use in discarding it when that expectation is no longer possible, thus, leading to processing difficulty. Jaeger and Snider (2013) added that to make language processing efficient, readers try to minimize the chance in encountering processing difficulty in the future. To do so, they integrate their recent experience from processing a new sentence to their past experience and adapt their expectation. The process of adaptation is done by assigning higher probability to a construction that has just been read, and lowering the probability for other competing constructions that turn out to be impossible. However, not all possible constructions receive the same degree of adaptation. To explain how much readers adapt their expectation on a particular construction, error-based models are used (Fine & Jaeger, 2013; Fine et al., 2013; Jaeger & Snider, 2013). According to this model, the less expected the construction is, the higher error signal will be when readers read such a construction. The higher the error signal is, the more readers adapt their expectation, expecting the construction more in the future. The model predicts that when readers read a preferred construction (i.e., a construction that is highly expected) their expectation adaptation (i.e., expecting such a construction more) will not be as high as when they read a dispreferred one. Experience with a dispreferred construction makes readers assign higher probability to this construction and lower that of the preferred one. If readers keep on encountering the dispreferred construction, the difference between processing difficulty of the two constructions should get smaller over time.

One of the studies that support surprisal theory is that of Fine et al. (2013). In the study, Fine and colleagues conducted a self-paced reading experiment using the ambiguity in regular past verbs which can function as a main verb (MV) as in (3a) or as a past participle introducing a reduced RC as in (3b).

(3) Ambiguous verbs

a. MV

The experienced soldiers warned about the dangers before the midnight raid.

b. reduced RC

The experienced soldiers warned about the dangers conducted the midnight raid.

In (3), *warned* is ambiguous because it can be interpreted as an MV or as a past participle introducing a reduced RC. In (3a), the phrase *before the midnight raid* resolves the ambiguity towards the MV interpretation. In contrast, the phrase *conducted the midnight raid* in (3b) indicates a reduced RC.

To measure the processing difficulty in reading the two interpretations in (3), Fine et al. compared RTs to sentences with ambiguous verbs as in (3) to RTs to sentences with unambiguous verbs as in (4).

(4) Unambiguous verb

a. MV

The experienced soldiers spoke about the dangers before the midnight raid.

b. RC

The experienced soldiers who were told about the dangers conducted the midnight raid.

In (4a), the verb *spoke* is clearly an MV as it can only be the past tense form of the verb *speak*. In (4b), the relative pronoun *who* makes it clear that the following verb is in an RC.

In corpora, the frequency of the MV interpretation is higher than that of the reduced RC (the reduced RCs – MV proportion was 1-99). Therefore, it is expected that participants would process reduced RC interpretation (3b) with difficulty. More crucially, since in the experiment, participants would read each interpretation (3a and 3b) in equal proportion, the frequency of reduced RCs in the experiment would be higher than what participants would encounter in real life. Therefore, Fine et al. (2013) hypothesized that experience during the experiment could affect participants' processing.

By adopting mixed effects models, Fine et al. (2013) found that the ambiguous verb in the reduced RC condition in (3b) was read slower than the unambiguous-verb in the unambiguous RC condition in (4b), but there was no difference between the two

MV conditions. This suggested that there was a processing difficulty in processing the reduced RC interpretation.

To capture the effect of experience during the experiment, Fine et al. (2013) added the number of test sentences participants had read so far up to each point of the experiment as a factor in the analysis. They found that as the experiment progressed, the RT difference between the two types of sentences in the RC conditions got smaller. This indicated that participants integrated new experience from reading test sentences to their experience prior to the experiment. Therefore, adaptation to statistics specific to the experiment was observed. However, for the MV conditions (3a and 4a), the change in RTs over the course of experiment was not reliable. There was only a numerical trend for the difference in RTs between the sentences with ambiguous and unambiguous MVs to increase as the experiment progressed. The findings showing that RTs to RC conditions reliably changed as the experiment progressed but those to MV conditions did not suggest that adaptation was asymmetrical. Fine and colleagues explained that the interpretation that was less expected (i.e., reduced RC), received a higher error signal when being processed, resulting in a large change in expectation.

To further test what would happen to the processing of the MV interpretation if participants' experience with reduced RCs was increased, Fine and colleagues conducted a second experiment, in which participants were divided into two groups namely the RC-first group and the filler-first group. The sentences were divided into three blocks. The types and the number of sentences used in each block are summarized in Table 3.1.

Table 3.1 Summary of Experimetn 2 of Fine et al. (2013)

Group	Block 1	Block 2	Block 3
RC-first group	8 unambiguous RC (as in 4b) 8 reduced RC (as in 3b)	5 unambiguous RC 5 reduced RC 20 fillers	5 unambiguous MV (as in 4a) 5 MV (as in 3a) 15 fillers
Filler-first group	16 fillers	5 unambiguous RC 5 reduced RC 20 fillers	5 unambiguous MV 5 MV 15 fillers

As can be seen from Table 3.1, the two groups were treated differently only in the first block. That is, in the first block, the RC-first group read eight sentences with unambiguous RC verbs as in (4b) and eight sentences with ambiguous verbs in which the ambiguity was resolved towards a reduced RC interpretation as in (3b). In contrast, the filler-first group read 16 fillers. The experience with the reduced RCs was given to the two groups in block 2. In block 3, the processing of sentences with unambiguous MV as in (4a) and sentences with ambiguous verbs in which the ambiguity was resolved towards MV interpretation as in (3a) was tested.

Participants read the sentences of the three blocks consecutively without a break in between. With the analysis using the data from blocks 1 and 2 of the RC-first group, Fine et al. (2013) found that the results replicated those of the first experiment. That is, the RT difference between the two types of sentences (i.e., sentences with unambiguous RC and those with reduced RC) got smaller over time.

With the data from block 3 of the two groups (i.e., the MV block), the RTs to sentences with MV interpretation (as in 3a) was slower than those to sentences with unambgiuous MV (as in 4a). More importantly, the RT difference between the sentences with MV interpretation and sentences with unambiguous MV of the RC-first group was larger than that of the filler-first group.

The results suggested that extra experience with reduced RC facilitated its later processing, but also made the MV interpretation harder to process. In other words, in terms of probability assignment, as participants assigned higher probability to the reduced RC interpretation, they lowered the probability of the MV interpretation.

Constraint satisfaction accounts

Constraint satisfaction accounts proposed that all types of information are used immediately and their importance depends on the weight that each type of information received (MacDonald, Pearlmutter, & Seidenberg, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998). In this accounts, experience is used for determining which information is more important in each situation. Constraint satisfaction accounts are different from other experience-based accounts which assume that only frequencies of syntactic structures built based on parts of speech can immediately affect processing (e.g., tuning hypothesis).

One of the evidence supporting constraint satisfaction accounts comes from studies reporting that readers used noun animacy and thematic role assignment in processing. Gennari and MacDonald (2009) asked participants to read object-extracted RCs in which the subject of RCs was of different type of animacy and the RC verb was different in terms of thematic roles it assigned to its arguments. An example is illustrated in (5).

(5)

a. animate subject, cause-experiencer RC verb

The lawyer that the colleague confused has appealed the state's court decision.

b. animate subject, agent-theme RC verb

The lawyer that the colleague criticized has appealed the state's court decision.

c. inanimate subject, cause-experiencer RC verb

The lawyer that the legislation confused has appealed the state's court decision.

By comparing the results of the study to production data (Gennari & MacDonald, 2008, 2009), Gennari and MacDonald (2009) found that at RC verb, RCs with an animate noun as a subject (e.g., 5a and 5b) were read faster than RCs with inanimate subject (e.g., 5c). This was because animate nouns often occurred in a subject position; therefore, readers expected them to be a subject. Gennari and MacDonald further explained that inanimate nouns in a cause role (e.g., *legislation* in 5c) hardly occupied a subject position; thus, there was processing difficulty when inanimate nouns in a cause role appeared as the subject. They also found that at the main auxiliary verb (e.g., *has* in (5)) where integration of an RC verb (e.g., *confused* in (5a, c) or *criticized* in (5b)) and thematic roles of nouns which were arguments of RC verb took place, sentences with agent-theme RC verb (5b) were read faster than sentences with cause-experiencer RC verb (e.g., 5a and 5c). This was because verbs that required cause-experiencer roles rarely occurred, and thus were unexpected. From the experiment, it was concluded that readers immediately use probability associated with noun animacy and probability of thematic role assignment in relation to the verb to expect upcoming interpretation (Gennari & MacDonald, 2008, 2009).

Constraint satisfaction accounts are different from experience-based accounts that have been discussed so far. That is, while other accounts assume that experience with the actual construction is crucial, some models assume that experience with similar constructions can affect processing of the target one as well (MacDonald & Christiansen, 2002). MacDonald and Christiansen (2002) discussed a processing transfer between similar constructions in terms of *frequency x regularity*. In their explanation, *regularity* of a construction is determined by similarities that it shares with other constructions. They suggest that processing of a regular construction is less affected by frequency of exposure to that construction in a language. This is because the processing of a regular cosntruciton is facilitated not only by readers' experience with the construction itself but also by experience readers have with other constructions sharing similarities with it. On the other hand, the processing of a less regular construction mostly relies on its frequency of exposure to that construction. Therefore, less regular constructions are harder to process than the regular ones. To support the claim, MacDonald and Christiansen (2002) used English as a case study and made use of the local ambiguity between subject-extracted RCs as in (6) and object-extracted RCs as in (7).

(6) The reporter that attacked the senator admitted the error.

(7) The reporter that the senator attacked admitted the error.

Subject-extracted RCs are known to be easier to process than object-extracted RCs. MacDonald and Christiansen claimed that this is because subject-extracted RCs are similar to simple sentences in terms of word order (SVO). Therefore, subject-extracted RCs are considered to be regular and the processing of subject-extracted RCs is facilitated not only by experience readers have with subject-extracted RCs themselves but also by experience with simple SVO sentences in English. On the other hand, the ease of processing object-extracted RCs (the less regular construction) depends only on experience with object-extracted RCs themselves since their word order (OSV) is rarely encountered in other constructions in English. To test their hypothesis, the authors trained ten simple recurrent networks to process simple sentences, sentences with subject-extracted RCs, and sentences with object-extracted RCs. The condition in the training phase was that the two types of RCs given to the networks were in equal proportion. After training, they let the networks predict the upcoming construction by using experience during the training phase. They found that with an equal amount of experience with the two types of RCs, subject-extracted RCs were easier to process than were object-extracted RCs. They argued that the results showed that the networks learnt to generalize the processing of simple sentences to the processing of subject-extracted RCs, thus leading to the processing facilitation for subject-extracted RCs. One problem with MacDonald and Christiansen's (2002) proposal is that they did not explain how similar the two constructions have to be in order to cause processing transfer. Therefore, the definition of regularity is also unclear. Word order of subject-extracted RCs is not exactly the same as that of simple sentences as in subject-extracted RCs an RC marker intervenes between the subject and the verb. If such word-order similarity is enough to cause processing transfer, the question is whether it implies that any constructions that share identical word order can cause it. Based on MacDonald and Christiansen (2002), although it is not clear how similar constructions have to be for facilitation to be transferred, it is probably reasonable to assume that constructions with identical word orders should facilitate each other.

Similar to the surprisal theory, constraint satisfaction accounts propose that extra experience will affect processing in an asymmetrical way. MacDonald and colleagues (MacDonald & Christiansen, 2002; Wells et al., 2009) explain such effect in terms of an interaction between frequency, regularity, and expereince (*frequency x regularity x experience*; Wells et al., 2009). According to them, processing regular constructions (e.g., subject-extracted RCs) will not be affected by extra experience as much as unique constructions (e.g., object-extracted RCs) are. To prove this claim, Wells and colleagues (2009) conducted a reading experiment in English with a focus on the processing of subject-extracted RCs as in (6) and object-extracted RCs as in (7). They found that in the pre-test session, participants read subject-extracted RCs faster than object-extracted RCs. According to Wells and colleagues, this result is compatible with frequency x regularity proposal suggesting that similarities between constructions in terms of word order can cause processing transfer. After the pre-test, Wells and colleagues asked participants to come to the lab again for two more times. During the lab visits, participants were exposed to more sentences with subject-extracted RCs and sentences with object-extracted RCs in equal proportion. Four or more days later after the last lab visit, participants attended the post-test session. Wells and colleagues found that participants could process object-extracted RCs faster such that the difference in the time participants spent on reading subject- and object-extracted RCs in the post-test session was reliably smaller than that in the pre-test session. Wells and colleagues claimed that the effect of experience on the processing of object-extracted RCs supports the frequency x regularity x experience proposal. That is, because subject-extracted RCs share similarity with SVO sentences which have already been prevalent in the language, adding a few more subject-extracted RCs to the experience does not improve the processing of subject-extracted RCs much more. On the other hand, object-extracted RCs have little support from other constructions; therefore, any extra experience is more helpful for participants to process them. However, since the definition of similarities between constructions is unclear, it is hard to define what regular constructions are and is hard to verify the proposals which based their claim on similarities between constructions (e.g, frequency x regularity, and frequency x regularity x experience proposals).

Episodic-processing accounts

Since episodic-processing accounts take into consideration the role of experience in sentence processing, for the purposes of this discussion, these accounts are grouped under experience-based accounts. Episodic-processing accounts explain the association between experience and language processing in terms of trace and retrieval in episodic memory (Borensztajn & Zuidema, 2011; Kaschak & Glenberg, 2004). More specifically, readers' linguistic experience is registered in episodic memory. Every time a construction is processed, traces relevant to that construction are reactivated, and thus, strengthened. The stronger the traces are, the easier for them to be retrieved in the future. With the ease of retrieval, processing is facilitated (Kaschack & Glenberg, 2004; Borensztajn & Zuidema, 2011, and references therein for related discussion).

Episodic-processing accounts are similar to some versions of constraint satisfaction accounts (e.g., frequency x regularity proposal; MacDonald & Christiansen, 2002) as they propose that experience with similar constructions affects processing of the target construction. However, for episodic processing accounts, the transfer occurs because similar constructions and the target construction share some traces. To prove this claim, Kaschak and Glenberg (2004) conducted experiments training participants to process a novel construction, namely *need + past participle* in which the past participle functions as a verb (the target construction, see (8) for an example) instead of *need + to be + past participle*

(8) The meal needs cooked given that dinner is in half an hour.

As predicted, they found that participants could generalize the processing of the target construction to the processing of *want*, a verb that shares similarities and thus shares some traces with *need*. Although the result supports the claim of episodic-processing accounts, it should be noted that this result cannot differentiate episodic processing accounts from some versions of constraint satisfaction accounts.

What makes episodic-processing accounts (Kaschak & Glenberg, 2004) different from other experience-based accounts that have been discussed so far is that they propose that in processing, even when a construction turns out to be irrelevant, reactivation of that construction can still facilitate its later processing because such reactivation has already left traces in memory. For other experience-based accounts, when a construction turns out to be wrong, it is discarded and thus, cannot facilitate its later processing. Indeed, in accounts such as surprisal theory when a construction turns out to be wrong, readers lower the probability for such construction, making its later processing harder. Kaschak and Glenberg (2004) tested the claim of episodic-processing accounts with two groups of participants. The test group read sentences with the target construction as in (8) and sentences with a standard construction as in (9) in which past participles were interpreted as an adjective.

(9) The meal needs cooked vegetable to make it complete.

In contrast, the control group read only sentences with the standard construction (as in (9)). Kaschak and Glenberg found that the test group could process sentences as in (9) faster than the control group. They explained that this was because when the test group processed the target construction (as in (8)), at the point of *need + past participle* the standard construction (past participle as an adjective as in (9)) was also reactivated. Although when readers read disambiguating word (e.g., *given* in (8)) and found that the standard construction turned out to be wrong, reactivation of the standard construction left traces in memory. These traces later helped the test group in processing the standard construction. Kaschak and Glenberg concluded that their results supported the claim of episodic-processing accounts.

A problem with Kaschack and Glenberg's claims on processing transfer between similar constructions and on the ease of processing is that the target construction in their study is ungrammatical in Standard English. Such ungrammaticality might make the construction salient and participants might adapt their expectation expecting ungrammatical construction for both *need* and the similar verb (i.e., *want*) such that they could process experimental sentences efficiently. Moreover, Fine and colleagues (2013) suggested that when the standard construction (i.e., past participle after *need* as an adjective) turned out to be wrong, participants might not simply discard such construction. Before discarding, participants might compare the ungrammatical construction they were reading to the standard construction they had in mind. By comparing them, participants had thought more about the two constructions; therefore, later processing of the standard construction was facilitated. Fine et al. (2013) showed that when studies involved processing of two standard constructions, facilitation for discarded interpreations was not observed. Thus, the evidence from Kaschak and Glenberg (2004) does not provide a clear support for the effect of experience with similar constructions and the ease of processing.

Production-Distribution-Comprehension

All the accounts reviewed up until now concern how experience with language, as shown in production data, affects comprehension but none of them explains what shapes production data. To account for this issue, the *Production-Distribution-Comprehension* (PDC) account was proposed (Gennari & MacDonald, 2009; Gennari, Mirković, & MacDonald, 2012; MacDonald, 2013). The PDC account takes into consideration how speakers produce utterances incrementally. According to MacDonald (2013), to make speech fluent (i.e., save time in creating a production plan), speakers tend to produce words that are more accessible (e.g., more frequent, more salient words) first and assign them to prominent syntactic position, leading to an *easy first* preference. They also tend to reuse sentence structures that have just been used or frequently used (*plan reuse*). Sometimes, they choose structures that allow them to reduce memory interference by, for example, avoiding similar entities in the production plan (*reduce interference*). Such production biases are claimed to affect the frequency in which constructions are produced, and these frequencies in turn determine biases during comprehension (MacDonald, 2013).

MacDonald (2013) reviewed numerous previous studies of hers and her colleagues to support the PDC. For example, MacDonald and colleagues found that when speakers were asked to produce RCs with the inanimate head (e.g., *toy*), they often produced object-extracted RCs (e.g., *the toy that the girl splashed*), with the animate noun (e.g., *girl*) as the subject of the clause instead of producing subject-extracted RCs with the inanimate noun as the subject. This shows that speakers used the *easy first* strategy by producing animate nouns first and making them occupy the subject position. However, when the head noun was changed to animate (e.g., *boy*), object-extracted RCs (e.g., *the boy that the girl splashed*) were rarely produced. Rather, speakers often produced passive RCs (e.g., *the boy that was splashed*) omitting the agent of the RC verb (e.g., *girl*). According to MacDonald and colleagues, the results show that speakers followed the *reduce interference* strategy. Omitting the agent helped reduce memory interference by avoding the inclusion of two nouns that are conceptually similar. MacDonald and colleagues argued that readers learn this production pattern and use it in processing. For example, because object-extracted RCs with an animate head noun (e.g., *the boy that the girl splashed*) were rarely produced, readers have difficulty in processing them (see Gennari & MacDonald, 2008; Gennari, Mirković, & MacDonald, 2012; MacDonald, 2013, for more details).

3.1.2 Experience-based accounts and learning

Schmidt and Bjork (1992) reviewed previous studies on learning in different paradigms. They found that what seems to maximize performance in one situation does not necessarily extend to every situation. When the situation or environment is changed, participants may perform not as well as expected. Scmidt and Bjork (1992) showed that training in a low degree of freedom situation (e.g., having participants performed tasks in a sequential order) improved participants' performance during training session but not during the test session which involved a high degree of freedom situation (e.g., having participants performed tasks in a random order). Based on the reviewed results, Schmidt and Bjork (1992) suggest that only participants' performance during training session cannot be used to argue for learning effect. They stated that to claim for a learning effect, the observed change in performance should be long lasting and should be able to be transferred to a high degree of freedom situation or to different environment.

From previous studies under the framework of experience-based accounts, Wells et al. (2009) and Fine et al. (2013) suggested that the change in expectation after extra exposure and the adaptation to statistics specific to the experiment implied that learning had implicitly taken place. However, based on Schmidt and Bjork’s (1992) review, it could be the case that the effect of experience found in the previous studies is not a learning effect but an effect limited to restricted situations.

Previous studies (Fine et al., 2013; Kamide, 2012; Wells et al., 2009) trained participants by having them read sentences which could be interpreted only in one way (e.g., either MV or reduced RCs, either subject-extracted RCs or object-extracted RCs). During training, participants did not have the freedom to interpret sentences in the way they preferred. Rather, they were trained on how to interpret sentences. This training session was a low degree of freedom situation. In those experiments, the proportion of the two competing constructions shown to participants (e.g., 50-50 in Fine et al.’s study) was markedly different from participants’ past experience (e.g., the reduced RCs - MVs proportion in participants' past experience was 1-99; see Fine et al., 2013; Roland, Dick, & Elman, 2007; for more details on such frequencies). Such a large difference might make participants change their expectation on purpose, especially when they were tested to determine whether their expectation for a given interpretation increased in the exact same low degree of freedom situation as that in which they were trained. Moreover, although in some studies (e.g., Wells et al.’s, 2009) the effect of experience was reported to be long lasting, the fact that participants came to the same lab to complete the experiment might suggest that the effect of experience observed in the experiment was tied to a specific setting. Therefore, even though those studies found that participants' expectation on a particular interpretation could change, the results do not guarantee that participants will continue changing their preference when they are tested in a high degree of freedom situation where they have freedom to choose the interpretation they prefer, or when they are tested in a different enviroment. If the effect of experience cannot be transferred to a high degree of freedom situation or to a different enviroment, the results of previous studies will only imply that participants learnt some kind of strategy that helped them performed better in the experiment.

Therefore, at this point it is premature to conclude that implicit learning has taken place in those previous experiments. To claim for implicit learning or to claim for the effect of experience on sentence processing, a test that involves different kinds of situations or different environments should be conducted to determine whether the effect of experience is still observed.

In sum, experience-based accounts propose that readers process sentences based on their past experience. Some accounts further suggest that both experience with the target construction and with similar constructions can affect the processing of the target construction. However, those accounts do not specify how similar the constructions have to be in order to cause a processing transfer. Moreover, although many studies reported that experience could affect processing, the observed effect might only be specific to a given situation or environment. In this dissertation, the effect of experience both with the target construction and with similar constructions on sentence processing, and processing transfer from one situation to a different situation will be tested using RC attachment in Thai (see Section 3.2.1, for more details about the target construction).

3.2 Thai

Thai is a language with consistently head-initial word order. In particular, it has a rigid SVO word order. Verbs and their direct objects have to be adjacent. Adjectives can intervene between the nouns and the RCs (schematically, *N adjective RC*). Thai has no plural markers or morphological agreement. Therefore, interpretation of structurally-ambiguous sentences is often based on plausibility.

Thai is a pro-drop language such that a noun phrase (NP) can be dropped when they can be inferred from context. According to Intratat (2005), a dropped NP or a zero pronoun can function as a subject, a direct object or an indirect object, although subjects are the most frequently dropped.

Clauses that provide information about a noun are of two types, namely RCs and sentential complements (SCs, Kullavanijaya, 2010; see also Comrie, 1996, for a different analysis). According to Kullavanijaya (2010), RCs and SCs are different from each other in that there is an extraction position in RCs but not in SCs. However, there are different views regarding the presence of an extraction position in RCs. Unlike Kullavanijaya (2010), some grammarians suggest that in Thai and other pro-dropped languages the missing constituent in an RC is a zero pronoun, not an extraction position (Comrie, 1996; see also Jenks, 2014, for related discussion). The different views on the extraction-position issue make it unclear whether an extraction position is a good criterion for distinguishing the two constructions. Moreover, in practice it can be hard to differentiate an extraction position from a zero pronoun. Therefore, the RCs and SCs used in this dissertation are differenetiated based on the definition and criteria in the following sections.

3.2.1 RCs

RCs, which are the main focus of this dissertation, are clauses that modify a noun by providing information necessary for identifying that noun from other nouns in the same set or adding additional information to it (Jenks, 2014). In Thai, RCs follow the noun they modify. Although what is counted as RC markers in Thai may vary depending on the framework held by each study (see Prompapakorn, 1996, for a comprehensive review on this issue; see alsoYaowapat, 2008, for related discussion), in this dissertation, it is assumed that *thî:*, *sɨ̂ŋ*, and *ʔan* are RC markers (following Iwasaki & Ingkaphirom, 2009; but see Ekniyom, 1971; Yuttapongtada, 2001, for different views). The focus of this dissertation is on RCs introduced by the marker *thî:* because this marker is the most commonly used and has relatively few stylistic restrictions (Iwasaki & Ingkaphirom, 2009).

In RCs, the noun that is co-referent with the head noun is often dropped. In this dissertation, the position in which a noun is missing will be referred to as an extraction position without assuming whether it is a gap (as assumed by Kullavanijaya, 2010) or a zero pronoun (as in Comrie, 1996). Adopting either approach to RCs has no impact on discussion on RCs in this dissertation.

As in other languages, RCs in Thai can be either restrictive or non-restrictive. However, as noted by Wasow, Jaeger and Orr (2011), the distinction between the two types of RCs are not clear-cut. In Thai, although the primary function of *thî:* is to introduced restrictive RCs (Iwasaki & Ingkaphirom, 2009), it can still be the case that RCs following this marker are non-restrictive. In this dissertation, restrictive RCs are not distinguished from non-restrictive RCs. However, we adopted Wasow, Jaeger and

Orr's (2011) solution. RC instances with a proper name or a pronoun as a head noun will not be included in the corpus counts or used in the experiments in this dissertation; therefore, some non-restrictive RCs are excluded.

In this dissertation, a construction in which an RC can modify one of the two nouns in a complex noun phrase is used as the target construction. The word order of the construction is *N1 khɔ̌:ŋ N2 thî*: *RC* where *khɔ̌:ŋ* is the preposition *of* and *thî*: is comparable to *that*. All RCs used are subject-extracted RCs. An example is provided in (10) with ø indicating the extraction position.

(10) โค้ชของนักวิ่งที่วาดรูปสวย

khó:t khɔ̌:ŋ nákwîŋ thî: ø wâ:t rû:p sǔaj

coach of runner that ø draw picture beautifully

"The coach of the runner that is good at drawing"

3.2.2 SCs

There are two types of SCs, namely, verbal and nominal. Verbal SCs complete the meaning of a verb (e.g., *I know that he is going to move*; adapted from Jenks, 2014). Nominal SCs complete the meaning of a noun (e.g., *The fact that he is going to move*; adapted from Jenks, 2014). From here on in this dissertation, SCs will be used exclusively to refer to nominal SCs.

SCs in Thai follow the nouns they complete their meaning and are introduced either by the marker *thî:* (Kullavanijaya, 2010) or by a combination of two markers, *thî:wâ:* (Jenks, 2014). Any NPs in SCs can be left implicit if they can be inferred from the context. Therefore, there can be a zero pronoun in SCs. If SCs are introduced by *thî:* and contain a zero pronoun in the exact same position as that of the extraction position in RCs, word order configurations of the two constructions are identical. For example, if SCs contain a zero pronoun in the subject position, their word order configuration will be identical to that of subject-extracted RCs (schematically, *N thî: ø predicate*, where *ø* represents either an extraction position or a zero pronoun and *predicate* refers either to the predicate of RCs or that of SCs). Therefore, the order of the head noun, the marker *thî:* and the zero pronoun makes SCs similar to *thî:*-marked RCs. These similarities allow Thai to be used for testing how processing a construction is affected by experience with a similar construction (MacDonald & Christiansen, 2002; see also Kaschack & Glenberg, 2004).

To differentiate SCs from RCs, properties of clauses after *thî:* and properties of head nouns have to be considered. For a string of words to be an SC, it has to have a structure of a clause. However, some arguments of a clause (e.g., subject) maybe omitted because of some grammatical rules (Dixon, 2008). Secondly, according to Dixon (2008), the clause has to be a proposition. It cannot be only about time and place. Thirdly, the head noun and the clause have to be in an appositive relation (Stowell, 1981). That is, they have to refer to the same thing. For example, in *John's claim that he would win*, "that he would win" is the thing being claimed (Stowell, 1981). An example in Thai is given in (11).

(11) ข่าวลือที่เขาจะย้ายบ้าน

khàwlɨː	*thîː*	khǎu	càʔ	jáːj	bâːn
rumor	that	he	going-to	move	house

"the rumor that he is going to move"

(adapted from Jenks, 2014)

In (11), the clause *thîː khǎu càʔ jáːj bâːn* "that he is going to move" is a proposition that is referred as *khàwlɨː* "rumor".

Restrictions on the head noun for SCs are as follows. The noun has to be a propositional noun, a noun that is able to take a proposition as an argement. The test for this is that the head noun has to be able to occur as a predicate of a copular *pēn* "be", taking the *thi*:-clause as its subject (Jenks, 2014; see also Mikkelsen, 2014, for related discussion). The test frame is given in (12) where XYZ represents the clause and N represents the head noun.

(12) *thîː* XYZ *pēn* N

Apart from the ability to be a predicate of a copula *pēn*, the noun has to specify what the *thîː*-clause is (Jenks, 2014). The example in (13) (adapted from Jenks, 2014) illustrates how the test frame in (12) is used when the head noun "rumor" and the clause "that he is going to move" in (11) are tested.

(13) ที่เขาจะย้ายบ้านเป็นข่าวลือ

thî:	khǎu	cà?	já:j	bâ:n	pēn	khàwlɨ:
that	he	going-to	move	house	be	rumor

"that he is going to move is a rumor"

(adapted from Jenks, 2014)

According to Jenks (2014), in (13) when "rumor" is put into the test frame with the copula *pēn*, the clause "that he is going to move" sounds natural as its subject. Moreover, "rumor" specifies that the clause "that he is going to move" is a rumor. It is not a fact. Since "rumor" passes the two tests, it is regarded as a propositional noun.

In sum, the tests above for the clause and those for the head noun are going to be used to differentiate SCs from RCs. The superficial similarities between the two constructions can then be used to test the effect of experience with a similar construction, namely SCs, on the processing of the target one. For this purpose, SCs (schematically, *N1 khɔ̌:ŋ N2 thî: SC*) such as the following one in (14) from the Thai National Corpus (TNC; Aroonmanakun, Tansiri, & Nittayanuparp, 2009) will be used in this dissertation.

(14) ดุลยพินิจของอนุญาโตตุลาการที่จะขยายเวลาออกไป

dūnlāʔjáʔphíʔnít	khɔ̌:ŋ	ʔànújā:tō:tùlā:kā:n	thî:	ø	càʔ	khàʔjǎj
judgment	of	arbitrator	that	ø	MODAL	extend

wēlā	ʔɔ̀:k	pāi
time	exit	go

lit: judgment of arbitrator that will extend the deadline

"judgment of arbitrator to extend the deadline"

In (14), the subject of the SC is missing (as indicated by ø) and it co-refers with N2, *ʔànújā:tō:tùlā:kā:n* "arbitrator", but the clause is not an RC. It is an SC completing the meaning of N1, *dūnlāʔjáʔphíʔnít* "judgment" by indicating what judgment has been made.

It should be noted that in general, SCs can be associated either with N1 or with N2. Moreover, it is not necessary for the SC to have a zero pronoun or for a zero pronoun to refer to N1 or N2 (see (15) and (16) for examples from the TNC; Aroonmanakun, Tansiri, & Nittayanuparp, 2009).

(15) ลักษณะของความพยายามที่จะเป็นอิสระจากอิทธิพลของผู้ให้กำเนิด

láksànàʔ khɔ̌ŋ khwāːmphājāːjāːm thîː ø càʔ pēn

characteristic of attempt that ø MODAL be

ʔìtsàràʔ càːk ìttíʔphōn khɔ̌ŋ phûhâjkāmnə̀t

free from influence of parent

lit: characteristic of attempt that is going to be free from influence of parent

"the characteristic of the attempt to be free from parent's influence"

In (15), the propositional noun whose meaning is completed by the SC is N2, *khwāːmphājāːjāːm* "attempt". Moreover, the dropped argument in the subject position of the SC (represented by *ø*) is neither N1 nor N2.

(16) ความลี้ลับของเรื่องราวที่เขาถูกนินทา

khwāmlíːláp khɔ̌ːŋ rɨ̂əŋrāːw thîː khǎw thùːk nīnthāː

mystery of story that he PASSIVE gossip

lit: mystery of story that he was the subject of gossip

"the mystery of the story of his being the subject of gossip"

In (16), the propositional noun whose meaning is completed by the SC is N2, *rɨ̂əŋrāːw* "story". There is no zero pronoun in the SC.

3.3 Models of sentence processing with a focus on RC attachment

At least since the 1970s, there have been reports suggesting that readers prefer to associate words locally (i.e., locality; to attach to the most recent word; Frazier, 1978; Gibson, 1998; Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok, 1996; Kimball, 1973; inter alia). One reason that is commonly provided for locality comes from working-memory constraints (Gibson, 1998). Activation of words that have been perceived decays over time as new words are being perceived; therefore, attaching new words to the non-local head involves high usage of working memory to reactivate the head. Moreover, keeping syntactic predictions in memory while interpreting intervening constituents requires large amounts of working memory. Hence, to decrease working memory demand, locality is preferred.

An example of a model that proposed locality preference is the garden path model (Frazier, 1978). It is suggested that sentence processing is guided by two principles namely minimal attachment and late closure. Minimal attachment states that readers prefer the least complex construction. For the case in which the competing constructions are equal in terms of complexity, for example, RC attachment as in (1) which is repeated here as (17), the second principle namely late closure comes into play.

(17) Someone shot the servant of the actress who was on the balcony.

(Cuetos & Mitchell, 1988)

Late closure predicts that the upcoming word will be attached to the most recent candidate host site (i.e., locality preference). Therefore, in the case of RC attachment as in (17), the garden path model predicts that readers will prefer attaching RC to N2, the most recent noun. In other words, they will prefer the actress to be on the balcony. It should be noted that in the garden path model, readers consider syntactic structure built using only parts of speech first. Effects such as those of lexical information (e.g., animacy and concreteness), plausibility (e.g., thematic fit) or context are delayed. The model stands in contrast to accounts such as constraint satisfaction which proposed that readers immediately consider all possible types of information when processing sentences. The garden path model fails to account for findings showing that contextual and lexical factors immediately affect RC attachment (see Section 3.4 for more details).

In 1988, Cuetos and Mitchell found that while English readers preferred N2 as the attachment site of RCs following locality, Spanish readers violated locality by preferring N1 attachment. Readers in most languages tested since then have also been shown to favor N1 (e.g., Italian, De Vincenzi & Job, 1995; Dutch, Desmet et al., 2006; French, Frenck-Mestre & Pynte, 2000; German, Hemforth, Konieczny, & Scheepers, 2000; Japanese, Kamide & Mitchell, 1997; Greek, Papadopoulou & Clahsen, 2003). These findings posed a challenge to the garden path model and other models that predict a locality preference.

In order to account for this locality violation, many accounts have been proposed. For experience-based accounts, this locality violation and cross-linguistic difference in the case of RC attachment can be explained in terms of speakers' different linguistic experience (see the tuning hypothesis in Section 3.1.1 for examples of RC-attachment studies based on experience-based accounts' framework). Other accounts explain such violation by using different linguistic factors. These include accounts such as the *modifier-straddling hypothesis* (Cuetos & Mitchell, 1988), *construal theory*

(Frazier & Clifton, 1996), *predicate proximity* (Gibson et al., 1996), *verb-object adjacency* (Miyamoto, 1999), and *attachment-binding dualism* (Hemforth, Konieczny, & Scheepers, 2000). However, the accounts using different linguistic factors fail to explain RC attachment in at least one of the languages tested so far.

Apart from the aforementioned accounts, the *implicit prosody hypothesis* (Fodor, 1998; 2002) suggested that when readers read a sentence in silence, a prosodic contour is assigned and it affects attachment decisions. In the case of RC attachment, it is proposed that there will be an N1 preference when a prosodic break intervenes between the two nouns and the RC (i.e., schematically, *N1 of N2 / RC*, where / indicates a prosodic break). Evidence supporting this hypothesis indicates that a line break between N2 and the RC induced an N1 preference both in Dutch (Swets, Desmet, Hambrick, & Ferreira, 2007) as well as in English (Traxler, 2009). However, Felser, Roberts, and Marinis (2003) found an N2 preference in English even though there was a line break. Fodor (2002) suggested that one of the factors that could influence the prosodic break is the length of RCs. That is, to make the RC and the host have similar lengths, short RCs are often grouped with N2, causing N2 attachment. However, if the RC is long, there will be a prosodic break between the two nouns and RCs, causing N1 attachment (see Jun, 2010, for a review of length effects in RC attachment).

A different approach has been suggested by a recent study according to which the N1 preference is the result of an alternative interpretation (Grillo & Costa, 2014). In languages in which N1 is favored (e.g., Spanish, Italian, French), some types of matrix verbs (e.g., perceptual verbs) take what superficially seem to be an RC (i.e., *pseudo RCs*) as their complement in order to provide information about an event being perceived. In such circumstances, only N1 which is the argument of the matrix verb can be the attachment site for the clause and the events in the two clauses (the matrix clause and the pseudo RC) are simultaneous. An example of pseudo RCs is to say “I saw the son of the doctor that ran” in Italian to mean “I saw the son of the doctor running.” Grillo and Costa noted that for these languages, when the pseudo RC interpretation is not available, N2 attachment is preferred (see Grillo & Costa, 2014; and references therein). The problem with the account is that Grillo and Costa did not show that the pseudo-RC interpretation was possible with test items used in previous literature. When this problem is taken into consideration, it is found that the account fails to explain N1 preference in Japanese (Kamide & Mitchell, 1997; Yamada, Arai, & Hirose, 2014) because none of the stimuli in Japanese experiments could be interpreted as instances of pseudo RCs but and N1 preference was still observed. Therefore, at this point, it is uncertain whether the previously reported N1-attachment preference was resulted from availability of pseudo-RC interpretation (see also Siriwittayakorn, Miyamoto, & Ratitamkul, 2015 for a possible generalization of contextual effects based on Rohde, Levy, & Kehler, 2011).

In sum, locality is violated in RC attachment in many languages. Many accounts have been proposed to account for such violation but no account is able to perfectly explain all the data currently available, and thus, a proper conclusion cannot be drawn.

3.4 Factors that may affect RC attachment

RC attachment has been shown to be affected by context surrouding the RC (H. Rohde, Levy, & Kehler, 2011; Siriwittayakorn, Miyamoto, & Ratitamkul, 2015) as well as lexical factors such animacy and concreteness (Acuña-Fariña, Fraga, García-Orza, &

Piñeiro, 2009; Desmet, Brysbaert, & Baecke, 2002; Desmet et al., 2006). Therefore, studies investigating RC attachment should pay attention to these factors so that a proper conclusion can be drawn.

3.4.1 Contextual effects

Context (i.e., materials surrounding the target construction) can be divided into two types namely *intra-sentential context*, which is context within the sentence containing the target construction (e.g., the matrix clause) and *inter-sentential context* which is context outside the sentence (e.g., sentences preceding the target sentence). For the effect of intra-sentential context in RC attachment, Rohde, Levy, and Kehler (2011) proposed that readers expect text to be coherent; therefore, intra-sentential context could affect attachment decision. To prove their claim, they conducted reading experiments in English, a language with N2-attachment preference. The results showed that readers changed their attachment preference attaching RCs to N1 if such attachment provided a reason or justification for the statement in the matrix clause. For example, when the matrix verb was *detest* as in *John detests the children of the musician who…*, readers expected the upcoming RC to provide a reason why John detests the children. Therefore, they read N1-attachment continuations as in (18a) faster than N2-attachment continuations as in (18b).

