Syntactic Processing Differences in First and Second Language: Evidence from Syntactic Priming

Basma Mohammad Ashraf Ibrahim Elkhafif

Submitted in accordance with the requirements for the degree of
Doctor of Philosophy

The University of Leeds
School of Psychology

June, 2019

Intellectual Property and Publication Statements

The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

All publications that resulted from this thesis are reported below with the location of each publication within the thesis. The work attributed to the candidate includes literature review, planning and designing experiments, data collection and analysis, and writing up, with co-authors contributing through review and advice throughout the whole process:

Elkhafif, B., Havelka, J, Weighall, A., & Burke, M (2017). The role of syntactic priming in auditory word identification. Poster Presentation at The Language Development & Cognition PGR Poster Conference, 15th March, 2017, Leeds Centre for Interdisciplinary Childhood and Youth Research, University of Leeds, UK (based on data reported in Chapter 2, Experiment 1).

Elkhafif, B., Havelka, J, Weighall, A., & Burke, M (2017). The effect of syntactic priming in auditory word identification among second-language speakers. Poster Presentation at The Experimental Psychology Society Conference, April 2017, Queen's University, Belfast, UK (based on data reported in Chapter 2, Experiments 2).

Elkhafif, B., Havelka, J, Weighall, A., & Burke, M. (2017). The effect of syntactic priming on auditory word identification among first- and second- language speakers. Oral Presentation given at the Postgraduate Student Affairs Group annual conference (PsyPAG), 26th-28th July, Newcastle University, UK (based on data reported in Chapter 2, Experiments 1 and 2).

Elkhafif, B., Havelka, J, Weighall, A., & Burke, M J. (2018). The effect of syntactic priming on auditory word identification among first- and second- language speakers. Poster Presentation at The Experimental Psychology Society Conference, 18-20 April, University of Leicester, Leicester, UK (based on data reported in Chapter 2, Experiments 1 and 2).

Elkhafif, B., Havelka, J, Weighall, A., & Burke, M. (2018). Cross-modal syntactic priming. Oral Presentation given at the Postgraduate Student Affairs Group annual conference (PsyPAG), 26th-28th July, Huddersfield University, UK (based on data reported in Chapter 3, Experiments 3 and 4).

Acknowledgements

First of all, I owe much gratitude to my main supervisor, Dr Jelena Havelka. Because of her continuous support and guidance, I always felt in safe hands. Thank you, Jelena, for helping me to develop as a researcher, for always being generous with your time even in the busiest days, for providing constructive advice with extreme kindness, and for your confidence in me throughout those years.

I wish to express my deep gratitude for my co-supervisors, Dr Melanie Burke and Dr Anna Weighall. I have been so lucky to work under the supervision of Mel. I am deeply grateful for her genuine ideas that helped with the progression of the work, her technical guidance in managing the eye-tracking technique, and for her detailed feedback drafts. I am grateful to Anna for her guidance and advice in designing the experimental material and procedure, and for supporting me at conferences.

I appreciate the support from administration and technical staff at the school of Psychology for offering all the facilities and support needed for creating a productive work environment. Specifically, I would like to thank Sue Flockton, Jennifer Rose, Neil Lowly, and Mark Hullah.

My deepest appreciation goes to my mother and father who have always cared for my intellectual development since I was five. I apologize to them for my absence these years. I am truly grateful for everything you have done to me.

Above all, I owe deep gratitude for my husband, Mostafa who shared my stresses and successes all the way. I have always relied on his encouragement, support, and knowledge. A special thank you goes to my daughters, Alya and Amina, who made every day towards the accomplishment of this work feels special. To Mostafa, Alya, and Amina, I dedicate this thesis.

Abstract

This thesis examines differences in syntactic priming between first and second language speakers. A series of experiments are presented which investigate different factors that affect the occurrence of shared syntactic representation of a primed structure. Experiments 1 and 2 used syntactic priming as a method to isolate the syntactic level of representation from other contextual effects to examine its influence in auditory word identification. Participants performed a lexical decision task (LDT) and an auditory masked word identification task in which the target word was heard through noise. Critical words were embedded in sentences with either a complex or a simple syntactic structure, primed by either a congruent or incongruent preceding sentence. For both L1 and L2 speakers, trial-to-trial syntactic priming had no effect on word recognition. Experiments 3 and 4 investigated cross-modal syntactic priming from reading to listening and from listening to reading to examine whether the mechanisms underlying syntactic processing differ across the two modalities. The study employed an accumulative priming paradigm in which repeated exposure resulted in syntactic adaptation to an unfamiliar structure. Auditory and visual lexical decision tasks were used to assess priming in listening and reading respectively. L1 group showed evidence of shared syntactic representation cross-modally. However, L2 listening difficulties resulted in no priming in listening, and from listening to reading. Experiments 5 and 6 examined the occurrence of accumulative syntactic priming across different thematic roles for L1 and L2 speakers respectively. The study employed a self-paced reading task with an eye-tracking technique to examine reading of prepositional phrases with the same or different thematic roles. L2 participants were less able to show syntactic adaptation across different thematic roles, indicating that priming in L2 was less abstract than in L1. The theoretical significance and future directions are discussed.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Definition of syntactic priming

The word priming is a cognitive phenomenon that involves repetition in which previous experience with a specific language form facilitates subsequent language processing. For example, a word like "*apple*" is more easily processed after an associated word like "*fruit*" than after a different word like "*hospital*". Priming underlies various linguistic forms, including phonological (e.g. when a prime word like "*dress*" affect the processing of a target word with similar phonemes like "*dread*"), semantic (when the prime and target word share the same meaning such as "*cow*" and "*bull*"), and syntactic priming.

The focus of the current thesis is syntactic priming. Syntactic priming occurs when the processing of a sentence (known as a prime sentence) affects the processing of a subsequent unrelated sentence that shares the same syntactic structure (known as a target sentence) (Bock, 1986). For example, participants are more likely to produce a passive sentence like "*the file was dropped by a clerk into the wastebasket*" after producing another passive sentence like "*one of the campaign workers was thanked by the president for his help*" than after producing an active sentence like "*a gunshot shattered the forest's stillness*". Corpus analysis studies have shown that syntactic priming is evident in both written discourse and natural speech (Gries, 2005; Snider, 2008).

Syntactic priming was first introduced by Bock (1986) in a study that employed a picture description task in which participants, on each trial, heard and repeated a prime sentence in either a passive or active form. Following each sentence, participants were presented with an unrelated target picture and asked to describe it. The study showed that subjects tend to describe the picture using the same syntactic structure they have just produced in the preceding prime sentence. Within the past two decades, subsequent

studies have extended this finding to other languages such as Dutch (Hatsuiker & Kolk, 1998) and German (Scheepers, 2003). Syntactic priming has been studied in production (Bock & Griffin, 2000; Branigan, Pickering, & Cleland, 2000; Cleland & Pickering, 2003), in comprehension (Arai, Van Gompel, & Scheepers, 2007, Ledoux, Traxler, & Swaab, 2007; Tooley, Traxler & Swaab, 2009; Traxler, 2008; Traxler & Tooley, 2008), and from comprehension to production (Bock, Dell, Chang & Onishi, 2007).

In comprehension, the processing of a prime sentence resulted in a facilitation in the processing of a target sentences as manifest in faster reading times (Traxler, 2008; Traxler, Pickering, & Tooley, 2015), anticipatory eye movements (Arai et al., 2007), and in biasing choices of pictures that correspond to ambiguous sentences (Branigan, Pickering, & Mclean, 2005). In addition, functional magnetic resonance imaging (fMRI) studies showed facilitation in comprehension resulting from syntactic priming (Ledoux et al., 2007; Tooley et al., 2009). Comprehension syntactic priming is the focus of the present study. The following sections discuss the main characteristics of comprehension priming, previous comprehension syntactic priming research in L1 and L2, and theoretical models of syntactic processing that contribute to understanding findings from comprehension syntactic priming research.

1.2 Lexical boost phenomenon

Most comprehension syntactic priming studies showed that syntactic priming only occurs when the verb in the prime and target is the same (see Pickering & Ferriera, 2008, for a review). The enhanced effect of repeating the verb in both the prime and target sentences was referred to as the lexical boost effect. The use of the same verb helps in directing the processing of the target sentences to apply the same parsing routine as the prime sentences. Studies that found syntactic priming effect in comprehension without verb repetition are limited (Traxler, 2008; Thothathiri & Senedeker, 2008), suggesting that syntactic priming in comprehension is a week effect that not only depends on shared syntactic representation between the prime and target, but also other types of shared representations such as lexical representation.

Lexical boost effect characterizes a difference between comprehension and production syntactic priming. In production, syntactic priming seems to be more abstract, occurring

in the absence of lexical overlap between prime and target, whereas in comprehension, priming mostly occurs only in the presence of the lexical boost effect (i.e. when the verb is repeated in prime and target), indicating that comprehension priming is lexically dependent. This is not unexpected when looking at the order of different representations activation in each process. Syntactic production starts with a conceptual message-level representation then sentence structure and words are generated (Bock & Levelt, 1994). In contrast, comprehension starts with sounds, words, structure, and lastly interpretation. The message is built incrementally and is known at the end. In contrast, production starts with the message on which abstract syntactic and semantic representations are built and precedes word choices. In most production models, activation of syntactic structure precedes word choices (Bock & Ferreira, 2014; Bock & Levelt, 1994). Conversely, comprehension models argue that it starts with lexical encoding which then guides how the structure is constructed (MacDonald, Pearlmutter, & Seidenberg, 1994). According to this lexical approach, comprehension depends on incremental interpretation based on multiple sources of information. Accordingly, priming in comprehension seems to be sensitive to these other sources of information (e.g. lexical information) along with syntax, which explains the lexically-dependent syntactic priming in comprehension. However, in other occasions, syntactic priming was found to persist despite lexical differences between prime and target, such as differences in animacy (Carminati, van Gompel, Scheepers, & Arai, 2008). This led to an assumption that the same mechanism underlies syntactic priming in production and comprehension. It is rather the use of ambiguous syntactic structures in comprehension, and not in production, priming research that results in its lexical dependence (Giavazzi et al., 2018).

1.3 Immediate vs. accumulative priming

Two distinct experimental manipulations were employed in syntactic priming research. The first manipulation involves inserting a prime sentence before each target sentence. If the prime carries the same syntactic structure as the target, the priming effect is generated. In this way, the generation of syntactic priming depends on the most recent preceding prime sentence or sentences. Data collected from target sentences only provide the evidence for syntactic priming, whereas prime data are either used as a

baseline, or not included in the analysis. The priming effect generated from this type of manipulation was referred to as trial-to-trial priming (Mahowald, James, Futrell, & Gibson, 2016). The rationale behind performing this type of manipulation corresponds to the residual activation account in which the combinatorial node representing the prime structure undergoes an activation, which transfers to the immediately following target sentence, leading to facilitation in processing (Pickering & Branigan, 1998) (see section 1.4 for full explanation). Nevertheless as discussed above, studies implementing trial-to-trial manipulation with comprehension rather than production tasks have repeatedly shown that syntactic priming in comprehension doesn't occur in most cases unless the target share the same main verb with the most recent preceding prime sentence.

In the second experimental manipulation, all experimental sentences carrying a particular structure are treated as targets. The occurrence of syntactic priming depends on the sentence order of presentation relative to other sentences that carry the same structure. Sentences presented at the beginning of the experimental session are less easily processed than later sentences, indicating that not only immediately preceding syntactic structure, but also exposure to the same syntactic structure in the wider context of the experimental session affects the occurrence of syntactic priming. Indeed, studies showed that strength of the priming effect detected at a sentence increases with the number of the preceding sentences carrying the same structure (Fine, Jaeger, Farmer, & Qian, 2013). This type of priming was referred to as accumulative priming, suggesting that the effect accumulated with repeated exposure to several instances of the studied experimental structure. This experimental manipulation corresponds to the implicit learning account of syntactic priming. According to the implicit learning account, The reader's context-based-expectations varies based on the statistics of the syntactic structure occurrence in the current linguistic environment (experimental session), therefore, evidence for the priming cumulativity comes from studies in which repeated exposure to an ambiguous syntactic structure leads the readers processing to converge to that less familiar structure, which results in a facilitation in processing. For example, Fine et al., (2013) presented participants with a main clause structure and its less frequent reduced relative counterpart. Due to the participants' prior experience that the

reduced relative is the less frequent interpretation, initial performance showed difficulty in processing the reduced relative structure. However, processing of reduced relatives sped up with repeated exposure to several instances of a reduced relative structure over the experimental session.

1.4 Models of syntactic priming

1.4.1 Residual Activation Model

Pickering and Branigan (1998) attempted to account for syntactic priming through the residual activation hypothesis. Their work is based on the activation-spreading network model for the representation of lexical access in word production (Dell, 1986; Roelofs, 1992; Lvelt, Roelofs, & Meyer, 1999). The model is composed of three strata: a conceptual stratum, a lemma stratum, and a form stratum. The lemma stratum contains lemma nodes for every lexical entry. These lemma nodes are attached to nodes at both the conceptual stratum, at which the semantic features are represented, and the form stratum where the word phonology and morphology are specified, for example, the word "*apple*" is attached to the concept "APPLE" at the conceptual strata and the word forms "*apple*" and "*apples*" at the form stratum. At the lemma stratum, both syntactic category information and gender information are represented by nodes that are attached to the lemma node. Lexical access of a word like "*apple*" starts with an activation of its semantic features. This activation spreads to the lemma node and then the phoneme and morpheme nodes. Dell (1986) suggested that the model is interactive involving bi-directional spread of both top-down and bottom-up activation. However, Roelofs (1993) suggested that the model is partly interactive, as the activation at the form stratum doesn't flow back to the lemma stratum.

Pickering and Branigan (1998) adjusted the model by modifying the type of information attached to lexical entries. Instead of the syntactic category and gender information, the model proposed three categories of information that are attached to the lemma node: a) syntactic category information, b) featural information (e.g. gender, aspect, number, etc.), and c) combinatorial information which specify how the word is attached to other linguistic items. When a lemma is activated, the categorical, featural, and combinatorial nodes linked to it are activated. For example, the word "*loves*" is linked to the syntactic

category Verb, and the grammatical features for tense and number Third Person and Singular respectively, and combinatorial information which specifies that "*gives*" occurs with three NPs as in "*family gives him confidence*", or two NPs and one PP as in "*family gives confidence to him*" (see Figure 1.1).