(18)

a. N1 attachment

John detests the children of the musician who are generally arrogant and rude.

b. N2 attachment

John detests the children of the musician who is generally arrogant and rude.

However, when the matrix verb did not require further explanation (e.g., *babysit*), readers preferred to attach RCs to N2. The results support the claim that readers look for text coherence and suggest that intra-sentential context (i.e., the matrix clause) can affect RC attachment.

In another study in which textual coherence was found to affect attachment (Siriwittayakorn, Miyamoto, & Ratitamkul, 2015), a questionnaire using corpus fragments was conducted in Thai. The target construction was presented either in isolation or with the entire corpus sentence (i.e., with intra-sentential context). An example pair is shown in (19).

(19)

a. In isolation

การสัมผัสของคำที่เร้าอารมณ์คนฟัง

kāːnsămphàt khɔ̌ːŋ khām thîː ráwʔ āːrōm khōnfāŋ

rhyme of words that arouse emotion listener

"Rhyme of words that aroused listeners' emotion"

b. With context

ผู้แต่งบรรจงคัดสรรถ้อยคำที่มีเสียงไพเราะมาเรียงร้อยให้เกิดจังหวะและให้มีการสัมผัสของคำที่

เร้าอารมณ์คนฟัง

phûːtɛ̀ŋ bāncōŋ khátsăn thɔ̂jkhām thîː mīː sǐəŋ phājrɔ́ʔ māː

writer deliberately choose words that have sound beautiful come

rīəŋrɔ́ːj hâj kə̀ːt cāŋwàʔ lɛ́ʔ hâj mīː kāːnsămphàt khɔ̌ːŋ khām

compose give create rhythm and give have rhyme of words

thîː ráwʔ āːrōm khōnfāŋ

that arouse emotion listener

"The writer deliberately chose words that have beautiful sounds to create rhythm and to make rhyme of words that aroused listeners' emotion."

When the target construction was presented in isolation, participants preferred one attachment site (e.g., N2, *khām* "words", in (19a)) but when it was presented with context, participants preferred the other site (e.g., N1, *kāːnsămphàt* "rhyme", in (19b) because rhyme tends to be related to the beautiful sounds mentioned in the matrix clause, and thus, should arouse listeners' emotion). The results of this study and that of Rohde, Levy, and Kehler (2011) indicate that intra-sentential context affects attachment as readers use causal justification (Rohde, Levy, & Kehler, 2011) and world knowledge (Siriwittayakorn, Miyamoto, & Ratitamkul, 2015) to determine attachment.

For effects of inter-sentential context, Desmet, De Baecke, and Brysbaert (2002) conducted a reading experiment in Dutch, a language with N1 attachment preference when the two nouns are animate-concrete. In the experiment, the sentence containing the target construction was preceded by a context. Their assumption was that if the discourse context introduced more than one potential referents either for N1 or for N2, participants would prefer attaching the RC to that noun so as to define whom exactly was being mentioned. An English-translated example of the test items with context favoring N2 attachment is given in (20).

(20) The judicial police are investigating a political scandal. An advisor, working for politicians, is charged with fraud. Although some politicians are seized by panic, the other ones remain calm.

a. N1 attachment

The police interrogate the advisor of the politicians who speaks with a soft voice.

b. N2 attachment

The police interrogate the advisor of the politicians who speak with a soft voice.

In (20), attachment was disambiguated using number agreement (singular in (20a), plural in (20b)). It was expected that in this type of test items, context would reverse attachment preference from N1 to N2 such that N2-attachment continuation (20b) would be read faster than N1-attachment continuation (20a). However, it was found that N1-attachment continuation was read faster than N2-attachment continuation regardless of discourse context, thus suggesting that inter-sentential context does not affect RC attachment (see Zagar, Pynte, & Rativeau, 1997, for comparable results for French).

It should be noted that the studies in Dutch (Desmet, De Baecke, & Brysbaert, 2002) and in French (Zagar, Pynte, & Rativeau, 1997) did not control for the effect of intra-sentential. Therefore, the lack of inter-sentential context effect and the preference for N1 attachment in the two langauges might result from intra-sentential context favoring N1.

3.4.2 Animacy and concreteness

The definitions of animacy and concreteness used in this dissertation are based on the discussions in the study of Desmet and colleagues (Desmet, Brysbaert, & De Baecke, 2002; Desmet et al., 2006), a study investigating the effect of animacy and concreteness on RC attachment. The definitions of each type of nouns are as follows.

- Animate nouns: nouns referring to living entities such as a person, a non-human
- Inanimate nouns: nouns referring to non-living entities such as a place, an object, an idea
- Concrete nouns: nouns such as those referring to people and objects, which can be perceived through the five senses (i.e., touch, hearing, sight, smell and taste)
- Abstract nouns: nouns such as those referring to thought, which cannot be perceived through five senses

The four types of nouns above yield four combinations as illustrated below. Examples of nouns in each combination are also given.

- animate-concrete: man, dog
- animate-abstract: government agency, trade union
- inanimate-concrete: house, box
- inanimate-abstract: goodness, loyalty

Mitchell and Brysbaert (1998) found that in Dutch, corpus frequencies did not match the comprehension preference for RC attachment. While the corpus data indicated that N2 attachment was more frequent than N1 attachment, the comprehension data showed a preference for N1 attachment. This piece of evidence was used for arguing against experience-based accounts. The problem with this study is that animacy and concreteness were not taken into consideration.

Later studies in Dutch found that RC-attachment frequencies in corpora were modulated by animacy and concreteness (Desmet, Brysbaert, & De Baecke, 2002; Desmet et al., 2006). This is because animate and concrete nouns are conceptually salient; therefore, they attract RCs (Desmet et al., 2006). The conclusions of the corpus count results in Dutch are summarized below.

I) The target construction was far more common when N1 was inanimate.

II) The frequency of the target construction was lowest when the two nouns were animate-concrete.

III) When collapsed across animacy patterns, N2-attachment was more frequent.

IV) There was no effect of N2-animacy.

V) Animate N1 attracted RCs such that there was an N1-bias when N1 was animate.

VI) There was an effect of N1 concreteness. That is, there was a strong N1-bias when N1 was animate-concrete but there was a strong N2-bias when N1 was inanimate-abstract.

Moreover, Desmet et al., (2006) conducted a reading experiment in Dutch to test whether the results would be compatible with the corpus data. There were two factors in a 2 x 4 design. The first factor was attachment: N1 or N2 attachment. The second factor was the type of N1: animate-concrete (e.g., "advisors"), animate-abstract (e.g., "organizations"), inanimate-concrete (e.g., "documents"), or inanimate-abstract (e.g., "decisions"). For N2, animate-concrete nouns were used for all conditions. An English-translated example pair of test sentences with animate-concrete N1 is given in (21).

(21)

a. N1 attachment

The population without any future perspectives respects the **advisors** of the **president** that <u>guarantee</u> there will be no war.

b. N2 attachment

The population without any future perspectives respects the **advisors** of the **president** that <u>guarantees</u> there will be no war.

In (21), the nouns in bold are N1 and N2. Attachment was disambiguated using number agreement on the verb (as underlined in the examples). According to the corpus results, Desmet et al. (2006) predicted that N1 attachment would be observed only when the two nouns were animate-concrete (e.g., (21)). For the other conditions, an N2 preference should be observed.

As predicted, Desmet et al. (2006) found that there was an interaction between the type of N1 and attachment. According to planned comparisons, N2 attachment was reliably slower than N1 attachment when both nouns were animate-concrete (as in 21). For the other conditions, the difference between the RTs to N1 and to N2 attachment versions was not reliable, but there was a numerical trend for N2 to be read faster than N1. Desmet et al. (2006) also found that there was a correlation between corpus data and RT data. The fact that attachment preference can be changed depending on animacy and concreteness of the two nouns suggested that these lexical features affect RC attachment (Desmet et al., 2006; see also Gennari & MacDonald, 2008; Gordon, Hendrick, & Johnson, 2001; Mak, Vonk, & Schriefers, 2002; Traxler et al., 2005; for the effect of animacy on other constructions).

Desmet and colleagues (Desmet, Brysbaert, & De Baecke, 2002; Desmet et al., 2006) argued that the effect of animacy and concreteness on RC attachment was evidence supporting experience-based accounts, but only for the versions that allowed detailed lexical information to come into play. The results of studies in Dutch (Desmet, Brysbaert, & De Baecke, 2002; Desmet et al., 2006; see also Acuña-Fariña et al., 2009 for similar animacy effects in Spanish) suggest that studies on RC attachment that ignore animacy and concreteness are incomplete in their conclusion (e.g., Mitchell and Brysbaert, 1998).

3.5 A previous study on RC attachment in Thai

RC attachment in Thai has been investigated with a corpus count a reading experiment (Siriwittayakorn et al., 2014). In the corpus count, lexical factors (animacy and concreteness) as well as context were taken into consideration. The results of the count indicated that N1 attachment was more frequent than N2 attachment regardless of animacy and concreteness. The result that lexical factors did not affect attachment contradicted results in Dutch (Desmet, Brysbaert, & De Baecke, 2002; Desmet et al., 2006) and in Spanish (Acuña-Fariña et al., 2009). Moreover, context was found to favor N1 attachment. However, the N1 preference remained even after removing instances where context did not determine attachment.

In the reading experiment, the two head nouns were animate-concrete and the target construction was placed after the matrix predicate. The ambiguity was resolved by means of plausibility (see (22) for an example of items used).

(22)

a. N1 attachment

คุณพ่อฝากของให้คุณครูของลูกชายที่สอนวิชาภาษาไทย

khunphɔ̂: fà:k khɔ̌:ŋ hâj khunkhru: khɔ̌:ŋ lû:kcha:j

father leave thing give teacher of son

thî: sɔ̌:n wíʔcha: pha:sǎ:thaj

that teach subject Thai language

“The father left something for the teacher of his son that teaches Thai.”

b. N2 attachment

คุณพ่อฝากของให้คุณครูของลูกชายที่สอบตกวิชาภาษาไทย

khunphɔ̂: fà:k khɔ̌:ŋ hâj khunkhru: khɔ̌:ŋ lû:kcha:j

father leave thing give teacher of son

thî: sɔ̀:ptòk wíʔcha: pha:sǎ:thaj

that fail subject Thai language

“The father left something for the teacher of his son that failed a Thai exam.”

In (22a), the RC (*thî: sɔ̌:n wíʔcha: pha:sǎ:thaj* “that teaches Thai”), is attached to N1 (*khunkhru:* “teacher”) as the teacher is more likely to teach Thai. In (22b), however, the RC (*thî: sɔ̀:ptòk wíʔcha: pha:sǎ:thaj* “that failed a Thai exam”) is attached to N2 (*lû:kcha:j* “son”) as the son is more likely to be the one who failed the exam.

It was found that N1-attachment sentences (as in 22a) were read faster than N2-attachment sentences (22b). Therefore, both RT results and corpus frequencies indicated that N1 attachment was preferred in Thai. The results are compatible with experience-based accounts, which assume that RT preferences reflect corpus frequencies.

However, there were a number of confounds. Firstly, in the corpus count, instances of SCs were mistakenly counted as RC instances. This may have inflated the number of N1 attachment instances and hence obscured the importance of lexical factors. Secondly, in the reading experiment, the string *N1 khɔ̌:ŋ N2 thî: RC* was placed after the matrix predicate. Therefore, it might be the case that the matrix clause played a role in RC attachment (see Section 3.4.1, for the effect of context on RC attachment). Finally, in the experiment, there was a line break between N2 and the RC, which may have favored N1 (see Section 3.3 for the *implicit prosody hypothesis*). These confounds are addressed in more careful corpus counts and reading experiments reported in this dissertation. Since the previous corpus count and the reading experiment (Siriwittayakorn et al., 2014) showed that there was an N1 attachment preference in Thai, it is tentatively hypothesized that even after the confounds have been addressed, N1-attachment preference should still be observed.

3.6 Summary

Experience-based accounts propose that readers' past experience guides the way they process new sentences. However, it is still unclear whether it is only experience with the target construction or both experience with the target constructions and experience with similar ones that affect readers' processing. If it is the latter case, it is not clear how similar a construction has to be in order for transfer to occur.

In Thai, RCs are similar to SCs in terms of marker, order of the clause in relation to the head noun and in some cases a missing constituent. Therefore, the word orders of the two constructions are superficially identical. Through the study of RC attachment in Thai, the similarities between RCs and SCs provide an opportunity for investigating the role of experience with the target construction and with a similar construction, namely SCs. Since a previous study (MacDonald & Christiansen, 2002) found that similarity in terms of word order can cause processing transfer, it is hypothesized that there should be processing transfer between constructions with identical word order such as RCs and SCs in Thai.

The effect of experience with target constructions was reported in several previous studies (Fine et al., 2013; Kamide, 2012; Wells et al., 2009). However, such effects were measured in a low degree of freedom situation. Therefore, it can be the case that the effect of experience found in those studies is situation specific and might not imply that experience can change readers' preference. More studies are needed to address such concerns.

For RC attachment in previous literature, it was found that readers from different languages had different attachment preferences. Many accounts including experience-based accounts have tried to explain such cross-linguistic difference. However, a proper conclusion cannot be drawn. Contextual and lexical factors were also found to affect RC attachment. Therefore, in order for results across languages to be compared and for an accurate conclusion to be made, studies investigating RC attachment should pay attention to these factors.

In Thai, a previous study on RC attachment (Siriwittayakorn et al., 2014) reported an N1 preference both for a corpus count and for a reading experiment. However, a number of confounds such as the inclusion of SCs in the corpus count, and the effects of line breaks and context in the reading experiment should be addressed in more careful studies. Based on the previous results (Siriwittayakorn et al., 2014), it is hypothesized that after the confounding factors are factored out, N1-attachment preference should still be observed.

Chapter 4
Corpus count

Experience-based accounts hypothesize that readers process new sentences based on their past experience; therefore, comprehension processes as measured in a behavioural experiment should reflect the frequency observed in corpus counts, under the assumption that corpora are representative of readers' past experience. Moreover, according to MacDonald and Christiansen (2002), it is not only the frequency of the construction under investigation that affects later processing but the frequency of similar constructions can also affect the comprehension process as well. In this dissertation, the assumptions of the experience-based accounts about the effect of experience with a particular construction and the effect of experience with similar constructions on comprehension are tested using RC attachment in Thai (i.e., *N1 khɔ̌ːŋ N2 thîː RC*, the target construction).

In this chapter, a corpus count in Thai is conducted to investigate the frequencies of RC attachment and determine which attachment pattern, N1 or N2 attachment, occurs most frequently. Based on a previous study in Thai (Siriwittayakorn et al., 2014), it is hypothesized that N1 attachment will be more frequent than N2 attachment. Moreover, because in Thai, SCs (as in *N1 khɔ̌ːŋ N2 thîː SC*, where the SC complements the meaning of the noun in the complex noun phrase) are similar to the target construction, the corpus count also include SC attachment. The results of the corpus count will be used to test whether the corpus count is compatible with the results of RT experiments and will be used as predictors for comprehension experiments testing whether SCs can affect the processing of RCs.

4.1 Methodology

A total of 4,800 instances of *khɔ̌ːŋ* “of” followed by *thîː* “that” with up to three intervening words were randomly selected from the six writing genres of the Thai National Corpus (approximately 32 million words; genres: fiction, newspaper, academic text, non-academic text, law and miscellanea; Aroonmanakun, Tansiri, & Nittayanuparp, 2009). The corpus sentences used for conducting the count are the same as those reported in Siriwittayakorn et al.’s (2014) and in Siriwittayakorn, Miyamoto, and Ratitamkul’s (2015). However, in Siriwittayakorn et al.’s (2014), instances of SCs were counted as RCs. In Siriwittayakorn, Miyamoto, and Ratitamkul (2015), mistakes in the 2014 study were corrected by counting SCs and RCs separately, using a gap as a criterion for differentiating RCs and SCs (but see Chapter 3, Section 3.2 for problems with such criterion). With different criteria (see Chapter 3, Section 3.2.2 for SC criteria used in this dissertation), the results in this chapter are slightly different from those in Siriwittayakorn, Miyamoto, and Ratitamkul’s (2015) study; but the overall trends are the same.

From the 4,800 instances, 2,556 irrelevant instances were eliminated. These were instances in which *thîː* was not used as an RC marker or *khɔ̌ːŋ* was not a preposition. The remaining 2,244 instances of *N1 khɔ̌ːŋ N2 thîː clause* were separated into either RCs or SCs. There were 2,065 instances of the target construction and 179 instances of SCs.

From the 2,065 instances of RCs, instances were eliminated if RC attachment was ambiguous (356 instances, 17.24%); if one of the head nouns was a pronoun, a proper name or a noun that biased attachment by requiring further information (e.g., *khōn* "person", *sìŋ* "thing"; 704 instances, 34.09%); or if they were repetitions (14 instances, 0.68%). Because the distinction is often subtle, RCs were not classified as restrictive or non-restrictive (see Wasow, Jaeger, & Orr, 2011, on the difficulty in such classifications), but some non-restrictives were probably eliminated as all instances of proper names as head nouns were excluded. After exclusion, there were 991 instances left.

Since coherence is important in writing (Trabasso, Suh, & Payton, 1995), it could be the case that instances of RCs found in the corpus are produced and attached according to the context that surrounded the target construction. Even though RC attachment may be affected by the surrounding context, almost all corpus studies have not taken contextual effects into account. In this chapter, these effects were taken into consideration. The remaining 991 instances of RCs were classified according to contextual effects. The process was done by using the position of the disambiguating point as an indicator specifying whether context was involved in the attachment decision.

If the disambiguating point was in the target construction (i.e., readers do not have to consult the surrounding context to determine attachment), it was coded as *internally-disambiguated*. We are assuming that attachment of internally-disambiguated instances was largely independent of context. An example is given in (1).

(1) เสียงของผู้ชายที่ถูกเปล่งออกมา

síəŋ khɔ̌ːŋ phûːchāːj thîː thùːk plèŋ ʔɔ̀ːk māː

voice of man that PASSIVE utter out come

“voice of man that was uttered”

In (1), attachment can be resolved within the target construction because only *síəŋ* “voice” can be uttered, and thus, can be modified by the RC.

If the disambiguating point was outside the target construction, it was coded as *externally-disambiguated*. In other words, attachment of externally-disambiguated instances was regarded to be context-dependent. An example is in (2).

(2) กรุงเทพเป็นเมืองหลวงของประเทศที่ยังคงมีกลิ่นอายของแหล่งประวัติศาสตร์

krūŋthêːp pēn mɯ̄əŋlǔaːŋ khɔ̌ːŋ pràʔthêːt thîː yāŋkhōŋ mīː

Bangkok is capital of country that still have

klìnʔāːj khɔ̌ːŋ lɛ̀ŋ pràʔwàtsàːt

scent of site historical

“Bangkok is the capital of the country that the presence of the historical sites still lingers in the air.”

In (2), without the matrix clause *krūŋthêːppēn* “Bangkok is”, it is unclear which noun (*mɯ̄əŋlǔaːŋ* “capital” or *pràʔthêːt* “country”) is modified by the RC. When the matrix clause is taken into consideration, *mɨ̄əŋlǔaːŋ* “capital” is more likely to be modified by the RC because it is associated with *krūŋthêːp* “Bangkok” mentioned in the matrix clause.

Saliency as dictated by the animacy and concreteness of N1 and N2, has been claimed to affect attachment (Desmet et al., 2006) and may interact with coherence (e.g., more salient nouns may lead to stronger coherence requirements). Since animate-concrete nouns will be used in reading experiments, instances in which N1 and N2 were animate-concrete (see Chapter 3 Section 3.4.2 for animacy and concreteness criteria) are also reported separately so that predictions for reading experiments specific to this type of nouns can also be made (see Appendix 3 for a count where instances were classified according to animacy and concreteness).

In sum, the relevant 991 instances were coded according to attachment (N1 or N2) and the position of the disambiguating point (internally-disambiguated or externally-disambiguated). Attachment pattern of instances in which the two head nouns were animate-concrete were also reported.

For the SC count, since SCs attach only to a propositional noun (see Chapter 3, Section 3.2.2 for criteria for a noun to be a propositional noun), context, and animacy and concreteness of the nouns are less likely to bias attachment. Therefore, the instances are not separated according to these factors. The attachment of SCs does not depend on whether one of the nouns was a biasing noun, a pronoun or a proper name either. In other words, those types of nouns cannot bias attachment in one way or another, unlike the case of RC attachment. Therefore, instances containing a biasing noun, a pronoun or a proper name as one of the head nouns were also counted in the SC count.

Two native Thai speakers coded all instances independently. Disagreements (5.22%) were settled after discussion with a third native Thai speaker.

4.2 Results

4.2.1 Results for RC attachment

Table 4.1 illustrates corpus frequency of the construction *N1 khɔ̌ːŋ N2 thîː RC*.

Table 4.1 Corpus frequency of *N1 khɔ̌ːŋ N2 thîː RC*

Position of disambiguating point	animate-concrete N1 animate-concrete N2		Total	
	N1	N2	N1	N2
Internally	9	12	401	480*
Externally	1	2	70*	40
Total	10	14	471	520

[1]*: frequency for RCs to attach to the indicated noun was reliably higher than 50% ($p < .05$ according to exact binominal tests)

In the table, the first column indicates whether ambiguity was resolved within or outside the target construction (i.e., whether context was needed for disambiguation). For the second column, the count was restricted to instances with animate-concrete head nouns. The third column contains the total number of all instances regardless of lexical information, namely animacy and concreteness. It should be noted that in the table, the frequencies reported in some cells were lower than five. Therefore, to determine whether frequencies of N1 or N2 attachment were reliably higher than 50% and to keep all analyses in the table the same, exact binominal tests were run (see Chapter 2, Section 2.3 for more details on such statistical tests). In the table, asterisks indicate that frequencies for RCs to attach to the indicated noun were reliably higher than 50% ($p < .05$). For the results reported in the text, when the frequencies were higher than five, and thus allowed the use of chi-square goodness of fit test, the chi-square was reported.

The first part of the results will be focused on the count in which lexical information was ignored (the *Total* column). When the count was restricted to instances in which ambiguity was resolved within the target construction (i.e., internally-disambiguated instances, the first row), and thus attachment was not contaminated by contextual effect, there were 401 instances with N1 attachment (45.52%) and 480 instances with N2 attachment (54.48%). From the percentages of N1 and N2 attachments, it can be said that N1-N2 attachment proportion was about 46-54. The bias towards N2 attachment was reliable ($\chi2$ (1) = 7.08, $p = .008$).

For externally-disambiguated instances (i.e., instances that context was needed for disambiguation), there was a reverse in the attachment pattern. That is, N1 attachment was more frequent than N2 attachment (N1 attachment: 70, 63.64%; N2 attachment: 40, 36.36%; $\chi2$ (1) = 8.18, $p = .004$). The fact that context often favored N1 is not surprising. To increase text coherence, writers may prefer N1 attachment as it is the head of the target construction and is part of the outer clause (e.g., the matrix clause).

For the last row of the *Total* column, the count included all instances regardless of the position of the point of disambiguation (i.e., regardless of context) and lexical information. Although the frequency of N2 attachment was numerically higher than that of N1 attachment (N1 attachment: 471, 47.53%; N2 attachment: 520, 52.47%), the difference was not reliable ($\chi2$ (1) = 2.42, p = .12). The weaker N2 preference shows that context can obscure the N2-bias.

For instances in which two head nouns were animate-concrete (the second column), the internally-disambiguated row shows that there were nine instances of N1 attachment (57.14%) and 12 instances of N2 attachment (42.86%). In other words, when the two nouns were animate-concrete, N1-N2 proportion was 57-43. Although there was no bias either towards N1 or N2 attachment, the frequency of N2 attachment was numerically higher than that of N1 attachment. Trend was the same when all instances including both internally- and externally-disambiguated instasnces were counted together. All the results in the second column suggest that for animate-concrete nouns, there was a numerical trend for N2 attachment to be more frequent than N1 attachment regardless of whether context was taken into consideration.

The trend for RC to attach to N2 in Thai when the two head nouns were animate-concrete (out of 881 internally-disambiguated instances, N1: 9, N2: 12; or out of 991 instances regardless of context, N1: 10, N2: 14) contradicts the trend reported in Dutch, as in Dutch when both nouns were animate-concrete, there was a numerical trend for RCs to attach to N1 (out of 1,065 instances regardless of context, N1: 19, N2: 10). However, in both languages, the numbers were small and the attachment bias was not reliable.

4.2.2 Results of SC attachment

There were 179 instances of SCs. The propositional nouns were inanimate abstract nouns (e.g., "duty", "right"). These nouns could be either in an N1 or in an N2 position. Of these 179 instances, there were 177 instances (98.88%) with N1 attachment and two (1.12%) instances with N2 attachment (see Chapter 3, Section 3.2.2 for examples of SCs; see also Chapter 7, Section 7.2.2 for an example of N1-attached SC).

If MacDonald and Christiansen's (2002) claim stating that both experience with the target construction and experience with similar constructions can affect the processing of the target one is right, it might be possible for experience with SCs to affect the processing of RCs, given their similarities. To determine what might happen if readers use both experience with RCs and experience with SCs to process RCs, the number of SCs was added to the number of RCs. It was found that regardless of animacy and concreteness of the two head nouns, for internally-disambiguated instances N1 attachment was more frequent than N2 attachment (N1-N2: 578-482, N1%: 54.53, $\chi 2$ (1) = 8.6943, p = .003; for all instances including both internally- and externally-disambiguated instances: 648-522, N1%: 55.38, $\chi 2$ (1) = 13.569, p < .001). These results will be used for making predictions for reading experiments which will be further discussed in the following section.

4.3 Discussion

From the corpus counts, it was found that for RC instances, N2 attachment was more frequent than N1 attachment when contextual effects were excluded and the counts were restricted to internally-disambiguated instances. The results falsify our working hypothesis stating that in production data of RC attachment, N1 attachment is more frequent than N2 attachment. The results contradict the results of a previous corpus count in Thai (Siriwittayakorn et al., 2014) reporting that N1 RC-attachment was more frequent than N2 RC-attachment regardless of contextual effects. In the previous corpus count, SC instances were mistakenly counted as RC instances; therefore, inflating the frequency of N1 attachment. This is clear in the new counts reported here as virtually all SCs were attached to N1 (177 out of 179 instances).

If experience as reflected in corpus frequencies affects comprehension as argued by experience-based accounts, it is expected that the results of reading experiments should be compatible with the corpus frequency. The predictions based on the results of the corpus counts for reading experiments in which the two head nouns are animate-concrete are summarized in Table 4.2.

Table 4.2 Predictions for reading experiments based on the results of the corpus count

RC disambiguation	SCs	Granularity	Corpus results	Prediction for reading experiments
Internally	Not included	N1: animate-concrete N2: animate-concrete	N2	(N2 preference)
		N1: all N2: all	N2*	N2 preference
	Included	N1: all N2: all	N1*	N1 preference
Internally + Externally	Not included	N1: animate-concrete N2: animate-concrete	N2	(N2 preference)
		N1: all N2: all	N2	(N2 preference)
	Included	N1: all N2: all	N1*	N1 preference

[1]all: all instances, regardless of animacy and concreteness

[2]*: reliable frequency differences (p < .01 according to exact binominal tests)

[3]( ): either a preference or a trend towards the indicated direction

In the first column of Table 4.2, point of disambiguation is used to indicate whether the predictions are based on the results excluding the contextual effect. That is, rows marked *internally* are restricted to instances where RC attachment can be resolved within the construction *N1 khɔ̌ːŋ N2 thîː RC*. Thus, attachment of the instances in these rows was independent of surrounding context. On the other hand, rows marked as *internally + externally* included all RCs regardless of whether context was needed for disambiguation (i.e., regardless of context). As indicated by the second column, the predictions are divided into two groups depending on whether or not SCs are included into the count. Even though this dissertation does not aim to test the effect of animacy and concreteness, the third column shows which features of the nouns (i.e., animacy and concreteness) are taken into consideration when making predictions such that predictions restricted to animate-concrete head nouns and predictions in general (i.e., regardless of lexical information) can be tested. The fourth column summarizes the results of the corpus count. Reliable frequency differences (i.e., $p < .01$ according to exact binominal tests) are indicated with an asterisk; all others cells are numerical trends ($p > .1$). The last column shows the predictions for the reading experiment. Parentheses indicate that there could be either a preference or a trend (not statistically reliable) towards the indicated direction since the difference between N1 and N2 attachments in the corpus count was not reliable.

For example, the first row of the table shows that when the count is restricted to RC instances in which contextual effects are factored out and both nouns are animate-concrete, there was a numerical trend for N2 attachment; therefore, there should be a preference (or a trend) for N2 in the reading experiments.

It would be preferable to restrict the predictions only to the first half of the table (as indicated by *internally* in the first column) as the results of the count is not contaminated by context and would be more similar to the experimental setting, where sentences are shown in isolation without prior context. However, the bottom half of the table is comparable to what has been reported in previous studies in other languages (previous study did not exclude contextual effect; Desmet et al., 2006), and the predictions for the reading experiments in Thai are largely the same, except for the strength of the predictions.

From Table 4.2, it can be seen that when only the count of RC attachment is considered, all the predictions for the reading experiments are in the same direction regardless of whether animacy and concreteness factors (as indicated in the third column) are taken into consideration. That is, for the count of RC attachment, the direction of all the predictions goes towards N2 preference. Therefore, the results of reading experiments reported in this dissertation cannot be used as evidence arguing for or against the claim that animacy and concreteness factors should be taken into consideration when conducting a corpus count so that an accurate prediction for reading experiments can be made (see Desmet et al., 2006 for related discussion; also Chapter 3, Section 3.4.2).

More importantly, the attachment preference predicted by the corpus results can be N1 or N2 depending on whether SCs are included in the counts or not. Therefore, no matter how the results of the reading experiments will be (i.e., whether N1 or N2 attachment preference is found), the results can be accounted for by some versions of the experience-based accounts (i.e., the version that proposes that experience with the target construction alone affects processing or the version that proposes that both experience with the target construction and experience with similar constructions affect processing). Therefore, the assumption of the experience-based accounts which states that the most frequently found pattern will be the pattern readers prefer in comprehension cannot be falsified by the evidence from the reading experiments on RC attachment in Thai, but the results of reading experiments can tell us of which version of experience is more likely to account for the data.

Therefore, based on the predictions made from the results of the corpus counts, what is tested in the next two experiments is which type of experience (i.e., experience with RCs, or experience both with RCs and with SCs) is compatible with the results of the reading experiments. In other words, the next two experiments tests whether experience with SCs can affect the processing of RCs by means of compatibility between corpus counts and behavioral experiments.

Chapter 5
Experiment 1

By assuming that experience as can be determined by corpus frequencies affects comprehension, the results of the corpus count in Chapter 4 predict that if only experience with RCs can affect later processing of RC attachment, there will be a trend or a preference for N2 attachment in comprehension experiment. This is regardless of animacy and concreteness of the head nouns. However, if both experience with RCs and experience with a similar construction, namely SCs, affect later processing, there will be a preference for N1 attachment (see Table 4.2 in Chapter 4, Section 4.3. for more details about the predictions).

In this chapter, we test the effect of experience with RCs and SCs on the processing of RC attachment through the compatibility between corpus data and the results of off-line reading experiment. That is, attachment preference after reading a sentence is investigated to determine which type of experience as indicated by corpus data (i.e., only experience with RCs, or both experience with RCs and SCs) affects comprehension.

Another goal of this experiment is that in a previous study (Fine et al., 2013), it was found that experience with test sentences which were unambiguous affected processing such that there was a change in preference as experiments progressed. In this experiment, we will expand the previous finding by exploring whether experience with ambiguous sentences affects preference along the experiment. The results of this experiment will be used for setting up Experiment 3.

In this and the other two subsequent experiments, only animate-concrete head nouns (i.e., human nouns) will be used so that the results can be compared to previous reports for other languages. As discussed in Chapter 4, it should be noted that whether or not lexical information namely animacy and concreteness can affect RC-attachment cannot be falsified by the results of this and any of the subsequent experiments. This is because regardless of such information, the corpus data predict the same results for the effect of experience with RCs on RC-attachment processing (i.e., N2 preference).

Before moving further, two hypotheses proposed in this dissertation need to be considered. Firstly, based on previous results of an RT experiment in Thai (Siriwittayakorn et al., 2014; see also Chapter 3, Section 3.5 for confounds that may have distorted these results), it is hypothesized that there will be an N1 attachment preference in comprehension compatible with the frequency pattern found in the corpus. As predicted by the corpus results, both N1 and N2 attachment is possible for reading experiments depending on whether or not SCs instances were counted together with RC instances. Thus, no matter how the results of this experiment turn out to be, the attachment preference in comprehension process will be compatible with the corpus frequency. Secondly, in this dissertation, it is hypothesized that both experience with RCs and experience with SCs affect the processing of RC attachment. For the two hypotheses to be validated, N1-attachment preference should be observed in this experiment as predicted by the results of the corpus count including both RCs and SCs instances.

5.1 Methodology

5.1.1 Participants

Twenty native Thai speakers volunteered to participate in the experiment. However, two participants were eliminated from the analyses reported because one of them had taken part in an earlier experiment on RC attachment and the other one reported to have studied in an English program in high school. Therefore, the results reported are from 18 participants (trends for the results were the same with 20 participants).

5.1.2 Materials

Since one goal of this dissertation is to investigate the effect of experience with test sentences on the processing of RC attachment, the number of items used in this experiment is larger than if we were just testing the factor *attachment* (see Chapter 2, Section 2.1.1 for more details about the number of test items).

A total of 24 ambiguous sentences in which an RC can be attached to either of two nouns in a complex noun phrase were created. To avoid possible confounds related to extraction position, all RCs were subject extracted. An example of test sentences is shown in (1).

(1) โค้ชของนักวิ่งที่วาดรูปสวยกำลังจะออกบวช

khó:t khɔ̌:ŋ nákwîŋ thî: wâ:t rû:p sǔaj kāmlāŋ-càʔ

coach of runner that draw picture beautifully MODAL

ʔɔ̀:kbùat

become-a-monk

"The coach of the runner that is good at drawing is going to become a monk."

In (1), the sentence is ambiguous because it is possible for either *khó:t* "coach" (N1) or *nákwîŋ* "runner" (N2) to be good at drawing.

To control for the effect of intra-sentential context, matrix clauses unrelated to the RCs were created (e.g., in (1), there is no relation between being good at drawing and becoming a monk). Five native Thai speakers who did not participated in any of the experiments reported in this dissertation confirmed that they could not find a relation between the topics in the RC and the matrix clause.

To make sure that it was equally plausible for the RC to modify either of the two nouns such that world knowledge or plausibility would not bias attachment in one way or another and thus contaminate the results of the experiment, a norming questionnaire was conducted. An initial set with as many items as it was possible to create were created and the best 28 items as (1) were used in the questionnaire. The RC of each item was paraphrased into two versions: N1 interpretation and N2 interpretation. For each version, the matrix clause was added as it may bias the interpretation of the RC (see Chapter 3, Section 3.4.1 for the effect of context). See (2) for the two versions created for (1).

(2)

a. N1-interpretation

โค้ชของนักวิ่งกำลังจะออกบวช

khó:t khɔ̌:ŋ nákwîŋ kāmlāŋ-càʔ ʔɔ̀:kbùat

coach of runner MODAL become-a-monk

"The coach of runner is going to become a monk."

โค้ชของนักวิ่งวาดรูปสวย

khó:t wâ:t rû:p sǔaj

coach draw picture beautifully

"The coach is good at drawing."

b. N2-interpretation

โค้ชของนักวิ่งกำลังจะออกบวช

khó:t khɔ̌:ŋ nákwîŋ kāmlāŋ-càʔ ʔɔ̀:kbùat

coach of runner MODAL become-a-monk

"The coach of runner is going to become a monk."

นักวิ่งวาดรูปสวย

nákwîŋ wâ:t rû:p sŭaj

runner draw picture beautifully

"The runner is good at drawing."

Sentences were distributed into two lists according to a Latin Square design. Each participant saw one list of the questionnaire. They rated each pair of sentence on a five-point scale (1 implausible, 5 plausible; see Appendix 4 for an example of a norming questionnaire). Apart from the test sentences, three fillers in which the interpretation was clearly unnatural were also included in the questionnaire to check whether participants were paying attention.

A new group of 35 native Thai speakers who did not participate in the main experiment answered the questionnaire. However, results reported are from 30 participants as five of them had participated in an RC-attachment experiment before, gave a wrong answer to one of the filler items, or did not finish the questionnaire. Out of the 28 items tested, 24 items with the smallest median differences across the two types of attachments were chosen. Of these 24 items, the largest median difference was

0.5 (see Appendix 5 for median plausibility-rating scores of each item; for the four excluded items, the smallest median difference was 1.5). Wilcoxon signed rank test results for the analyses by subjects and by items indicated that the two interpretations were equally natural ($V_1 = 0$, $p = .346$; $V_2 = 0$, $p = 1$).

According to the norming results, 24 items were used in Experiment 1 (see Appendix 5 for the list of test items). Since the results indicated that these 24 items were equally natural with either type of interpretation, whatever differences in the main experiment were unlikely to be related to differences in plausibility between the two types of RC attachment.

Apart from test sentences, 60 fillers were created. The filler constructions are as follows and the number of items is indicated in parentheses.

- *N1 khɔ̌:ŋ N2 thî:* not followed by an RC (8 items)
- *N1 khɔ̌ŋ N2* not followed by *thî:* (8 items)
- *thî:* not followed by RC (8 items)
- other unambiguous constructions not containing a complex NP with *khɔ̌:ŋ*, a *thî:* marker, and an RC (8 items)
- other ambiguous constructions such as pronominal ambiguity and adverb of time attachment (28 items)

For these 60 fillers, there were six items which involved a construction in which *thî:* introduced an unambiguous RC (i.e., schematically *N thî: RC*).

5.1.3 Procedure

Participants in this and other subsequent experiments sat alone in a room and read the sentences from a 14-inch laptop. The experiment was run using E-prime 2.0. All sentences and questions were presented in the monospaced font RD CHULAJARUEK Regular.

For this experiment, a whole-sentence presentation was adopted (see Chapter 2, Section 2.2 for more details; see also Appendix 1 for an example of instructions and presentation). Test items were shown in a fixed pseudo-random order interspersed with 60 fillers so that at least one filler intervened between test items. Sentences were shown individually without line breaks.

After each sentence, a question was displayed on a new screen. This procedure was adopted to prevent participants from consulting previous items or re-reading the sentence when answering the question and thus, noticing the ambiguity. Each question was followed by two alternatives with the order counterbalanced across items. For the test items, the question was about attachment (e.g., "Who is good at drawing?") with N1 (e.g., "coach") as the first alternative for half of the items and as the second alternative for the other half. For 46 fillers, the question had only one possible answer to verify that participants were paying attention. For the other 14 fillers which were ambiguous sentences, the questions asked about the ambiguity to make them similar to the test items.

The test session was divided into two sub-sessions with an optional break in-between and lasted for about 15 minutes.

5.1.4 Analyses

All participants scored over 95% correct in the 46 fillers with only one correct alternative; therefore, none of them was eliminated from the analyses.