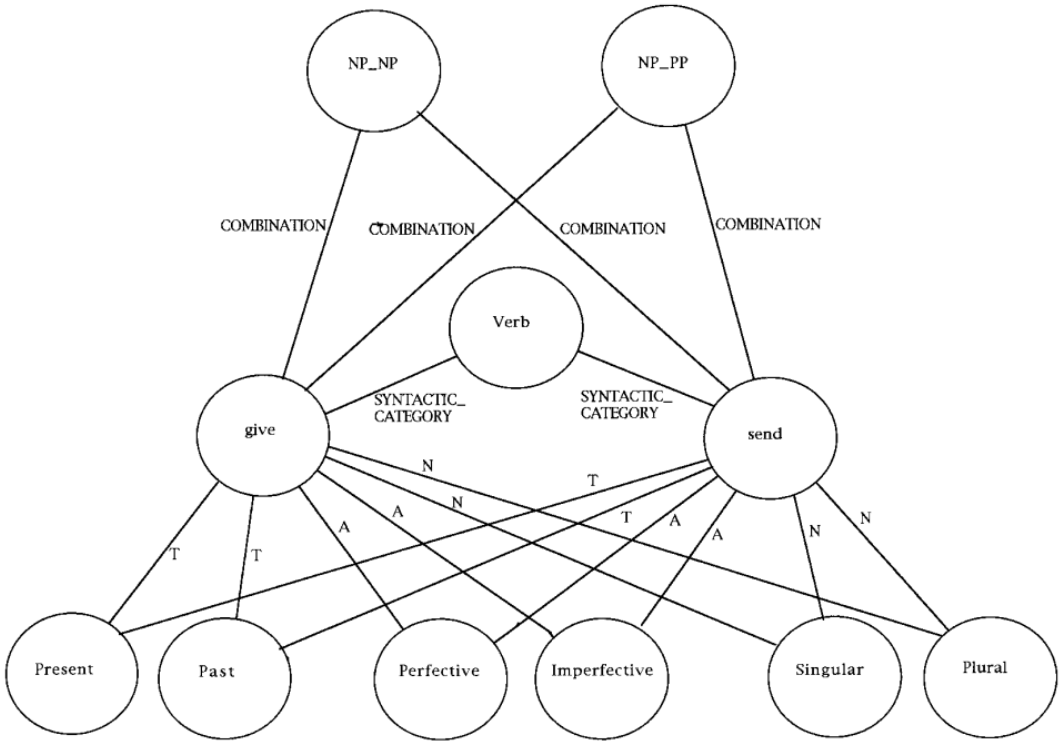

Figure 1.1 Network model for the activation of syntactic information associated with the verb. Reprinted from Pickering and Branigan (1998), Copyright (1998), with permission from Elsevier.

Pickering and Branigan (1998) argued that the combinatorial nodes and its links are the most crucial for the occurrence of syntactic priming. When a word is activated, the corresponding lemma node, combinatorial node, and links between them are activated. This activation decays gradually; however, during this laps of time, when a subsequent sentence that share the same syntactic structure is encountered, it will be easily processed due to the already activated combinatorial node that corresponds to this syntactic structure. Accordingly, It is predicted that the priming effect can transfer across two verbs that differ in feature (*give*, *gave*, *gives*, *is giving*) because it is the word lemma that the combinatorial node is attached to, not the word form. Moreover, priming

can transfer across different verbs (*give*, *show*, *send*, etc.), but the priming effect would be smaller. This is because, when the same verb is shared between prime and target sentences, the priming effect results from the residual activation of the lemma node, the link between the lemma node and the combinatorial node (e.g. V_NP_PP), and the combinatorial node itself. The repetition of verb results in a greater priming effect due to the activation of these three components altogether (i.e. lexical boost); however, when the verb is different between prime and target sentences, the priming effect is produced from the activation of the combinatorial node solely, which results in a weaker priming effect. In this way, the residual activation model succeeded in explaining the lexical boost effect.

To test their model, Pickering and Branigan (1998) conducted a written completion task in which participants were presented with sentence fragments that are either in a direct object or a prepositional object dative structure. Prime sentences can be completed with only one of the two structures, whereas target sentences can be completed in either structure as in:

1) Prime sentence:
    a) The racing driver showed the torn overall…
    b) The racing driver showed the helpful mechanic…
    c) The racing driver gave the torn overall…
    d) The racing driver gave the helpful mechanic…
2) Target sentence:
    a) The patient showed…

Prime fragments as in (1a) and (1c) ended in a patient, so it has to be completed with a prepositional object, whereas fragments like (1b) and (1d) ended in a beneficiary and, therefore, should be completed with a direct object.

The study involved five experiments. The first experiment aimed to test whether varying the verb between the prime and target would result in a smaller priming effect compared to when the verb is repeated. The second experiment preceded the target with two primes, rather than one. The two primes differed in the verb from the target to confirm that the task would show priming in the case of varying verbs. The third, fourth and fifth experiments examined employing verbs that differ in tense, aspect, and

number respectively. Results confirmed the assumptions of the residual activation model. First, syntactic priming effect occurred whether the verb is the same or not. Second, repeated verbs resulted in a greater priming effect. Lastly, syntactic priming occurred despite differences in tense, aspect, and number.

As discussed above, there is a general finding in comprehension syntactic priming research that the priming effect tends to be lexically dependent. Very few studies showed lexically independent priming[1] effect that occurs in the absence of verb repetition between prime and target (e.g. Traxler, 2008; Thothathiri & Senedeker, 2008). Given that the residual activation model predicts the occurrence of both lexically independent and dependent priming, this model failed to fully explain results from comprehension syntactic priming studies that found lexically dependent, and not lexically independent priming.

1.4.2 Implicit learning account

The implicit learning account (Chang, Dell, & Bock, 2006) suggests that syntactic priming is a function of an error-based learning that results in an adjustment in linguistic experience. Language users continuously engage in a context based predictions about the incoming linguistic input. When the predicted input differs from the actually observed input, a signal is produced for the system to adapt to the new linguistic experience. The model of Chang et al. (2006) is a connectionist model in which linguistic knowledge is updated through changing weights in the connectionist network. Accordingly, in syntactic priming, repeated exposure to a particular syntactic structure leads to strengthening the connection weight for that structure. Therefore, infrequently occurring structures shows difficulty in processing due to the weak connection weights for those structures. Repeated exposure strengthens connection weights for a particular syntactic structure, leading it to be more easily processed.

The error-based learning model suggests that priming effects are long lasting. Such persistent effect cannot result from the quickly degrading activation predicted by the

[1] The intended type of priming here is trial-to-trial priming rather than accumulative priming. This is because lexical dependence (lexical boost effect) is a characteristic of trial-to-trial priming.

residual activation model. Instead, it results from implicit learning mechanisms that lead to strengthening the connection weights between the constituents of a particular syntactic structure, leading the effect to persist for longer time. Previous studies showed long-lived priming effect in comprehension, for example, Luka and Barsalou (2005) conducted a reading task in which participants were exposed to a series of sentences, and then performed a 5-minute distracting analytic reasoning or arithmetic task. After that participants completed a rating task in which they rated a set of sentences for grammatical accessibility. Some of these sentences were in the original set, and some were new. Results revealed that the participants rated sentences as grammatically accessible both when they were identical to sentences in the original set, and when they were new sentences that shared the same syntactic structure, which can be attributed to the occurrence of syntactic priming effect that led to a facilitation in processing sentences that share the same syntactic structure as the previously read sentences. Most crucial to our discussion, a long time lag and many intervening sentences separated between the reading task and the following rating task, indicating a long-lasting priming effect, contrary to the type of priming proposed by the residual activation model

The assumption that priming is error-based is additionally supported by the inverse frequency effect that refers to the common finding that syntactic structures occurring relatively infrequently tend to produce greater priming than more frequent structures. This finding was replicated with a myriad of syntactic structures such as the reduced relative clauses as in "*the manager proposed by the directors was a bitter old man*" (Ledoux et al., 2007; Traxler, Tooley, & Pickering, 2014), coordinate noun phrases within sentences as in "*a difficult to read book and a risky to cross street were mentioned by John's friend* " (Scheepers & Crocker, 2004; Sturt, Keller, & Dubey, 2010), high-low attachments ambiguities as in "*The policeman hit the man with a mustache*" (Branigan et al., 2005), and modifier-goal ambiguity as in "*the girl tossed the blanket on the bed into the laundry this morning*" (Traxler, 2008). However, the general finding was that the resulted priming was week and can only occur by lexical boost through repeating the verb between the prime and the target. This finding contradicted with the long lasting priming effect predicted by the implicit learning account of syntactic priming. Given that the above mentioned studies had a trial-to-trial

syntactic priming manipulation, then it can be inferred that different mechanisms underlie trial-to-trial lexically dependent priming on one hand and the accumulative priming on the other hand, which led to the dual mechanism account discussed in the following section.