Since the data collected were from forced binary-choice questions and thus were regarded as a categorical variable, analyses were performed using mixed logit models (see Chapter 2, Section 2.3 for more details on advantages of mixed logit models over ANOVA). In the analyses, participants' responses choosing N1 as the attachment site were coded as 1 and those for N2 were coded as 0. These responses were set as the dependent variable.

A previous study (Fine et al., 2013) suggested that participants' preferences did not remain stable across the experiment. For this experiment, as the experiment progressed, there were three possible scenarios for the change in attachment patterns. First, participants started the experiment with a weak preference and ended up with a strong preference for a given noun. Second, they started with a strong preference but ended up with a weak preference for a given noun. Third, there was a reverse in the attachment pattern. Therefore, to test whether participants' preferences changed as the experiment progressed, two factors were included. The first factor was test-item order (i.e., TIorder), which is the number of test items read up to each point in the experiment. The TIorder was added to the model to test whether exposure to test items (ambiguous RCs) affected participants' responses. The second factor was the trial number including both test items and fillers participants had read at each point in the experiment (i.e., Sorder). The Sorder was added to capture the general trend for participants to get used to the experimental setting. Another reason for including Sorder is to factor out the effect of fixed trial order. For Sorder, because the effect is usually smaller for later trials (i.e., with large trial number), trial number was log transformed (i.e., logSorder) to decrease the importance of large numbers.

There is not a priori reason for assuming TIorder and logSorder to affect the results of the analyses in one way or another. However, they were included in the models such that the results of this experiment can be used as a baseline for the test on the effect of exposure manipulation that is going to be conducted in Experiment 3.

Trends for results reported are the same when logSorder was removed from models or was replaced with raw Sorder. Trends are also the same when none of the factors was included in the model.

Random intercepts were included for participants and items. According to backward selection (see Chapter 2, Section 2.3 for related discussion on backward selection), only logSorder was included in the by-participants random slope. The formula is provided in (3).

(3) response ~ TIorder + logSorder + (1 + logSorder | participant) + (1 | item)

In (3), the tilde (~) indicates that the variable on its left is the dependent variable, which is to be explained according to the variables on the right. The variables on the right can be called independent variables, fixed factors, or predictors. In (3), we are investigating the relationship between responses (N1 or N2) participants gave to the question of each test item, and TIorder and logSorder. A plus "+" sign, which links the two variables (TIorder and logSorder in (3)) indicates that only the individual variables but not the interaction are included as fixed factors. If the interaction between the two variables is also included, the two variables are linked with an asterisk "*".

Responses from the same participant cannot be considered independent because they are affected by the personal idiosyncrasies of this participant. To account for individual differences, participants are included in the model as random effects, and random intercepts (as indicated by *1*) are included to specify that the intercept value (i.e., baseline level) for each participant is different. In Winter's (2013, p. 4) term, the *(1 | participant)* lets the model know that "there is going to be multiple responses per subject, and these responses will depend on each subject's baseline level."

As is the case for participants' idiosyncrasy, each item also has its own uniqueness. For example, words in each item used in this experiment might not affect participants' attachment decision in a similar way. Therefore, items are included as random effects, and random intercepts for items are also included. This is indicated by *(1 | item)* in (3).

For each participant or for each item, the effect of fixed factor such as TIorder or logSorder can also be different. For example, the effect of experience with test items (as indicated by TIorder) might be stronger for participant 1 than for participant 2. Therefore, fixed factors (or interaction, if any) can be included as random slopes (e.g., the logSorder in *(1 + logSorder | participant)* in (3)) to indicate that each participant or each item can be different from one another in terms of slopes for the effect of fixed factors (or interactions) that are included (see Winter, 2013 for a more detailed explanation). In this dissertation, which fixed factors to include in random slopes is based on backward selection process (see Chapter 2, Section 2.3 for related discussion on backward selection).

To reduce multicollinearity (i.e., a situation in which two or more fixed factors in the model are inter-correlated; see Baguley, 2013 for detailed discussion on multicollinearity), all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled. In the model, all the correlations were low (rs < .2; see Appendix 6 for the exact values), except the correlation between TIorder and logSorder (r = -.89), which is to be expected (see Fine et al., 2013, for a similar high correlation and a discussion on this high correlation not having impact on the factors of interest).

5.2 Results and discussion

Overall, with by-participants means, the rate of N1 attachment was 33.1% and that of N2 attachment was 66.9%. The summary of the mixed logit model is given in Table 5.1. The main effect of each predictor is not reported unless relevant to the discussion, but can be found in Table 3 in Appendix 6.

Table 5.1 Summary of the mixed logit model

Predictor	Estimate	SE	*Z*	*p*
Intercept	-1.02	0.36	-2.83	.005
logSorder	-0.75	0.42	-1.78	.075
TIorder	0.05	0.06	0.79	.433

In Table 5.1, the estimate for the intercept is negative, indicating a reliable preference for N2 attachment (p = .005; note that an estimate close to zero would have indicated no preference, a positive estimate would have indicated a preference for N1 attachment; see Chapter 2, Section 2.3 for explanation on mixed logit models). Recall that TIorder and logSorder are numerical factors. The second row indicates that there was a marginal effect of logSorder (p = .075) such that as participants read more test sentences and fillers (i.e., as the trial number increased), participants' preference for N2 increased. In the last row, the estimate for TIorder is positive. It indicates that as participants read more test sentences, the rate of choosing N2 attachment got weaker. However, the effect of TIorder was not significant. Therefore, the result indicates that as experiment progressed, experience with test sentences which were ambiguous RCs did not change participants' attachment preference.

The results in Table 5.1 suggest that there was an N2 attachment preference in comprehension. Therefore, the hypothesis stating that there would be an N1 attachment preference in Thai is rejected. Moreover, with the N2-attachment preference, the hypothesis posited that both experience with RCs and experience with SCs would affect

RC-attachment processing is disproved because the N2-preference is compatible with the results of the corpus count in which only RC instances were included. In other words, the results suggest that only past experience with RCs, the target construction, can affect later processing.

However, it is still conceivable that there is an N1 preference in Thai and there is an effect of SCs on comprehension of RC attachment but the results of this experiment do not reflect such a preference. The observed N2 attachment preference in this experiment might just be an unintended effect of the matrix clauses used. That is, readers may avoid attaching the RC to N1 when it is unrelated to the matrix clause so as to avoid two unrelated clauses referring to the same entity. To address this concern an on-line experiment, which observes a preference during reading, is reported in the next chapter.

Another reason for conducting an on-line experiment is that the N2 preference found in this experiment contradicts the results of a previous study in Thai, which found an N1 attachment preference (Siriwittayakorn et al., 2014). However, in the previous study (Siriwittayakorn et al., 2014), the results were from an on-line experiment. Since the experiment in the previous study and this experiment used different methodologies, an on-line experiment is needed to provide data more directly comparable to the previous experiment and confirm that those early results were affected by methodological problems.

Chapter 6
Experiment 2

The experiment in this chapter investigates the on-line RC-attachment preference as each word in the sentence is read. It has three purposes. Firstly, this experiment was conducted to address confounds in a previous on-line experiment on RC-attachment in Thai (Siriwittayakorn et al., 2014; see also Chapter 3, Section 3.5 for more details on the confounds).

Secondly, the off-line data from Experiment 1 indicated that there was an N2 preference in Thai; therefore, only experience with RCs was likely to affect RC attachment given the corpus frequencies reported in Chapter 4. However, there was still a possible confound related to the influence of the matrix clause. Therefore, this experiment was conducted to test whether there is an N2 preference before readers can determine whether the clauses are coherent.

Thirdly, according to experience-based accounts, the relative frequency of the different types of test sentences along the experiment can affect processing because participants integrate the experience during the experiment to their past experience (experience before starting the experiment) and use such newly integrated experience in processing a new sentence (Fine et al., 2013; also Kaschack & Glenberb, 2004). The corpus data reported in Chapter 4 indicated that in native Thai speakers' past experience, N1 RC-attachment is less frequent than N2 RC-attachment (the N1-N2 proportion in participants' past experience is roughly 46-54 for all internally-disambiguated instances; trend for instances with animate-concrete nouns was similar).

However, in this experiment the N1 and N2 RC-attachment interpretations are shown in equal proportion (i.e., N1-N2 proportion: 50-50).

For surprisal theory (specifically, error-based models; Fine et al., 2013), processing the less frequent interpretation results in higher error signal, and thus makes participants adapt their expectation expecting such interpretation more. Therefore, the model predicts that in this experiment, the effect of experience should be stronger for N1 attachment because it is less frequent than N2 attachment in participants' past experience.

In contrast, in episodic-processing accounts (Kaschak & Glenberg, 2004), processing of the less frequent interpretation (i.e., N1 attachment) can facilitate later processing of the more frequent interpretation (i.e., N2 attachment). This is because during the processing of N1 attachment, the interpretation of N2 attachment is also reactivated and leaves traces in memory. Therefore, this type of model predicts that the effect of experience should be stronger for N2.

This experiment was conducted to test whether experience with unambiguous RCs in an experiment can affect participants' processing as an experiment progresses and in which direction the effect goes. Based on experience-based accounts' predictions (Fine et al., 2013; also Kaschack & Glenberb, 2004), it is hypothesized that experience with test sentences along the experiment can affect processing.

6.1 Methodology

Before discussing the methodology in details, it should be noted that one goal of this experiment is to investigate the effect of experience on the processing of RC attachment as the experiment progresses. Moreover, in on-line experiments in which RTs are collected, effects tend to be smaller than those investigated in off-line experiments. Because of these two reasons, the number of participants and the number of test items in this experiment were higher than what would be expected if just a simple comparison between two conditions was to be conduced (see Chapter 2, Section 2.1.1 for more details).

6.1.1 Participants

Forty-two native Thai speakers undergraduate students at Chulalongkorn University volunteered to participate in the experiment.

6.1.2 Materials

The test items were comprised of 24 pairs of unambiguous sentences. For all test items, the two head nouns were animate-concrete (i.e., human nouns). The RC was subject-extracted and modified the subject of the matrix clause so that the matrix clause would not contaminate the RTs to the RC. Disambiguation was based on plausibility (see (1) for an example).

(1)

a. N1 attachment

หลานชายของคุณหญิงที่เพิ่งหย่ากับอนงค์เมื่ออาทิตย์ที่แล้วชอบไปเที่ยวที่เชียงใหม่

lǎ:nchā:j | khɔ̌:ŋ | khūnjǐŋ | thî: | phə̂:ŋ jà: | kàp ʔànōŋ |

nephew of duchess that just divorce with Anong(f)

mɨ̂a ʔā:thít thî:lɛ́:w | chô:p pāj thîaw | thî: chīaŋmàj

when week past like go travel at Chiang Mai

"The nephew of the duchess that got divorced from Anong(f) last week likes traveling to Chiang Mai."

b. N2 attachment

หลานชายของคุณหญิงที่เพิ่งหย่ากับยงยุทธเมื่ออาทิตย์ที่แล้วชอบไปเที่ยวที่เชียงใหม่

lǎ:nchā:j | khɔ̌:ŋ | khūnjǐŋ | thî: | phə̂:ŋ jà: | kàp jōŋjút |

nephew of duchess that just divorce with Yongyut(m)

mɨ̂a ʔā:thít thî:lɛ́:w | chô:p pāj thîaw | thî: chīaŋmàj

when week past like go travel at Chiang Mai

"The nephew of the duchess that got divorced from Yongyut(m) last week likes traveling to Chiang Mai."

In (1), the vertical bars indicate the segmentation used in the experiment. The disambiguating segment (i.e., the underlined part) involves gender stereotypes. The "f" and "m" in the glosses indicate the gender of the preceding noun. In (1a), the RC modifies N1 (*lǎ:nchā:j* "nephew") but in (1b), the RC modifies N2 (*khūnjǐŋ* "duchess") as only a man and a woman can get divorced according to current Thai laws. For each pair of test items, all the words except those in the disambiguating part were kept the same.

To confirm the plausibility biases for each RC, a stimulus norming was conducted. As many items as possible were created and the best 32 pairs as in (1) were included in the norming. Four versions of each pair were created in a 2 (noun: N1 or N2) by 2 (plausibility: plausible or implausible) design. For (1), the four versions in (2) were created.

(2)

a. N1 plausible

นี่คือหลานชายของคุณหญิง หลานชายเพิ่งหย่ากับอนงค์

nî: khɨ: lǎ:nchā:j khɔ̌:ŋ khūnjǐŋ | lǎ:nchā:j phɤ̂:ŋ jà: kàp

this is nephew of duchess nephew just divorce with

ʔànōŋ

Anong(f)

"This is the nephew of the duchess. The nephew got divorced from Anong"

b. N1 implausible

นี่คือหลานชายของคุณหญิง หลานชายเพิ่งหย่ากับยงยุทธ

nî: khɨ: lǎ:nchā:j khɔ̌:ŋ khūnjǐŋ | lǎ:nchā:j phə̂:ŋ jà: kàp

this is nephew of duchess nephew just divorce with

jōŋjút

Yongyut(m)

"This is the nephew of the duchess. The nephew got divorced from Yongyut."

c. N2 plausible

นี่คือหลานชายของคุณหญิง คุณหญิงเพิ่งหย่ากับยงยุทธ

nî: khɨ: lǎ:nchā:j khɔ̌:ŋ khūnjǐŋ | khūnjǐŋ phə̂:ŋ jà: kàp

this is nephew of duchess duchess just divorce with

jōŋjút

Yongyut(m)

"This is the nephew of the duchess. The duchess got divorced from Yongyut."

d. N2 implausible

นี่คือหลานชายของคุณหญิง คุณหญิงเพิ่งหย่ากับอนงค์

nîː khɨː lǎːnchāːj khɔ̌ːŋ khūnjǐŋ | khūnjǐŋ phə̂ːŋ jàː kàp

this is nephew of duchess duchess just divorce with

ʔànōŋ

Anong(f)

"This is the nephew of the duchess. The duchess got divorced from Anong."

In Thai writing, there is no space between words, only between sentences. Thus, in the transcriptions in (2), a vertical bar marks such space.

In this norming, the matrix clause was not included because in the main experiment, participants make attachment decisions before seeing the matrix clause. Therefore, the matrix clause cannot affect the attachment decision. The two plausible conditions (e.g., (2a) and (2c)) were compared to guarantee that N1 attachment and N2 attachment did not differ in the naturalness of their intended meanings. By comparing the two implausible conditions such as (2b) and (2d), the unintended interpretations were tested to make sure they were similarly implausible.

The four versions of sentences were distributed into four lists according to a Latin Square design (see Appendix 7 for an example questionnaire). For each list, three fillers with an unambiguous answer, which had been used in the norming study of Experiment 1, were included. A new group of 59 native Thai speakers answered the questionnaire but the results reported are from 47 participants as 12 participants gave wrong answers to the fillers. The procedure was the same as the one for the norming questionnaire of Experiment 1.

Out of the 32 items, 24 items of which the median plausibility-rating scores for the two plausible conditions were higher than three and the median plausibility-rating scores for the two implausible conditions were lower than three were chosen. These 24 items were also the items with the smallest median differences. For these 24 items, Wilcoxon signed-rank tests revealed that the two plausible conditions were rated equally high (medians: N1 = 5, N2 = 5; the largest median difference: 1.5; by-subjects: $V_1 = 41.1$, $p = .145$; by items: $V_2 = 2$, $p = .789$) and the two implausible conditions were rated equally low (medians: N1 = 1, N2 = 1; the largest median difference: 1.5; $V_1 = 97$, $p = .626$; $V_2 = 18$, $p = .544$; see Appendix 8 for median plausibility-rating scores of each item).

Based on the norming results, the 24 pairs of sentences were included in Experiment 2 (see Appendix 8 for the list of test items). According to Wilcoxon signed rank tests, word and bigram frequencies of the disambiguating part of each sentence pair (extracted from the TNC; Aroonmanakun, Tansiri, & Nittayanuparp, 2009) were not different (all *p*s > .2).

Apart from the test sentences, the experiment included 60 fillers. The filler constructions were as follows with the number of items used indicated in parentheses. None of the fillers involved RC or *thî: + RC*.

- *N1 khɔ̌ŋ N2 thî:* not followed by an RC (12 items)
- *N1 khɔ̌ŋ N2* not followed by *thî:* (12 items)
- *thî:* not followed by RC (12 items)
- other constructions not containing the word *thî:* (24 items)

6.1.3 Procedure

The 24 pairs of test items were distributed into two lists according to a Latin Square design. Each list and the 60 fillers were ordered pseudo-randomly. The order of sentences was fixed.

All sentences were divided into nine segments as indicated by the vertical bars in (1). The disambiguating part or the critical segment where the attachment ambiguity was resolved was always the sixth segment. Table 6.1 illustrates a schematic representation of the segmentation used.

Table 6.1 Schematic representation of the segmentation used

Segment	Structure
1	N1
2	*khɔ̌:ŋ* (“of”)
3	N2
4	*thî:* (“that”)
5	first part of the RC
6	Disambiguating words
7	Last part of the RC
8	First part of the matrix clause
9	Last part of the matrix clause

A non-cumulative moving-window self-paced reading presentation was adopted (see Chapter 2, Section 2.2 for the procedure; see also Appendix 2 for an example of instructions and presentation). Participants read sentences segment by segment. After reading each sentence, a comprehension question was shown on a new screen. The question did not query about attachment to avoid drawing participants' attention to the point of the experiment. To fit the width of the screen, all sentences were broken into two lines (between segments 7 and 8). For the test items, the nouns and the RC were always shown together on the first line to avoid prosodic effects (as in the *implicit prosody hypothesis*; Fodor, 1998).

6.1.4 Analyses

Question-response accuracy for all items (i.e., including both test sentences and fillers) was checked to determine whether participants paid attention to the experiment. All participants scored over 94% and the mean for question-response accuracy was 99.04%; therefore, all participants' data were included in the analyses reported.

Question-response accuracy for the test items was analyzed to determine if there were any accuracy differences between the two types of attachment. Since the data were categorical, mixed logit models were used. The correct answers were coded as 1 and the wrong answers were coded as 0. Attachment (i.e., attach) was centered and was set as a fixed factor. The random structure included both by-participants and by-items random intercepts. Based on backward selection, the model used for analyzing the data was as follows.

(3) answers ~ attach + (1 | participant) + (1 | item)

For the RT analyses, only items with correct answers were analyzed. Before submitting the RT data to analyses, outliers were eliminated. Firstly, items in which RTs were lower than 50 ms were also eliminated as they were unlikely to reflect reading latencies (lexical access is unlikely to be performed under 50 ms). Secondly, it was found that there were two items with large difference between the means for N1 and N2 attachments of segment 1 (207.52 ms and 142.67 ms; for the remaining 22 items, mean = 45.829, SD = 50.154). The difference was unexpected because the two versions of sentences contained the same word. Therefore, to avoid spurious differences, the two items were eliminated from further analyses. Lastly, the data were trimmed based on the models (Baayen, 2008).

RTs of the test items were converted into residual reading times (RRTs; see Chapter 2, Section 2.3 for advantages in using RRTs instead of raw RTs). When calculating the RRTs for all segments except segments 6 and 7, RTs were regressed against length (i.e., number of characters). RTs of segments 6 (i.e., the critical segment) and 7 were regressed against length, plausibility and implausibility median scores obtained from the norming, log-transformed word frequency and log-transformed bigram frequency. This is because for segment 6, words in this segment were different for each attachment version and such difference might affect RTs. For segment 7, although words for the two attachment versions were the same, any effects of word difference in segment 6 might spill over to this segment. The regression models for all RRT calculations included by-participants random intercept to capture individual differences. Which factors to include in the by-participants random slopes were based on backward selection.

For analysis purposes, data from all nine segments were collapsed into six regions. Region 1 was data of segment 1 (i.e., N1). This is because participants might sometimes rest at the beginning of a new sentence and unexpected effects might be observed in the first segment. Therefore, to make sure that there was nothing wrong in this segment, the data were analyzed separately. Region 2 comprised of data from segments 2 and 3 (i.e., *khɔ̌:ŋ N2*). Data from segment 4 (i.e., the marker *thî:*) and from segment 5 (i.e., the first part of the RC) were included in region 3 as they preceded the disambiguating segment and were temporarily ambiguous. To investigate attachment preference, data of the crucial segment (i.e., segment 6) were set as region 4 (i.e., the critical region). Region 5 included data from segment 7, which was analyzed separately to observe the spillover effect. Region 6 included segments 8 and 9 which comprised the matrix clause. Table 6.2 illustrates the details for each region in the analyses.

Table 6.2 Details for each region in the analyses

Data	Segment in experiment	Region
N1	1	1
khɔ̌:ŋ ("of")	2	2
N2	3	
thî: ("that")	4	3
first part of the RC	5	
Disambiguating words	6	4
Last part of the RC	7	5
First part of the matrix clause	8	6
Last part of the matrix clause	9	

For all regions, analyses were performed using mixed-effects models (see Chapter 2, Section 2.3 for more details on advantages of mixed-effects models over ANOVA). For all models, attachment (i.e., *attach*) was included in order to investigate which type of attachment (i.e., N1 or N2 attachment) was read faster. The number of test items that participants had read at each point of the experiment (i.e., TIorder) and its interaction with attach were also added to the models to capture the effect of experience with test items along the experiment (i.e., adaptation to the statistics specific to the experiment). As the experiment progressed, participants were likely to get used to the procedure and read faster; therefore, to capture such effects, the logarithm of trial order (i.e., the total number of test items and fillers seen at each point; logSorder, for short) was included in the model. Inclusion of logSorder can also factor out effects from the single pseudo-random order used for all participants. By-participants and by-items random intercepts were included in all models. However, terms included in the random structure of each model were different depending on backward selection (see Appendix 9 for the exact model of each analysis).

To reduce multicollinearity, all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled. All correlations were low (rs < .4) except the correlation between TIorder and logSorder (rs > .8; see Appendix 9 for the exact values of each analysis). The high correlation between TIorder and logSorder should not affect the factors of interest (i.e., attach, for this experiment; see Fine et al., 2013 for relevant discussion).

Trends were the same when raw RTs were used as the dependent variable. Trends are also the same when logSorder was removed from models or was replaced with raw Sorder.

6.2 Results

Comprehension question-response accuracy

Accuracy for both N1- and N2-attachment conditions was high (mean accuracy for N1 attachment: 99.80%, for N2 attachment: 98.81%) and response-accuracy for the two conditions was not statistically different (p = .214).

Reading times

There were no reliable differences in region 1 except for logSorder (p = .001). The results suggest that as the experiment progressed, participants read this region faster. The effect of logSorder is expected as participants can read faster when they get used to the procedure of the experiment; therefore, from here on it will not be reported in the main text, but can be found in the appendix unless of theoretical interest (the full results can be found in the tables of Appedix 9).

For regions 2 and 3 neither main effect of attach nor interaction between attach and TIorder was present.

For the crucial region (region 4), the results are shown in Table 6.3.

Table 6.3 Summary of the analyses for region 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	21.60	15.61	29.50	1.38	.177
attachN2	-26.53	12.78	794.60	-2.08	.038
logSorder	-70.27	40.02	25.70	-1.76	.091
TIorder	3.26	5.82	21.70	0.56	.582
attachN2:TIorder	3.32	1.94	806.00	1.71	.088

In Table 6.3, the intercept represents the base condition which is N1 attachment; therefore, the RRTs to N1 attachment was 21.6 ms. When attachment is not specified, the predictors are for the base condition. Predictors that are not for the base condition are always compared to their base-condition counterpart. The second row compares N2 attachment to the intercept. It indicates that N2 attachment was read significantly faster than N1 attachment (estimate = -26.53, p = .038; see Figure 6.1 for model estimates per condition for the RRTs to region 4; see also Appendix 9 for a figure of RRTs per region for each condition with by-participants means).

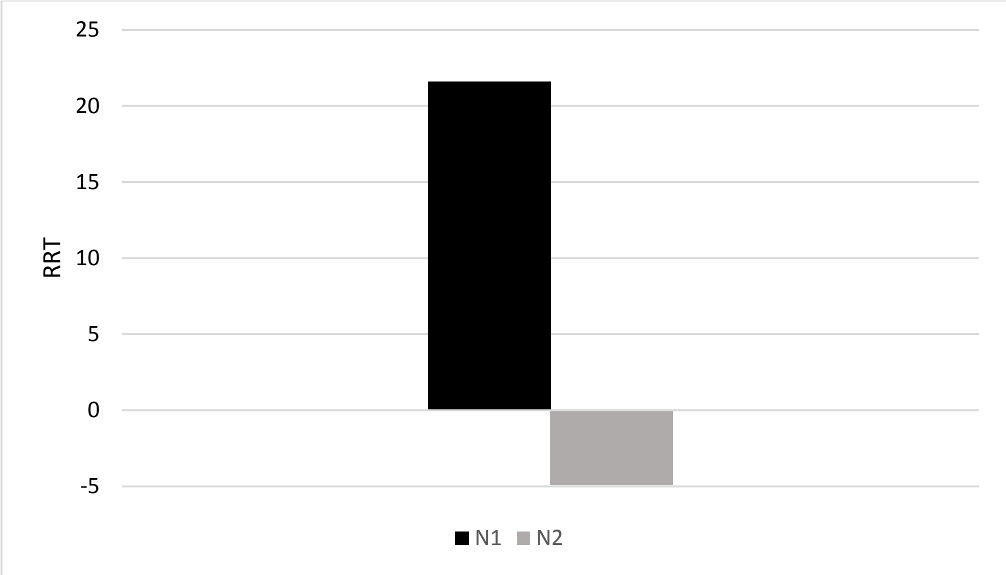

Figure 6.1 Model estimates per condition for the RRTs to region 4

The logSorder row summarizes the effect of logSorder on the base condition. It indicates that as the experiment progressed (i.e., as participants read more test sentences and fillers), RRTs to N1 attachment got marginally faster (estimate = -70.27, p = .091). Since the interaction between attach and logSorder was not included in the model, the effect of logSorder on N2 attachment cannot be found in the summary table, but the results hold even when both N1 and N2 conditions were taken into consideration (see Table 15 in Appendix 9 for main effect of the analyses for region 4).

There was a marginal interaction between attach and TIorder (see Table 15 in Appendix 9 for more details) but the marginal interaction was driven by the effect of TIorder on N2 attachment. In Table 6.2, the TIorder row shows the effect of TIorder on the base condition. The estimate in the TIorder row indicates that as participants read more test sentences, they got slower in reading N1 attachment but the effect was not reliable. Importantly, the last row compares the effect of TIorder on N2 attachment to that on N1 attachment. It indicates that as participants read more test sentences, N2 attachment got marginally progressively slower (estimate = 3.32, p = .088); and therefore, the RT difference between the two types of attachments got marginally smaller over the course of the experiment. Figure 6.2 illustrates the change of RRTs in the critical region over the course of experiment. The trend lines for each condition were generated from linear regressions.

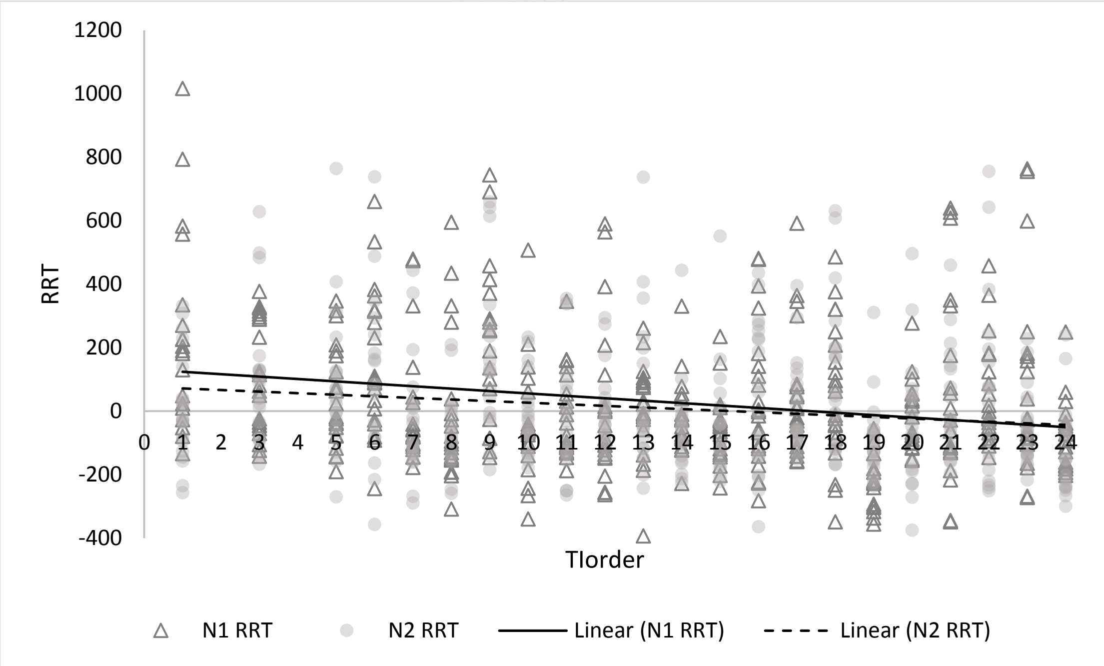

Figure 6.2 The change of residual reading times (RRTs) of the critical region over the course of experiment

In regions 5 and 6, the RRTs to N1 and N2 attachments were not reliably different. There was no interaction between attach and TIorder either.

6.3 Discussion

The results of the critical region showing that N2 attachment was read faster than N1 attachment indicate that there was an N2 attachment preference. This confirms the results of the off-line reading experiment (Experiment 1). Because in Experiment 2 the preference was observed before the matrix predicate was read, the result cannot be ascribed to contextual effects (e.g., participants trying to find a coherence between the attachment and the matrix clause). The results of this experiment indicate that the N1-attachment preference found in a previous RT experiment in Thai (Siriwittayakorn et al., 2014) was likely to have been affected by factors that were not controlled for such as line breaks and surrounding context.

In Experiment 2, the tendency for the N1-N2 difference to get smaller as the experiment progressed suggests that experience with unambiguous test sentences affects processing such that there is an adaptation to the statistics specific to the experiment. Like previous results (Fine et al., 2013), the present results is not compatible with the prediction of episodic-processing accounts, but compatible with that of surprisal theory (specifically, error-based models, Fine et al., 2013) as the results show that adaptation to N1 and N2 attachments was asymmetrical (i.e., N2 attachment got marginally progressively slower). Under models that explain RTs based on probabilities that readers assign to each interpretation such as surprisal theory (Levy, 2008, 2013), as participants encountered N1-attachment sentences, they assigned higher probability to such interpretation and decreased the probability of N2-attachment. Similarly, when they read N2-attachment sentences, they increased the N2 probability and lowered the N1 probability. However, normally N1 attachment is less frequent and thus less expected than N2 attachment. According to error-based models, when RCs turned out to be N1 attachment, the error signal associated with participants' expectation was higher than when RCs attached to N2. Therefore, the extent to which participants adapted their expectation for N1 attachment was larger than the extent to which they adapted their expectation for N2 attachment (see Fine & Jaeger, 2013; Fine et al., 2013; Jaeger & Snider, 2013; for related discussions on error-based model).

In this experiment, adaptation to statistics specific to the experiment was not as clear as that observed in Fine et al.'s (2013) study, as the adaptation effect was reliable in Fine et al.'s study but only marginally reliable in this experiment. One possibility is that although the proportion of N1 and N2 attachments in participants' past experience is different from the proportion shown in the experiment, such difference is not as extreme as that in the previous study. That is, in the present experiment, the proportion of N1 and N2 attachments in participants' past experience is about 46-54 compared to the 50-50 proportion in the experiment (see Chapter 4, Section 4.2.1 for the results of the RC count). However, the proportion of the two interpretations (i.e., reduced RC and MV interpretations) used in Fine et al.'s study is markedly different from that in participants' past experience (i.e., the proportion of reduced RCs and MVs in the study: 50-50, in participants' past experience: 1-99). Since the probability of reduced RCs in participants' past experience was extrememly low, based on error-based model, the error-signal in processing reduced RCs in Fine et al.'s study should be higher than the error-signal in processing N1 attachment in the present experiment. Therefore, it seems reasonable to assume that the extent to which participants in Fine et al.'s study increased their expectation for reduced RCs was clearer than the extent to which participants in the present experiment increased their expectation for N1 attachment. Nevertheless, the current result provides evidence for adaptation even when the distribution manipulations are not as extreme as in previous research.

In Experiments 1 and 2, compatibility between corpus counts and behavioral experiments was used as a way of testing for effects of experience. It was found that the results of the two experiments were compatible with corpus frequencies in which only RC instances were included. According to experience-based accounts, this compatibility suggests that only experience with RCs but not with SCs, affects RC processing. However, a corpus is just a rough measure of experience. In the next experiment, we will directly test the effect of experience with SCs on RC-attachment processing by exposing participants to sentences with SC attachment. Moreover, in Experiment 2, it was found that experience given to participants during the experiment could affect processing as the experiment progressed. Therefore, in the next experiment, we will investigate whether in general, experience in one situation can be generalized to a different situation.

Chapter 7
Experiment 3

Preference in sentence processing can be measured either locally or globally. Local preference (or on-line preference) is usually measured by having participants read unambiguous sentences which involve local ambiguity. At the point where there is an ambiguity, considering parts of sentences that have been read so far, participants may prefer one interpretation to the other. However, when the ambiguity is resolved, participants have to interpret sentences in the way researchers intended. The assumption is that RTs should be faster if the local preference coincides with the intended interpretation. The local preference in RC attachment has been tested in Experiment 2. On the other hand, global preference (or off-line preference) is gauged by having participants read ambiguous sentences. Since sentences are ambiguous, participants are allowed to interpret sentences in the way they preferred and in determining interpretation, they can re-read the whole sentence and consider all information provided in the sentence (e.g., consult the matrix clause). Global preference is what has been tested in Experiment 1.

Previous studies (e.g., Fine et al., 2013; Kamide, 2012; Wells et al., 2009) exposed participants to a set of unambiguous sentences in which the proportion of two interpretations was markedly different from participants' past experience, and then measured participants' local preference after exposure. They claimed that a change in local preference (i.e., change in expectation expecting the interpretation that was more frequent than usual) implies that learning has taken place. However, the setting in those previous studies can be viewed as a low degree of freedom situation and it is conceivable that the results do not necessarily indicate that experience during experiments generally changed preferences. In those experiments, participants entered the experiment expecting one interpretation. However, for each sentence when the local ambiguity was resolved, participants had to interpret sentences as manipulated. As experiments proceeded, participants may change their expectation to make it align with probability for each interpretation to occur in experiments. In other words, at the point where there was local ambiguity, participants expected the ambiguity to be resolved towards the interpretation that was frequent in the experiment. To this end, the change in expectation in a low degree of freedom situation might not indicate a general change in preference, but a kind of strategic learning that helps participants to process experimental sentences better. According to Schmidt and Bjork (1992), to claim that there was learning taking place or that participants can change their preference, researchers should test whether participants' performance is still the same in a high degree of freedom situation where participants are allowed to freely interact with the stimuli. In the case of sentence processing, a test in a high degree of freedom situation might be done by having participants read ambiguous sentences after exposure to unambiguous sentences and measure their global preference. Since participants are free to interpret sentences, re-read sentences and consult the matrix clause, if participants' global preference changes, it should imply that exposure changes their preference.

In Experiment 2, it was found that experience with unambiguous RCs affected RC-attachment processing as experiment progressed such that participants expected more N1 attachment. However, as in previous studies (e.g., Fine et al., 2013; Kamide, 2012; Wells et al., 2009), the effect of experience was tested only in a low degree of freedom situation. That is, in the experiment, participants read unambiguous RCs in which the frequency of N1 attachment was higher than usual. Such high frequency might make participants expected more N1 attachment. However, it is unclear whether the effect of experience reflects general change in preference as assumed by experience-based accounts or strategic learning specific to a low degree of freedom situation. Therefore, Experiment 3 is conducted to test whether experience with RCs in a low degree of freedom situation can affect processing of RC-attachment in a high degree of freedom situation.

To investigate the effect of experience with RCs on the processing of RC attachment in different situations, Experiment 3 is conducted by combining Experiments 1 and 2. That is, in Experiment 3 we will have participants read unambiguous RCs as in Experiment 2. Based on the results of Experiment 2, it is expected that experience with RCs affects RC processing along the experiment (i.e., causes a change in expectation as experiment progresses). Then, we will have participants read ambiguous RCs as in Experiment 1 to investigate whether there are still signs of adaptation. Since it is possible that the change in expectation reported in previous studies (e.g., Fine et al., 2013; Kamide, 2012; Wells et al., 2009) results from strategic learning, it is hypothesized that in Experiment 3, experience in a low degree of freedom situation cannot be transferred and affect processing of RC attachment in a high degree of freedom situations. If this is the case, the results will pose a challenge to experience-based accounts. This is because the results will suggest that a change in expectation after exposure to unambiguous sentences does not necessarily imply that experience has changed processing preferences in a more fundamental way.

Another goal of Experiment 3 is that regardless of situation (i.e., low degree of freedom or high degree of freedom situations), the compatibility between corpus counts and results of Experiments 1 and 2 show that SCs does not affect RC-attachment processing. However, a corpus is a rough measure of experience. Therefore, Experiment 3 is conducted to directly test the effect of experience with SCs by manipulating participants' experience along the experiment (i.e, exposing participants to unambiguous SCs) and investigating whether experience with unambiguous SCs during the experiment affects RC-attachment processing in any situation. According to experience-based accounts, past experience as determined by corpora should be the same as experience during experiments, and therefore, should yield the same effect. That is, if readers past experience cannot affect processing, experience during experiment should not be able to do so either. Since the compatibility between corpus counts and Experiments 1 and 2 indicates that there is no effect of SCs, in Experiment 3 the effect of SCs along the experiment should not be present either. However, if in Expeirment 3 there is an effect of SCs on RC-attachment as experiment progresses, the results will pose a challenge to experience-based accounts. Firstly, if there is an effect of unambiguous SCs on RC-attachment processing only in a low degree of freedom situation, it will indicate strategic learning as it shows that experience can affect processing only in a specific situation. Secondly, if experience with unambiguous SCs affects processing of RC attachment both in a low degree of freedom situation and in a high degree of freedom situation, according to Schmidt and Bjork (1992) the results will indicate that experience with SCs affects attachment preference in a fundamental way; and therefore, contradict the results of Experiments 1 and 2. Such contradiction goes against experience-based accounts' assumptions as it indicates either that corpora are not a good measurement of past experience or that effects of experience during experiments are different from effects of past experience.

7.1 Overview of the experiment

7.1.1 Experimental design

This experiment employed a between-subject design. There were two groups of participants, namely the experimental group and the control group. The two groups participated in two tasks namely an unambiguous-sentence reading task which is a low degree of freedom situation and an ambiguous-sentence reading task which is a high degree of freedom situation. Firstly, an experimental design for the experimental group will be spelt out.

Table 7.1 Summary of the tasks and sentences of the experimental group

Task	Sentences	Situation
Unambiguous-sentence reading	Unambiguous RCs	Low degree of freedom
	Unambiguous SCs	
Ambiguous-sentence reading	Ambiguous RCs	High degree of freedom

Table 7.1 summarizes the tasks and sentences of the experimental group. In the unambiguous-sentence reading task, participants read unambiguous RCs as in Experiment 2 and unambiguous SCs. This task is a low degree of freedom situation. The first purpose of this task was to give participants experience with RCs and experience with SCs attachment. The second purpose was to test effects of experience

in a low degree of freedom situation. That is, it was used to test whether experience with unambiguous SCs affected RC-attachment processing as the experiment progressed, and additionally, to test whether experience with unambiguous RCs affected RC attachment as the experiment progressed replicating the results of Experiment 2.

The ambiguous-sentence reading task is a high degree of freedom situation. Participants read ambiguous RCs and freely chose attachment site as in Experiment 1. In this task, participants could base their attachment decision on their initial preference (i.e., preference before participating in the experiment or preference based on their past experience) or could continue adapting their preference making it align with statistics of how local ambiguity in the unambiguous-sentence reading task was often resolved. This task was used for testing whether the effect of experience with RCs and experience with SCs in a low degree of freedom situation could be transferred to RC processing in a high degree of freedom situation.

Experiment 3 comprised of six blocks. An experimental design for the experimental group is illustrated in Table 7.2 and explanation for each block is also provided below.

Table 7.2 Summary of the experimental design for the experimental group

Block	Sentences	Measurement
1	Ambiguous RCs	Forced binary-choice
2	Unambigous RCs	RT
3	Unambiguous SCs	-
4	Unambiguous RCs	RT
5	Unambiguous SCs	-
6	Ambiguous RCs	Forced binary-choice

[1]Grey rows indicate an ambiguous-sentence reading task, otherwise an unambiguous-sentence reading task

[2]Measurement is for attachment preference

[3]-: Nothing was measured

- **Block 1**: ambiguous-sentence reading task

  In this block, participants read ambiguous RCs and chose attachment site by answering a forced binary-choice question. This block was used to determine participants' global preference before participants were exposed to unambiguous RCs and unambiguous SCs.

- **Block 2**: unambiguous-sentence reading task

  Participants read unambiguous RCs with N1 and N2 attachments in a 50-50 proportion and RTs to each attachment condition were measured. It was used to determine participants' local preference before the experience with SCs was given to participants. Another purpose of this block was to expose participants to RC attachment in which probability of N1 attachment was higher than usual (in participants' past experience as determined by corpus counts, the proportion of N1-N2 attachment was about 46-54).

- **Block 3**: unambiguous-sentence reading task

  This block was used to expose participants to SCs with N1-attachment interpretation. In this block, nothing was measured because we were not interested in the effect of SCs on SC processing.

- **Block 4**: unambiguous-sentence reading task

  Participants read unambiguous RCs and RTs were measured as in block 2. This block was used to test whether participants' expectation on RC attachment changed after exposure to N1-attached SCs. With the data from this block and those from block 2, we also tested whether there was an effect experience with RCs on RC processing in a low degree of freedom situation, replicating the results of Experiment 2 (i.e., tested whether there was a change in RTs to RCs over the course of the experiment).

- **Block 5**: unambiguous-sentence reading task

  Since in block 4, participants read N1 and N2 RC-attachment in a 50-50 proportion, the strength of the effect of experience with N1 attachment might be lessened by experience with N2 RC-attachment. This block gave participants more experience with N1-attached SCs to reinforce N1 attachment and as in block 3, nothing was measured in this block.

- **Block 6**: ambiguous-sentence reading task

  Participants read ambiguous RCs and chose attachment site as in block 1. This block was used to determine whether participants' global preference changed after exposure to unambiguous RCs and unambiguous SCs in which proportion of N1 attachment was higher than usual. In other words, this block was used to test whether effects of experience in a low degree of freedom situation can be transferred to a high degree of freedom situation.

From the experimental design for the experimental group, it can be seen that participants in the experimental group read both unambiguous RCs and unambiguous SCs in which the probability of N1 attachment was higher than usual. To differentiate the effect of SCs from the effect of RCs, a control group which did not read SCs was needed. In this experiment, the control group was treated in the same way as the experimental group. The only exception was that in blocks 3 and 5, the control group was exposed to fillers instead of SCs.

Since the control group was not exposed to SCs, the results of this group were used as a base line for making a comparison with the results of the experimental group to verify the effect of SCs. The results of the control group were also compared to those of Experiments 1 and 2 where there was no experience manipulation to investigate the effect of RCs.

The summary of the experimental design for the two groups is in Table 7.3.

Table 7.3 Summary of the experimental design

Group Block	Experimental	Control	Measurement
1	Ambiguous RCs		Forced binary-choice
2	Unambigous RCs		RT
3	Unambiguous SCs	SC-based fillers	-
4	Unambiguous RCs		RT
5	Unambiguous SCs	SC-based fillers	-
6	Ambiguous RCs		Forced binary-choice

[1]Grey rows indicate an ambiguous-sentence reading task, otherwise an unambiguous-sentence reading task

[2]Measurement is for attachment preference

[3]-: Nothing was measured

7.1.2 Questions and predictions

Predictions made are based on the results of Experiments 1 and 2 where there was no experience manipulation.

Questions 1 and 2 spell out the predictions for the unambiguous-sentence reading task where local preference was measured (blocks 2 and 4). They deal only with a preference in a low degree of freedom situation.

Question 1: Does experience with unambiguous RCs affect RC-attachment processing during the unambiguous-sentence reading task?

The first question is an ancillary question checking whether there was an effect of RCs on RC attachment as the experiment progresses replicating the results of Experiment 2. In Experiment 2, participants read N1 and N2 RC-attachment in a 50-50 proportion. When test-item order (i.e., TIorder), the factor that directly captured the effect of experience with test sentences (i.e., RC-attachment sentences) was included in the analyses, it was found that there was a marginal effect of adaptation such that N2 attachment got marginally slower as participants read more test sentences. The result of Experiment 2 indicates that in an unambiguous-sentence reading task, experience with RCs affects RCs processing.

For Experiment 3, since the control group was not exposed to SCs, it is expected that the result of this group will replicate that of Experiment 2, finding a marginal adaptation effect. For the experimental group, there should also be a marginal adaptation effect, and the direction of the effect should be similar that of the control group. However, the adaptation effect of the experimental group might be stronger than that of the control group because of the effect of N1-attached SCs. Whether or not the adaptation effect of the experimental group is partly accounted for by the effect of experience with SCs will be investigated in question 2.

Question 2: Does extra experience with SCs affect participants' expectation on RC attachment in unambiguous-sentence reading task?

Before spelling out the predictions, it should be noted that in Experiment 2 where there was no experience manipulation, participants preferred N2 attachment.

- In block 2, the results should indicate that both groups expect RCs to be N2-attachment. However, in block 4 if extra experience with SCs can affect RC attachment in an unambiguous-sentence reading task, the experimental group should expect less N2 attachment or change their expectation to N1 attachment while the control group should still expect N2 attachment.
- If extra experience with SCs cannot affect RC attachment, there should be no effect of group or interaction between group and block. That is, both groups should expect RC to be N2 attachment in both blocks.

Questions 3 and 4 are meant to spell out the predictions for the ambiguous-sentence reading task where global preference was measured (blocks 1 and 6, a high degree of freedom situation).

Question 3: Can experience with RCs and experience with SCs in an unambiguous-sentence reading task be transferred to an ambiguous-sentence reading task?

In Experiment 1 where there was no experience manipulation, N2 was the preferred attachment site. Therefore, in Expeirment 3 there should be an N2-attachment preference in block 1, a block before exposure to unambiguous RCs and unambiguous

SCs. In block 6, there are two possibilities. That is, there is or there is not a transfer of the effect of experience from an unambiguous-sentence reading task to an ambiguous-sentence reading task. If none of the effect can be transferred, in block 6 the two groups should prefer N2 attachment as in block 1. However, if the effect of experience can be transferred, the results in block 6 can be in one of the following ways.

- If N2 preference is weakened by the 50-50 unambiguous RCs and N1-attached SCs, N2 preference of both groups should get weaker than that of block 1 but N2 preference of the experiemental group should be weaker than that of the control group.
- If N2 preference is weakened only by 50-50 unambiguous RCs, there should be no difference between groups. The N2 preference of both groups should be weaker than that in block 1.
- If N2 preference is weakened only by N1-attached SCs, N2 preference of the experimental group should get weaker than that in block 1 but N2 preference of the control group should not be different from that in block 1.

Question 4: Does experience with ambiguous RCs in an ambiguous-sentence reading task affect participants' attachment decision?

This question is to verify that any effects that might be observed in question 1 do not result from the experience with ambiguous RCs in an ambiguous-sentence reading task. In Experiment 1 where there was no experience manipulation, there was no effect of test-item order (i.e., TIorder) such that experience with ambiguous RCs did not affect participants' global preference. It is expected that the results of blocks 1 and 6 of Experiment 3 will be the same (i.e., no effect of experience with ambiguous RCs).

7.2 Methodology

7.2.1 Participants

Eighty-six native Thai undergraduate students at Chulalongkorn University volunteered to participate in the experiment. However, two participants were eliminated because one of them had participated in Experiment 2 and the other reported to study in an English program. Therefore, the results reported included only 84 participants.

7.2.2 Materials

Sentences with RCs

Twenty-four sentences with ambiguous RCs in Experiment 1 were used in an ambiguous-sentence reading task. They were divided into two sets, each with 12 items. The first set was used in block 1 and the other set was used in block 6. With attachment-preference data and plausibility norming data from Experiment 1, mixed logit model indicated that there was no difference between the two item sets (p = .924). Therefore, any differences between attachment preference in blocks 1 and 6 observed in Experiment 3 cannot be ascribed to differences between the items of the two sets.

Twenty-four pairs of sentences with unambiguous RC attachment from Experiment 2 were used in an unambiguous-sentence reading task. The items were divided into two sets, each with 12 items. The first set was used in block 2 and the other set was used in block 4. Analyses on the RT data and the plausibility norming scores from Experiment 2 confirmed that there was no interaction between attachment and set (mixed-effect model p = .256). Therefore, any effects observed in blocks 2 and 4 cannot be attributed to differences between the two sets of items.

Sentences with SCs

There were 44 sentences containing *N1 khɔ̌:ŋ N2 thî: SC* construction in which the SCs always attach to N1. Of these 44 sentences, 32 sentences were used in block 3 and the other 12 sentences were used in block 5. There were more sentences in block 3 because we would like to give participants experience with SCs as much as possible such that this experience might be able to affect RC processing in block 4. In block 5, 12 SCs were used to reinforce N1 attachment before participants started block 6 (the ambiguous-RC reading post-test).

All the sentences were from the Thai National Corpus (Aroonmanakun, Tansiri & Nittayanuparp, 2009). Following Wells et al.'s (2009) study, when necessary, sentences were modified to make them easier to understand when they were presented in isolation (i.e., without discourse context). Words that were the same as the two head nouns or the disambiguating words of RC sentences were removed or were replaced by their synonym to avoid the effect of participants learning noun and verb pair. N1 was always inanimate-abstract and N2 was always human in one of the following forms: a common noun, a proper name, or a pronoun. For all SCs, there was a zero pronoun in subject position and it always referred to N2. An example of SCs is shown in (1).

(1) ศาลปฏิเสธคำร้องของตำรวจที่ขอให้การพิจารณาคดีทำโดยลับ

sǎːn pàʔtìʔsèːt khāmrɔ́ːŋ khɔ̌ːŋ tāmrùət thîː khɔ̌ː hâj

court reject petition of officer that request give

kāːnphítjaːráʔnāːkhāʔdīː thām dōj láp

trial do by secret

lit: "The court rejected the petition of the officer that requested for the trial to be held secretly."

"The court rejected the petition of the officer about requesting for the trial to be held secretly."

In (1), the underlined clause is an SC that lets one know what petition was rejected by the court.

To make sure that the clauses were SCs completing the meaning of N1, stimulus norming was conducted. Fifty-two sentences with *N1 khɔ̌:ŋ N2 thî: SC* construction were included in the norming questionnaire. Each sentence was followed by two alternatives that were the two possible interpretations of the subordinate clause. The examples in (2) are the two alternatives created for the sentence in (1).

(2)

a. SC interpretation (N1 attachment)

ตำรวจมีคำร้องที่ขอให้การพิจารณาคดีทำโดยลับ

tāmrùət mī: khāmrɔ́:ŋ thî: khɔ̌: hâj kā:nphítja:ráʔnā:khāʔdī:

officer have petition that ask give trial

thām dōj láp

do by secret

"The officer filed a petition requesting the trial to be held secretly."

b. RC interpretation (N2 attachment)

ตำรวจที่ขอให้การพิจารณาคดีทำโดยลับมีคำร้องบางอย่าง

tāmrùət thî: khɔ̌: hâj kā:nphítja:ráʔnā:khāʔdī: thām dōj láp

officer that ask give trial do by secret

mī: khāmrɔ́:ŋ bā:ŋjà:ŋ

have petition something

"The officer that requested the trial to be held secretly filed a petition about something."

To reduce participants' burden, sentences were split into two lists. Each list contained 26 items (see Appendix 10 for an example of a norming questionnaire). Six fillers with one correct answer were added into each list to check for participants' attention.

Twenty-four native Thai speakers who did not participate in any of the RC-experiments answered either list of the norming questionnaire by choosing one of the alternatives that best represents the meaning of the subordinate clause. However, the results reported included only 21 participants as the other three gave wrong answers to the fillers.

The percentages of the number of times participants interpreted the clause to be an SC (i.e., choosing the alternative in which the clause completed the meaning of N1) were calculated. Out of 52 sentences, 44 with the highest SC bias (mean: 93.18%, range: 80%-100%; see Appendix 11 for a list of the 44 items and a percentage for SC bias of each item) were chosen to be used in the main experiment (for the 32 sentences in block 3: mean = 92.44%; for the 12 sentences in block 5: mean = 95.15%).

Fillers

There were 160 fillers. The fillers were divided into three sets namely fillers for ambiguous RCs, fillers for unambiguous RCs and SC-based fillers.

Fillers for ambiguous RCs comprised of 60 items. They were used with the sets of ambiguous sentences in blocks 1 and 6. The following demonstrates the constructions of the fillers with the parentheses indicating the number of fillers.

- *N1 khɔ̌:ŋ N2* not followed by *thî:* (6 items)
- *thî:* not followed by RC (6 items)

- sentences with homonym of which the meaning is ambiguous (adapted from Nagarachinda, 2014; 16 items)
- other unambiguous constructions not containing a complex genitive NP, *thî:*, or RCs (32 items)

There were 48 fillers for unambiguous RCs. They were used in blocks 2 and 4. The following illustrates the constructions of the fillers. The parentheses indicate the number of the fillers.

- *N1 khɔ̌:ŋ N2 thî:* not followed by an RC (6 items)
- *N1 khɔ̌:ŋ N2* not followed by *thî:* (8 items)
- *thî:* not followed by RC (6 items)
- sentences with homonym of which the meaning is unambiguous (16 items, adapted from the stimuli of Nagarachinda, 2014)
- Other unambiguous constructions not containing *N1 khɔ̌:ŋ N2*, *thî:*, or RCs (12 items)

The SC-based fillers were adapted from the 44 SCs used in blocks 3 and 5 of the experimental group (see Appendix 12 for the list of SC-based fillers). They were used in blocks 3 and 5 of the control group. These fillers were divided into two groups. The first group comprised of 32 fillers and was used in block 3. The second group contained 12 fillers and was used in block 5.

In creating these fillers, as much as possible the words and word order of the original SC sentences were kept the same. For most items, *thî:* and the SC were replaced by a prepositional phrase. For example, an SC in (1) was changed to a prepositional phrase as in (3) (the underlined part).

(3) ศาลปฏิเสธคำร้องของตำรวจเกี่ยวกับการขอให้การพิจารณาคดีทำโดยลับ

sǎ:n pàʔtìʔsè:t khāmrɔ́:ŋ khɔ̌:ŋ tāmrùət kìəwkàp kā:nkhɔ̌:

court reject petition of officer about request

hâj kā:nphítja:ráʔnā:khāʔdī: thām dōj láp

give trial do by secret

“The court rejected the petition of the officer about the request for the trial to be held secretly.”

To keep the naturalness of the sentence, in some items, material corresponding to the SC was moved to the position right after N1. For items in which an SC cannot be replaced by a prepositional phrase, N1 and its SC were rephrased into either a new independent clause or a dependent clause joining by a conjunction “because”. For example, the underlined part in (4) is an SC. It was changed into two clauses joining by “because” as indicated by an underline in (5).

(4) นับเป็นโชคดีของจุ๋งจิ๋งที่ได้อยู่กับคนที่มันรักและรักมันทั้งในโลกนี้และโลกหน้า

náp pēn chô:kdī: khǒ:ŋ cǔŋcǐŋ thî: dâi jù: kàp khōn
count is luck of Jungjing that get stay with person

thî: mān rák lɛ́ʔ rák mān tháŋ nāi lô:k ní: lɛ́ʔ nāi
that it love and love it both in world this and in

lô:k nâ:
world next

lit: “It is the good luck of Jungjing that is able to stay with the one that it loves and loves it for this and the next life time.”

“It is the good luck of Jungjing in being able to stay with the one that it loves and loves it for this and the next life time.”

(5) นับเป็นโชคดีของจุ๋งจิ๋งเพราะมันได้อยู่กับคนที่มันรักและรักมันทั้งในโลกนี้และโลกหน้า

náp pēn chô:kdī: khǒ:ŋ cǔŋcǐŋ phrɔ́ʔ mān dâi jù: kàp
count is luck of Jungjing because it get stay with

khōn thî: mān rák lɛ́ʔ rák mān tháŋ nāi lô:k ní: lɛ́ʔ
person that it love and love it both in world this and

nāi lô:k nâ:
in world next

“It is the good luck of Jungjing because it is able to stay with the one that it loves and loves it for this and the next life time.”

7.2.3 Procedure

For blocks 1 and 6 which were ambiguous-sentence reading task, a whole-sentence presentation was adopted. All the sentences were presented on a single line. The questions for these blocks were forced binary-choice. For test items in blocks 1 and 6, participants chose which noun was the attachment site of the RC. For filler questions of each block, eight items asked about the ambiguity of a homonym. Twelve questions asked participants to make an inference from the text. The other ten items asked about information stated in the sentence. It can be said that for the fillers of each block, there were 22 items with a correct answer. The other eight had no correct answer, and thus, resembled those of test items. The procedure was the same as that of the Experiment 1.

For blocks 2 and 4 in which participants read unambiguous RCs, test items were distributed into two lists according to a Latin Square design and were intermixed with fillers. A non-cumulative moving-window self-paced reading presentation in which participants read sentences segment by segment was adopted and RTs were measured. All the sentences were presented on a single line. Comprehension questions, which were used for controlling participants' attention, were forced binary-choice. For the questions of the test items of each block, six of them were about the matrix clause. The other six questions were about information in the RC, but never about the attachment. The process was adopted to prevent participants from thinking that questions were only about the matrix clause and they did not have to pay attention to the RC. For the fillers of each block, there were four questions asking about the meaning of a homonym. Other questions asked about the information stated in the text. Otherwise, the procedure was as described in the Experiment 2.

For blocks 3 and 5 which were either SCs or SC-based fillers, whole-sentence presentation was used for presenting sentences. This is to make the procedure different from that in blocks 2 and 4. If there are any effects of SCs on RCs processing, the effects cannot be ascribed to the strategic learning associated with task procedure (see Wells et al., 2009 for related discussion on making the procedure of the task different). It is assumed that the difference in presentation procedures cannot affect the results of the study as a previous study found that the effect of experience in an unambiguous-sentence reading task using whole sentence presentation could show up in an unambiguous-sentence reading task with self-paced reading presentation (see Wells et al., 2009 for such results). The important point is that the sentences are unambiguous and at the disambiguating point, participants have to interpret sentences as manipulated. Therefore, regardless of presentation, blocks 3 to 5 were always in a low degree of freedom situation as were blocks 2 and 4. Since sentences with SCs were different from one another and different from unambiguous RCs in terms of sentence structure, position of construction *N1 khɔ̌ːŋ N2 thîː clause*, and the type of N2, fillers other than SC-based fillers were not given to participants in these blocks. The absence of fillers allowed more possibility for experience with SCs to affect RC processing. Moreover, it made the experiment practical in that participants could finish the experiment within a single lab visit. Since some of the sentences were too long to fit on a single line, those sentences were presented in two lines. The only condition was that for the experimental group, the construction *N1 khɔ̌ːŋ N2 thîː SC* was in the same line to prevent the effect of *implicit prosody* (Fodor, 1998). For the control group, the presentation of the sentences were made parallel with that of the experimental group. Since the only purpose of blocks 3 and 5 was to give participants experience with SCs, nothing was being measured except comprehension questions which were used for monitoring participants' attention. Questions were forced binary-choice and were about the information stated in the sentences, but never about attachment.

Participants completed block 1. Then, depending on their attachment preference, participants were assigned either to the experimental group or to the control group. The only condition in assigning participants into each group was that the overall attachment preference of the two groups was kept similar. Then, participants continued reading sentences in blocks 2 to 6. For blocks 2 to 6, participants were blind to the design of the different blocks. That is, all blocks were presented as one single session. Although both unambiguous-sentence reading and ambiguous-sentence reading tasks involve forced binary-choice questions, the purpose of the questions for each task is different. That is, for ambiguous-sentence reading task, questions were used to determine attachment preference. For unambiguous-sentence reading task, questions were used to determine participants' attention to the task. One benefit for having forced binary-choice questions in all tasks is that they help obscure the difference between tasks. Sentences were presented in a fixed pseudo-random order. Before proceeding to the next item, participants were allowed to take a break. The experiment lasted about 45-60 minutes. The experimental design and the procedure are summarized in Table 7.4.

Table 7.4 Summary of the experimental design and procedure

Group Block	Experimental	Control	Procedure	Measurement	Questions
	Type of sentences				
1	12 ambiguous RCs 30 fillers		Whole-sentence	Forced binary-choice	
2	6 N1-attachment RCs 6 N2-attachment RCs 24 fillers		Self-paced reading	RT	
3	32 SCs	32 SC-based fillers	Whole-sentence	-	Forced binary-choice
4	6 N1-attachment RCs 6 N2-attachment RCs 24 fillers		Self-paced reading	RT	
5	12 SCs	12 SC-based fillers	Whole-sentence	-	
6	12 ambiguous RCs 30 fillers		Whole-sentence	Forced binary-choice	

[1]Grey rows indicate an ambiguous-sentence reading task, otherwise an unambiguous-sentence reading task

[2]Measurement is for attachment preference

[3]-: Nothing was measured

7.2.4 Analyses

Responses from fillers of blocks 1 and 6 which had one correct answer and responses from blocks 2 to 5 were analyzed. All participants scored higher than 88% (mean = 95.83%); therefore, none of them were eliminated from the analyses. Accuracy of the control group (mean: 95.64%) and that of the experimental group (96%) were not different (p = .452).

Response accuracy of unambiguous-RC sentences in blocks 2 and 4 of the unambiguous-sentence reading task was also analyzed to determine whether the accuracy of the two groups and the two attachment conditions were different. The mean accuracies for N1-attachment condition of the control group and of the experimental group were 98.73% and 98.10% respectively. For the N2-attachment condition, the mean accuracy of the control group was 97.46% and that of the experimental group was 96.83%. Data were analyzed in an essentially the same process as described in Experiment 2. However, since questions in Experiment 3 asked either about the content in the matrix clause or about the content in the RCs, it might be the case that types of questions (TypeOfQ) affected participants' responses. Therefore, TypeOfQ was included in the model to factor out any effects of such factor. The exact formula derived from backward selection is given in (6).

(6) answer ~ attach * group * TypeOfQ + (1 | participant) + (1 | item)

For blocks 2 and 4 (an unambiguous-sentence reading task) in which RTs were collected, data were analyzed like in Experiment 2. The process for excluding outliers and the process in calculating RRTs was the same as those described in Experiment 2 (see Chapter 6, Section 6.1.4 for more details). Segments in the self-paced reading presentation were also collapsed into six regions as in Experiment 2. The six regions in Table 6.2 are presented again in Table 7.5. For all RT analyses, only items with correct answer were analyzed.

Table 7.5 Details for each region in the analyses

Data	**Segment in experiment**	**Region**
N1	1	1
khɔ̌:ŋ (“of”)	2	2
N2	3	
thî: (“that”)	4	3
first part of the RC	5	
Disambiguating words	6	4
Last part of the RC	7	5
First part of the matrix clause	8	6
Last part of the matrix clause	9	

For the RT data from blocks 2 and 4, it is crucial to report that there were problems with the RT data of the control group. For all analyses of region 1, it was found that the control group read N2-attachment condition faster than N1-attachment condition (all *p*s $< .04$). This effect is unexpected because attachment was not manipulated at this region (i.e., all the words for N1 and N2 attachment conditions were the same). Moreover, since participants in the control group were not exposed to SCs, they were treated in a similar way as those in Experiment 2. Therefore, there should have been an N2 preference in the crucial region (region 4) or in region 5 (the region possible for spillover effect). The RRTs to N1- and N2-attachment conditions in regions 4 and 5 were not reliably different (all *p*s $> .2$). Similar trends were observed when analyses were run using raw RTs. It is unclear whether the absence of attachment preference was resulted from the difference in region 1. Since there were problems with the control group, the control group will be discarded from all of the RT analyses and discussion of questions 1 and 2 (see Appendix 13, for detailed analyses of the three regions of the control group). In other words, to answer questions 1 and 2, only data from the experimental group will be analyzed and discussed. Results of experimental group will be compared to those of Experiment 2 where there was no experience manipulation.

For blocks 1 and 6 (an ambiguous-sentence reading task) in which the data were responses for forced binary-choice questions, the data were analyzed like in Experiment 1. Since participants of the experimental group and of the control group performed well on comprehension questions, and thus showing that they paid attention to the experiment (all participants scored higher than 88%), there is not a priori reason for excluding the control group from the analyses. Therefore, in the analyses for blocks 1 and 6, the data of both groups were analyzed.

7.3 Results

7.3.1 Question-response accuracy

The analysis revealed that the two groups behaved similarly and there was no difference between the two attachment conditions (all *p*s > .4). However, there was a main effect of TypeOfQ ($p = .01$) such that participants performed better when the questions were about the matrix clause. This might be because the information in the matrix clause was more recent than that in the RCs, making it easier for participants to remember and answer the questions.

7.3.2 Unambiguous-sentence reading task (RTs to unambiguous RCs, blocks 2 and 4)

For the unambiguous-sentence reading task, RT data from blocks 2 and 4 of the experimental group were analyzed.

Question 1: Does experience with unambiguous RCs affect RC-attachment processing during the unambiguous-sentence reading task?

The purpose of the first question is to investigate whether experience with unambiguous RCs caused adaptation to the statistics specific to the unambiguous-sentence reading task, replicating the results of Experiment 2. To answer this question, blocks 2 and 4 were collapsed and the data were submitted to analyses, taking attachment (i.e., attach, N1 or N2), TIorder, interaction between attach and TIorder, and logSorder as factors (see Chapter 6, Section 6.1.4 for the analysis procedure; see also Appendix 14 for details of the analyses).

To reduce multicollinearity, all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled. Multicollinearity remained low (*r*s < .3) except for the correlation between TIorder and logSorder (*r*s > .9; see correlation of fixed factors tables in Appendix 14 for more details). The high correlation between TIorder and logSorder should not affect the factors of interest (i.e., attach; see Fine et al., 2013 for relevant discussion).

In regions 1 and 2, there was no main effect or interaction.

In region 3, there was no main effect of attach. There was a marginal interaction between attach and TIorder (see Table 46 in Appendix 14 for more details) but the marginal interaction was driven by the effect of TIorder on N2 attachment as N2 attachment was marginally slower as the task progressed (estimate = 4.12, p = .069). The marginal effect was unexpected as there was no attachment manipulation in this region.

In the critical region (region 4), none of the main effects or interaction was present. In fact, N1 attachment was numerically faster than N2 attachment (estimate = 2.32, p =.961). The results were different from those of the critical region of Experiment 2, an experiment in which there was no experience manipulation. In Experiment 2, N2 attachment was read faster than N1 attachment and there was a marginal effect of TIorder on N2 attachment such that N2 attachment was marginally progressively slower, making the difference between RRTs to N1 and N2 attachments smaller as the experiment progressed. One possibility for the lack of the N2 preference in Experiment

3 is that the original N2 preference cancelled out with the N1 preference from SCs. If this is the case, SCs should make participants read N2 attachment slower as the experiment progressed. However, such effect was not reliable (estimate = 1.99, p = .772).

For region 5, the results of the analysis are shown in Table 7.6.

Table 7.6 Summary of analyses for region 5

Predictor	Estimate	SE	df	t	p
Intercept	35.04	34.42	37.10	1.02	.315
attachN2	-71.98	34.82	814.20	-2.07	.039
logSorder	112.42	82.16	22.00	1.37	.185
TIorder	-34.78	12.62	23.50	-2.76	.011
attachN2:TIorder	3.74	5.25	834.00	0.71	.477

In Table 7.6, the intercept is N1 attachment. The second row demonstrates that N2 attachment was read faster than N1 attachment (estimate = -71.98, p = .039). The results are compatible with the results of the critical region of Experiment 2 (see Chapter 6, Section 6.2 for detailed results of Experiment 2), suggesting that in Experiment 3, the effect of attachment manipulation spilt over to region 5. Recall that there was a spurious marginal effect of TIorder on N2 attachment in region 3, but the results in region 5 were unlikely to be a carryover from the earlier effect because the trends were in the opppsite direction (in region 3, N2 was marginally slower as the task progressed). In Table 7.6, there was also an effect of TIorder for N1-attachment condition (estimate = -34.78, p = .011) such that participants got faster in reading N1 attachment as they read more test items. The effect of TIorder on N2 atachment did not differ from that of N1 attachment.

In region 6, there was a marginal interaction between attach and TIorder (see Table 55 in Appendix 14 for more details), but the marginal interaction was driven by a marginal effect of TIorder on N2 attachment. As participants read more test sentences, N2 attachment got marginally progressively slower (estimate = 6.74, p = .097). Therefore, the RT difference between the two types of attachments got smaller over the course of the task. Figure 7.1 demonstrates the change of RRTs over the course of the task. The trend lines for each condition were generated from linear regressions.

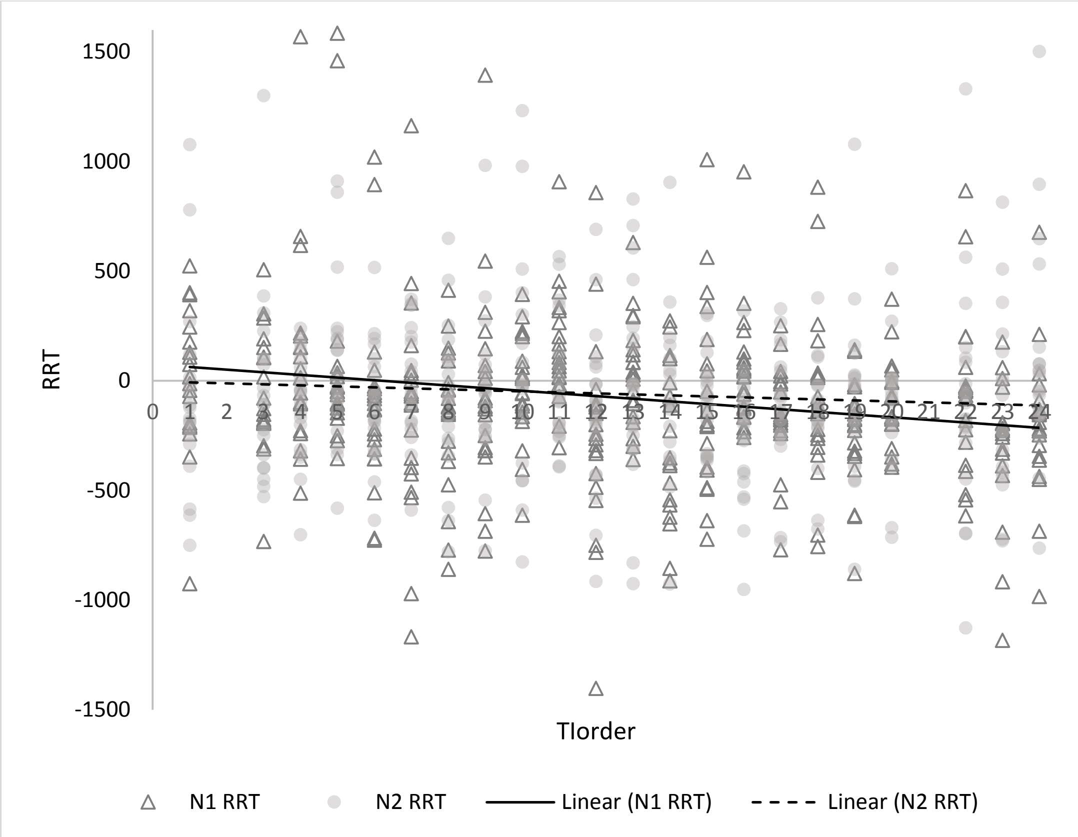

Figure 7.1 The change of residual reading times (RRTs) of region 6 over the course of experiment

There were at least four possible ways for interpreting the marginal effect of TIorder on N2 attachment in region 6. Possibility 1, it might be an unexplainable effect continuing from region 3 (in region 3, there was a marginal effect of TIorder on N2 attachment in the same direction). Possibility 2, some might suggest that the interaction in this region resulted from the effect of clause wrap-up (see Warren, White, & Reichle, 2009 for related discussion on clause wrap-up effect). That is, relating the RC to the matrix clause might be easier when the RC attaches to N1 which is a part of the matrix clause. However, we view possibility 2 to be unlikely. If the interaction resulted from the clause wrap-up effect, the same interaction should have been observed in region 6 of Experiment 2, the experiment in which the same set of stimuli was used. Possibility 3, it might be a trend for experience with unambiguous-RC sentences to affect RC attachment as was the case for the critical region of Experiment 2, but the effect in Experiment 3 was delayed to the last region. Possibility 4, it might be a delayed effect of experience with N1-attached SCs. That is, experience with N1-attached SCs made N1 attachment become easier to understand than N2 attachment as the experiment progressed. At this point, possibilities 3 and 4 are likely to be the case. However, since we lack the data of the control group, we cannot differentiate the two possibilities. The next question which directly involves the analyses of the effect of SCs on RC-attachment processing will address this concern.

Question 2: Does extra experience with SCs affect participants' expectation on RC attachment in unambiguous-sentence reading task?

To answer question 2, RRTs of the experimental group were analyzed as a function of attach (N1 or N2), block (2 or 4), interaction between attach and block, and logSorder. Attach was included to determine whether RRTs to the two attachment conditions were statistically different. Block was used to capture whether participants behaved differently before (block 2) and after exposure to SCs (block 4). Interaction between attach and block was added to determine whether exposure to SCs affected the two attachments in block 4 differently. LogSorder was used to capture the effect of familiarity to the task and the effect of fixed trial order. Other analytical procedures were same as those described in Experiment 2 (see Appendix 15 for details of the analyses).

To reduce multicollinearity, all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled. Multicollinearity for all analyses was low (*r*s < .3) except for correlation between block and logSorder (rs > .9; see correlation of fixed factors tables in Appendix 15 for more details).

Trends for the results reported are similar when logSorder was replaced by raw Sorder, or when logSorder was removed from the model. Trends are also the same for the analyses with raw RT.

In region 1, there was no effect of attach or interaction between attach and block. There was a main effect of logSorder (p = .028) such that participants got faster when reading more sentences. This effect is expected and will not be reported in the main text from here on unless necessary (the full results can be found in the tables of Appedix 15).

In region 2, there was no main effect of attach. Participants got marginally slower in reading N1-attachment condition in block 4 (estimate = 113.64, p = .062). RRTs to N2-attachment condition in block 4 also got slower but they were not different from that to N1-attachment condition. The slower RRTs in block 4 might have resulted from experience with SCs in block 3. Recall that region 2 is “of N2”, and N2 in SC sentences (blocks 3 and 5) was always inanimate while that in RC sentences (both in blocks 2 and 4) was always human. Reading 32 SCs consecutively in block 3 might have made participants get used to the type of the nouns. Therefore, when N2 was changed to human noun in block 4, the time participants took to process N2 in block 4 was longer than that they took in block 2, a block before exposure to SCs (before they got used to inanimate N2). No matter what reasons made block 4 slower than block 2, since RRTs to the two attachment conditions in block 4 were not different, the slower RRTs should not be a cause for any differences between the two attachment conditions that might be observed in the following regions.

In region 3, there was no main effect of attach. N1-attachment condition in block 4 was read slower than that in block 1 (estimate = 162. 17, p = .014). RRTs to N2-attachment condition in block 4 also got slower but they were not different from those of N1-attachment condition.

In the critical region (region 4), there was no main effect of attach. N1 attachment in block 4 was read slower than that in block 2 (estimate = 724.32, p = .007). RRTs to N2 attachment in block 4 were not different from that to N1 attachment. The lack of the main effect of attach contradicts the results of Experiment 2, an experiment in which there was no experience manipulation, as in Experiment 2 there was a preference for N2 attachment. Since there was no interaction between attach and block (p = .140; see Table 69 in Appendix 15 for more details), the absence of the main effect of attach is unlikely to be ascribed to the effect of experience with SCs. As in the analyses for question 1, the spillover effect was observed in the next region.

The results of region 5 are given in Table 7.7.

Table 7.7 Summary of analyses for region 5 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	40.91	38.93	41.28	1.05	.300
attachN2	-83.53	47.19	30.81	-1.77	.087

block4	155.65	159.59	25.20	0.98	.339
logSorder	-175.91	79.39	24.73	-2.22	.036
attachN2:block4	-23.88	84.95	32.91	-0.28	.780

In Table 7.7, the intercept is N1 attachment of block 2. In block 2, N2 attachment was marginally faster than N1 attachment (estimate = -83.53, *p* = .087). This shows that the effect of attachment manipulation spilt over from the critical region to this region. There was neither main effect of block nor interaction between attach and block. The lack of interaction indicates that there was a trend for participants to expect RCs to be N2 attachment for both blocks 2 and 4 (see Figure 7.2 for model estimates per condition and per block for the RRTs to region 5; see also Appendix 15 for a figure illustrating RRTs per region for each condition and each block in ms with by-participants means).

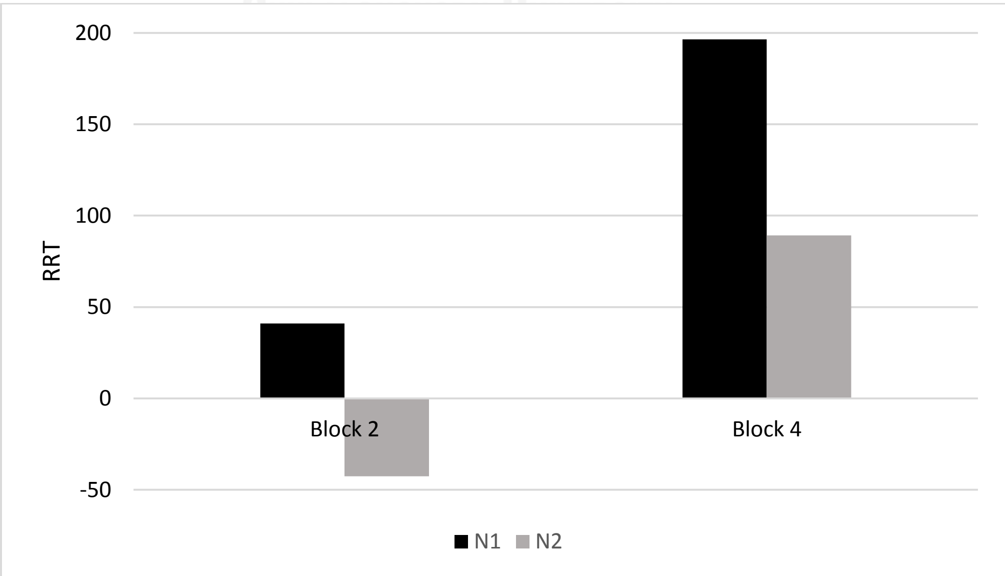

Figure 7.2 Model estimates per condition and per block for the RRTs to region 5

When the data of the critical region (region 4) of Experiment 2 were analyzed in the same way as those reported in Table 7.7 (i.e., RRT ~ attach * block + logSorder), trends for the results were similar to those in Table 7.7. The lack of interaction between attach and block and the similarities between the results in Table 7.7 and the results of the critical region of Experiment 2 indicate that extra experience with SCs did not affect RC processing in unambiguous-sentence reading task.