The implicit learning account doesn't provide an explanation for the lexical boost effect, given that a wide range of comprehension studies showed no priming in the absence of lexical boost. In addition, it was noticed that almost all studies that showed a decay of the priming effect involved lexical repetition, whereas studies that demonstrated long persistent priming didn't use lexical repetition, which led to the assumption that two mechanisms underlie syntactic priming effect; a short-lived lexically dependent priming resulting from the lexical boost and another long-lasting priming effect predicted by the implicit learning account (Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008). Therefore, further accounts were provided to encompass both the lexically dependent and independent effect by bridging between both the residual activation and implicit model as discussed in the coming section.

1.4.3 Dual mechanism account

The dual mechanism account was proposed to account for the full range of results observed in production and comprehension (Chang, Janciauskas, & Fitz, 2012; Fitz, Chang & Christiansen, 2011; Hartsuiker et al., 2008). The dual mechanism account suggests that lexically independent syntactic priming effects result from an implicit learning mechanism based on error-corrections, whereas lexically dependent syntactic priming effects are derived by residual activation. While the former effects are long lasting, the latter are short-term effects. In production, Hartsuiker et al., (2008) examined the dual mechanism in both spoken and written sentences. The study employed a dialogue method in which participants and computer software take turns in describing pictures. The study varied between the numbers of filler sentences intervening between prime and target items so that a lag of 0, 2, or 6 filler picture descriptions intervened between the computer production of the prime description and the participants' description of the target picture. Results showed that the syntactic

structure used by the computer to describe a picture affected the syntactic structure that the participants used in describing a following picture. Most crucially, this syntactic priming effect persisted for up to six intervening filler sentences; however, the increase in the size of the priming effect caused by verb repetition between primes and targets (lexical boost) didn't persist across any intervening sentences, suggesting that while lexically independent priming is long-lived, lexically dependent priming resulting from lexical boost decays very rapidly which indicated that both types of priming are derived by different mechanisms.

Tooley and Traxler (2010) proposed the dual mechanism account in comprehension. In a recent study, Tooley and Traxler (2018) investigated whether lexically dependent and lexically independent abstract priming are both driven by the same or different mechanisms. In an eye tracking study, participants read sentences in reduced relative structure as in (3) below over five sessions:

3) a) The mailman expected by the secretary arrived too late
   b) The deliveryman expected by the woman was right on time.

The verb was repeated between prime and target pairs presented in a single session. Half of the verbs were repeated across the sessions, whereas, the other half were new to each session. Reading times of target sentences were predicted to reflect changes in the immediate effect of prime on target sentences across sessions. If lexically dependent priming is underlined by the same mechanism as the long-lived lexically independent priming. Then priming should increase across sessions for the prime-target pairs that have the same verbs as in previous sessions. Results showed facilitation in the processing of reduces-relative prime sentences across session, indicating the occurrence of lexically independent long-lasting priming. However, the magnitude of the immediate effect between prime and target pairs sharing the same verb hasn't changed over the sessions, suggesting that this lexically-dependent effect is short lived and is derived by a mechanism that is different from the long-lasting learning mechanism underlying lexically-independent priming. These results supported the dual mechanism account in comprehension.

One difference between priming in comprehension and production is that comprehension studies showed an absence of the priming effect without lexical boost;

however, in production, the priming effect occurs in the absence of lexical boost, but the effect is weaker compared to the condition where the verb is repeated between prime and target pairs. The residual activation model accounted for this weaker effect in production by suggesting that lexically mediated priming results from the activation of the verb lemma node, syntactic structure combinatorial node, and links between them, whereas lexically independent priming is a function of the activation of the combinatorial node solely, which results in a weaker effect in production (see section 1.4.1 for further discussion). To account for the absence of priming without lexical boost in comprehension, Tooley and Traxler (2010) suggested a modification to the residual activation model (see Figure 1.2). The new model restricts the activation to the link between the verb occurring in a previous structure and the combinatorial node representing that structure rather than activation of the combinatorial node itself.

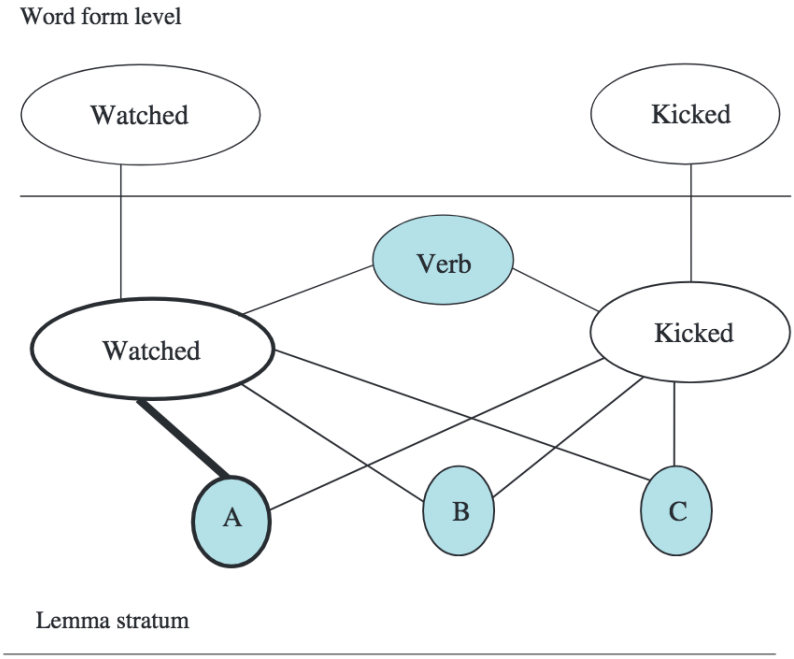

Figure 1.2 Modified residual activation mechanism for syntactic priming in comprehension (The residual activation is specific to the link between the verb and syntactic structure repeated between the prime and target sentences (structure A). Reprinted from Tooley and Traxler (2012), Copyright (2012), with permission from Wiley.

1.5 Comprehension priming in L1

1.5.1 Trial-to-trial priming

Research on syntactic priming in production has mainly focused on syntactic alternatives that share the same meaning. Two syntactic alternatives that were widely employed in production priming are prepositional object dative (PO) vs. double object dative (DO) (e.g. "*The lifeguard tossed the struggling child a rope*" and "*The lifeguard tossed a rope to the struggling child*" respectively) as well as active vs. passive structure (e.g. "*The file was dropped by a clerk into the wastebasket*" and "*A clerk dropped the file into the wastebasket*" respectively). Conversely, studies on syntactic priming during comprehension focused mainly on ambiguous syntactic structures such as reduced relatives (Traxler, Pickering, & Tooley, 2015), modifier-goal ambiguity, and high-low attachment ambiguity (Boudewyn, Zirnstein, Swaab, & Traxler, 2014; Branigan et al., 2005; Traxler, 2008). These comprehension studies demonstrated that L1 participants processing of an ambiguous structure is facilitated after being exposed to a sentence that carries the same structure. This facilitation in processing was evident in on-line tasks such as self-paced reading and visual world paradigm (Traxler, 2008; Traxler, Pickering, & Tooley, 2015; Arai, et al., 2007), off-line task such as picture matching (Branigan et al., 2005), and event-related potentials studies (Boudewyn et al., 2014; Ledoux et al., 2007; Tooley et al., 2009).