The results of the analyses for question 2 rules out possibility 4. They confirm that any effects observed in the analyses for region 6 of question 1 did not result from the experience with SCs. However, possibility 3 which statest that in the analyses for question 1, the marginal effect of TIorder on N2 attachment in region 6 resulted from the effect of experience with unambiguous RCs along the experiment but was delayed from the critical region to region 6 is still unclear and will be further discussed in the analyses for question 3.

In region 6, there was no main effect of attach. Participants got slower in reading N1-attachment condition in block 4 (estimate = 225.70, p = .033). RRTs to N2-attachment condition in block 4 also got slower but they were not different from that of N1-attachment condition.

7.3.3 Ambiguous-sentence reading task (blocks 1 and 6)

For questions 3 and 4, the focus of the analyses was whether effect of experience in an unambgiuous-sentence reading task was transferred to an ambiguous-sentence reading task.

Question 3: Can the extra experience with RCs and SCs in an unambiguous-sentence reading task be transferred to an ambiguous-sentence reading task?

The data from blocks 1 and 6 were analyzed. The models included four fixed factors. The first factor was block (1 or 6). It was included to capture the change in preference after extra exposure to RCs and SCs. The second factor was group (experimental or control). This is to capture whether the two groups behaved differently. More importantly, interaction between block and group was included to test whether after extra exposure to RCs and SCs, the experimental group behaved differently from the control group. The last factor was logSorder. It was included to capture the effect of familiarity to the task and the effect of fixed trial order. According to backward selection, the random structure included by-participants and by-items random-intercepts, and block was included in by-participants random slope (see (7) for the formula).

(7) response ~ block * group + logSorder + (1 + block | participant) + (1 | item)

To reduce multicollinearity, all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled. Multicollinearity was low (*r*s < .1; see Appendix 16 for exact values) except for the correlation between block and logSorder (*r* = -0.87). The high correlation between block and logSorder should not affect the factor of interest (see Fine et al., 2013, for related discussion on such high correlation).

Trend for results reported was similar when raw Sorder was replaced by logSorder. The results were different when logSorder was removed from the model. However, the model comparison suggested that the model with logSorder (as in (7)) was the best in accounting for the data ($p < .001$). The results are given in Table 7.8.

Table 7.8 Summary of analyses for blocks 1 and 6 of the experimental and the control groups

Predictor	Estimate	SE	*Z*	*p*
Intercept	-0.61	0.19	-3.20	.001
Block6	2.35	0.54	4.35	< .001
groupExperimental	-0.03	0.32	-0.09	.926
logSorder	-1.33	0.26	-5.13	< .001
Block6: groupExperimental	0.45	0.36	1.25	.212

In Table 7.8, the intercept is the attachment bias in block 1 of the control group. The intercept row indicates that in block 1 of the control group, the rate of attaching RCs to N2 was higher than that to N1 (estimate = -0.61, $p = .001$). The third row indicates that in block 1, the rate of attaching RCs to N2 of the experimental group was not different from that of the control group. This is as expected since this was a criterion when assigning participants into groups. Since in block 1, the two groups behaved the same, any effects observed later cannot be ascribed to the difference between the two groups from the beginning of the experiment. In block 6, N2 preference of the control group was weaker than that in block 1 (estimate = 2.35, $p < .001$). There was no interaction between group and block. This indicates that the experimental group behaved in the same way as the control group. The weaker N2 preference of the two groups indicates that only the effect of experience with RCs in an unambiguous-sentence reading task (i.e., a low degree of freedom situation) can be transferred to an ambiguous-sentence reading task (i.e., a high degree of freedom situation). The result suggests that exposure to N1 and N2 attachments in a 50-50 proportion modulates participants' N2-attachment preference. There was a main effect of logSorder ($p < .001$) such that N2 preference got stronger as the task proceeded (see Table 77 in Appendix 16 for main effects).

The similar model as in (7) was run using data from Experiment 1, an experiment in which there was no experience manipulation. The results of Experiment 1 were the same as those of Experiment 3 except that there was no effect of block. This suggests that in Experiment 3, experience with RCs in an unambiguous-sentence reading task (i.e., blocks 2 and 4) affected RC processing in an ambiguous-sentence reading task.

A transfer of the effect of experience with RCs from an unambiguous-sentence reading task to an ambiguous-sentence reading task suggests possibility for the effect of experience with RCs in an unambiguous-sentence reading task to be present. Therefore, the results of the analyses for question 3 suggest that the marginal effect of TIorder on N2 attachment found in region 6 of the analyses for question 1 (i.e., analyses for the effect of RCs on RC-attachment processing in an unambiguous-sentence reading task) is likely to be due to possibility 3, suggesting that there was adaptation to statistics of RCs specific to the unambiguous-sentence reading task.

Question 4: Does experience with ambiguous RCs in an ambiguous-sentence reading task affect participants' attachment decision?

To confirm that any effects observed in question 3 are not from effects of experience with ambiguous RCs, analyses for question 4 were run. Blocks (1 and 6) were collapsed and responses were analyzed in the same way as those of Experiment 1 (see Chapter 5, Section 5.1.4 for more details about analyses). That is, responses were analyzed as a function of group (experimental or control), TIorder, interaction between group and TIorder, and logSorder. TIorder and its interaction with group capture the effect of experience with ambiguous RCs on each group. The formula used in (8).

(8) response ~ group * TIorder + logSorder + (1+ TIorder | participant) + (1 | item)

As in every analyses, all fixed factors and numerical factors were centered and the log-transformed numerical factors were scaled to reduce multicollinearity. Multicollinearity was low (*r*s < .2; see Appendix 17 for exact values), except that for TIorder and logSorder (*r* = .92).

Similar trends for the results of the analyses were observed when logSorder was replaced by Sorder or removed from the analyses. The results are shown in Table 7.9 (see also Table 79 in Appendix 17 for main effects).

Table 7.9 Summary of analyses for the experimental and the control groups

Predictor	Estimate	SE	*Z*	*p*
Intercept	-0.61	0.21	-2.89	.004
groupExperimental	-0.02	0.32	-0.06	.955
TIorder	-0.05	0.06	-0.79	.432
logSorder	< 0.01	0.41	0.01	.995
groupExperimental:TIorder	0.02	0.03	0.93	.351

In Table 7.9, the intercept is the attachment bias of the control group. It demonstrates that the control groups preferred attaching RCs to N2 (estimate = -0.61, p = .004). The preference of the experimental group was not different from that of the control group. This confirms the finding of Experiment 1, showing that there is an N2 attachment preference in Thai. Importantly, there was no effect of TIorder. This confirms that effects observed in question 3 were not affected by experience with ambiguous RCs. The results also show that there was no effect of logSorder. This was different from the results reported in Experiment 1 as in Experiment 1, the preference for N2 attachment got stronger as participants read more test sentenceas and fillers (see Table 5.1 in Chapter 5, Section 5.2 for the results of Experiment 1). However, we argue that the lack of logSorder effect in the analyses for question 4 does not contradict the results of Experiment 1. Rather, we argue that the lack of this effect in the analyses for question 4 resulted from the effect of extra experience during the unambiguous-sentence reading task. It can be seen from the analyses for question 3 that when block was added to directly capture the effect of extra experience during the unambiguous-sentence reading task, the effect of logSorder was present and it was in the same direction as that in Experiment 1 (see Table 7.8 for the effect of logSorder in the analyses for question 3).

7.4 Discussion

Both analyses for unambiguous-sentence reading task and analyses for ambiguous-sentence reading task indicate that there was an N2 attachment preference, replicating the findings of Experiments 1 and 2. Moreover, analyses of Experiment 3 show that extra experience with SCs affected RC processing in neither tasks. The absence of the SC effect is also compatible with the results of Experiments 1 and 2, indicating that neither past experience with SCs as indicated by the corpus data nor experience with SC during the experiment can affect RC-attachment processing.

For the analyses for question 1 in which the data from blocks 2 and 4 were analyzed, the marginal effect of TIorder on N2 attachment in region 6 indicates that experience with RCs affected RC attachment in the unambiguous-sentence reading task (i.e., a low degree of freedom situation). Moreover, for the analyses for question 3 in which the data from blocks 1 and 6 were analyzed, the results show that experience with RCs in the unambiguous sentence reading task can be transferred and affected RC-processing in the amaiguous-sentence reading task (i.e., a high degree of freedom situation). The results disprove the hypothesis stating that the effect of experience in low degree of freedom situation cannot be transferred to a high degree of freedom situation.

It should be noted that in this experiment, we lack another control group of which participants are not exposed to unambiguous RC-attachment sentences (i.e., participants do not read unambiguous RCs in blocks 2 and 4). The transfer of the effect of experience with RCs claimed in this experiment was based on the comparison between the results of this experiment to those of Experiments 1 and 2. Such comparison can partially confirm the transfer. Future study with a base line group is needed to address this concern.

The results demonstrating the effect of experience with RCs show that although the proportion of the two interpretations shown in the experiment (i.e., proportion of N1-N2: 50-50) is not much different from what participants would encounter in daily life (i.e., about 46-54 as indicated by the corpus data), such small difference can rapidly affect RC processing.

The effect of experience with RCs on RC attachment in the low degree of freedom situation (as indicated by a marginal effect of TIorder on N2 attachment; see analyses for region 6 of question 1) and the effect of experience with RCs in the high degree of freedom situation (as indicated by the effect of block; see analyses for question 3) can be explained in terms of probability learning. As explained in Experiment 2, participants assigned higher probability to N1 attachment and lowered the probability of N2 attachment as experiment progressed. The degree of adaptation to N1 attachment was higher than that to N2 attachment because the error-signal in the processing of N1 attachment was higher than that in the processing of N2 attachment. Therefore, the preference for N2 attachment was weakened.

There might be a concern on whether the way participants changed their preference in ambiguous-sentence reading task is also a kind of strategic learning. That is, participants might notice the point of the experiment in the unambiguous-sentence reading task and expect that the point for the ambiguous-sentence reading task is the same. We argue that the change in preference in an ambiguous-sentence reading task is unlikely to result from strategic learning.

Strategic learning is a kind of learning that is specific to the task. It helps learners to perform better in a specific situation. In unambiguous-sentence reading task, participants' expectation on the upcoming interpretation (i.e., local preference) was measured. Since the target construction was in the subject position, participants' expectation was not affected by information in the matrix clause. Later, when local ambiguity was resolved, participants had to interpret sentences as manipulated. In this task, strategic learning might occur as participants could use information on how the local ambiguity was often resolved to expect the upcoming interpretation of the next items so that they could perform better in the task. On the contrary, in ambiguous-sentence reading task, more than one interpretation is possible. Participants had freedom to choose the attachment site for RCs (i.e., high degree of freedom situation). In making attachment decision, participants could re-read sentences as many times as they want. They could also consider probability for each interpretation to occur, relation between the matrix clause and the RC, or any information available to them. Therefore, attachment decision participants made (i.e., global preference) in ambiguous-sentence reading task was more complex than expectation that participants made in the unambiguous-sentence reading task. Given that the ambiguous-sentence reading task involves higher degree of freedom situation and attachment decision is more complex, strategic learning that might happen during the unambiguous-sentence reading task is unlikely to affect processing in the ambiguous-sentence reading task.

Rather, if participants noticed the point of the unambiguous-sentence reading task and adapted their global preference to make it align with statistics specific to that task, we view the change in global preference in the ambiguous-sentence reading task as participants learning speaker's (or writer's) identity (see Kamide, 2012, for adaptation to speakers' identity). That is, interacting with a computer during the experiment might be regarded as interacting with a specific speaker (or writer). Once participants noticed that the speaker preferred N1 attachment, participants expected more N1 attachment so that they could interact with that speaker better.

Chapter 8
General discussion and future directions

In this dissertation, we adopted the techniques used in experience-based accounts to investigate the processing of RC attachment in Thai so that the nature of experience in sentence processing could be understood. Specifically, we tested whether experience with RCs and experience with a similar construction namely SCs affect processing of RC attachment and whether the effect of experience can be transferred to a different situation. First and foremost, we found that native Thai speakers preferred attaching RCs to N2. This is true for both the corpus count and comprehension experiments. In the corpus count, we also found that context could create a bias towards N1 attachment. In comprehension, we found that experience with RCs affected RC processing not only as the experimental session progresses but also that such experience got transferred to a different situation. That is, in a low degree of freedom situation where local preference was measured, we found that participants could rapidly adapt their expectation to the statistics specific to the experiment (i.e., N1-N2 attachment in 50-50 proportion) such that the difference between RTs to N1- and N2-attachments got smaller over the course of the experiment. We also found that after participants were exposed to unambiguous RC-attachment sentences in a low degree of freedom situation, their preference in a high degree of freedom situation also changed such that their global preference for N2 attachment got weaker. The results suggest that as has been observed for English, the effect of experience on N1 and N2 attachment was asymmetrical such that the effect of experience was stronger for the dispreferred construction (i.e., N1 attachment). Lastly, we found that experience with SCs did not affect processing of RC attachment. The results were consistent regardless of the method used in testing the effect of experience. That is, we tested the effect of experience with SCs by comparing corpus data and behavioral experiments but we found that the results of reading experiments (Experiments 1 and 2) were compatible with the corpus count that included only RC instances. In Experiment 3, we gave extra experience with N1-attachment SCs to participants but such experience did not affect their preference.

8.1 Why readers prefer N2 attachment

In general, experience-based accounts propose that readers prefer interpreting sentences following the interpretation they frequently encounter. Following experience-based accounts, because in Thai N2 attachment is more frequent than N1 attachment, N2 attachment is preferred. One problem with such explanation is that it leaves unspecified what makes N2 attachment more frequent than N1 attachment.

Under the framework of experience-based accounts, MacDonald (2013) proposed the production-distribution-comprehension (PDC) model. According to PDC, speakers follow some production strategies when producing sentences in order to make their speech fluent. The construction that is often produced results in higher frequency, and thus affects processing. The three strategies proposed by MacDonald (2013) are *easy first*, *reduce interference* and *plan reuse* (see Chapter 3, Section 3.1.1 for more details on the PDC).

Easy first is responsible for word order variation, and thus, irrelevant to the production of N2 RC-attachment in a construction *N1 of N2 RC*. Reduce interference results in demoting or omitting one of the similar entities in production plan and is not relevant to the production of N2 RC-attachment either. It is possible for one to claim that plan reuse promotes frequency of N2 attachment more than that of N1 attachment. Because there are other constructions in a language that attach locally (i.e., attach to the most recent word being perceived), speakers reuse such plan when producing RC attachment construction, resulting in high frequency of N2 attachment. If this is the case, the question why other constructions attach locally remains to be answered. The problem with plan reuse also arises when we consider attachment of RC to a single head noun (schematically, *N + RC*). In this case, there are two possible predictions from plan reuse and there is not a priori reason to decide which one is valid. In *N + RC* (e.g., *khǎwchɔ̂ːptháʔnāːjthîːphûtphāːsǎːcīːndâːjkhlɔ̀ŋ*, "he likes the lawyer that speaks Chineses fluently"), N ("the lawyer") might be viewed as an argument of the matrix verb ("likes"). In this case, reusing such plan should promote production of N1 attachment for the construction *N1 of N2 RC* since N1 has potentiality to be an argument of the matrix verb. On the other hand, if N in *N + RC* is viewed as a local noun (i.e., a noun that is adjacent to an RC), plan reuse should promote production of N2 attachment in *N1 of N2 RC* as N2 is adjacent to the RC. It can be seen that plan reuse is not a good candidate for explaining why N2 attachment is produced more frequently than N1 attachment.

Another way of explaining N2 preference is to assume that comprehension is not tightly related to production process as assumed by the PDC. Regardless of whether production process can or cannot bias production of N2 attachment, N2 preference in comprehension may reflect nothing but a universal locality preference. Some researchers proposed that because language processing is incremental and working memory resources are limited, locality is preferred such that working memory's burden can be lessened (Frazier, 1978; Gibson, 1998; Gibson et al., 1996). For example, according to Gibson (1998), activation of words that have been perceived decays over time as new words are being perceived. Moreover, keeping syntactic predictions in memory while interpreting intervening constituents requires large amounts of working memory. Attaching RC to N1 is a burden to working memory as it involves higher demand in reactivating the noun. In addition, prediction for non-local attachment will increase the use of working memory. This is because while processing the intervening constituents which are *of N2* and the first part of the RC (i.e., the part before the disambiguating point), readers need to keep the non-local noun and non-local attachment prediction in mind (see Gibson, 1998 for related discussion on integration and memory costs). Because attaching RCs to N2 can reduce memory demands, readers prefer attaching RCs to N2.

There might be objections regarding the claim that locality preference explains N2 attachment because previous studies in languages such as Spanish (Cuetos & Mitchell, 1988), Dutch (Desmet et al., 2006), and Japanese (Kamide & Mitchell, 1997; Yamada, Arai, & Hirose, 2014) reported a preference for non-local attachment. We argue that since those studies did not control for contextual effect, it is possible that context obscured N2 preference in those studies.

8.2 Contextual effect and RC attachment

In Chapter 4 (i.e., the corpus count chapter), we reported an N2 bias for the internally-disambiguated instances but an N1 bias for the externally-disambiguated instances suggesting that context can affect RC attachment in production by reversing the attachment pattern, causing a bias towards N1 attachment. In previous RC-attachment processing studies, context was found to bias attachment as readers looked for textual coherence while reading (Rohde, Levy, & Kehler, 2011; Siriwittayakorn, Miyamoto, & Ratitamkul, 2015). The results of the RC count together with the contextual effects on comprehension of RC attachment found in previous studies suggest that studies investigating RC attachment should take the influence of context into consideration. This is true for work using corpora, given the rich contexts that often precede the target construction. But it is also true for experiments showing individual sentences in isolation given that intra-sentential context can be a crucial factor affecting attachment.

A previous study suggested that Thai speakers preferred N1 attachment (Siriwittayakorn et al., 2014). In this dissertation, we have shown that when stimuli were better controlled especially in relation to contextual factors, the previously reported N1 attachment preference in Thai turns out to be wrong. This is in line with the possibility that contextual effects contaminated the results of previous studies in other languages.

With regards to violation of locality preference, Grillo and Costa (2014) arrived at a similar conclusion suggesting that N1 attachment is only favored when the matrix clause can give rise to an alternative interpretation (*pseudo RCs*) in which the events in the two clauses are simultaneous and only the N1 interpretation is possible. However, the availability of pseudo RCs cannot explain the change in preference reported in a questionnaire in Thai (Siriwittayakorn, Miyamoto, & Ratitamkul, 2015), asking participants to choose attachment site for RCs when RCs were embedded in the matrix clause or were shown in isolation. In the questionnaire study, none of the RCs could be interpreted as pseudo RCs. Therefore, the preference reversal is unexpected if pseudo RCs are the only (or the main) factor leading to N1 preference. Pseudo RCs cannot explain N1-attachment preference reported in Japanese (Kamide & Mitchell, 1997; Yamada, Arai, & Hirose, 2014) either as test items of those studies did not involve pseudo RCs. Moreover, in Japanese it was reported that there was an initial preference for the local noun and a late reversal favoring the non-local noun as the matrix clause was read. The pseudo-RC proposal does not make any predictions on such preference reversal. However, the results in Japanese are compatible with the assumption that locality is observed initially but is overridden by text coherence later as the matrix clause is read. Since readers prefer text to be coherent and the matrix clause can bias attachment, the results that pseudo RCs have been claimed to explain may be reduced to contextual effects. That is, some types of matrix verb (e.g., perception verb) may make participants attach the RC to N1 to make the time reference of the RC overlap with the time of the matrix clause.

Clearly, further studies are needed but if previously-reported N1 attachment preferences in various languages can be ascribed to context, then a local attachment preference can be held as a universal principle, without the need for cross-linguistic parameterizations in the way people process sentences.

It should be noted that positing a locality preference does not mean that we exclude other factors that may come into play when readers process sentences. Animacy and concreteness may interact with locality biasing attachment in one way or another as suggested by previous studies (Acuña-Fariña et al., 2009; Desmet, Brysbaert, & Baecke, 2002; Desmet et al., 2006). However, since those studies did not take contextual effect into consideration, we do not know to what extent attachment decision is affected by such factors. We leave it for future study to investigate such role. At this point, what we are arguing is that when everything is equal (e.g., the two head nouns are animate-concrete), locality should be preferred.

8.3 Effects of experience in sentence processing

Even when locality is preferred, experience can still play a role in sentence processing. From the results of this dissertation, we found that preference for N2 attachment can be modulated by readers' experience with N1 attachment. These results contribute to literature in sentence processing in three ways. Firstly, we extend previous findings showing that the effect of experience with two competing constructions in a 50-50 proportion can be observed in the processing of constructions other than subject-extracted and object-extracted RCs (Wells et al., 2009), and main verbs and reduced RCs (Fine et al., 2013).

Secondly, we found that experience with test items in experiments could affect participants' processing even when the proportion of the two competing constructions in the experiment is not markedly different from participants' experience prior to the experiment. That is, for this dissertation and previous studies (Fine et al., 2013; Wells et al., 2009), two competing constructions that were shown in experiments were in a 50-50 proportion. However, for those previous studies, the proportion of the two competing constructions in participants' experience prior to the experiment (as determined by corpus data) was markedly different from 50-50 proportion. For example, Fine and colleagues (Fine et al., 2013) studied the processing of regular past verb that can be interpreted as either a past participle introducing reduced RCs or a main verb. The proportion of the two competing constructions in participants' past experience was 1-99. Because the proportion of the two competing constructions in Fine et al.'s (2013) study was markedly different from participants' experience, the contrast made it clear in which direction the accommodation should occur. In this dissertation, the proportion of N1 and N2 attachment obtained from raw frequency pattern found in the corpus count was about 46-54. Therefore, the proportion of N1 and N2 attachment in participants' experience prior to the experiment was not much different from the proportion of the two attachments in the experiments. Nevertheless, we still found that participants could rapidly learn the probability for each attachment to occur in the experiment and change their preference to make it align with the statistics of the experiments. From the results showing change in expectation over the course of experiments, a previous study claimed that participants could rapidly adapt to statistics specific to experiments (Fine et al., 2013). We expand such claim by showing that participants are more sensitive to statistics specific to experiments than what can be assumed from previous results.

Thirdly, we extend previous studies (Fine et al., 2013; Kamide, 2012; Wells et al., 2009) by showing that the effect of experience in one situation can be transferred to a different situation which involves a higher degree of freedom, and thus, suggesting that experience can change readers' processing preference in a more pervasive manner. In previous studies, the effect of experience was tested only in a low degree of freedom situation. That is, participants were exposed to sentences which could be interpreted only in one way. Later sessions tested whether such experience could modify processing preferences. In those findings, it is unclear whether the change in expectation indicates that participants learnt from probability for each construction to occur and generally changed their preference, or they just learnt some kind of strategy that helped them perform better in a specific situation. From a comprehensive review concerning the effect of learning in different paradigms (Schmidt & Bjork, 1992), it is suggested that to claim for a learning effect, experience in a low degree of freedom situation should be transferrable to a high degree of freedom situation where learners have a chance to perform freely. With the results of Experiment 3, we have shown that reading unambiguous RCs which can be considered to be processing in a low degree of freedom situation could affect participants' attachment decision in a high degree of freedom situation. The results of Experiment 3 suggest that participants learnt from their experience can generalize it.

The results of this dissertation support the claim of experience-based accounts as they show that experience with the target construction can affect its later processing. The finding that experience can change participants' preference also contributes to the nature-nurture debate as they show that experience with the target construction can be one of the sources for learning. From this dissertation, although we cannot directly address what exactly the learning mechanism is, we can be sure that mechanism involving reactivation and traces in episodic memory as proposed by Kaschak and Glenberg (2004) cannot account for adaptation process in this dissertation. This is because such explanation wrongly predicts that experience with N1 attachment facilitates N2 processing; therefore, a change in preference should not be observed (see Fine et al., 2013 for a similar conclusion). One possibility is to follow Fine et al.'s (2013) assumption assuming that participants learnt from the error signal which is related to the probability for each interpretation to occur. That is, since participants preferred N2 attachment and they experienced N2 attachment more frequently than N1 attachment, participants expected sentences they read in experiments to be N2 attachment. If sentences turned out to be N1 attachment, there was a high error signal, but if sentences turned out to be N2 attachment, the error signal was low. Every time participants finished processing a sentence, they assigned higher probability to the construction that turned out to be right and lowered probability of the construction that turned out to be wrong so that they could reduce the processing error that might occur in processing in the future. Since the error signal associated with processing N1 attachment was higher than that of N2 attachment, the extent to which participants increased the probability for N1 attachment was higher than that for N2 attachment. Therefore, although participants processed N1 and N2 attachment in equal proportion, they could learn from the error signal and change their preference. It should be noted that in this discussion, we roughly estimated the error signal from the frequencies found in a corpus. Previous studies (Fine & Jaeger, 2013; Jaeger & Snider, 2013) suggest that the error signal can be calculated by following surprisal theory (Levy, 2008, 2013). To test whether participants actually learn from the error signal, future studies should make more exact calculations to test surprisal and error signal detection.

To tie the results of the effect of experience found in this dissertation to sentence processing studies in the literature regardless of which framework is adopted, firstly it should be kept in mind that by means of on-line methodology, it is inevitable to have participants read two competing constructions and compare which construction is read faster. Since experience with test items can rapidly affect processing, a caution regarding data analysis as suggested by Fine et al. (2013) should be emphasized. That is, whether or not effects of experience are of central interest of a study, it is important to pay attention to the effect of experience with test items. Any studies analyzing experimental data without taking effects of experience into consideration may risk a chance in getting some types of effects stronger or weaker than they should be.

8.4 Why does experience with SCs not affect processing of RC attachment?

MacDonald and Christiansen (2002; also Kaschak & Glenberg, 2004) proposed that experience with similar constructions can facilitate processing of a given target construction. Although MacDonald and Christiansen left their proposal unspecified as to how similar constructions have to be in order to cause processing transfer, they proposed that similarity in terms of word order can cause it. In their proposal, they argued that because in English subject-extracted RCs share similarity in terms of word order (SVO) with simple sentences, subject-extracted RCs are easier to process than object-extracted RCs.

In this dissertation, given that word order of RCs and SCs can be superficially identical, we tested processing transfer between these similar constructions by means of compatibility between corpus counts (Chapter 4) and behavioral experiments (Chapters 5 and 6) and by means of exposing participants to more instances with SCs (Chapter 7). However, we did not find an effect of experience with SCs on RC attachment in any of the experiments. With the results of this dissertation, we argue that if similarities between constructions can cause processing transfer as proposed by MacDonald and Christiansen (2002), only similarity in terms of word order is not enough to cause it.

It is possible that in processing readers might consider information such as animacy and concreteness of the two head nouns (Desmet et al., 2006), thematic role of the missing noun in a subordinate clause (Gennari & MacDonald, 2008, 2009), or the antecedent of the missing noun in the subordinate clause (Hemforth, Konieczny, & Scheepers, 2000) when making attachment decisions. Therefore, one possible reason for us not being able to detect the effect of SCs is that we did not take all of the possible factors that readers may consider in processing into consideration when tallying corpus frequencies for RCs and SCs or when constructing stimuli for experiments. For this reason, the results of this dissertation cannot be used to argue against the influence of similar constructions on the processing of a given target construction.

Given the results of Experiment 3, SCs are unlikely to affect RC attachment in terms of anaphoric resolution. This is because in Experiment 3, all SCs that participants were exposed to contained a zero pronoun in the subject position and that zero pronoun referred to N2. If participants had considered the antecedent of the zero pronoun when making the attachment decisions, participants should have learnt from their exposure to SCs that the zero pronoun was always N2 and such extra experience with SCs should have made participants expect the extraction in the subject position of RCs to refer to N2.

When conducting corpus counts, different criteria can be applied. If only structure built based on parts of speech of words are taken into account without reference to specific lexical properties, the frequency obtained is known to be *coarse-grained frequency*. On the other hand, if factors other than parts of speech such as lexical information of the nouns are taken into account, the frequency obtained are known to be *fined-grained frequency*. It should be noted that there is not a priori definition exists for frequency granularity. One corpus count may be in a finer grain than the other depending on how many factors are taken into consideration when doing the count.

In the corpus counts of this dissertation, we counted instances of RCs taking animacy and concreteness into consideration but for SCs, we ignored such lexical factors since SCs are likely to attach only to a propositional noun and other lexical properties are unlikely to bias attachment. At this point, one might suggest that the incompatibility between the corpus counts and the results of Experiments 1 and 2 may have been the result from the different granularities used for the two constructions. Consequently, if readers take factors other than parts of speech into consideration, then the prediction for the effect of SCs on the processing of RC attachment that we made based coarse-grained frequency might be wrong from the very beginning, resulting in the incompatibility we reported. To address this concern, corpus data of both RCs and SCs should be recounted in the same way, taking factors that might be relevant in processing such as lexical properties of the two head nouns into consideration. In reading experiments, stimuli should be constructed in parallel to the way instances were tallied in the corpus count. Then, reading experiments should be conducted to test whether the results are compatible with the results of the corpus.

However, one drawback with research testing the effect of experience in sentence processing through the compatibility between corpus data and behavior data is that it is virtually impossible to falsify experience-based accounts since proponents can always come up with a new type of granularity to account for discrepancies. As far as we are aware, there is currently no way of determining a priori what the appropriate granularity should be for a given construction in a given language.

8.5 A problem with the frequency x regularity, and frequency x regularity x experience proposals

Frequency x regularity (MacDonald & Christiansen, 2002), and *frequency x regularity x experience* proposals (MacDonald & Christiansen, 2002; Wells et al., 2009) propose that *regularity* of a construction is determined by similarities that it shares with other constructions (MacDonald & Christiansen, 2002). However, with the results of this dissertation, we argue that the definition of similarity between constructions is unclear; and therefore, the definition of regularity cannot be determined either.

There is at least one evidence supporting that the definition of regularity is unclear. In a construction of RC attachment (schematically, *N1 of N2 RC*), it is unclear how one can judge which attachment (N1 or N2 attachment) is more regular than the other. This is because attachment of RC to a single noun (schematically, *N + RC*) can promote either N1 or N2 attachment to be a more regular construction depending on whether *N* in *N + RC* is viewed as an argument or a local noun (see Section 8.1 for related discussion on plan reuse). Since there is a problem with definition of regularity from the very beginning, there is a possibility that frequency x regularity, and freuqnecy x regularity x experience proposals are not a good alternative in explaining the effect of experience.

MacDonald & Christiansen (2002) introduced the frequency x regularity proposal and used it to explain why subject-extracted RCs were easier to process than object-extracted RCs. They propose that in English subject-extracted RCs are regular because they share similarity in terms of word order (SVO) with simple sentences. On the other hand, object-extracted RCs contain rare word order (OSV), and thus, considered to be less regular. In processing, subject-extracted RCs are easier to process than object-extracted RCs because the processing of subject-extracted RCs is facilitated both by experience with subject-extracted RCs themselves and by experience with simple sentences, whereas the processing of object-extracted RCs depends heavily on experience with object-extracted RCs.

For frequency x regularity x experience proposal (MacDonald & Christiansen, 2002; Wells et al., 2009), it is proposed that regular constructions will be less affected by extra experience. Therefore, following the proposal, it is predicted that processing of object-extracted RCs, but not of subject-extracted RCs, will be much affected by extra experience. Wells and colleagues (Wells et al., 2009) conducted a reading experiment and found that participants were better in processing subject-extracted RCs. However, after extra experience with the two constructions was given to participants in an equal proportion, only in the processing of object-extracted RCs was there large improvement in processing. Wells and colleagues claimed that their results support the frequency x regularity x experience proposal.

If the frequency x regularity, and frequency x regularity x experience proposals are discarded, the question is whether there are any other proposals that can explain the ease in the processing of subject-extracted RCs and the asymestircal effect of extra experience on the processing of subject-extracted and object-extracted RCs.

To explain the origin of the ease of subject-extracted RC processing, there are at least two possibilities. The first possiblity is that readers consider lexical features of the head noun when processing RCs. According to Gennari and MacDonald (2008, 2009), when the head noun is animate, readers expect it to continue as a subject and as an agent of a given RC. In Wells et al.'s (2009) study, the head nouns of all test items were animate. Based on Gennari and MacDonald's (2008, 2009) proposal, it is possible that in Wells et al.'s study, processing of subject-extracted RCs was facilitated because the animate head nouns continued as the subject and as the agent of RCs as readers had expected (see Wells et al., 2009 for related discussion).

It might also be the case that other factors such as locality as assumed by working-memory based models facilitate the processing of subject-extracted RCs. For example, according to Gibson (1998), processing of RCs involves integrating extraction with the RC verb. In doing so, readers need to associate such extraction back to the relative pronoun *who*. In object-extracted RCs (e.g., *the reporter who the senator attacked*), such integration is non-local because there are two intervening constituents between the object extraction and *who* (i.e., the RC subject and the RC verb; e.g., *the senator* and *attacked*). On the contrary, in subject-extracted RCs (e.g., *the reporter who attacked the senator*), there is no intervening constituent. Therefore, processing subject-extracted RCs requires smaller amounts of working memory than processing object-extracted RCs, and thus, making subject-extracted RCs easier to process (see Gibson, 1998 for more details). It should be noted that by assuming locality, we leave open whether other factors such as lexical features of the head noun can interact with locality.

For the asymmetrical effect of extra experience on the processing of subject- and object-extracted RCs, there is a high possibility that learning mechanism underlying the results of Wells et al.'s (2009) study can be explained in terms of error signal. That is, since object-extracted RCs are less frequent than subject-extracted RCs, the error signal from processing object-extracted RCs is higher than that from processing subject-extracted RCs. Therefore, participants assigned higher probability to object-extracted RCs than to subject-extracted RCs. In other words, high error signal made participants expect more on object-extracted RCs, resulting in stronger effect of experience on processing of object-extracted RCs. However, future studies are needed to directly address whether learning through error signal can explain such results.

8.6 Conclusion

To understand the nature of experience in sentence processing, we adopted techniques used in experience-based accounts to conduct experiments on RC attachment in Thai. Both corpus counts and reading experiments show that there is an N2 attachment preference. We propose that the origin of the N2 preference in comprehension results from a locality preference which is assumed to be universal. We found that in the corpus counts, context could affect attachment by obscuring the N2 bias. With the results of our corpus counts and the results of behavioral experiments in previous studies (Rohde, Levy, & Kheler, 2011; Siriwittaykorn, Miyamoto, & Ratitamkkul, 2015), it is possible that failure in observing N2 preference in previous studies of RC attachment in other languages was due to the influence of context. Since previous studies did not control for contextual effects, direct comparison across languages cannot be conducted at this point.

We found that experience with RCs could rapidly affect processing of RC attachment even when the distributions used in the experiment diverged minimally from participants' experience in general. We also found that the effect of experience could be transferred to a different situation. These results suggest that even though N2 attachment seems to be a universal principle, experience can modulate such preference. The results support the claim of the experience-based accounts stating that readers' experience with the target construction guides the way they process new sentences. As in previous studies (Fine et al., 2013; Wells et al., 2009), we found that the effect of experience on each construction is asymmetrical. Experience tends to have more effect on the less preferred construction.

We also found that experience with a construction that shared a superficially identical word order configuration, namely SCs, could not affect the processing of RC attachment. The result indicates that superficial similarity between constructions in terms of word order is not a sufficient condition to cause a processing transfer. However, future studies are needed address more fine-grained versions of such claims.

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APPENDIX

Appendix 1

An example of an experiment with whole-sentence presentation

The following is an example of instructions and graphic demonstrations of an experiment with whole-sentence presentation.

Instructions

ในการทดลองนี้คุณจะได้อ่านประโยคทีละประโยค

1. ประโยคจะปรากฏขึ้นบนหน้าจอ

2. คุณต้องอ่านด้วยความเร็วปกติ และทำความเข้าใจประโยค ไม่จำเป็นต้องอ่านออกเสียง

3. คุณจะได้เห็นคำถามเกี่ยวกับประโยคที่ได้อ่านไป

ให้กดปุ่ม "F" เพื่อตอบ 1. หรือกดปุ่ม "J" เพื่อตอบ 2.

4. กรุณาตอบคำถามให้เร็วที่สุดเท่าที่จะเป็นไปได้โดยใช้ความคิดแรกของคุณในการตอบ

4. หลังการตอบคำถาม เครื่องคอมพิวเตอร์จะนำคุณเข้าสู่ส่วนถัดไปโดยอัตโนมัติ

5. คุณสามารถหยุดพักได้***ต่อเมื่อมีข้อความอนุญาตเท่านั้น***

กรุณากด space bar เพื่อดำเนินการต่อ

Graphic demonstrations of an experiment with whole-sentence presentation

Figure 1. An ambiguous sentence for experiment with whole-sentence presentation

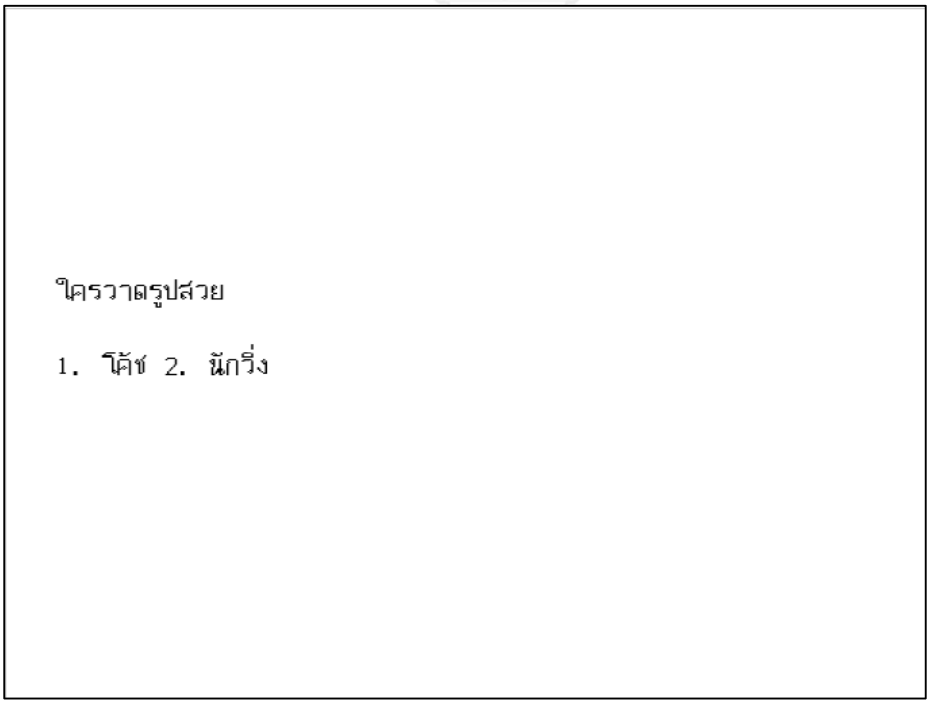

Figure 2. A question for the ambiguous sentence

Appendix 2

An example of a non-cumulative moving-window self-paced reading experiment

The following is an example of instructions and graphic demonstrations of a non-cumulative moving-window self-paced reading experiment.

Instructions

ยินดีต้อนรับเข้าสู่การทดลอง

ต่อไปนี้คือขั้นตอนการทดลอง

1. ดอกจันจะปรากฏบนหน้าจอ คุณต้องกด space bar เพื่ออ่านแต่ละส่วนในประโยค

2. คุณต้องอ่านด้วยความเร็วปกติ และทำความเข้าใจประโยค ไม่จำเป็นต้องอ่านออกเสียง

3. คุณจะได้เห็นคำถามเกี่ยวกับประโยคที่ได้อ่านไป

ให้กดปุ่ม "F" เพื่อตอบ 1. หรือกดปุ่ม "J" เพื่อตอบ 2.

4. หลังการตอบคำถาม เครื่องคอมพิวเตอร์จะนำคุณเข้าสู่ส่วนถัดไปโดยอัตโนมัติ

5. คุณสามารถหยุดพักได้***ต่อเมื่อมีข้อความอนุญาตเท่านั้น***

กรุณากด space bar เพื่อดำเนินการต่อ

Graphic demonstrations of a non-cumulative moving window-self-paced reading experiment

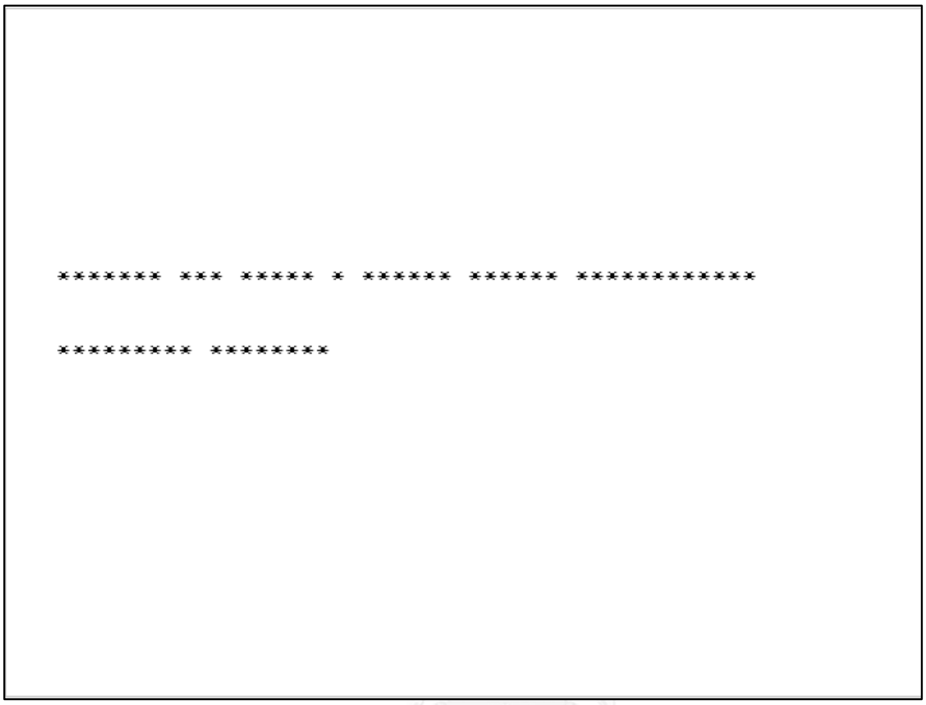

Figure 3. A string of symbols masking a sentence

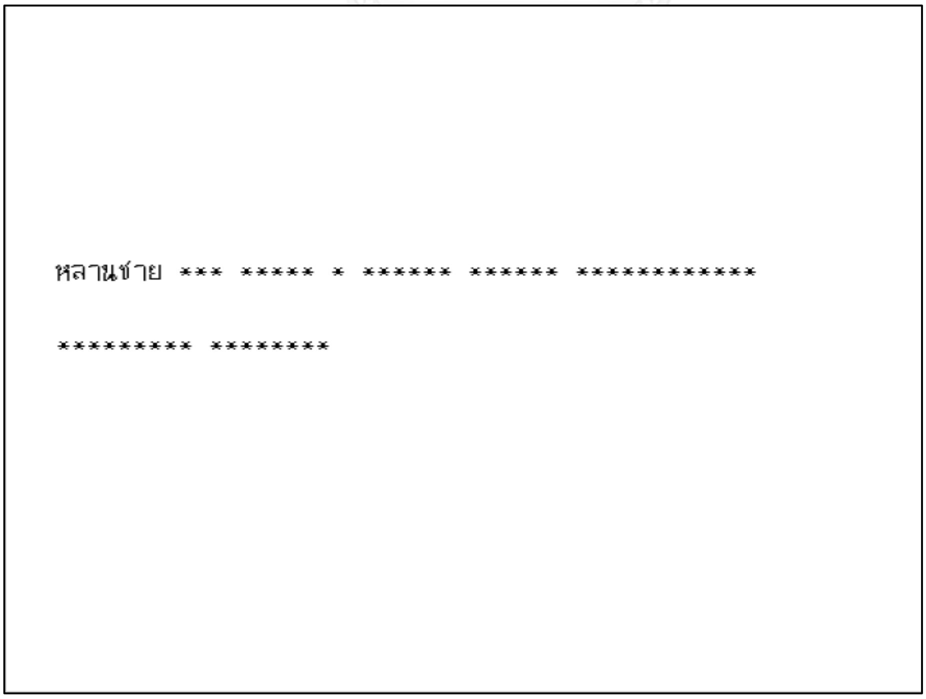

Figure 4. Segment 1

******* ของ ***** * ****** ****** ************

********* ********

Figure 5. Segment 2

******* *** คุณหญิง * ****** ****** ************

********* ********

Figure 6. Segment 3

******* *** ***** ที่ ****** ****** ************

********* ********

Figure 7. Segment 4

******* *** ***** * เพิ่งหย่า ****** ************

********* ********

Figure 8. Segment 5

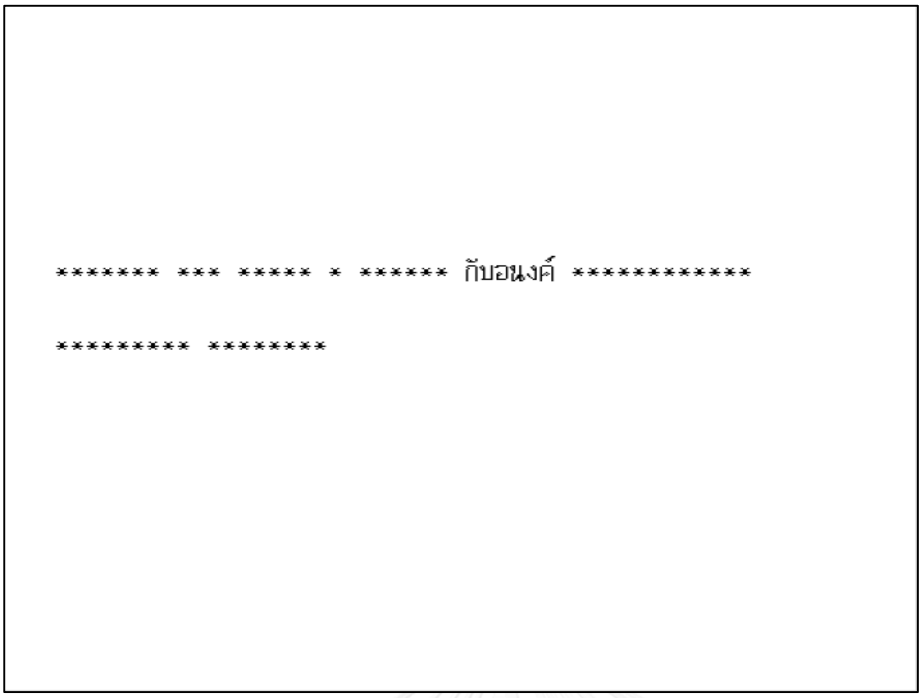

Figure 9. Segment 6

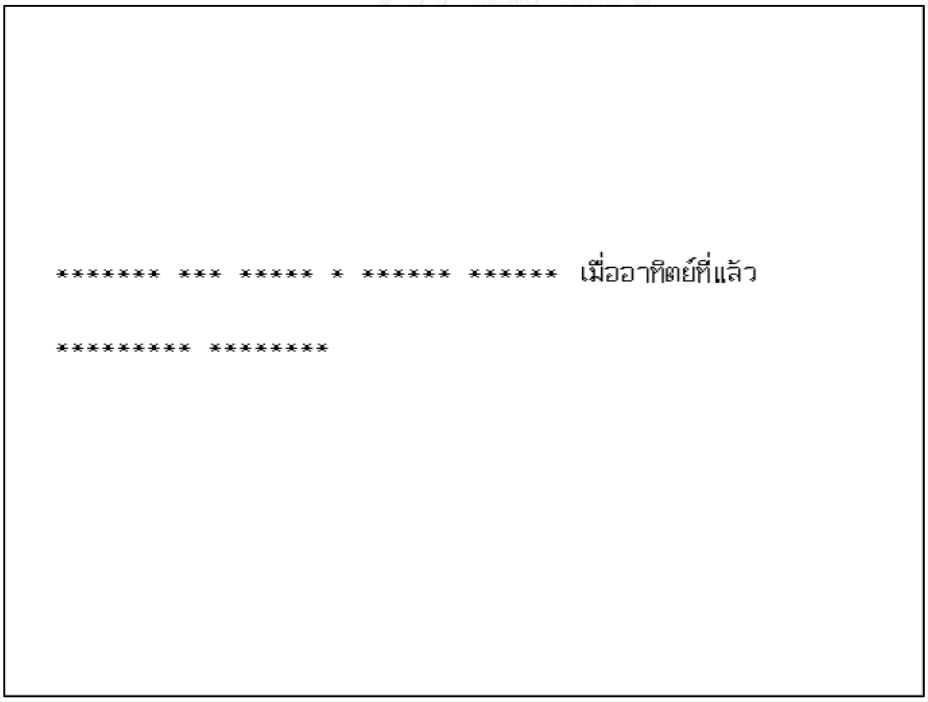

Figure 10. Segment 7

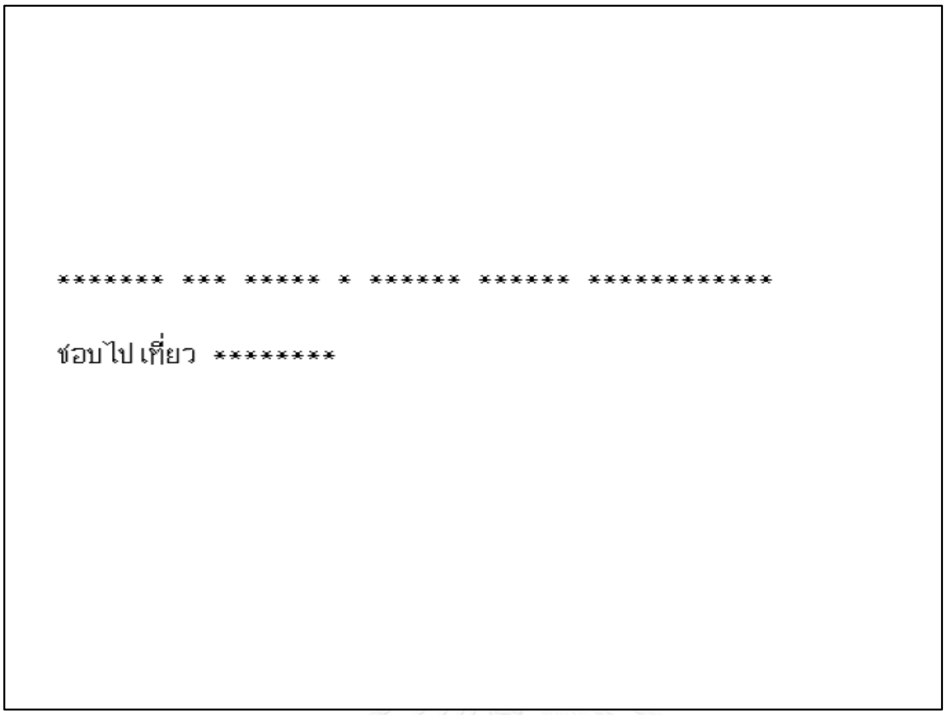

Figure 11. Segment 8

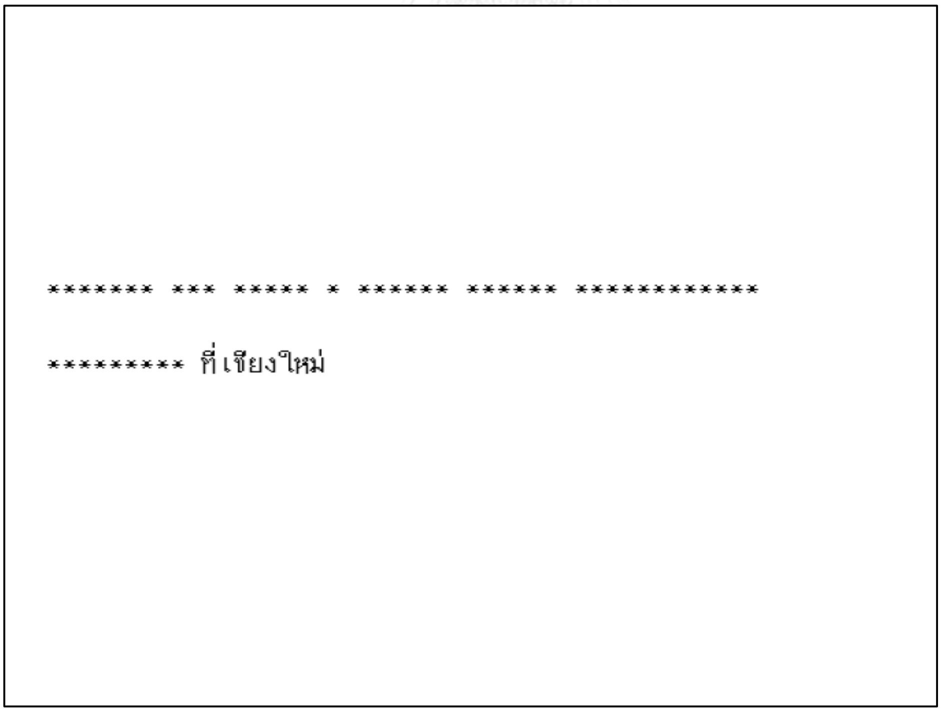

Figure 12. Segment 9

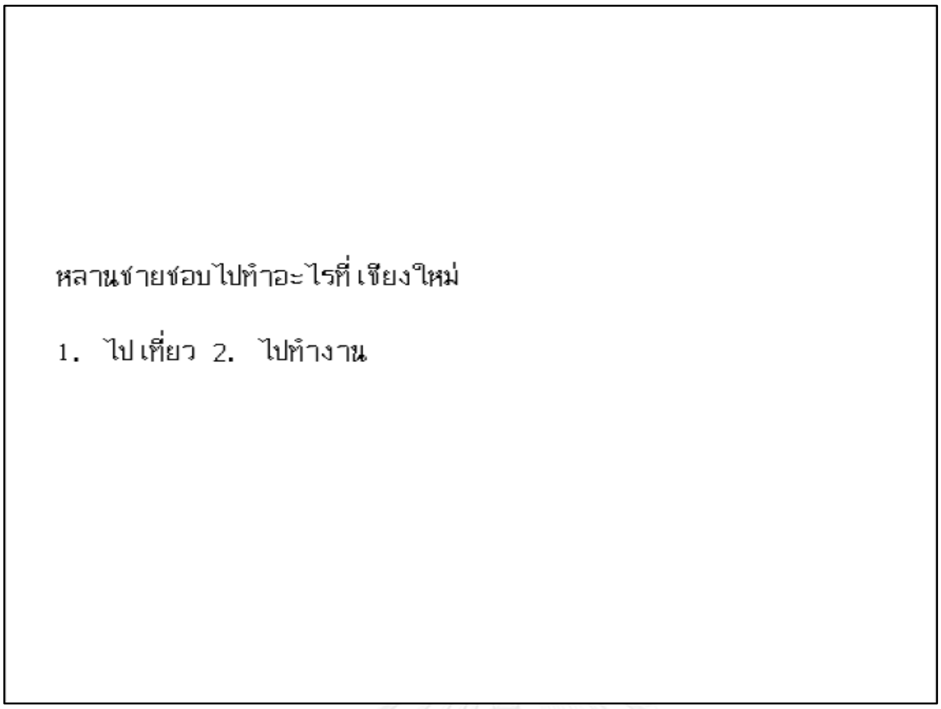

Figure 13. A question for the unambiguous sentence

Appendix 3

Corpus count according to animacy and concreteness

Results of the corpus count in which internally-disambiguated instances were coded according to attachment (N1 or N2) and lexical features of N1 and N2 (animacy and concreteness) are illustrated in Table 1.

Table 1. Attachment distribution in internally-disambiguated tokens

	N2	animate		inanimate		Total
N1		concrete	abstract	concrete	abstract	
animate	concrete	9-12	11-11	4-3	**0-1**	24-27
	abstract	1-5	**35-3***	0-2	0-0	36-10*
inanimate	concrete	42-46	23-6*	28-47*	10-3^{+}	103-102
	abstract	77-101^{+}	**64-47**	50-123*	47-70*	238-341*
Total		129-164*	133-67*	82-175*	57-74	401-480*

[1]Each cell indicates the number of N1 and the number of N2 attachments (N1-N2)

[2]*: $p < .05$ according to exact binomial tests

[3]+: $p < .10$ according to exact binomial tests

[4]underlined text: trends can be accounted for by animacy and concreteness

[5]bold text: trends cannot be accounted for by animacy and concreteness

For animacy and concreteness, results are reported for the internally-disambiguated instances because for those instances, the attachment was not affected by contextual effect. Therefore, the animacy and concreteness effect observed cannot be contaminated by such effect. In the table, the frequencies reported in some cells were lower than five. Therefore, to determine whether frequencies of N1 or N2 attachment were reliably higher than 50% and to keep all analyses the same, exact binominal tests were run (see Chapter 2, Section 2.3 for more details on such statistical tests). In the table, asterisks indicate that frequencies for RCs to attach to the indicated noun were reliably higher than 50% ($p < .05$). If the *p* values are less than .10, a plus sign is used. For the results reported in the text, when the frequencies were higher than five, and thus allowed the use of chi-square goodness of fit test, the chi-square was reported.

When collapsed across animacy and concreteness patterns, N2 attachment was more frequent than N1 attachment (N1 attachment: 401, 45.52%; N2 attachment: 480, 54.48%; $\chi 2$ (1) = 7.08, $p = .008$). The result indicates that regardless of animacy and concreteness, there was a bias towards N2 attachment. However, when taking animacy and concreteness into consideration, for some cells there was a reverse in the attachment pattern (i.e., cells with either underlined or bold text in Table 1). That is, N1 attachment was more frequent than N2 attachment (although for some of those cells such N1 bias was not statistically reliable).

For cells in which the text was underlined, the trends can be accounted for by animacy and concreteness and are compatible with the effect of animacy and concreteness found in Dutch (Desmet et al., 2006). For example, animate nouns were likely to attract RCs such that there was a trend for RCs to attach to N1 when N1 was animate-concrete and N2 was inanimate-concrete (N1 attachment: 4, 57.14%; N2 attachment: 3, 42.86%). Concrete nouns also attracted RCs such that RCs were more frequently attached to N1 when it was inanimate-concrete and N2 was animate-abstract (N1 attachment: 23, 79.31%; N2 attachment: 6, 20.69%; $\chi 2$ (1) = 9.97, p = .002).

Nevertheless, for cells with bold text, attachment pattern cannot be accounted for by animacy and concreteness. For example, when N1 was inanimate-abstract and N2 was animate-abstract, animate nouns did not attract RCs (N1 attachment: 64, 57.66%; N2 attachment: 47, 42.34%). Animacy and concreteness cannot account for N1 bias when the two nouns were animate-abstract either (N1 attachment: 35, 92.11%; N2 attachment: 3, 7.89%; $\chi 2$ (1) = 26.95, $p < .001$). The trend reported in the cell in which the two nouns were animate-abstract also contradicts trends in the other cells in which the two nouns shared identical animacy and concreteness features because for those cells, there was an N2-bias.

From the results reported in Table 1, since lexical information namely animacy and concreteness can account for N1 bias only in some circumstances, it is unclear whether such information affects RC attachment. However, analyses and results reported in this appendix should be considered with caution. Since it is not the aim of this dissertation to investigate the effect of animacy and concreteness on RC attachment, instances were only roughly classified according to such lexical information. That is, for the results of the count reported in Table 1, nouns such as “government agency” and “trade union” were all labelled as animate-abstract because most of those nouns functioned as an agent, but nouns such as “school” were all coded as inanimate-concrete because for most instances such nouns denoted a location (see also Chapter 3, Section 3.4.2 for animacy and concreteness criteria). However, it is inevitable to say that in some situations, nouns such as “government agency” can denote a location and nouns such as “school” can function as an agent. Since we ignored thematic information when coding the data, the results reported in this appendix might be distorted. Detailed analyses on the effect of animacy and concreteness on RC attachment would require new extensive work.

Appendix 4

An example of a norming questionnaire for ambiguous RCs

Instructions

<u>คำสั่ง</u> เมื่อพิจารณาประโยคในแต่ละข้อแล้ว ประโยคเหล่านั้นมีความเป็นไปได้มากน้อยเพียงใด **<u>กรุณาวงกลมคะแนน</u>**ความเป็นไปได้ของประโยค โดยที่

<u>1 = **เป็นไปไม่ได้เลย**   5 = **เป็นไปได้มาก**</u>

(*เป็นไปได้น้อย หมายถึง เหตุการณ์ที่ระบุในประโยคทั้งสองมีใจความขัดแย้งกันอย่างชัดเจน หรือประโยคใดประโยคหนึ่งเป็นเหตุการณ์ที่ไม่มีโอกาสเกิดขึ้นได้ อ่านแล้วขัดกับหลักความเป็นจริง*)

ตัวอย่าง

1 ลูกของครูใหญ่ขาหักเมื่อวานนี้ ลูกไปวิ่งมาราธอนเมื่อเช้า

<u>คำตอบ</u> <u>1 เป็นไปไม่ได้</u> เพราะคนขาหักไม่สามารถไปวิ่งมาราธอนได้

ตัวอย่าง

2 น้องสาวของนายตำรวจแขนหักเมื่อวาน น้องสาวชอบทานไอศครีม

<u>คำตอบ</u> <u>5 เป็นไปได้</u> เพราะน้องสาวสามารถแขนหักได้ และน้องสาวสามารถชอบทานไอศครีมได้

ตัวอย่าง

3 เมียน้อยของเสี่ยเกลียดสัตว์ทุกชนิด เสี่ยมีอาชีพเป็นโคโยตี้ในจังหวัดระยอง

<u>คำตอบ</u> <u>1 เป็นไปไม่ได้</u> เพราะแม้ว่าเมียน้อยมีโอกาสที่จะเกลียดสัตว์ทุกชนิดได้ แต่เสี่ยไม่น่าจะมีอาชีพเป็นโคโยตี้

ตัวอย่าง

4 แฟนเพลงของนักร้องชอบสะสมแสตมป์ นักร้องเข้ามาแจกลายเซ็นเมื่อบ่ายวันนี้

<u>คำตอบ</u> <u>5 เป็นไปได้</u> เพราะแฟนเพลงสามารถชอบสะสมแสตมป์ได้ และนักร้องสามารถเข้ามาแจกลายเซ็นได้

List 1

1 **โค้ชของนักวิ่งกำลังจะออกบวช**
นักวิ่งวาดรูปสวย
เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **ทนายของผู้ต้องหาเคยชิมอาหารอินเดีย**
ทนายสูงสองเมตร
เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

List 2

1 **โค้ชของนักวิ่งกำลังจะออกบวช**
โค้ชวาดรูปสวย
เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **ทนายของผู้ต้องหาเคยชิมอาหารอินเดีย**
ผู้ต้องหาสูงสองเมตร
เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

Appendix 5

Ambiguous RCs

The following is the list of 24 ambiguous RC-attachment items used in Experiment 1 and in the ambiguous-sentence reading task of Experiment 3. The numbers in the parentheses indicate median plausibility-rating scores from the norming questionnaire.

1. ผู้ช่วยของทันตแพทย์ที่เลี้ยงเป็ดห้าตัวถูกปล้นบ้านเมื่อคืนนี้ (median for N1 attachment: 5, median for N2 attachment: 5)

   "The assistant of the dentist that has five ducks had their house robbed last night."

2. โค้ชของนักวิ่งที่วาดรูปสวยกำลังจะออกบวช (5,5)

   "The coach of the runner that is good at drawing is going to become a monk."

3. ช่างแต่งหน้าของผู้ประกาศข่าวที่ปลูกมังคุดไว้ที่บ้านถูกหวยรางวัลที่หนึ่ง (5,5)

   "The make-up artist of the news reporter that grows mangosteen at their house won the first prize lottery."

4. ลูกมือของเชฟที่คลั่งซีรี่เกาหลีเป็นคนจังหวัดเชียงราย (5,5)

   "The kitchen assistant of the chef that is crazy about Korean series is from Chiang Rai."

5. ผู้ช่วยวิจัยของศาสตราจารย์ที่ผัดผักได้อร่อยมากติดละครหลังข่าว (5,5)

   "The research assistant of the professor that is good at cooking stir-fried vegetable is addicted to the after-news soap opera."

6. รุ่นพี่ของวิศวกรที่เคยชนะการแข่งกินไปร้องคาราโอเกะเมื่อคืน (5,5)

“The senior of the engineer that once won an eating competition went out for karaoke last night.”

7. เจ้าหนี้ของมือกลองที่รักรถเวสป้าห่อของขวัญไม่เป็น (5,5)

“The creditor of the drummer that loves Vespa does not know how to wrap a gift.”

8. รุ่นน้องของนักบินที่ขี่ม้าเก่งเครียดเรื่องอาการป่วยของแม่ (5,5)

“The junior of the pilot that is good at horse riding worries about his mother's sickness.”

9. ที่ปรึกษาของนักการเมืองที่สะดุดสายไฟอยากกินอาหารใต้ (5,5)

“The consultant of the politician that stumbled over the wire wants to eat southern food.”

10. คู่หูของดาราตลกที่ทาสีบ้านด้วยตัวเองเป็นโรคตับอักเสบ (5,5)

“The buddy of the comedian that painted the house by themself suffers from hepatitis.”

11. ครูฝึกของนักแม่นปืนที่เติมน้ำมันที่ปั๊มบางจากเป็นประจำรู้ภาษาญี่ปุ่นเล็กน้อย (5,5)

“The trainer of the gunner that always fills up their gas tank at Bangjak gas station knows Japanese a little.”

12. ผู้บังคับบัญชาของนายทหารที่ชาร์ตแบตมือถือทิ้งไว้ดีดกีตาร์เพราะมาก (5,5)

"The commander of the soldier that left his cell-phone battery charged is good at playing guitar."

13. ลูกพี่ลูกน้องของนักดับเพลิงที่อ่านหนังสือพิมพ์วันเว้นวันเคยสร้างห้องสมุดให้เด็กยากจน (5,5)

"The cousin of the fireman that reads newspaper every other day once built a library for poor children."

14. คนไข้ของนักกายภาพบำบัดที่ดาวน์โหลดวินโด้ปลอมมาใช้ช็อปปิ้งที่จัตุจักรบ่อยมาก (5,5)

"The patient of the physiotherapist that downloaded the pirated Windows often goes shopping at the Jatujak Market."

15. ช่างทำผมของพิธีกรที่ถักผ้าพันคอขายอบบราวนี่เมื่อเช้า (5,5)

"The hair stylist of the emcee that knits scarves for sale baked brownies this morning."

16. ลูกหนี้ของมาเฟียที่เกิดวันเสาร์ไม่อาบน้ำตอนเช้า (5,5)

"The debtor of the mafia that was born on Saturday does not take a shower in the morning."

17. สถาปนิกของเจ้าสัวที่ดื่มนมวันละสามแก้วไปพายเรือที่สวนสามพราน (5,5)

"The architect of the Chinese billionaire that drinks three glasses of milk a day went out for rowing a boat at the Sampran garden."

18. เด็กเดินไฟของผู้จัดละครที่ซอยผมสั้นถอดรองเท้าไว้ข้างตึก (5,5)

"The spotlight carrier of the film maker that has short hair left their shoes beside the building."

19. พนักงานบัญชีของนายทุนที่ใส่เสื้อกันหนาวเคยปีนหน้าผา (5,5)

"The accountant of the investor that is wearing a sweater had ever climbed a rock."

20. คนรู้จักของนักศึกษาที่เคยหลงทางในมาเลเซียแกะสลักผลไม้สวยมาก (5,5)

"The acquaintance of the student that once got lost in Malaysia is good at carving fruit."

21. ทนายของผู้ต้องหาที่สูงสองเมตรเคยชิมอาหารอินเดีย (4.5, 5)

"The lawyer of the suspect that is two-meter tall has ever tasted Indian food."

22. หัวหน้าของพนักงานขายที่ใส่แว่นกรอบสีดำเขียนจดหมายถึงพ่อ (5,5)

"The head of the salesperson that is wearing black-framed glasses wrote a letter to their father."

23. ตัวแทนของผู้จัดการที่มักนอนหลับดึกเพิ่งล้างจานเสร็จ (5,5)

"The representative of the manager that often sleeps late has just finished washing dishes."

24. บอดี้การ์ดของนักธุรกิจที่ละเมอเป็นประจำเคยเรียนภาษาเยอรมัน (5,5)

"The bodyguard of the businessman that always does something in his sleep has ever studied German."

Appendix 6

Details of Experiment 1 analyses

Correlation of fixed factors and main effects of fixed factors in the analyses of Experiment 1 are reported in Tables 2 and 3 respectively.

Table 2. Correlation of fixed factors of the analyses for Experiment 1

Predictor	Intercept	TIorder
TIorder	0.02	
logSorder	0.18	-0.89

Table 3. Analysis of deviance of Experiment 1

Predictor	$\chi2$	df	*p*
TIorder	0.62	1	.433
logSorder	3.18	1	.075

Appendix 7

An example of a norming questionnaire for unambiguous RCs

Instructions

<u>คำสั่ง</u> เมื่อพิจารณาความสัมพันธ์ระหว่างประโยคที่ 1 และประโยคที่ 2 แล้ว **<u>ประโยคที่ 2 มีความเป็นไปได้มากน้อยเพียงใด</u>**

<u>กรุณาวงกลมคะแนน</u>ความเป็นไปได้ของประโยค โดยที่

<u>1 = **เป็นไปไม่ได้เลย** 5 = **เป็นไปได้มาก**</u>

(***เป็นไปได้น้อย หมายถึง กรณี เช่น เมื่ออ่านแล้วรู้สึกขัดหู หรือ อ่านแล้วเกิดคำถามว่าเป็นไปได้จริงหรือ***)

ตัวอย่าง 1 นี่คือน้องชายของนางเอก น้องชายเป็นนักเรียนของโรงเรียนหญิงล้วนชื่อดัง

<u>คำตอบ</u> <u>1 เป็นไปไม่ได้</u> เพราะน้องชายเป็นเพศชาย ไม่สามารถเรียนที่โรงเรียนหญิงล้วนได้

ตัวอย่าง 2 นี่คือภรรยาของ รปภ. ภรรยาแท้งลูก

<u>คำตอบ</u> <u>5 เป็นไปได้</u> เพราะภรรยาเป็นเพศหญิง สามารถตั้งท้อง และมีโอกาสแท้งลูกได้

ตัวอย่าง 3 นี่คือแม่ของทารก ทารกเข้าไปขโมยนมในซุปเปอร์มาร์เก็ต

<u>คำตอบ</u> <u>1 เป็นไปไม่ได้</u> เพราะทารกยังไม่สามารถทำอะไรได้ด้วยตนเอง จึงไม่สามารถขโมยนมได้

ตัวอย่าง 4 นี่คือคุณครูของนักเรียน นักเรียนสอบตกวิชาภาษาไทย

<u>คำตอบ</u> <u>5 เป็นไปได้</u> เพราะการเป็นนักเรียนจะมีการสอบเสมอ และอาจเป็นไปได้ที่นักเรียนจะสอบตก

List 1

1 **นี่คือหลานชายของคุณหญิง** **หลานชายเพิ่งหย่ากับอนงค์เมื่ออาทิตย์ที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **นี่คือคนรับใช้ของหมอดู** **หมอดูกำลังตั้งใจบอกคำทำนายเรื่องความรัก**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

3 **นี่คือลูกสาวของนายพล** **นายพลมีข่าวเตียงหักกับสุพจน์เมื่อเดือนที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

4 **นี่คือป้าของนายสถานี** **ป้าเพิ่งทะเลาะกับภรรยาเมื่อวันพุธ**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

List 2

1 **นี่คือหลานชายของคุณหญิง** **หลานชายเพิ่งหย่ากับยงยุทธเมื่ออาทิตย์ที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **นี่คือคนรับใช้ของหมอดู** **คนรับใช้กำลังตั้งใจฟังคำทำนายเรื่องความรัก**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

3 **นี่คือลูกสาวของนายพล** **นายพลมีข่าวเตียงหักกับรัชนีเมื่อเดือนที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

4 **นี่คือป้าของนายสถานี** **นายสถานีเพิ่งทะเลาะกับสามีเมื่อวันพุธ**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

List 3

1 **นี่คือหลานชายของคุณหญิง คุณหญิงเพิ่งหย่ากับอนงค์เมื่ออาทิตย์ที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **นี่คือคนรับใช้ของหมอดู คนรับใช้กำลังตั้งใจบอกคำทำนายเรื่องความรัก**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

3 **นี่คือลูกสาวของนายพล ลูกสาวมีข่าวเตียงหักกับสุพจน์เมื่อเดือนที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

4 **นี่คือป้าของนายสถานี นายสถานีเพิ่งทะเลาะกับภรรยาเมื่อวันพุธ**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

List 4

1 **นี่คือหลานชายของคุณหญิง คุณหญิงเพิ่งหย่ากับยงยุทธเมื่ออาทิตย์ที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

2 **นี่คือคนรับใช้ของหมอดู หมอดูกำลังตั้งใจฟังคำทำนายเรื่องความรัก**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

3 **นี่คือลูกสาวของนายพล ลูกสาวมีข่าวเตียงหักกับรัชนีเมื่อเดือนที่แล้ว**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

4 **นี่คือป้าของนายสถานี ป้าเพิ่งทะเลาะกับสามีเมื่อวันพุธ**

เป็นไปไม่ได้เลย 1 2 3 4 5 เป็นไปได้มาก

Appendix 8

Unambiguous RCs

The following is the list of 24 unambiguous RCs used in Experiment 2 and in unambiguous-sentence reading task of Experiment 3. N1 attachments are shown in (a) and N2 attachments are shown in (b). Vertical bars indicate the segmentation used in the self-paced presentation. The (f) and (m) in the gloss indicate gender of the preceding noun. The numbers in the parentheses indicate median plausibility-rating scores from the norming questionnaire. For the last two items, asterisks indicate eliminated items.

1. a. น้องสาว | ของ | นายตำรวจ | ที่ | เข้าพิธีแต่งงาน | กับสมศักดิ์ | เมื่อวันจันทร์ | กำลังซื้อของ | อยู่ที่ตลาดนัด (median for N1-plausible condition: 5, median for N1-implausible condition: 1)

   "The sister of the policeman that married Somsak(m) on Monday is buying things at the flea-market."

   b. น้องสาว | ของ | นายตำรวจ | ที่ | เข้าพิธีแต่งงาน | กับสมศรี | เมื่อวันจันทร์ | กำลังซื้อของ | อยู่ที่ตลาดนัด (median for N2-plausible condition: 5, median for N2-implausible condition: 1)

   "The sister of the policeman that married Somsri(f) on Monday is buying things at the flea-market."

2. a. แฟนเพลง | ของ | นักร้อง | ที่ | เข้ามา | ขอลายเซ็น | เมื่อบ่ายวันนี้ | ชอบสะสมสแตมป์ | เป็นที่สุด

(5, 1)

“The follower of the singer that comes to ask for an autograph in the afternoon likes collecting stamps the most.”

b. แฟนเพลง | ของ | นักร้อง | ที่ | เข้ามา | แจกลายเซ็น | เมื่อบ่ายวันนี้ | ชอบสะสมสแตมป์ | เป็นที่สุด

(5, 1)

“The follower of the singer that comes to give an autograph in the afternoon likes collecting stamps the most.”

3. a. หลานสาว | ของ | พ่อครัว | ที่ | จดทะเบียนสมรส | กับสมพงษ์ | เมื่ออาทิตย์ก่อน | อยากไป | งานสัปดาห์หนังสือ (5, 1)

“The niece of the chef(m) that signed a marriage-certificate with Sompong(m) last week wants to go to a book fair.”

b. หลานสาว | ของ | พ่อครัว | ที่ | จดทะเบียนสมรส | กับปราณี | เมื่ออาทิตย์ก่อน | อยากไป | งานสัปดาห์หนังสือ (5, 1)

“The niece of chef(m) that signed a marriage-certificate with Pranee(f) last week wants to go to a book fair.”

4. a. น้องชาย | ของ | แม่ค้า | ที่ | เพิ่งหมั้น | กับบุษบา | เมื่อไม่กี่วันก่อน | จะเปิดร้านเบเกอรี่ | ที่หัวหิน

(5, 1)

"The younger brother of the seller(f) that has just engaged with Busaba(f) a few days ago will open a bakery shop at Huahin."

b. น้องชาย | ของ | แม่ค้า | ที่ | เพิ่งหมั้น | กับอนันต์ | เมื่อไม่กี่วันก่อน | จะเปิดร้านเบเกอรี่ | ที่หัวหิน

(5, 1)

"The younger brother of the seller(f) that has just engaged with Anan(m) a few days ago will open a bakery shop at Huahin."

5. a. ป้า | ของ | นายสถานี | ที่ | เพิ่งทะเลาะ | กับสามี | เมื่อวันพุธ | ออกรถใหม่ | สองคัน

(5, 1)

"The aunt of the train controller that has just quarreled with her husband on Wednesday bought two new cars."

b. ป้า | ของ | นายสถานี | ที่ | เพิ่งทะเลาะ | กับภรรยา | เมื่อวันพุธ | ออกรถใหม่ | สองคัน

(5, 1)

"The aunt of the train controller that has just quarreled with his wife on Wednesday bought two new cars."