1.5.1.1 Trial-to-trial priming studies in L1 reading

The most widely researched structure in reading was the prepositional phrase (PP) attachment structure that is of interest to the present thesis (Branigan, Pickering, & Mclean, 2005; Boudewyn et al., 2014; Traxler, 2004, 2008). For example, in the sentence "*the girl tossed the apple on the plate into the fridge*", the prepositional phrase "*on the plate*" could be initially be interpreted either as a modifier or as a location for the theme object "*the apple*". Traxler (2008) examined the occurrence of syntactic priming effect on target sentences carrying a 'modifier PP' as in "*The girl tossed the blanket on the bed into the laundry this morning*" when it followed prime sentences carrying either the same structure or the 'goal PP' structure as in "*The girl tossed the blanket into the laundry this morning*". The study employed eye-tracking technique to

monitor participants' eye movements while reading prime and target sentences of both types. Results showed that participants more easily processed the modifier PP structure following another modifier PP prime than following a goal PP prime, indicating the occurrence of priming. This effect was observed whether the prime-target pairs had the same main verb, or not. The result that priming on this type of sentences can occur without lexical boost led Traxler (2008) to assume that comprehension priming in adjuncts such as modifier PP is lexically independent (i.e. occurs without 1exical boost).

Prepositional phrase attachment structure was re-studied by Boudewyn et al., (2014) who examined the occurrence of syntactic priming in two distinct structures that contain an ambiguous modifier PP attachment: low attachment structure and its non-ambiguous high-attachment alternative as in (4a) and (4b) respectively as well as modifier ambiguity and its non-ambiguous goal alternative as in (5a) and (5b) respectively:

4) a) The girl hit the boy with the bruise earlier today.
   b) The girl hit the boy with the paddle earlier today.
5) a) The chef dropped the egg on the counter in the bowl before breakfast.
   b) The chef dropped the egg in the bowl before breakfast.

In the first experiment, eye-tracking technique was employed to examine the processing of ambiguous low-attachment target such as (4a) after exposure to either another low-attachment prime sentence or a high-attachment prime sentences as in (4b). Results revealed that processing of low-attachment target sentence was faster when it was preceded by low-attachment prime than following a high-attachment prime. Nevertheless, low-attachment PP in both primes and targets had not only the same syntactic attachment, but also the same semantic role (i.e. modifier); therefore, it is not clear whether the resulted facilitation in processing is the result of semantic rather than syntactic processes. To examine this, a second experiment employed ERPs to examine whether it is the semantic or syntactic aspect that undergone facilitation in processing. Specifically, N400 ERP component is typically observed with semantic difficulties (for a review, see Swaab, Ledoux, Camblin, & Boudewyn, 2001) whereas, syntactic difficulties associated with syntactically ambiguous structures was shown to affect P600 component of the ERP (Osterhout & Holocomb, 1992). Results revealed that low-

attachment target produced reduced P600 immediately following the disambiguation area. Although this result indicates the existence of a syntactic component to the priming effect, it doesn't negate the existence of a semantic component in this type of structure. Swaab et al., (2001) stated that previous research showed that P600 doesn't reflect a pure syntactic difficulty but is also produced when there is contradiction between semantics and syntax (e.g. "*the eggs would eat*….") (Kuperberg, 2007), therefore, the presence of P600 in the priming condition doesn't mean that the effect is purely syntactic, but rather there might be a semantic component to the facilitation for the priming condition. Boudewyn et al., (2014) conducted a third experiment to examine the occurrence of priming in the modifier-goal ambiguity as in (5a) and (5b). The aim was to examine whether results from their second study would extend to a different, but related structure. Results revealed the occurrence of reduced P600 at the disambiguation PP area of the modifier PP targets following modifier PP primes, indicating the occurrence of comprehension priming for the modifier-goal ambiguity.

Reduced relative is another structure that was repeatedly studied in priming research using reading tasks (Ledoux et al., 2007; Pickering & Traxler, 2004; Traxler & Pickering, 2005; Traxler &Tooley, 2008; Traxler et al., 2014). For example, Traxler & Tooley (2008) used eye tracking and self-paced reading to investigate whether priming in the reduced relative structure as in " *The defendant examined by the lawyer was unreliable*" results from increased activation or from explicit strategic cues. Given the widespread finding that priming occurs only when the verb is repeated between the prime and target pairs, it might be the case that participants notice this association and use the repeated verb as a strategic cue to predict the forthcoming target structure. In this way, syntactic priming might be a result of a short-term explicit memory of the prime. The first and second experiments employed an eye tracking technique to record participants' eye fixations while reading, whereas the third experiment employed a self-paced moving window reading paradigm. In the first experiment, filler sentences were formed in a way that annuls the repeated verb function as a strategic cue. Specifically, filler sentences carried two alternative structures that differed syntactically while sharing the same verb. This prevented participants from performing association between the verb and its argument structure to use the verb as a retrieval cue. The second

experiment included repeated nouns between prime-target pairs rather than repeated verbs so that participants can use them as strategic cues. In the third experiment, participants were explicitly informed to expect a forthcoming relative clause. Results showed the occurrence of priming in the absence of the repeated verb cue in the first experiment, whereas, no priming was observed in the second and third experiment in which valid cues were provided. This finding indicates that priming is a result of increased activation of the verb argument structure rather than strategic processing.

1.5.1.2 Trial-to-trial priming studies in L1 listening

Most listening studies employed visual world paradigm in which participants eye movements were recorded while listening to prime and target sentences carrying Prepositional Object (PO) / Direct Objective (DO) structures (Arai, Gompel, & Scheepers, 2007; Carminati et al., 2008; Scheepers & Crocker, 2004; Thothathiri & Senedeker, 2008). This structure was widely researched in production research and yielded priming without lexical boost (i.e. lexically-independent); therefore, the aim was to examine whether such non-ambiguous structure would similarly result in lexically independent priming in comprehension. Participants were presented with a depiction of, for example, a "*pirate*", a "*princess*", and a "*necklace*" while listening to either a PO dative as in "*the pirate will send the necklace to the princess*" or a DO dative as in "*the pirate will send the princess the necklace*". Results showed that at the target sentences, participants' anticipatory eye movements tend to be directed to the animate (i.e. "*the princess*") object following DO primes and to inanimate objects (i.e. "*the necklace*") following PO primes, indicating that processing of the target sentence was facilitated by processing the same structure in a preceding sentence. In some of these studies, comprehension priming occurred only when the verb was repeated across the prime and target pairs (Arai et al., 2007, Experiment 1; Carminati et al., 2008; Thothathiri & Senedeker, 2008, Experiments 1a, 2a), whereas syntactic priming without verb overlap was shown in other studies (Thothathiri & Senedeker, 2008, Experiments 1b, 2b).

Carminati et al., (2008) sought to examine the type of mechanisms underlying comprehension priming, for instance, whether syntactic priming is the result of a shared syntactic representation solely, or other types of representations can contribute to the priming effect depending on the examined syntactic structure. In ditransitive PO/DO structure, prime and target sentences not only shared sentence structure, but also the order of animacy for the two objects following the verb, for example, in prepositional object structure as in "*the pirate will send the necklace to the princess*" and "*the monarch will send the painting to the president*", the verb in both sentences is followed by an inanimate theme ("*necklace*", "*painting*") then an animate recipient ("*princess*", "*president*"), whereas, in double object structure as in "*the pirate will send the princess the necklace*" and "*the monarch will send the president the painting*", the first object in both sentences is an animate recipient followed by an animate theme. Therefore, the priming effect produced might be a result of the shared animacy rather than the shared syntactic structure. This is because participants can anticipate that the first post-verbal noun is animate following a DO structure, or inanimate following a PO structure. To examine this, Carminati et al., (2008) varied the animacy between prime and target sentences while keeping the structure the same. Using the same visual world paradigm task, participants read prime sentences in PO and DO structures in which the first and second post-verbal nouns differed in animacy ("*painting*", "*president*") as in (6a) and (6b), or were both animates as in (7a) and (7b) ("*envoy*", "*president*"), then participants listened to target sentences such as (8a) and (8b) while their eye movements to pictures depicting the nouns were recorded. Post-verbal nouns in all target sentences differed in animacy ("*prince*", "*poison*"). It was hypothesized that if priming depends on shared animacy between the primes and targets, then there should be no priming effect in case of primes in which both objects are animates.