6. a. เมียน้อย | ของ | เสี่ย | ที่ | มีอาชีพเป็น | โคโยตี้ | ในจังหวัดระยอง | เกลียดสัตว์ | ทุกชนิด (5, 1)

"The mistress of the millionaire(m) that works as a naked dancer in Rayong hates every kind of animals."

b. เมียน้อย | ของ | เสี่ย | ที่ | มีอาชีพเป็น | พ่อค้าพลอย | ในจังหวัดระยอง | เกลียดสัตว์ | ทุกชนิด (5, 1)

"The mistress of the millionaire(m) that works as a ruby seller(m) in Rayong hates every kind of animals."

7. a. พี่ชาย | ของ | แม่บ้าน | ที่ | เคยสารภาพรัก | กับพจนีย์ | เมื่อสองปีที่แล้ว | ได้งานใหม่ | ที่แคนาดา (5, 2)

"The older brother of the housekeeper that once said a love word to Podjanee(f) two years ago got a new job at Canada."

b. พี่ชาย | ของ | แม่บ้าน | ที่ | เคยสารภาพรัก | กับณรงค์ | เมื่อสองปีที่แล้ว | ได้งานใหม่ | ที่แคนาดา (5, 2)

"The older brother of the housekeeper that once said a love word to Narong(m) two years ago got a new job at Canada."

8. a. แม่ครัว | ของ | นายอำเภอ | ที่ | กำลังจะ | เป็นแม่คน | ในอีกไม่กี่เดือน | ไปรับญาติ | ที่สถานีรถไฟ

(5, 1)

“The cook(f) of the sheriff that is going to be a mother in a few months picked their relative up at the train station.”

b. แม่ครัว | ของ | นายอำเภอ | ที่ | กำลังจะ | เป็นพ่อคน | ในอีกไม่กี่เดือน | ไปรับญาติ | ที่สถานีรถไฟ

(5, 1)

“The cook(f) of the sheriff that is going to be a father in a few months picked their relative up at the train station.”

9. a. ลุง | ของ | นักเทนนิส | ที่ | ตั้งอกตั้งใจ | มาเชียร์การแข่งขัน | ในวันนี้ | เป็นคนน่ารัก | อัธยาศัยดี

(5, 1.5)

“The uncle of the tennis player that came and watched the match attentively today is a nice person.”

b. ลุง | ของ | นักเทนนิส | ที่ | ตั้งอกตั้งใจ | สู้ศึกการแข่งขัน | ในวันนี้ | เป็นคนน่ารัก | อัธยาศัยดี (5, 2)

“The uncle of the tennis player that played in the match attentively today is a nice person.”

10. a. ลูกชาย | ของ | สาวใช้ | ที่ | เพิ่งเลิก | กับอัญชลี | เมื่อตอนต้นเดือน | เคยกู้เงิน | แบบนอกระบบ

(5, 2.5)

"The son of the maid that has just broken up with Unchalee(f) at the beginning of the month once borrowed money from an illegal financial institution."

b. ลูกชาย | ของ | สาวใช้ | ที่ | เพิ่งเลิก | กับไพโรจน์ | เมื่อตอนต้นเดือน | เคยกู้เงิน | แบบนอกระบบ

(5, 1)

"The son of the maid that has just broken up with Pairot(m) at the beginning of the month once borrowed money from an illegal financial institution."

11. a. นายจ้าง | ของ | คนงานก่อสร้าง | ที่ | รีบมา | จ่ายเงินเดือน | เมื่อช่วงเช้า | ชอบทำบุญ | กับคนพิการ

(5, 1)

"The employer of the worker that hurriedly came to pay salary this morning likes making merit for disabled people."

b. นายจ้าง | ของ | คนงานก่อสร้าง | ที่ | รีบมา | รับเงินเดือน | เมื่อช่วงเช้า | ชอบทำบุญ | กับคนพิการ

(5, 1)

"The employer of the worker that hurriedly came to get salary this morning likes making merit for disabled people."

12. a. ลูกศิษย์ | ของ | หลวงพ่อ | ที่ | ไม่ได้ | ตามไปบิณฑบาต | ในตอนเช้า | ชอบช่วยเหลือ | หมาจรจัด

(5, 1)

“The disciple of the monk that did not accompany to ask for food in the morning likes helping stray dogs.”

b. ลูกศิษย์ | ของ | หลวงพ่อ | ที่ | ไม่ได้ | เดินไปบิณฑบาต | ในตอนเช้า | ชอบช่วยเหลือ | หมาจรจัด

(5, 1)

“The disciple of the monk that did not went out to ask for food in the morning likes helping stray dogs.”

13. a. น้าชาย | ของ | นางพยาบาล | ที่ | เพิ่งคบหา | กับสัตวแพทย์หญิง | เมื่อไม่กี่สัปดาห์ | ได้รับรางวัล | ลูกกตัญญูแห่งปี (5, 2.5)

“The uncle of the nurse that has just started dating with veterinarian(f) for a few weeks won the best-child-of-the-year prize.

b. น้าชาย | ของ | นางพยาบาล | ที่ | เพิ่งคบหา | กับนายสัตวแพทย์ | เมื่อไม่กี่สัปดาห์ | ได้รับรางวัล | ลูกกตัญญูแห่งปี (5, 1)

“The uncle of the nurse that has just started dating with veterinarian(m) for a few weeks won the best-child-of-the-year prize.”

14. a. หลาน | ของ | คุณยาย | ที่ | มีอายุ | ครบสิบปี | ในวันนี้ | ลื่นล้ม | ที่หน้าบ้าน (5, 1)

"The grandchild of the grandmother that is turning to ten years old today fell down at the front of the house."

b. หลาน | ของ | คุณยาย | ที่ | มีอายุ | ครบร้อยปี | ในวันนี้ | ลื่นล้ม | ที่หน้าบ้าน (5, 1)

"The grandchild of the grandmother that is turning to one hundred years old today fell down at the front of the house."

15. a. ลูกเขย | ของ | เภสัชกรหญิง | ที่ | เคยเป็นแฟน | กับนางร้ายชื่อดัง | เมื่อตอนต้นปี | มีคอนโด | แถวอารีย์ (5, 2.5)

"The son-in-law of the pharmacist(f) that used to be a partner of a famous TV-villain(f) during the first months of the year owns a condominium room near Aree."

b. ลูกเขย | ของ | เภสัชกรหญิง | ที่ | เคยเป็นแฟน | กับพระเอกชื่อดัง | เมื่อตอนต้นปี | มีคอนโด | แถวอารีย์ (4, 1)

"The son-in-law of the pharmacist(f) that used to be a partner of a famous leading-actor(m) during the first months of the year owns a condominium room near Aree."

16. a. น้องเขย | ของ | สาวโรงงาน | ที่ | เคยป่วย | เป็นมะเร็งต่อมลูกหมาก | เมื่อเก้าปีก่อน | เข้ามาสมัครงาน | ในกรุงเทพ (5, 1)

"The younger brother-in-law of laborer(f) that once suffered from prostate cancer nine years ago went to Bangkok to apply for a job."

b. น้องเขย | ของ | สาวโรงงาน | ที่ | เคยป่วย | เป็นมะเร็งปากมดลูก | เมื่อเก้าปีก่อน | เข้ามาสมัครงาน | ในกรุงเทพ (5, 1)

"The younger brother-in-law of laborer(f) that once suffered from cancer of cervix nine years ago went to Bangkok to apply for a job."

17. a. พี่สาว | ของ | นายธนาคาร | ที่ | เคยจะ | แย่งผู้ชาย | ของเพื่อนสนิท | ได้ตั๋วเครื่องบินฟรี | สองที่นั่ง (5, 2)

"The older sister of the bank officer that once tried to get a boyfriend of her close friend got plane tickets for two seats for free."

b. พี่สาว | ของ | นายธนาคาร | ที่ | เคยจะ | แย่งผู้หญิง | ของเพื่อนสนิท | ได้ตั๋วเครื่องบินฟรี | สองที่นั่ง (5, 2.5)

"The older sister of the bank officer that once tried to get a girlfriend of his close friend got plane tickets for two seats for free."

18. a. ลูกสาว | ของ | นายพล | ที่ | มีข่าวเตียงหัก | กับสุพจน์ | เมื่อเดือนที่แล้ว | ชอบทาน | อาหารฝรั่งเศส

(4.5, 1)

"The daughter of the colonel that was said to break up with Supot(m) a month ago likes French food."

b. ลูกสาว | ของ | นายพล | ที่ | มีข่าวเตียงหัก | กับรัชนี | เมื่อเดือนที่แล้ว | ชอบทาน | อาหารฝรั่งเศส

(5, 1)

"The daughter of the colonel that was said to break up with Ratchanee(f) a month ago likes French food."

19. a. คนรับใช้ | ของ | หมอดู | ที่ | กำลังตั้งใจ | ฟังคำทำนาย | เรื่องความรัก | จะไปพม่า | ช่วงปีใหม่ (5, 1)

"The servant of the fortune teller that is listening to love fortune attentively will go to Burma on New Year."

b. คนรับใช้ | ของ | หมอดู | ที่ | กำลังตั้งใจ | บอกคำทำนาย | เรื่องความรัก | จะไปพม่า | ช่วงปีใหม่

(5, 1)

"The servant of the fortune teller that is telling love fortune attentively will go to Burma on New Year."

20. a. หลานชาย | ของ | คุณหญิง | ที่ | เพิ่งหย่า | กับอนงค์ | เมื่ออาทิตย์ที่แล้ว | ชอบไปเที่ยว | ที่เชียงใหม่

(5, 1)

"The nephew of the duchess that has just divorced from Anong(f) last week likes travelling to Chiang Mai."

b. หลานชาย | ของ | คุณหญิง | ที่ | เพิ่งหย่า | กับยงยุทธ | เมื่ออาทิตย์ที่แล้ว | ชอบไปเที่ยว | ที่เชียงใหม่

(5, 1)

"The nephew of the duchess that has just divorced from Youngyut(m) last week likes travelling to Chiang Mai."

21. a. ลูกค้า | ของ | แม่มด | ที่ | เข้ามา | รับยา | ในห้องมืด | เคยมีไฝ | อยู่กลางหน้าผาก (5, 1)

"The customer of the witch that came to the dark room to get pills used to have a mole at the middle of their forehead."

b. ลูกค้า | ของ | แม่มด | ที่ | เข้ามา | ปรุงยา | ในห้องมืด | เคยมีไฝ | อยู่กลางหน้าผาก (5, 1)

"The customer of the witch that came to the dark room to make pills used to have a mole at the middle of their forehead."

22. a. ผู้ปกครอง | ของ | เณร | ที่ | เพิ่งจะ | ถวายเพล | เมื่อชั่วโมงที่แล้ว | กำลังสนทนาธรรม | กับเจ้าอาวาส

(5, 1)

"The parent of the novice that has just given lunch is talking to the abbot."

b. ผู้ปกครอง | ของ | เณร | ที่ | เพิ่งจะ | ฉันเพล | เมื่อชั่วโมงที่แล้ว | กำลังสนทนาธรรม | กับเจ้าอาวาส

(5, 1.5)

"The parent of the novice that has just eaten lunch is talking to the abbot."

23. *a. พี่เขย | ของ | แพทย์หญิง | ที่ | แอบจูบ | กับแอร์โฮสเตส | เมื่อวันก่อน | ชอบออกงานสังคม | เป็นอย่างมาก (5, 2)

"The older brother-in-law of the doctor(f) that secretly kissed the air hostess the day before likes hanging out very much."

*b. พี่เขย | ของ | แพทย์หญิง | ที่ | แอบจูบ | กับสจ๊วต | เมื่อวันก่อน | ชอบออกงานสังคม | เป็นอย่างมาก (5, 2)

"The older brother-in-law of the doctor(f) that secretly kissed the steward the day before likes hanging out very much."

24. *a. พี่เลี้ยง | ของ | เจ้าหญิง | ที่ | นั่งลง | เช็ดมงกุฎ | หน้าโต๊ะเครื่องแป้ง | ลืมผ้าเช็ดหน้า | ไว้ที่ร้านอาหาร (3.5, 1.5)

"The nanny of the princess that sat down and cleaned a crown in front of the makeup table left a handkerchief at a restaurant."

*b. พี่เลี้ยง | ของ | เจ้าหญิง | ที่ | นั่งลง | สวมมงกุฎ | หน้าโต๊ะเครื่องแป้ง | ลืมผ้าเช็ดหน้า | ไว้ที่ร้านอาหาร (5, 2)

"The nanny of the princess that sat down and wore a crown in front of the makeup table left a handkerchief at a restaurant."

Appendix 9

Analyses of Experiment 2

Analyses of each region of Experiment 2 are provided below. For each region, the exact formula used is given first. Then, the summary table, the correlation of fixed factors table, and the analysis of deviance table are given respectively. At the end of Appendix 9, Figure 1 shows RRTs per region for each condition in ms with by-participants means.

Region 1

Formula: RRT ~ attach * TIorder + logSorder + (1 + TIorder + logSorder | participant) + (1 | item)

Table 4. Summary of the analyses for region 1

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-98.35	10.64	46.40	-9.24	< . 001
attachN2	-10.87	7.78	796.30	-1.40	.163
logSorder	-56.27	16.88	27.20	-3.33	.002
TIorder	3.06	2.42	23.60	1.26	.219
attachN2:TIorder	-0.59	1.19	804.30	-0.49	.624

Table 5. Correlation of fixed factors of the analyses for region 1

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.00			
TIorder	0.04	0.01		
logSorder	-0.10	-0.01	-0.91	
attachN2:TIorder	0.00	-0.03	-0.00	0.01

Table 6. Analysis of deviance of region 1

Predictor	$\chi 2$	df	*p*
attachN2	2.00	1	.156
TIorder	1.59	1	.208
logSorder	11.11	1	.001
attach:TIorder	0.24	1	.624

Region 2

Formula: RRT ~ attach * TIorder + logSorder + (1 + logSorder | participant) + (1 | item)

Table 7. Summary of the analyses for region 2

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-80.11	8.75	46.30	-9.15	< .001
attachN2	-4.03	7.12	1713.40	-0.57	.572
logSorder	-38.54	15.86	24.60	-2.43	.023
TIorder	0.07	2.33	21.60	0.03	.976
attachN2:TIorder	-0.50	1.09	1715.50	-0.46	.644

Table 8. Correlation of fixed factors of the analyses for region 2

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	-0.00			
TIorder	-0.00	0.00		
logSorder	-0.09	-0.00	-0.90	
attachN2:TIorder	0.00	-0.02	0.00	-0.00

Table 9. Analysis of deviance of region 2

Predictor	$\chi 2$	df	*p*
attachN2	0.33	1	.566
TIorder	0.00	1	.975
logSorder	5.90	1	.015
attach:TIorder	0.21	1	.643

Region 3

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach + TIorder | participant) + (1 + attach | item)

Table 10. Summary of the analyses for region 3

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-53.83	9.74	36.29	-5.51	< .001
attachN2	2.12	9.26	19.26	0.23	.821
logSorder	-17.39	21.61	21.99	-0.81	.430
TIorder	-3.66	3.39	24.69	-1.08	.290
attachN2:TIorder	-0.82	1.33	17.03	-0.62	.547

Table 11. Correlation of fixed factors of the analyses for region 3

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.32			
TIorder	-0.03	-0.05		
logSorder	0.00	-0.00	-0.90	
attachN2:TIorder	-0.00	-0.02	0.08	0.00

Table 12. Analysis of deviance of region 3

Predictor	$\chi 2$	df	*p*
attachN2	0.05	1	.830
TIorder	1.08	1	.300
logSorder	0.65	1	.421
attach:TIorder	0.38	1	.539

Region 4

Formula: RRT ~ attach * TIorder + logSorder + (1 + logSorder | participant) + (1 | item)

Table 13. Summary of the analyses for region 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	21.60	15.61	29.50	1.38	.177
attachN2	-26.53	12.78	794.60	-2.08	.038
logSorder	-70.27	40.02	25.70	-1.76	.091
TIorder	3.26	5.82	21.70	0.56	.582
attachN2:TIorder	3.32	1.94	806.00	1.71	.088

Table 14. Correlation of fixed factors of the analyses for region 4

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.00			
TIorder	-0.00	-0.00		
logSorder	-0.08	0.00	-0.89	
attachN2:TIorder	-0.00	-0.02	0.00	-0.00

Table 15. Analysis of deviance of region 4

Predictor	$\chi2$	df	*p*
attachN2	4.15	1	.042
TIorder	0.31	1	.579
logSorder	3.08	1	.079
attach:TIorder	2.92	1	.087

Region 5

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach + logSorder | participant) + (1 | item)

Table 16. Summary of the analyses for region 5

Predictor	Estimate	SE	df	*t*	*p*
Intercept	78.49	13.00	28.20	6.04	< .001
attachN2	-7.56	16.22	87.10	-0.47	.642
logSorder	-97.94	32.02	24.30	-3.06	.005
TIorder	2.31	4.70	21.40	0.49	.629
attachN2:TIorder	3.46	2.28	818.60	1.52	.129

Table 17. Correlation of fixed factors of the analyses for region 5

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.16			
TIorder	-0.00	-0.01		
logSorder	-0.05	-0.08	-0.90	
attachN2:TIorder	-0.01	-0.01	0.00	0.00

Table 18. Analysis of deviance of region 5

Predictor	$\chi 2$	df	*p*
attachN2	0.21	1	.647
TIorder	0.24	1	.625
logSorder	9.36	1	.002
attach:TIorder	2.31	1	.128

Region 6

Formula: RRT ~ attach * TIorder + logSorder + (1 + logSorder | participant) + (1 | item)

Table 19. Summary of the analyses for region 6

Predictor	Estimate	SE	df	*t*	*p*
Intercept	18.46	12.57	48.90	1.47	.148
attachN2	-0.25	8.36	1716.40	-0.03	.976
logSorder	-84.47	24.37	23.60	-3.47	.002
TIorder	3.30	3.62	21.60	0.91	.372
attachN2:TIorder	-0.55	1.27	1715.80	-0.43	.666

Table 20. Correlation of fixed factors of the analyses for region 6

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.00			
TIorder	-0.00	-0.00		
logSorder	0.01	0.00	-0.91	
attachN2:TIorder	0.00	-0.02	0.01	-0.01

Table 21. Analysis of deviance of region 6

Predictor	$\chi2$	df	*p*
attachN2	0.00	1	.970
TIorder	0.84	1	.361
logSorder	12.01	1	.001
attach:TIorder	0.19	1	.666

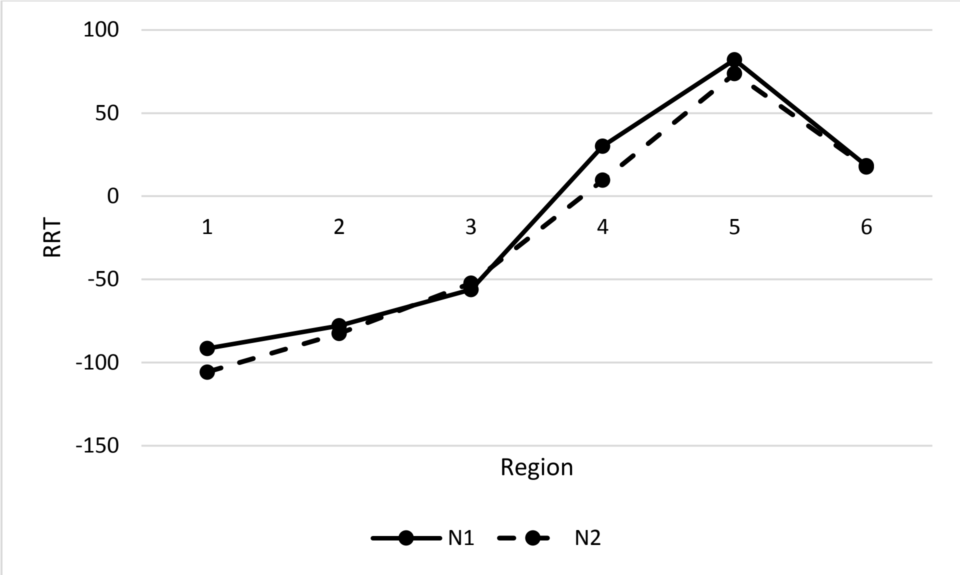

Figure 14. Residual reading times (RRTs) per region for each condition in ms with by-participants means

Appendix 10

An example of a norming questionnaire for SCs

Instructions

กรุณาพิจารณาประโยคที่ให้ และเลือกตัวเลือกที่สื่อความหมายของสิ่งที่กล่าวไปในประโยคได้ดีที่สุด

1. เป้าหมายหลักของทีโอทีที่จะมุ่งสู่การเป็นผู้ให้บริการการสื่อสารชั้นนำของประเทศฟังดูจะเป็นไปได้ยาก
   a. ทีโอทีมีเป้าหมายหลักในการเป็นผู้ให้บริการการสื่อสารชั้นนำ
   b. ทีโอทีที่จะมุ่งสู่การเป็นผู้ให้บริการการสื่อสารชั้นนำมีเป้าหมายหลักบางอย่าง
2. รถยนต์ของพนักงานที่กำลังเดินเลือกซื้อผลไม้ถูกเจาะยาง
   a. พนักงานมีรถยนต์ที่กำลังเดินเลือกซื้อผลไม้ผลไม้มีรถยนต์
   b. พนักงานที่กำลังเดินเลือกซื้อ

List 1

- ศาลปฏิเสธคำร้องของตำรวจที่ขอให้การพิจารณาคดีทำโดยลับ
  a. ตำรวจมีคำร้องที่ขอให้การพิจารณาคดีทำโดยลับ
  b. ตำรวจที่ขอให้การพิจารณาคดีทำโดยลับมีคำร้องบางอย่าง
- ระหว่างนั้นชาก็ปรึกษาแม่ว่าทำไงดี ก็มาสรุปว่าถ้ามันเป็นความภาคภูมิใจของเราที่ได้เล่นหนังเรื่องนี้เราก็ควรจะรับเล่น
  a. ถ้าเราที่ได้เล่นหนังเรื่องนี้มีความภาคภูมิใจบางอย่างเราควรจะรับเล่น
  b. ถ้าเรามีความภูมิใจที่ได้เล่นหนังเรื่องนี้เราควรจะรับเล่น

List 2

- กฎหมายบัญญัติให้เป็นดุลยพินิจของเจ้าพนักงานตำรวจที่จะให้ประกันหรือไม่ให้ประกันก็ได้
  a. เจ้าพนักงานตำรวจที่จะให้ประกันหรือไม่ให้ประกันก็ได้มีดุลยพินิจในบางเรื่อง
  b. เจ้าพนักงานตำรวจมีดุลยพินิจที่จะให้ประกันหรือไม่ให้ประกันก็ได้
- ปีเตอร์ โซโคโลว์สกี้ ผู้ช่วยบรรณาธิการอธิบายว่ามันไม่ใช่การตัดสินใจของเราที่เลือกคำนี้บรรจุในพจนานุกรม
  a. เราที่เลือกคำนี้บรรจุในพจนานุกรมไม่ได้มีการตัดสินใจในการกระทำบางอย่าง
  b. การตัดสินใจในการเลือกคำนี้บรรจุในพจนานุกรมไม่ใช่การตัดสินใจของเรา

Appendix 11

N1-attached SCs

The following is the list of 44 N1-attached SCs items used in Experiment 3. For each item, the percentage in the parentheses indicates SC bias derived from the norming questionnaire.

1. กฎหมายกำหนดให้เป็นหน้าที่ของนายจ้างที่จะต้องจัดให้ลูกจ้างได้มีวันหยุดประจำปี ปีละไม่น้อยกว่า 30วัน (100%)

   Lit: "The law stipulates that it is the duty of the employer that must provide employees with annual leave of least 30 days a year."

   "The law stipulates that it is the duty of the employer to provide employees with annual leave of at least 30 days a year."

2. พ.ร.บ.ตำรวจแห่งชาติ ระบุไว้ว่าเป็นหน้าที่ของนายกรัฐมนตรีที่ต้องเสนอชื่อผบ.ตร.คนใหม่ (100%)

   Lit: "The National Police Act stated that it is the duty of the prime minister that must nominate a new police commissioner general."

   "The National Police Act stated that it is the duty of the prime minister to nominate a new police commissioner general."

3. ปัญหาน้ำท่วมและเส้นทางถูกตัดขาดเป็นหน้าที่ของ ส.ส. ที่จะต้องช่วยเหลือประชาชนในพื้นที่ (90%)

Lit: "Flooding and road closure problems are the responsibility of the representatives that have to help the people in the area."

"Flooding and road closure problems are the responsibility of the representatives to help the people in the area."

4. นายพิภพกล่าวว่า ทางรัฐบาลไม่เคยวางมาตรการป้องกันความรุนแรงในการชุมนุมจึงเป็นหน้าที่ของประชาชนที่จะต้องหยุดยั้งรัฐบาลเพื่อไม่ให้บริหารประเทศต่อไป (90%)

Lit: "Mr. Phiphop said that, the government never lays down measures to prevent violence in demonstration; thus, it is the responsibility of the people that must stop the government from administering the country any further."

"Mr.Phiphop said that, the government never lays down measures to prevent violence in demonstration; thus, it is the responsibility of the people to stop the government from administering the country any further."

5. กรณีสถานบริการมีการให้เยาวชนอายุต่ำกว่า 20 ปีเข้าไปใช้บริการเป็นหน้าที่ของตำรวจที่จะต้องตรวจสอบดำเนินการเพราะมีกฎหมายบังคับใช้อยู่แล้ว (90.91%)

   Lit: "In cases that entertainment venues allow youths below 20 years of age to use their service, it is the duty of the police that must check and enforce compliance since the law applies already."

   "In cases where entertainment venues allow youths below 20 years of age to use their service, it is the duty of the police to check and enforce compliance since the law applies already."

6. ถ้าคุณไม่มีเวลาก็เป็นสิทธิของคุณที่จะไม่ไปเที่ยวห้างสรรพสินค้าตามคำชวนของเพื่อน (100%)

   Lit: "If you do not have the time, it is your right that will not go to the mall as invited by your friend."

   "If you do not have the time, it is your right not to go to the mall as invited by your friend."

7. สิทธิของจำเลยที่จะอุทธรณ์ฎีกาแก้อุทธรณ์ฎีกาหรือถอนอุทธรณ์ฎีกาเป็นสิทธิเดียวกับฝ่ายโจทก์ (100%)

   Lit: "The rights of the defendant that will appeal, amend an appeal or withdraw an appeal are the same as that of the plaintiff."

   "The rights of the defendant to appeal, amend an appeal or withdraw an appeal are the same as that of the plaintiff."

8. คานธีให้เหตุผลว่าความสามารถทางกายของคนเราที่จะรับใช้มีจำกัดจึงต้องเลือกที่จะรับใช้ครอบครัวเป็นอันดับแรก (100%)

Lit: “Gandhi reasoned that the physical ability of human that will serve is limited; thus, one must choose to serve the family as first priority.”

“Gandhi reasoned that the physical ability of human to serve is limited, thus, one must choose to serve the family as first priority.”

9. ลีลาวรรณศิลป์ในบทประพันธ์นี้คือความสามารถอย่างยอดเยี่ยมของกวีที่จะผสมผสานความประณีตวิเศษของขนบวรรณศิลป์ไทยเข้ากับการสร้างอารมณ์สะเทือนใจ (81.82%)

Lit: “The style in this literary work is an excellent ability of the writer that combines the exquisiteness and magnificence of Thai literary tradition with the creation of emotional mood.”

“The style in this literary work is an excellent ability of the writer to combine the exquisite and magnificent Thai literary tradition with the creation of emotional mood.”

10. แม้นักวิชาการส่วนใหญ่จะพยายามระมัดระวังการอภิปรายของตนให้อยู่ในหลักวิชาการ แต่ก็ยังมีผู้อภิปรายหลายคนกล่าวถึงความฝันของตนที่จะได้เห็นระบบสังคมนิยมในสังคมไทย (90.91%)

Lit: “Even though most academics are trying to be cautious to keep their debate academic, but there are still many debaters who express the dream of theirs that will see socialism in Thai society.”

“Even though most academics are trying to be cautious to keep their debate academic, but there are still many debaters who express their own dreams of seeing socialism in Thai society.”

11. พงศกรสรุปเอาเองว่านี่คงเป็นความฝันอย่างหนึ่งของน้ำที่จะก้าวไปข้างหน้าเหมือนคนอื่น ๆ อีกหลายคน (80%)

Lit: “Phongsakorn concluded by himself that this is perhaps the dream of Nam that will advance like many others.”

“Phongsakorn concluded by himself that this is perhaps Nam’s dreams of advancing like many others.”

12. ศาลปฏิเสธคำร้องของตำรวจที่ขอให้การพิจารณาคดีทำโดยลับ (100%)

Lit: “The court rejected the petition of the officer that requested for the trial to be held secretly.”

“The court rejected the petition of the officer about requesting for the trial to be held secretly.”

13. ความสุขของเตือนตาเลือนหายและกลายเป็นความขมขื่นเมื่อนึกถึงพฤติการณ์ของผัวที่ดุและขู่ในบางเวลา (100%)

Lit: “Tuenta’s happiness fades and turns into bitterness when she thinks about the behaviors of her husband that is fierce and threatening some of the times.”

“Tuenta’s happiness fades and turns into bitterness when she thinks about the behaviors of her husband being fierce and threatening some of the times.”

14. ใจเด็ดเอ่ยปากถามอาการเจ็บคอของคุณแก้วอย่างเป็นห่วงเป็นใย จึงเป็นภาระของสุบินที่จะตอบแทนว่าเริ่มทุเลาลงแล้วแต่ยังใช้เสียงไม่ได้ถนัด (80%)

Lit: “Jai-ded asked about the sore throat that Kaew has with concern; thus, it was the obligation of Su-bin that answered in her place that she was getting better but still cannot use her voice with ease.”

“Jai-ded asked about the sore throat that Kaew has with concern; thus, it is the obligation of Su-bin to answer in her place how she was getting better but still cannot yet use her voice with ease.”

15. วิธีของพระสังข์เป็นวิธีการของนักเลงที่จะชำระคู่ต่อสู้ด้วยการทำให้ได้อาย และความอายนั้นจะติดตัวไปตลอดชีวิต (100%)

Lit: “The method of Phra Sangha is the method of a thug that settles the opponent by shaming and such shame remains with the person for life.”

“The method of Phra Sangha is the method of a thug in settling the opponent by shaming, and such shame remains with the person for life.”

16. นายบุญจง วงศ์ไตรรัตน์ กล่าวว่าเป็นเสรีภาพของประชาชนที่จะทำการชุมนุมได้ (100%)

Lit: “Mr. Boonjong Wongtrairat said that it is the freedom of the people that will conduct demonstration.”

“Mr. Boonjong Wongtrairat said that it is the freedom of the people in conducting demonstration.”

17. ถ้ามีกระแสของประชาชนที่เรียกร้องในประเด็นการคอรัปชั่นอย่างเข้มแข็งมากขึ้นก็น่าจะทำให้รัฐบาลเปลี่ยนแปลงได้ (90.91%)

Lit: “If there is a trend of people that petitions on the issue of corruption more strongly, it might cause the government to change.”

“If there is a trend of people to petition on the issue of corruption more strongly, it might cause the government to change.”

18. กฎหมายบัญญัติให้เป็นดุลยพินิจของเจ้าพนักงานตำรวจที่จะให้ประกันหรือไม่ให้ประกันก็ได้ (90.91%)

Lit: “The law prescribes that it is at the discretion of the police officer that can either give or refuse bail.”

“The law prescribes that it is at the discretion of the police officer to either give or refuse bail.”

19. เจ้าชายตีลังกาหลบดาบของมังนันทะสูทำให้มังนันทะสูรู้สึกพอใจกับการกระทำของศิษย์เอกที่ให้ความเคารพไม่ร่วมต่อสู้ (90%)

Lit: “The prince somersaulted away from the sword of Mangnantasu which makes Mangnantasu satisfied with the action of his top student that respects and fights him not.”

“The prince somersaulted away from the sword of Mangnantasu making Mangnantasu satisfied with the action of his top student in respecting and fighting him not.”

20. ครูควรมีคุณธรรมจริยธรรมของผู้สอนที่จะต้องไม่กักความรู้ไว้เพื่อสอนพิเศษ (90%)

Lit: “Teacher should possess the ethics of an instructor that must not withhold knowledge in order to tutor.”

“Teacher should possess the ethics of an instructor in not withholding knowledge in order to tutor.”

21. มติของสภาผู้แทนราษฎรที่เห็นชอบด้วยในการแต่งตั้งบุคคลใดให้เป็นนายกรัฐมนตรีต้องมีคะแนนเสียงมากกว่ากึ่งหนึ่งของจำนวนสมาชิกทั้งหมด (81.82%)

Lit: “The resolution of the House of Representatives that agrees to appoint someone as the prime minister must secure more than half of the vote of all the members.”

“The resolution of the House of Representatives agreeing to appoint someone as the prime minister must secure more than half of the vote of all the members.”

22. ในการแก้ไขรายการละเอียดการก่อสร้างให้ผู้รับสัมปทานยื่นคำขอต่ออธิบดี และให้เป็นอำนาจของอธิบดีที่จะอนุมัติได้ (80%)

Lit: "To amend the construction details, the concessionaire is to file an application to the director-general and it is the authority of the director-general that is able to approve."

"To amend the construction details, the concessionaire is to file an application to the director-general and it is within the authority of the director-general to approve."

23. หลังจากนี้ 2-3 สัปดาห์จะมีปัญหาตามมาอีกมากกับบริษัทนำเที่ยวแห่งนี้ เนื่องจากความไม่พอใจของลูกค้าที่เดินทางไปต่างประเทศแล้วกลับไม่ได้ (80%)

Lit: "Two or three weeks after this, there will be even more problems with this tour agent company for dissatisfaction of customers that traveled abroad and cannot return."

"Two or three weeks after this, there will be even more problems with this tour agent company for dissatisfaction of customers in traveling abroad and not being able to return."

24. การว่างงานเนื่องจากการหางานถือเป็นความประสงค์ของประชาชนที่จะไม่เลือกงานในขณะนั้น

(80%)

Lit: “Unemployment as a result of finding a job is considered an intention of the people that choose not to work at the moment.”

“Unemployment as a result of finding a job is considered an intention of the people in choosing not to work at the moment.”

25. หญิงสาวยืนคอแข็งเม้มปากแน่นเพราะเห็นภาพความสนิทสนมแบบจำยอมผสานกับท่าทีของธรรศที่ทรีตทิพกฤตาเสียจนสาว ๆ ทั้งฮอลล์ริษยา (90%)

Lit: “The girl stood speechlessly and tight-lipped as she unwillingly saw the scene of an intimacy and the manner of Thas that treats Thipkritta to the point where all the girls in the hall became jealous.”

“The girl stood speechlessly and tight-lipped as she unwillingly saw the scene of an intimacy and Thas’s manner of treating Thipkritta to the point where all the girls in the hall became jealous.”

26. อรถือถ้วยชามไปล้างในห้องน้ำเงียบๆ เป็นกิจวัตรของหล่อนที่จะล้างจานชามหลังอาหารทุกวัน

(100%)

Lit: “Orn took the dishes and washed them in the bathroom quietly; it is the routine of hers that cleans the dishes after the meal every day.”

“Orn took the dishes and wash them in the bathroom quietly; it is her routine to clean the dishes after the meal every day.”

27. กระผมขอยืนยันให้ท่านสมาชิกได้ทราบอีกครั้งถึงความตั้งใจจริงของกระผมที่จะรักษาประเทศชาติของเราให้อยู่รอดไว้ด้วยชีวิต (100%)

Lit: “I reassure you dear member once again of genuine intention of mine that will ensure our country’s survival with my life.”

“I reassure you dear member once again of my genuine intention to ensure our country’s survival with my life.”

28. อยากจะฝากเยาวชนทั้งหลายไว้ด้วยว่าความพยายามของเราที่จะพัฒนาสังคมจะต้องใช้เวลาอีกยาวนานพอสมควร (100%)

Lit: “I would like to leave a word to all youths that effort of ours that will improve the society will require a considerable amount of time.”

“I would like to leave a word to all youths that our effort to improve the society will require a considerable amount of time.”

29. คุณเก่เขาเป็นคนน่ารัก ความจริงไม่ใช่ความผิดของเขาที่เกิดมาเป็นคนต่างชนชั้นกับเรา (100%)

Lit: “Mr. Kae is a lovely person; in fact it is not the fault of his that was born to a different class from us.”

“Mr. Kae is a lovely person; in fact it is not his fault being born to a different class from us.”

30. ปีเตอร์ โซโคโลว์สกี้ ผู้ช่วยบรรณาธิการอธิบายว่ามันไม่ใช่การตัดสินใจของเราที่เลือกคำนี้บรรจุในพจนานุกรม (100%)

Lit: "Peter Sokolowski, the assistant editor explained that it was not the decision of ours that chose to put this word in the dictionary."

"Peter Sokolowski, the assistant editor explained that it was not the decision of ours choosing to put this word in the dictionary."

31. แล้วมันธุระอะไรของคุณที่จะต้องไปนั่งเฝ้าไข้จนติดไข้กลับมาแบบนี้ (90.91%)

Lit: "So what business of yours that have to look after the sick to the point where you get sick like this?"

"So what business is it of yours, having to look after the sick to the point where you get sick like this?"

32. คราวนี้ก็เป็นโอกาสของเราที่จะล้วงความจริงจากมันไงล่ะ (90%)

Lit: "This time, it is the chance of ours that will spill the truth out of him."

"This time, it is our chance to spill the truth out of him."

33. กฎหมายกำหนดให้เป็นหน้าที่ของนายจ้างที่จะต้องนำข้อตกลงเกี่ยวกับสภาพการจ้างงานไปจดทะเบียนต่ออธิบดีกรมแรงงาน (100%)

Lit: "The law requires that it is the duty of the employer that must take the collective agreement and register it to the director general of labor department."

"The law requires that it is the duty of the employer to take the collective agreement and register it to the director general of labor department."

34. ตามธรรมเนียมของประเทศญี่ปุ่นวันไวท์เดย์จะเป็นหน้าที่ของผู้ชายที่ต้องให้ของขวัญกับผู้หญิง (100%)

Lit: "According to the traditions of Japan, on White Day, it is the responsibility of men that must offer gifts to women."

"According to Japanese tradition, on White Day, it is the responsibility of men to offer gifts to women."

35. เขาไม่ได้รู้สึกขอบคุณในการกระทำของโทะกิโกะเพราะเขารู้สึกว่านั่นเป็นสิทธิชอบธรรมของสามีที่จะได้รับการปฏิบัติเช่นนั้น (100%)

Lit: "He does not feel grateful towards the action of Tokiko because he feels that it is the rights of a husband that is to be treated so."

"He does not feel grateful towards Tokiko's action because he feels that it is the rights of a husband to be treated so."

36. คณะลูกขุนลงความเห็นว่าเจมส์ ลี ครัมเมล มีความผิดจริงและได้ยกคำร้องของทนายที่อ้างว่าจำเลยมีความผิดปรกติทางสมอง (100%)

Lit: “The jury concluded that James Lee Crummel is guilty and rejected the petition of the attorney that claims that the defendant has a brain abnormality.”

“The jury concluded that James Lee Crummel is guilty and rejected the petition of the attorney about claiming that the defendant has a brain abnormality.”

37. ความสามารถทางสติปัญญาของมนุษย์ที่จะหยั่งรู้ว่าอะไรผิดคือความรู้สึกผิดชอบชั่วดีในจิตใจของมนุษย์นั่นเอง (90%)

Lit: “The intellectual ability of human that discerns the wrong is indeed the conscience in the human mind.”

“The intellectual ability of human to discern the wrong is indeed the conscience in the human mind.”

38. เมื่อพระโอรสทุกพระองค์แย่งกันครองราชสมบัติ เสนาบดีจึงจัดการตามบัญชาของพระราชาที่ให้พระโอรสตอบปริศนา (100%)

Lit: “Since all the princes fought over the crown, the minister therefore managed according to the order of the king that have the princes answered riddles.”

“Since all the princes fought over the crown, the minister therefore managed according to the order of the king in regard to having the princes answered riddles.”

39. หากโรงพยาบาลมีเครื่องมือช่วยชีวิตจำนวนจำกัดทำให้ไม่สามารถรักษาผู้ป่วยบางรายได้ทัน ถือเป็นความบกพร่องของผู้บริหารที่ไม่ได้เตรียมการแก้ปัญหาไว้ล่วงหน้า (90.91%)

Lit: "If the hospital has a limited number of life-saving equipment, and is unable to cure certain patients in time, it is the fault of the administrators that did not prepare solution in advance."

"If the hospital has a limited number of life-saving equipment, and is unable to cure certain patients in time, it is the fault of the administrators in regard to not preparing solution in advance."

40. ในรถไม่มีใครยอมรับว่าเป็นคนเรอ น้าสินเลยสรุปว่ามันเป็นกลไกใหม่ของร่างกายมนุษย์ที่เรอแล้วไม่รู้ตัว (100%)

Lit: "No one in the car admitted to have burped, so uncle Sin concluded that it is the new mechanism of the body that burped without realizing it."

"No one in the car admitted to have burped, so uncle Sin concluded that it is a new mechanism of the body to burp without realizing it."

41. นับเป็นโชคดีของจุ๋งจิ๋งที่ได้อยู่กับคนที่มันรักและรักมันทั้งในโลกนี้และโลกหน้า (100%)

Lit: "It is the good luck of Jungjing that is able to stay with the one that it loves and loves it for this and the next life time."

"It is the good luck of Jungjing in being able to stay with the one that it loves and loves it for this and the next life time."

42. ระหว่างนั้นษาก็ปรึกษาแม่ว่าทำไงดี ก็มาสรุปว่าถ้ามันเป็นความภาคภูมิใจของเราที่ได้เล่นหนังเรื่องนี้ เราก็ควรจะรับเล่น (90%)

Lit: "Meanwhile, Sa consulted her mother about what to do, then concluded that if it is the pride of hers that stars in this movie, she should accept the role."

"Meanwhile, Sa consulted her mother about what to do, then concluded that if it is the pride of her to star in this movie, she should accept the role."

43. จุดประสงค์แท้จริงของผู้เข้าร่วมแข่งขันคือการมีชื่อเสียงโด่งดังและทำตามความฝันของตนที่อยากเป็นนักร้องหรือนักแสดงคุณภาพ (80%)

Lit: "The real purpose of the competitors is to become famous and to follow the dream of one's own that wishes to become a singer or a performer of quality."

"The real purpose of the competitors is to become famous and to follow the dream of one's own to become a singer or a performer of quality."

44. ลุงทุมคิดว่าไอ้ถมเป็นสมบัติชิ้นหนึ่งของบ้านนี้ เป็นความรับผิดชอบของแกที่จะต้องดูแลรักษา (90.91%)

Lit: "Uncle Thoom thinks that Thom is a treasure of this house; it is the responsibility of his that must look after it."

"Uncle Thoom thinks that Thom is a treasure of this house; it is his responsibility to look after it."

Appendix 12

SC-based fillers

The following is the list of 44 SC-based fillers used in Experiment 3.

1. กฎหมายกำหนดให้นายจ้างมีหน้าที่ในการจัดให้ลูกจ้างได้มีวันหยุดประจำปี ปีละไม่น้อยกว่า30วัน

   "The law obliges the employer the duty to provide employees with annual leave of at least 30 days."

2. พ.ร.บ.ตำรวจแห่งชาติ ระบุไว้ว่านายกรัฐมนตรีมีหน้าที่ในการเสนอชื่อผบ.ตร.คนใหม่

   "The National Police Act stated that the prime minister has the duty to nominate a new police commissioner general."

3. ปัญหาน้ำท่วมและเส้นทางถูกตัดขาดเป็นหน้าที่ของ ส.ส. ในการช่วยเหลือประชาชนในพื้นที่

   "Problems regarding floods and road closures are the duty of the representatives in providing help to the people in the area."

4. นายพิภพกล่าวว่า ทางรัฐบาลไม่เคยวางมาตรการป้องกันความรุนแรงในการชุมนุมจึงเป็นหน้าที่ของประชาชนในการหยุดยั้งรัฐบาลเพื่อไม่ให้บริหารประเทศต่อไป

   "Mr.Phiphop said that, the government never lays down measures to prevent violence in demonstration; thus, it is the responsibility of the people to stop the government from administering the country any further."

5. กรณีสถานบริการมีการให้เยาวชนอายุต่ำกว่า 20 ปีเข้าไปใช้บริการเป็นหน้าที่ของตำรวจในการตรวจสอบดำเนินการเพราะมีกฎหมายบังคับใช้อยู่แล้ว

   "In cases that entertainment venues allow youths below 20 years of age to use their service, it is the duty of the police to check and enforce compliance since the law already applies."

6. ถ้าคุณไม่มีเวลาคุณก็มีสิทธิในการไม่ไปเที่ยวห้างสรรพสินค้าตามคำชวนของเพื่อน

   "If you do not have the time, you have the right not to go to the mall as invited by your friend."

7. สิทธิของจำเลยในการอุทธรณ์ฎีกา แก้อุทธรณ์ฎีกา หรือถอนอุทธรณ์ฎีกา เป็นสิทธิเดียวกับฝ่ายโจทก์

   "The rights of the defendant to appeal, amend an appeal or withdraw an appeal are the same rights as the plaintiff."

8. คานธีให้เหตุผลว่าความสามารถทางกายของคนเราในการรับใช้มีจำกัดจึงต้องเลือกที่จะรับใช้ครอบครัวเป็นอันดับแรก

   "Gandhi reasoned that the physical ability of human to serve is limited; hence one must choose to serve the family as first priority."

9. ลีลาวรรณศิลป์ในบทประพันธ์นี้คือความสามารถอย่างยอดเยี่ยมของกวีในการผสมผสานความประณีตวิเศษของขนบวรรณศิลป์ไทยเข้ากับการสร้างอารมณ์สะเทือนใจ

"The style in this literary work is an excellent ability of the writer to combine the exquisiteness and magnificence of Thai literary tradition with the creation of emotional mood."

10. แม้นักวิชาการส่วนใหญ่จะพยายามระมัดระวังการอภิปรายของตนให้อยู่ในหลักวิชาการ แต่ก็ยังมีผู้อภิปรายหลายคนกล่าวถึงความฝันของตนเกี่ยวกับการได้เห็นระบบสังคมนิยมในสังคมไทย

"Even though most academics are trying to be cautious about keeping their debate academic, there are still several debaters expressing dreams of their own of seeing socialism in Thai society."

11. พงศกรสรุปเอาเองว่านี่คงเป็นความฝันอย่างหนึ่งของน้ำ เป็นความฝันในการก้าวไปข้างหน้าเหมือนคนอื่น ๆ อีกหลายคน

"Phongsakorn concluded by himself that this is perhaps the dream of Nam, dream of advancing like many others."

12. ศาลปฏิเสธคำร้องของตำรวจเกี่ยวกับการขอให้การพิจารณาคดีทำโดยลับ

"The court rejected the petition of the officer about the request for the trial to be held secretly."

13. ความสุขของเตือนตาเลือนหายและกลายเป็นความขมขื่นเมื่อนึกถึงพฤติการณ์ในด้านการดุและขู่ในบางเวลาของผัว

"Tuenta's happiness fades and turns into bitterness when she thinks of behaviors in being fierce and threatening some of the times of her husband."

14. ใจเด็ดเอ่ยปากถามอาการเจ็บคอของคุณแก้วอย่างเป็นห่วงเป็นใย จึงเป็นภาระของสุบินในการตอบแทนว่าเริ่มทุเลาลงแล้วแต่ยังใช้เสียงไม่ได้ถนัด

"Jai-ded asked about Kaew's sore throat with concern, hence it was obligation of Subin to answer in her place that she was getting better but cannot yet use her voice with ease."

15. วิธีของพระสังข์เป็นวิธีการของนักเลง เป็นวิธีชำระคู่ต่อสู้ด้วยการทำให้ได้อาย และความอายนั้นจะติดตัวไปตลอดชีวิต

"Phra Sangha's method is the method of a thug, the method in settling the opponents by shaming, and such shame remains with the person for life."

16. นายบุญจง วงศ์ไตรรัตน์ กล่าวว่าเป็นเสรีภาพของประชาชนในการทำการชุมนุม

"Mr. Boonjong Wongtrairat said that it is the freedom of the people in conducting demonstration."

17. ถ้าประชาชนมีกระแสเรียกร้องในประเด็นการคอรัปชั่นอย่างเข้มแข็งมากขึ้นก็น่าจะทำให้รัฐบาลเปลี่ยนแปลงได้

"If people have a trend to petition on the issue of corruption more strongly, it might cause the government to change."

18. กฎหมายบัญญัติให้ดุลยพินิจในการให้ประกันหรือไม่ให้ประกันเป็นของเจ้าพนักงานตำรวจ

"The law prescribes that the discretion to give or refuse bail is up to the police officer."

19. เจ้าชายตีลังกาหลบดาบของมังนันทะสูทำให้มังนันทะสูรู้สึกพอใจกับการกระทำในการให้ความเคารพไม่ร่วมต่อสู้ของศิษย์เอก

"The prince somersaulted away from Mangnantasu's sword making Mangnantasu satisfied with the show of respect and refusal to fight by his top student."

20. ครูควรมีคุณธรรมจริยธรรมของผู้สอนในด้านการไม่กักความรู้ไว้เพื่อสอนพิเศษ

"Teacher should possess the ethics of an instructor in the sense of not withholding knowledge in order to tutor."

21. มติของสภาผู้แทนราษฎรเกี่ยวกับการเห็นชอบด้วยในการแต่งตั้งบุคคลใดให้เป็นนายกรัฐมนตรีต้องมีคะแนนเสียงมากกว่ากึ่งหนึ่งของจำนวนสมาชิกทั้งหมด

"The resolution of the House of Representatives in agreeing to appoint someone as the prime minister must secure more than half of the vote of all the members."

22. ในการแก้ไขรายการละเอียดการก่อสร้างให้ผู้รับสัมปทานยื่นคำขอต่ออธิบดี และให้เป็นอำนาจของอธิบดีในการอนุมัติ

"To amend the construction details, the concessionaire is to file an application to the director-general and it is within the authority of the director-general to approve."

23. หลังจากนี้ 2-3 สัปดาห์จะมีปัญหาตามมาอีกมากกับบริษัทนำเที่ยวแห่งนี้ เนื่องจากความไม่พอใจของลูกค้าเกี่ยวกับการเดินทางไปต่างประเทศแล้วกลับไม่ได้

"Two or three weeks after this, there will be even more problems with this tour agent company for dissatisfaction of customers in traveling abroad and not being able to return."

24. การว่างงานเนื่องจากการหางานถือเป็นความประสงค์ของประชาชนในการไม่เลือกงานในขณะนั้น

"Unemployment as a result of finding a job is considered an intention of the people in choosing not to work at the moment."

25. หญิงสาวยืนคอแข็งเม้มปากแน่นเพราะเห็นภาพความสนิทสนมแบบจำยอมผสานกับท่าทีของธรรศในการทรีตทิพกฤตาเสียจนสาว ๆ ทั้งฮอลล์ริษยา

"The girl stood speechlessly and tight-lipped as she unwillingly saw the scene of an intimacy and the manner of Thas of treating Thipkritta to the point where all the girls in the hall became jealous."

26. อรถือถ้วยชามไปล้างในห้องน้ำเงียบๆ หล่อนมีกิจวัตรในการล้างจานชามหลังอาหารทุกวัน

"Orn took the dishes and wash them in the bathroom quietly; she has the routine of cleaning the dishes after the meal every day."

27. กระผมขอยืนยันให้ท่านสมาชิกได้ทราบอีกครั้ง กระผมมีความตั้งใจจริงในการรักษาประเทศชาติของเราให้อยู่รอดไว้ด้วยชีวิต

"I reassure you dear member once again. I have a genuine intention to ensure our country's survival with my life."

28. อยากจะฝากเยาวชนทั้งหลายไว้ด้วยว่าความพยายามของเราในการพัฒนาสังคมจะต้องใช้เวลาอีกยาวนานพอสมควร

"I would like to leave a word to all youths that the effort of ours to improve the society will require a considerable amount of time."

29. คุณเก่เขาเป็นคนน่ารัก ความจริงการเกิดมาเป็นคนต่างชนชั้นกับเราไม่ใช่ความผิดของเขา

"Mr. Kae is a lovely person. In fact, being born to a different class from us is not his fault."

30. ปีเตอร์ โซโคโลว์สกี้ ผู้ช่วยบรรณาธิการอธิบายว่ามันไม่ใช่การตัดสินใจของเราในการเลือกคำนี้บรรจุในพจนานุกรม

"Peter Sokolowski, the assistant editor explained that it was not the decision of ours in choosing to put this word in the dictionary."

31. ธุระในการไปนั่งเฝ้าไข้จนติดไข้กลับมาแบบนี้เป็นธุระของคุณหรือ

"Looking after the sick to the point where you get sick like this is the business of yours?"

32. คราวนี้ก็เป็นโอกาสของเราในการล้วงความจริงจากมันไงล่ะ

"This time, it is the chance of ours to spill the truth out of him."

33. กฎหมายกำหนดให้นายจ้างมีหน้าที่ในการนำข้อตกลงเกี่ยวกับสภาพการจ้างงานไปจดทะเบียนต่ออธิบดีกรมแรงงาน

"The law obliges employers has responsibility to take the collective agreement and register it to the director general of labor department."

34. ตามธรรมเนียมของประเทศญี่ปุ่นผู้ชายมีหน้าที่ในการให้ของขวัญกับผู้หญิงในวันไวท์เดย์

"According to Japanese tradition, men has responsibility to offer gifts to women on White Day."

35. เขาไม่ได้รู้สึกขอบคุณในการกระทำของโทะกิโกะเพราะเขารู้สึกว่าสามีมีสิทธิชอบธรรมในการได้รับการปฏิบัติเช่นนั้น

"He does not feel grateful towards Tokiko's action because he feels that a husband has the rights to be treated so."

36. คณะลูกขุนลงความเห็นว่าเจมส์ ลี ครัมเมล มีความผิดจริงและได้ยกคำร้องของทนาย คำร้องนั้นอ้างว่าจำเลยมีความผิดปรกติทางสมอง

"The jury concluded that James Lee Crummel is guilty and rejected the attorney's petition, the petition claiming that the defendant has a brain abnormality."

37. ความสามารถทางสติปัญญาของมนุษย์ในการหยั่งรู้ว่าอะไรผิดคือความรู้สึกผิดชอบชั่วดีในจิตใจของมนุษย์นั่นเอง

"The intellectual ability of human to discern the wrong is indeed the conscience in the human mind."

38. เมื่อพระโอรสทุกพระองค์แย่งกันครองราชสมบัติ เสนาบดีจึงจัดการตามบัญชาของพระราชาเกี่ยวกับการให้พระโอรสตอบปริศนา

"Since all the princes fought over the crown, the minister therefore managed according to the order of the king in regard to having the princes answered riddles."

39. หากโรงพยาบาลมีเครื่องมือช่วยชีวิตจำนวนจำกัดทำให้ไม่สามารถรักษาผู้ป่วยบางรายได้ทัน ถือว่าผู้บริหารมีความบกพร่องเนื่องจากไม่ได้เตรียมการแก้ปัญหาไว้ล่วงหน้า

"If the hospital has a limited number of life-saving equipment, causing inability to cure certain patients in time, the administrator is found guilty of not preparing solution in advance."

40. ในรถไม่มีใครยอมรับว่าเป็นคนเรอ น้าสินเลยสรุปว่ามันเป็นกลไกใหม่ของร่างกายมนุษย์ในการเรอแล้วไม่รู้ตัว

“No one in the car admitted to have burped, uncle Sin therefore concluded that it is a new mechanism of the body to burp without realizing it.

41. นับเป็นโชคดีของจุ๋งจิ๋งเพราะมันได้อยู่กับคนที่มันรักและรักมันทั้งในโลกนี้และโลกหน้า

“It is the good luck of Jungjing because it is able to stay with the one that it loves and loves it for this and the next life time.”

42. ระหว่างนั้นษาก็ปรึกษาแม่ว่าทำไงดี ก็มาสรุปว่าถ้าเรามีความภูมิใจจากการได้เล่นหนังเรื่องนี้เราก็ควรจะรับเล่น

“Meanwhile, Sa consulted her mother about what to do, then concluded that if she takes pride to star in this movie then she should accept the role.”

43. จุดประสงค์แท้จริงของผู้เข้าร่วมแข่งขันคือการมีชื่อเสียงโด่งดังและทำตามความฝันของตนในการเป็นนักร้องหรือนักแสดงคุณภาพ

“The real purpose of the competitors is to become famous and to follow the dream of theirs in becoming a singer or a performer of quality.”

44. ลุงทุมคิดว่าไอ้ถมเป็นสมบัติชิ้นหนึ่งของบ้านนี้ แกจึงต้องมีความรับผิดชอบในการดูแลรักษา

“Uncle Thoom thinks that Thom is a treasure of this house so he has the responsibility to take care of it.”

Appendix 13

RT analyses for unambiguous-sentence reading task (blocks 2 and 4) of the control group

Additional analyses for unambiguous-sentence reading task (blocks 2 and 4) of Experiment 3 for regions 1, 4 and 5 of the control group are reported to demonstrate problems with the RT data of this group. Two types of analyses were run. For the first type of analyses, data of both blocks were collapsed and the analyses included attach (N1 or N2), TIorder and logSorder as fixed factors. This type of analyses was run in order to investigate whether the result of Experiment 2 showing that as experiment proceeded, RTs to N2 attachment got marginally slower was replicated. The second type of analyses included attach (N1 or N2), block (2 or 4) and logSorder as fixed factors. This type of analyses was run in order to be a base line for making a comparison with the results of the experimental group to verify the effect of SCs. For both types of analyses, there should have not been a main effect of attach in region 1 but there should have been a main effect of attach either in region 4 or in region 5. The first type of analyses for regions 1, 4 and 5 were reported first, then the second type of analyses.

Analyses with attach, TIorder and logSorder as fixed factors

Region 1

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach + TIorder + logSorder | participant) + (1 | item)

Table 22. Summary of the analyses for region 1

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-169.89	24.79	54.50	-6.85	< .001
attachN2	-32.71	15.13	45.20	-2.16	.036
logSorder	-92.81	64.23	22.90	-1.45	.162
TIorder	6.58	9.54	21.80	0.69	.497
attachN2:TIorder	3.22	2.02	764.80	1.60	.111

Table 23. Correlation of fixed factors of the analyses for region 1

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.07			
TIorder	0.03	-0.04		
logSorder	-0.03	0.09	-0.96	
attachN2: TIorder	-0.00	0.00	0.00	0.00

Table 24. Analysis of deviance of region 1

Predictor	$\chi 2$	df	*p*
attach	4.68	1	.030
TIorder	0.48	1	.491
logSorder	2.09	1	.148
attach:TIorder	2.55	1	.111

Region 4

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach + logSorder | participant) + (1 | item)

Table 25. Summary of the analyses for region 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	187.76	57.13	41.30	3.29	.002
attachN2	-53.21	49.97	36.70	-1.07	.294
logSorder	-28.18	178.45	21.50	-0.16	.876
TIorder	-12.67	26.74	21.00	-0.47	.641
attachN2:TIorder	-3.51	6.25	747.90	-0.56	.575

Table 26. Correlation of fixed factors of the analyses for region 4

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	-0.20			
TIorder	-0.00	0.00		
logSorder	-0.01	0.03	-0.96	
attachN2: TIorder	-0.00	-0.01	0.00	-0.00

Table 27. Analysis of deviance of region 4

Predictor	χ2	df	*p*
attach	1.14	1	.286
TIorder	0.22	1	.637
logSorder	0.03	1	.875
attach:TIorder	0.32	1	.575

Region 5

Formula: RRT ~ attach * TIorder + logSorder + (1 + TIorder | participant) + (1 | item)

Table 28. Summary of the analyses for region 5

Predictor	Estimate	SE	df	*t*	*p*
Intercept	6.63	26.12	31.60	0.25	.801
attachN2	27.63	32.12	812.30	0.86	.390
logSorder	-13.35	82.14	21.70	-0.16	.872
TIorder	-3.40	12.49	22.40	-0.27	.788
attachN2:TIorder	4.97	4.84	828.70	1.03	.305

Table 29. Correlation of fixed factors of the analyses for region 5

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.00			
TIorder	-0.08	0.00		
logSorder	0.00	-0.01	-0.96	
attachN2: TIorder	-0.00	-0.01	0.00	-0.00

Table 30. Analysis of deviance of region 5

Predictor	$\chi 2$	df	*p*
attach	0.76	1	.385
TIorder	0.08	1	.784
logSorder	0.03	1	.871
attach:TIorder	1.05	1	.305

Analyses with attach, block and logSorder as fixed factors

Region 1

Formula: RRT ~ attach * block + logSorder + (1 | participant) + (1 | item)

Table 31. Summary of analyses for region 1 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-170.94	24.64	54.10	-6.94	< .001
attachN2	-31.03	13.49	827.10	-2.30	.022
block4	60.15	97.17	21.70	0.62	.542
logSorder	-77.99	48.58	21.60	-1.61	.123
attachN2:block4	25.26	27.08	828.60	0.93	.351

Table 32. Correlation of fixed factors of the analyses for region 1 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.00			
block4	0.00	0.000		
logSorder	-0.00	-0.00	-0.95	
attachN2:block4	-0.00	-0.00	0.00	-0.00

Table 33. Analysis of deviance of region 1

Predictor	$\chi 2$	df	*p*
attach	5.28	1	.022
block	0.38	1	.537
logSorder	2.58	1	.108
attach:block	0.87	1	.351

Region 4

Formula: RRT ~ attach * block + logSorder + (1 + attach + block + logSorder | participant) + (1 | item)

Table 34. Summary of analyses for region 4 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	192.87	59.69	41.30	3.23	.002
attachN2	-30.42	49.80	44.40	-0.61	.544
block4	606.59	307.30	25.70	1.97	.059
logSorder	-405.50	159.17	28.60	-2.55	.017
attachN2:block4	-72.27	80.04	756.90	-0.90	.367

Table 35. Correlation of fixed factors of the analyses for region 4 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	-0.01			
block4	0.12	0.16		
logSorder	-0.12	-0.16	-0.94	
attachN2:block4	0.00	-0.01	0.00	0.00

Table 36. Analysis of deviance of region 4

Predictor	$\chi2$	df	*p*
attach	0.38	1	.537
block	3.90	1	.048
logSorder	6.49	1	.011
attach:block	0.82	1	.367

Region 5

Formula: RRT ~ attach * block + logSorder + (1 + block + logSorder | participant) + (1 | item)

Table 37. Summary of analyses for region 5 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	11.95	27.10	32.90	0.44	.662
attachN2	16.33	32.33	806.30	0.51	.614
block4	49.41	134.64	23.50	0.37	.717
logSorder	-54.33	65.07	22.50	-0.84	.413
attachN2:block4	-2.60	64.64	804.60	-0.04	.968

Table 38. Correlation of fixed factors of the analyses for region 5 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.00			
block4	0.10	-0.00		
logSorder	-0.13	-0.00	-0.93	
attachN2:block4	-0.00	-0.01	0.00	0.00

Table 39. Analysis of deviance of region 5

Predictor	$\chi 2$	df	*p*
attach	0.26	1	.614
block	0.14	1	.714
logSorder	0.70	1	.404
attach:block	0.00	1	.968

Appendix 14

Results of the analyses for question 1 of Experiment 3

Question 1 of Experiment 3 is whether experience with unambiguous RCs affects RC-attachment processing during the unambiguous-sentence reading task (blocks 2 and 4). Blocks were collapsed. Analyses of each region of the experimental group are reported.

Region 1

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach * TIorder | participant) + (1 + attach | item)

Table 40. Summary of the analyses for region 1

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-190.10	29.01	58.85	-6.55	< .001
attachN2	-17.57	11.70	38.43	-1.50	.142
logSorder	-91.67	61.70	20.97	-1.49	.152
TIorder	6.52	9.36	21.44	0.70	.493
attachN2:TIorder	2.01	1.74	46.28	1.15	.255

Table 41. Correlation of fixed factors of the analyses for region 1

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	-0.15			
TIorder	0.01	-0.01		
logSorder	0.00	0.00	-0.96	
attachN2: TIorder	0.15	-0.19	-0.07	-0.01

Table 42. Analysis of deviance of region 1

Predictor	χ2	df	*p*
attach	1.71	1	.191
TIorder	0.60	1	.437
logSorder	2.21	1	.137
attach:TIorder	1.33	1	.249

Region 2

Formula: RRT ~ attach * TIorder + logSorder + (1 + TIorder | participant) + (1 + attach | item)

Table 43. Summary of the analyses for region 2

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-136.01	18.67	53.47	-7.29	< .001
attachN2	-5.45	9.60	20.21	-0.57	.577
logSorder	-44.99	36.85	21.38	-1.22	.235
TIorder	-1.01	5.72	23.88	-0.18	.861
attachN2:TIorder	1.51	1.48	20.37	1.03	.317

Table 44. Correlation of fixed factors of the analyses for region 2

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.09			
TIorder	0.05	-0.01		
logSorder	0.00	0.01	-0.94	
attachN2: TIorder	0.00	0.03	0.03	0.01

Table 45. Analysis of deviance of region 2

Predictor	$\chi2$	df	*p*
attach	0.36	1	.547
TIorder	0.04	1	.836
logSorder	1.49	1	.222
attach:TIorder	1.05	1	.305

Region 3

Formula: RRT ~ attach * TIorder + logSorder + (1 + logSorder | participant) + (1 + attach | item)

Table 46. Summary of the analyses for region 3

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-21.60	14.10	37.90	-1.53	.134
attachN2	-1.05	14.84	1366.40	-0.07	.944
logSorder	-28.91	41.68	24.80	-0.69	.494
TIorder	-6.18	6.08	21.90	-1.02	.321
attachN2:TIorder	4.12	2.27	1395.50	1.82	.069

Table 47. Correlation of fixed factors of the analyses for region 3

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.016			
TIorder	0.002	-0.007		
logSorder	-0.034	0.007	-0.936	
attachN2: TIorder	0.001	0.023	0.001	0.003

Table 48. Analysis of deviance of region 3

Predictor	$\chi 2$	df	*p*
attach	0.01	1	.911
TIorder	1.04	1	.309
logSorder	0.48	1	.488
attach:TIorder	3.31	1	.069

Region 4

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach + logSorder | participant) + (1 + attach | item)

Table 49. Summary of the analyses for region 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	145.93	72.62	53.75	2.01	.050
attachN2	2.32	47.37	21.92	0.05	.961
logSorder	91.87	178.57	22.50	0.52	.612
TIorder	-22.26	26.65	21.63	-0.84	.413
attachN2:TIorder	1.99	6.75	19.43	0.29	.772

Table 50. Correlation of fixed factors of the analyses for region 4

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	0.30			
TIorder	0.00	-0.00		
logSorder	0.05	0.03	-0.96	
attachN2: TIorder	0.00	0.01	0.00	0.00

Table 51. Analysis of deviance of region 4

Predictor	$\chi 2$	df	*p*
attach	0.00	1	.964
TIorder	0.70	1	.403
logSorder	0.26	1	.607
attach:TIorder	0.09	1	.769

Region 5

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach * TIorder | participant) + (1 | item)

Table 52. Summary of the analyses for region 5

Predictor	Estimate	SE	df	*t*	*p*
Intercept	42.16	37.01	34.77	1.14	.262
attachN2	-70.70	39.45	43.83	-1.79	.080
logSorder	66.38	77.20	21.76	0.86	.399
TIorder	-29.89	11.84	23.11	-2.53	.019
attachN2:TIorder	8.02	6.21	56.95	1.29	.202

Table 53. Correlation of fixed factors of the analyses for region 5

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	-0.04			
TIorder	-0.10	0.01		
logSorder	0.00	0.01	-0.95	
attachN2: TIorder	0.30	-0.10	-0.09	0.00

Table 54. Analysis of deviance of region 5

Predictor	$\chi 2$	df	*p*
attach	2.81	1	.093
TIorder	5.83	1	.016
logSorder	0.74	1	.390
attach:TIorder	1.67	1	.197

Region 6

Formula: RRT ~ attach * TIorder + logSorder + (1 + attach * TIorder | participant) + (1 | item)

Table 55. Summary of the analyses for region 6

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-57.40	24.31	45.47	-2.36	.023
attachN2	2.94	26.44	42.95	0.11	.912
logSorder	-6.56	64.83	21.85	-0.10	.920
TIorder	-13.18	10.00	23.83	-1.32	.200
attachN2:TIorder	6.74	3.98	52.37	1.69	.097

Table 56. Correlation of fixed factors of the analyses for region 6

Predictor	Intercept	attachN2	TIorder	logSorder
attachN2	-0.13			
TIorder	-0.02	0.09		
logSorder	0.00	-0.95	0.00	
attachN2: TIorder	-0.14	-0.31	-0.12	0.01

Table 57. Analysis of deviance of region 6

Predictor	$\chi 2$	df	*p*
attach	0.44	1	0.506
TIorder	1.27	1	0.259
logSorder	0.01	1	0.919
attach:TIorder	2.86	1	0.091

Appendix 15

Results of the analyses for question 2 of Experiment 3

Question 2 of Experiment 3 is whether experience with SCs affects participants' expectation on RC attachment in an unambiguous-sentence reading task (blocks 2 and 4). Analyses of each region of the experimental group are reported. At the end of Appendix 15, Figure 15 shows RRTs per region for each condition and each block in ms with by-participants means.

Region 1

Formula: RRT ~ attach * block + logSorder + (1 + attach * block + logSorder | participant) + (1 | item)

Table 58. Summary of analyses for region 1 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-187.84	28.87	58.99	-6.51	< .001
attachN2	-17.93	11.26	39.39	-1.59	.120
block4	131.18	102.58	22.08	1.28	.214
logSorder	-115.08	52.21	23.54	-2.20	.038
attachN2:block4	18.57	21.02	40.79	0.88	.382

Table 59. Correlation of fixed factors of the analyses for region 1 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.06			
block4	-0.09	0.02		
logSorder	0.11	-0.00	-0.94	
attachN2:block4	0.13	-0.10	-0.04	0.04

Table 60. Analysis of deviance of region 1

Predictor	$\chi 2$	df	*p*
attach	2.28	1	.131
block	1.72	1	.190
logSorder	4.86	1	.028
attach:block	0.78	1	.377

Region 2

Formula: RRT ~ attach * block + logSorder + (1 + block + logSorder | participant) + (1 + attach | item)

Table 61. Summary of analyses for region 2 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-135.63	18.33	52.10	-7.40	< .001
attachN2	-7.40	9.90	20.14	-0.75	.464
block4	113.64	58.35	27.72	1.95	.062
logSorder	-106.12	32.43	36.30	-3.27	.002
attachN2:block4	21.54	19.77	20.09	1.09	.289

Table 62. Correlation of fixed factors of the analyses for region 2 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.08			
block4	-0.07	0.01		
logSorder	0.11	-0.01	-0.93	
attachN2:block4	0.00	0.02	0.05	-0.00

Table 63. Analysis of deviance of region 2

Predictor	$\chi2$	df	*p*
attach	0.58	1	.446
block	3.59	1	.058
logSorder	10.71	1	.001
attach:block	1.19	1	.276

Region 3

Formula: RRT ~ attach * block + logSorder + (1 + block + logSorder | participant) + (1 | item)

Table 64. Summary of analyses for region 3 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-21.83	13.20	36.20	-1.65	.107
attachN2	1.15	14.85	1715.90	0.08	.938
block4	162.17	61.35	26.50	2.64	.014
logSorder	-145.35	36.27	33.40	-4.01	< .001
attachN2:block4	36.55	29.61	1711.30	1.23	.217

Table 65. Correlation of fixed factors of the analyses for region 3 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.00			
block4	-0.03	0.00		
logSorder	-0.01	0.00	-0.93	
attachN2:block4	0.00	0.02	0.01	-0.01

Table 66. Analysis of deviance of region 3

Predictor	$\chi2$	df	*p*
attach	0.00	1	.954
block	6.94	1	.008
logSorder	16.06	1	< .001
attach:block	1.52	1	.217

Region 4

Formula: RRT ~ attach * block + logSorder + (1 + attach + block + logSorder | participant) + (1 + attach | item)

Table 67. Summary of analyses for region 4 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	143.03	69.65	52.96	2.05	.045
attachN2	7.82	46.33	23.18	0.17	.867
block4	724.32	248.28	24.52	2.92	.007
logSorder	-405.23	133.37	30.08	-3.04	.005
attachN2:block4	123.86	83.86	19.49	1.48	.156

Table 68. Correlation of fixed factors of the analyses for region 4 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.230			
block4	-0.069	-0.078		
logSorder	0.130	0.128	-0.936	
attachN2:block4	0.001	0.013	-0.063	0.002

Table 69. Analysis of deviance of region 4

Predictor	$\chi2$	df	*p*
attach	0.02	1	.881
block	9.10	1	.003
logSorder	9.23	1	.002
attach:block	2.18	1	.140

Region 5

Formula: RRT ~ attach * block + logSorder + (1 + attach * block + logSorder | participant) + (1 + attach | item)

Table 70. Summary of analyses for region 5 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	40.91	38.93	41.28	1.05	.300
attachN2	-83.53	47.19	30.81	-1.77	.087
block4	155.65	159.59	25.20	0.98	.339
logSorder	-175.91	79.39	24.73	-2.22	.036
attachN2:block4	-23.88	84.95	32.91	-0.28	.780

Table 71. Correlation of fixed factors of the analyses for region 5 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	-0.21			
block4	0.12	-0.02		
logSorder	-0.20	-0.01	-0.92	
attachN2:block4	-0.08	-0.01	-0.20	0.05

Table 72. Analysis of deviance of region 5

Predictor	χ2	df	*p*
attach	3.15	1	.076
block	0.88	1	.348
logSorder	4.91	1	.027
attach:block	0.08	1	.779

Region 6

Formula: RRT ~ attach * block + logSorder + (1 + block + logSorder | participant) + (1 | item)

Table 73. Summary of analyses for region 6 of blocks 2 and 4

Predictor	Estimate	SE	df	*t*	*p*
Intercept	-60.01	24.87	45.30	-2.41	.020
attachN2	6.84	20.01	1640.80	0.34	.732
block4	225.70	100.50	27.60	2.25	.033
logSorder	-196.39	52.72	30.50	-3.73	.001
attachN2:block4	40.40	39.96	1631.90	1.01	.312

Table 74. Correlation of fixed factors of the analyses for region 6 of blocks 2 and 4

Predictor	Intercept	attachN2	block4	logSorder
attachN2	0.00			
block4	-0.13	0.00		
logSorder	0.07	0.00	-0.94	
attachN2:block4	0.00	0.01	0.00	-0.00

Table 75. Analysis of deviance of region 6

Predictor	χ2	df	*p*
attach	0.11	1	.741
block	5.038	1	.025
logSorder	13.88	1	< .001
attach:block	1.02	1	.312

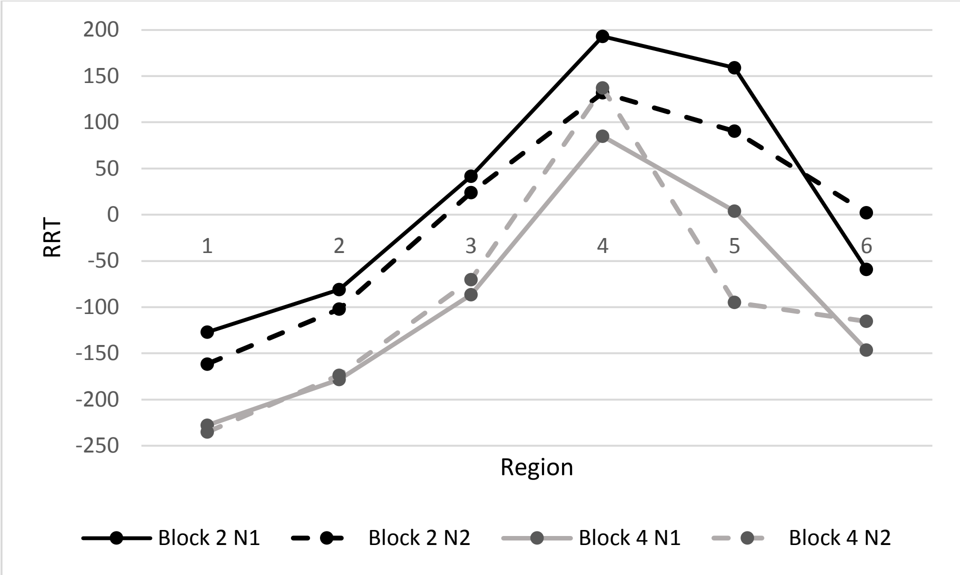

Figure 15. RRTs per region for each condition and each block in ms with by-participants means

Appendix 16

Results of the analyses for question 3 of Experiment 3

Question 3 of Experiment 3 is whether experience with RCs and experience with SCs in an unambiguous-sentence reading task can be transferred to an ambiguous-sentence reading task. Data from blocks 1 and 6 of the experimental and the control groups were analyzed. Tables 76 and 77 illustrate correlation of fixed factors and main effects of fixed factors respectively.

Table 76. Correlation of fixed factors of the analyses for blocks 1 and 6 of the experimental and the control groups

Predictor	Intercept	block6	groupExperimental	logSorder
block6	-0.03			
groupExperimental	-0.00	-0.01		
logSorder	0.02	-0.87	0.00	
block6: groupExperimental	-0.01	0.00	-0.05	-0.01

Table 77. Analysis of deviance of blocks 1 and 6 of the experimental and the control groups

Predictor	$\chi 2$	df	p
block	18.92	1	< .001
group	0.00	1	.97
logSorder	26.36	1	< .001
group:block	1.56	1	.212

Appendix 17

Results of the analyses for question 4 of Experiment 3

Question 4 of Experiment 3 is whether experience with ambiguous RCs in an ambiguous-sentence reading task affects participants' attachment decision. Blocks 1 and 6 were collapsed and data of the experimental and the control groups were analyzed. Tables 78 and 79 illustrates correlation of fixed factors and main effects of fixed factors in the analyses of question 4.

Table 78. Correlation of fixed factors of the analyses for the experimental and the control groups

Predictor	Intercept	groupExperimental	TIorder	logSorder
groupExperimental	-0.00			
TIorder	0.04	-0.00		
logSorder	-0.01	0.00	-0.92	
groupExperimental: TIorder	-0.00	0.20	-0.01	0.00

Table 79. Analysis of deviance of the experimental and the control groups

Predictor	$\chi 2$	df	*p*
group	0.06	1	.800
TIorder	0.61	1	.435
logSorder	0.00	1	.995
group:TIorder	0.87	1	.351

VITA

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