Prime sentences:

6) a) The monarch will send the painting to the president.
   b) The monarch will send the president the painting.
7) a) The monarch will send the envoy to the president.
   b) The monarch will send the president the envoy.

Target sentences:

8) a) The wizard will send the terribly powerful poison to the prince.

b) The wizard will send the prince the terribly powerful poison.

Results showed that upon hearing the verb, participants gazed more on the recipient following a DO prime and more on the theme following a PO prime regardless of whether the two post verbal nouns in the prime differed in animacy or were both animates.

More recently, Giavazzi et al, (2018) employed a listening picture matching task with active vs. passive structure sentence alternatives. Participants listened to prime and target sentences then answered which one of two presented pictures correctly depicted the sentence. This specific task and structure were widely researched in production research and resulted in lexically independent priming. Giavazzi et al., (2018) aimed to examine whether employing the same task and structure in comprehension would similarly yield lexically independent priming. Results revealed the occurrence of lexically independent syntactic priming. Giavazzi et al, (2018) concluded that comprehension priming may occur independent of lexical overlap and that the reason for the non-occurrence of lexically independent comprehension priming in previous studies is not the absence of lexical boost, but rather the use of ambiguous structure and online tasks that don't allow for full parsing of the prime.

1.5.2 Accumulative priming (syntactic adaptation) in L1

Studies discussed so far involve a trial-to-trial experimental manipulation in which sentences are paired as prime and target sentences. Priming in such manipulation occur when target sentence share the same structure with the immediately preceding prime. As discussed earlier, another type of experimental manipulation is the accumulative manipulation in which participants gradually adapt to a less familiar structure after repeated exposure to several instances of that structure throughout the experimental session (see section 1.3 for a detailed description of the difference between the two paradigms). In what follows, examples of studies involving accumulative priming will be discussed.

1.5.2.1 Accumulative priming in L1 reading

Fine, Qian, Jaeger, and Jacobs (2010) examined the occurrence of adaptive accumulative priming in a study which was conducted to examine adaptation to the change in the probability of occurrence for the ambiguous sentence complement (SC) structure as in (9a). Readers tend to interpret a post verbal noun phrase (NP) (i.e. "*the study*") as the direct object rather than the less frequent SC structure (Garnsey, Pearlmutter, Myers & Lotocky, 1997), which causes longer RTs at the disambiguating noun phrase than sentences in which a complementizer ("*that*") as in (9b) precedes a noun phrase:

9) a) The reviewers acknowledged the study had been revolutionary.
   b) The reviewers acknowledged that the study had been revolutionary.

Fine et al., (2010) tested the effect of frequent exposure to a less familiar SC syntactic structure on self-paced reading time. SC sentences were presented frequently to the participants along with sentences including the complemintizer "*that*". Results showed that although the infrequent SC structure initially produced longer response times, participants became to read the SC structure more quickly when it was presented frequently over the duration of the experiment. A belief update Bayesian model applied on the data indicated that the ease with which participants process a less frequent structure can be varied through manipulating its probability of occurrence in the linguistic environment of the experiment.

In addition to ambiguous structures, novel constructions can also be primed in comprehension through repeated exposure. Kaschak and Glenberg (2004) performed a reading task in which participants were repeatedly presented with a novel construction 'needs construction' as in (10a). This construction was new to their participants. In addition, familiar control sentences as in (10b) were presented:

10) a) The meal needs cooked.
    b) The meal needs to be cooked.
11) The wood floor needs cleaned corners.

Repeated exposure to sentences such as (10a) led to faster reading times of similar sentences than repeated exposure to sentences such as (10b). Moreover, given that the word "*cooked*" in (10a) tends temporarily to be analyzed as a modifier as in "*the meal*

needs cooked vegetables", sentences containing a modifier (e.g. "*cleaned*") such as (11) were more easily processed after repeated exposure to sentences such as (10a) than after repeated exposure to sentences such as (10b).

Unlike trial-to-trial comprehension syntactic priming, accumulative priming can persist over several weeks. Wells, Christiannsen, Race, Acheson, and MacDonald (2009) showed that syntactic knowledge is not static, but rather dynamic and changes according to changes in the comprehender's linguistic experience. Wells, Christianson, Race, and Acheson (2009) employed an experimental group and a control group that were both matched as to reading span scores. Over three training sessions, the experimental group of participants was repeatedly exposed to an equal number of subject and object relative clause sentences as in (12a) and (12b) respectively, whereas the control group read sentences with other types of syntactic structures:

12) a) The amateur golfer that had beaten many of the pros won the celebrated state championship.
    b) The actor's daughter that the Italian ambassador met last year loved Sicilian food.

Object relatives are associated with higher processing difficulty than subject relatives as they follow an object-subject-verb (OSV) word order that is non-canonical in English, thereby producing a higher surprisal effect. It was hypothesized that the increased experience with object and subject relative clauses would facilitate the processing of both structures, but the facilitation would be higher for the object relatives. Online processing of both structures was assessed before and after the training using a self-paced reading task. Results revealed that after the training, RT profile of the experimental group became to match that of high-span readers for both subject and object reduced relative clauses; however, the facilitation in processing was greater for object relatives than for subject relatives. The three training sessions were spread over several weeks, indicating the long-lasting effect of accumulative syntactic priming.

Accumulative priming also differs from trial-to-trial priming in being lexically independent effect that is not modulated by verb repetition between primes and targets. Fine and Jaeger (2016) examined the effect of verb repetition on the occurrence of accumulative priming. In a self-based reading task, readers were presented with

sentences carrying ambiguous and unambiguous relative clause RC structures as in (13a) and (13b) respectively:

13) a) The experienced soldiers warned about the dangers conducted the midnight raid.

b) The experienced soldiers who were warned about the dangers conducted the midnight raid.

The study included three experiments. Verbs were repeated across the sentences in the first experiment, whereas, different verbs were used in the second experiment. In the third experiment, critical sentences didn't share any of their content words whether they were verbs, nouns, adjectives, or adverbs. The study examined the accumulative facilitation in the processing the ambiguous RC structure as the readers proceed through the experimental items. The accumulative priming was found across the three experiments regardless of any lexical repetition, indicating the lexical independency of syntactic adaptation.

1.5.2.2 Accumulative priming in L1 listening

Only one accumulative priming study has been conducted so far on L1 listening (Fine &Jaeger, 2013). Although the study didn't examine the effect of repeated exposure to several instances of a structure, the hallmark of accumulative priming - sensitivity to prediction error - was examined. It was predicted that the size of priming effect detected on the target would correlate with the strength of the prediction error resulting from processing the preceding two primes. This prediction error is the mechanism responsible for the syntactic convergence found in accumulative priming research. Stronger priming effect is hypothesized to result from higher prime prediction error. The study used data from (Thothathiri &Snedeker, 2008). Thothathiri and Senedeker (2008) examined priming without lexical overlap in the two dative constructions. On the target trials, participants were presented with visual displays while listening to dative sentences. The visual displays were four toys, two animals and two inanimate objects, on a physical stage. Dative sentence were ambiguous at the onset of the first noun. For example, participants listened to " *show the hor* ….." while viewing a doll, a horn, a horse, and a dog. In this way, two of the words matched the first syllable of the first noun (i.e. *horn* and *horse*). After that, participants acted out the sentence using the

toys in front of them (show the horse the book). Results revealed that participants were more likely to gaze at the recipient following a DO prime, and more likely to gaze at the theme following a PO.

Fine and Jaeger (2013) conducted a norming study to quantify the prediction error related to the stimuli used in Thothathiri and Snedeker (2008). It was expected that participants' performance on the targets would differ according to the prediction error calculated for the prime based on the norming study. Results showed that the error signal resulting from processing a prime correlates with the participants' subsequent performance on the target sentence, which supports the occurrence of the kind of error-based learning involved in accumulative priming.

In spite of the existing evidence for accumulative priming, it has not been ubiquitously shown in previous research. For example, Stack, James, and Watson (2018) failed to replicate Fine et al., (2013)'s study which reported that repeated exposure decreased reading times to reduced relative clause structure. Stack et al., (2018) reported that the small statistical power is the reason for the failure in replicating the syntactic adaptation found on the original study. Specifically, for the syntactic adaptation to occur, a sufficient power would require double the participants and four times the items used in the original study, indicating that for the reduced relative ambiguous structure, a brief exposure to few instances might not be enough for the occurrence of syntactic adaptation.

In summary, the occurrence of syntactic adaptation has not been always consistent in previous research. The present thesis compares syntactic adaptation in two different modalities in the second study, and across different thematic features in the third study with the purpose of increasing our understanding of the factors that modulates the occurrence of syntactic adaptation.

1.6 Comprehension priming in L2

1.6.1 Trial-to-trial priming in L2

Very limited previous research compared between L1 and L2 comprehension syntactic priming, however; results acquired so far showed that L2 speakers show trial-to-trial syntactic priming that is similar to, and sometimes greater than, native speakers.

1.6.1.1 Trial-to trial priming in L2 reading

The greater comprehension priming effect in L2 was supported in reading by Harrington and Dennis (2003) and Weber and Indefrey (2009). Weber and Indefrey (2009) examined syntactic priming of German passives. The study analyzed reading time of German-English bilinguals on a visual sentence comprehension task both within and across languages. Although there was no reliable priming effect in the first language (German), L2 results showed priming. Harrington and Dennis (2003) investigated syntactic priming in online comprehension of subject and object extraction as in "*Who did Joe think saw Irene in the class*" and "*Who did Joe think Irene saw in the class?*" respectively. The study employed a self-paced reading task in which each sentence appeared once in a Match condition, in which prime-target pairs share the same structure, and a Mismatch condition, in which each sentence carry a different structure. Reading time data revealed that L2 speakers were faster in reading target sentences in the Match condition compared to the Mismatch condition, which indicates the occurrence of priming among L2 speakers. No priming was found among L1 speakers. Harrison and Dennis attributed this result to the previous suggestion made by (Pickering & Branigan, 1999) that priming is a function of limited recourses. Individuals with more limited cognitive resources are likely to be susceptible to priming than L1 speakers who are more experienced with the language, and therefore, store alternatives of the appropriate structure. These alternatives may suppress the effect of the prime sentence.

It can be assumed that L2 speakers might be more affected by syntactic priming because repeated exposure to language formulates their processing skills. Given their processing difficulties compared to L1 speakers, they rely on the prime sentences as a learning

model which they can consult in processing the target sentence. If they need to interpret an ambiguous sentence or match between a sentence and its corresponding picture, a good strategy for them might be to imitate the way they processed a previously encountered sentence.

Although syntactic priming in L2 was shown, in some cases, to have a stronger effect than in L1, in other cases, L2 syntactic priming appeared to be similar to L1 (Wei et al., 2017, 2019). For example, the common finding that comprehension priming doesn't occurs unless the verb is repeated between prime and target sentences (i.e. lexically-dependent priming) was demonstrated in L2 by Wei et al. (2017). The study employed word-by-word self-paced reading task to examine the occurrence of comprehension syntactic priming of the relative-clause structure (e.g. "*The defendant examined by the lawyer turned out to be unreliable*") among Chinese L2 speakers of English. The aim of the study was not only to examine lexical dependence of priming in L2, but also to examine the effect of word order differences between the speakers' first and second languages on the occurrence of syntactic priming. Although English and Chinese share the same Subject-Verb-Object (SVO) word order, reduced relative structure in Chinese has a word order that differs significantly. Results revealed that target sentence were processed faster following prime sentences that included the same verb, but no priming was produced when the verb differed between prime and target pairs, indicating the occurrence of lexically dependent priming. This result is consistent with previous studies conducted on L1 English speakers (Ledoux et al., 2007; Tooley, Traxler, & Swaab, 2009; Traxler & Tooley, 2008; Traxler, Tooley, & Pickering, 2014). In addition, syntactic priming in L2 was shown to persist for up to 2 intervening sentences (Wei et al., 2019) similar to L1 priming (Tooley, Swaab, Boudewyn, Zirnstein, & Traxler, 2014). Wei et al., (2019) used self-paced reading task to investigate the persistence of syntactic priming of reduced relatives among Chinese L2 speakers of English. Results showed that the priming effect can persist for up to two intervening filler sentences.

1.6.1.2 Trial-to trial priming in L2 listening

Nitschke, Kidd, and Serratrice (2010) examined the occurrence of syntactic priming among German and Italian L1 and L2 speakers and found syntactic priming among L2

but not L1 Italian speakers. The examined relative clause structure is an ambiguous structure in German as it can be interpreted either as subject or object, for example "*here is the ballerina that the girl scares*" and "*here is the ballerina that scares the girl*". In this example, it is obvious that the ballerina is the object of the verb scares in the former sentence and the subject in the latter. However, in German, this noun is ambiguous as it can have either subject or object role assignment. Nevertheless, Both German and Italian participants show preference for the subject interpretation of that noun. The study used a picture-matching task in which participants listened to alternating sentences, each followed by two pictures from which participants are required to choose the corresponding one. The study included three phases: a) a baseline phase to test participants initial preferences in allocating a subject or object role to the ambiguous noun, b) a priming phase to shift participants syntactic preference to adapt to an object relative clause, and c) a post test phase to test the persistence of the primed object relative clause. Results revealed the occurrence of priming for L1 German, L2 German, and L2 Italian participants. L1 Italian participants were prone to the priming effect as they showed a persistent preference to the subject reduced relative throughout the experiment. Nitschke et al. (2014) attributed this to the extreme scarcity of the object-reduced relative in Italian.

In an additional study, Nitschke, Serratrice, and Kidd (2014) compared syntactic priming with native and non-native speakers of German and found greater syntactic priming of German relative clauses among non-native speakers. The study employed the same picture matching and the three phases as in Nitschke et al., (2010). Picture matching findings showed that non-native participants had a greater tendency to interpret the target expression in the same way that they had interpreted the prime expression. The authors attributed this non-native advantage to an experience-based approach. Non-native participants are less experienced with the language compared to their L1 counterparts. Reduced exposure to L2 leads L2 speakers to perform weaker linguistic representations which make them more susceptible to the priming effect.

1.6.2 Accumulative priming in L2

Comprehension accumulative priming in L2 has been studied in one reading study (Kaan et al., 2018), which is far less often than in L1. In addition, no L2 accumulative priming research has been conducted in the listening domain. Therefore, it is not clear whether L2 processing is sensitive to the mechanisms underlying syntactic adaptation. Although a number of previous studies showed that trial-to-trial priming is stronger among L2 speakers compared to L1 speakers. This might not be the case with accumulative syntactic priming. As previously discussed, the occurrence of accumulative priming depends on adjusting language user's predictions to converge to the properties of the context. Based on this account, the occurrence of syntactic priming is modulated by predictive processing. Studies on second language learners, however, showed that predictive processing in L2 is limited (Hopp, 2015; Kaan, Kirkham, & Wijnen, 2016; Lew-Williams & Fernald, 2010; Martin et al., 2013). Non-native speakers don't show predictive processing to the same degree as native speakers despite knowing the particular linguistic input used. Because non-native speakers rely more on their attentional resources in L2 processing, they are less likely to allocate enough resources to an attention-demanding predictive processing, instead, their cognitive resources are consumed in alternative processes such as conflict monitoring, lexical suppression, construction or revision of contextual representations. Previous studies argued that predictive processing decreases with increasing cognitive control and limited cognitive resources (Slevc & Novick, 2013; but see Otten & Van Berkum, 2009), which makes L2 speakers less likely to form specific predictions about the upcoming linguistic input. Hopp (2013), for example, found that the anticipatory use of gender information is correlated with the speed of lexical access. Given that predictive processing is the main mechanism underling the priming effect, then it can be hypothesized that L2 speakers are less prone to the priming effect.

Kaan, Futch, Fernandez Fuertes, Mujcinovic, and Alvarez de la Fuente (2018) examined the effect of exposure on L1 and L2 speakers in processing of two ambiguous syntactic structures. L2 speakers were Spanish learners of English. The first structure was filled-gap structure such as "*The builder wondered what the worker repaired the leak with before going home*" and its control structure as in "*The builder wondered*

whether the worker repaired the leak with some tape before going home". Filled-gap sentences are ambiguous because readers mistakenly tend to initially analyze "*what"* as the object of the verb "*repaired*" whereas it is in fact the completion of the preposition "*with*". The second examined structure was the coordination construction as in "*The servant cleaned the table and the floor was cleaned by the maid*" and its control structure "*The servant cleaned the table but the floor was cleaned by the maid*". The and-coordination construction is difficult because readers tend mistakenly to interpret "*and*" as coordinating two noun phrases. In a moving window self-paced reading task, participants were presented with the two ambiguous structures and their controls in an alternating fashion. Results showed syntactic adaptation only for the L1 speakers and only for the filled-gap structure. Kaan et al., (2018) suggested that experiencing a prediction error is not enough for adaptation. Although both groups of participants initially showed difficulty derived by the prediction error, only L1 speakers showed adaptation.

1.7 Syntactic processing of ambiguous structures in L1

1.7.1 The modularity theory

A large body of research in psycholinguistic investigates the processing of temporarily ambiguous syntactic structures known as garden-path sentences. The garden-path phenomenon refers to the situation when the perceivers realize that their first interpretation of a sentence is wrong (Pritchett, 1992). Most studies on syntactic priming in comprehension have re-examined these ambiguous structures with the aim of investigating whether syntactic priming can be used as a method of improving understanding and facilitation of complex and unfamiliar structures. The occurrence of syntactic priming is, therefore, modulated by the way the parser analyze these ambiguous structure.

There are multiple models explaining how the processor resolves syntactic ambiguity. The modularity theory proposed by Fodor (1983) and Frazier (1987) assumed that the processor depends primarily on syntactic information during the early stages of processing. Other extra-linguistic information, such as the discourse or visual context, is not used until later stages of processing when the misanalysis occurs. The syntactic

processor automatically assigns a grammatical structure to a lexical string by the use of some parsing strategies, among which the most prominent is 'minimal attachment'. Minimal attachment guides the syntactic processor to resolve the syntactic ambiguity by adopting the analysis that leads to the minimal number of parsing nodes. For example, in the modifier-goal PP ambiguity as in "*Sam tossed the apple on the plate*", the PP could be either the modifier that specifies the location of the post-verbal noun (i.e. "*apple*"), or the goal of the verb. Because the modifier interpretation of the PP leads to an additional higher NP node (see Figure 1.3), PP is initially interpreted as a goal (i.e., modifier of the verb rather than of the noun). Response time studies found that participants indeed take less time to process the goal interpretation of the PP both in first language (Ferreira & Clifton, 1986) and second language (Fujita, 2016).

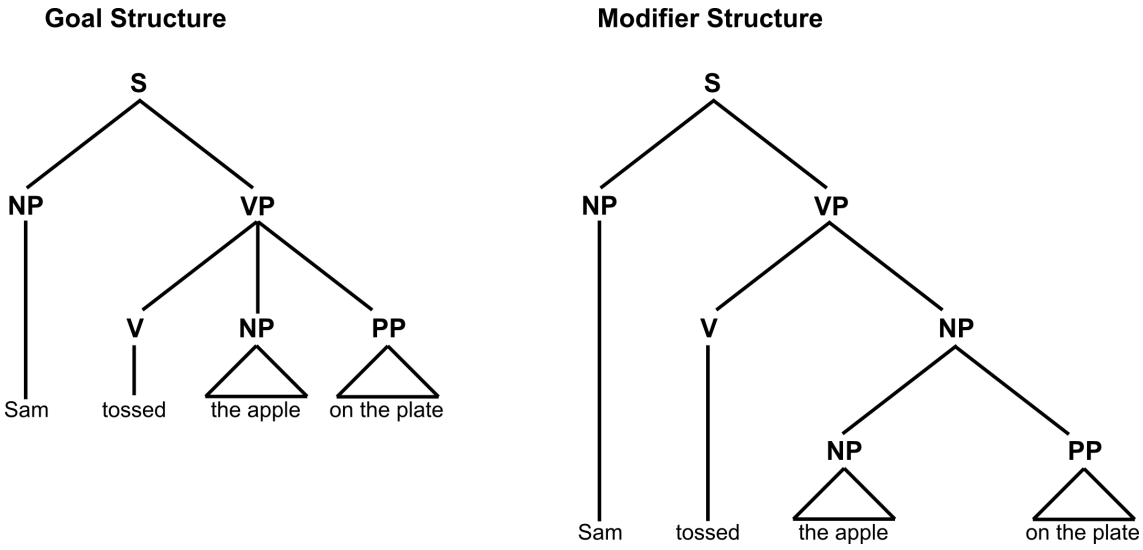

Figure 1.3 Parsing tree for the ambiguous modifier PP and its familiar goal PP alternative.

1.7.2 The constraint-based approach

The modularity theory was challenged by the constraint-based approach by MacDonald, Pearlmutter, and Seidenberg (1994) which opposed the full independence of the syntactic processor and argued that different sources of information may interfere to guide syntactic interpretation in early stages of processing and lead us to override the ambiguity. According to this approach, semantic information, discourse context, and even non-linguistic information interact with the syntactic processor and can override

the garden-path effect imposed by PP attachment structure. For example, Brit (1994) found that when a disambiguating adjective precedes the noun, the PP isn't interpreted as a NP modifier as in "*He threw the shallow essay on the desk*" and the garden-path effect is overridden. Chambers, Tanenhaus, and Magnuson (2004) and Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy (1995) found that non-linguistic environmental information can combine with linguistic information in syntactic ambiguity resolution. They used sentences like "*pour the egg in the bowl into the flour*" in which the phrase "*in the bowl*" could be interpreted either as a modifier or as a location for the theme object "*the egg*". The study employed the visual world paradigm in which the participants hear an utterance while looking at an experimental display. The participants' eye movements are recorded for later analysis. Results showed that participants are more likely to resolve this ambiguity if the target object (an egg in a liquid form) is accompanied with an incompatible competitor referent (an egg in a solid form) than if the competitor referent is in a compatible form (another egg in a liquid form). This is because participants make use of both the semantic characteristics of the predicate (the verb pour which go with liquid referents) and the properties of the objects in the environment (the liquid egg that is pourable as opposed to the solid egg).

The constraint-based approach contributed to the study of the reduced relative clause structure that is of interest to the present thesis (see Chapter 2, Experiments 1 and 2). Relative clauses ambiguity resolution has been extensively studied in language comprehension research since Bever (1970) proposed his classic sentence "*The horse raced past the barn fell*" in which "*raced*" is ambiguous between a past tense main verb of the sentence and a past participle introducing the relative clause. This ambiguity occurs because function words that introduce a relative clause, such as "*which was*", can be legally omitted in the language. The present thesis (see Chapter 2, Experiments 1 and 2) employs similar reduced relative structure as in:-

14) The woman struggled to prepare the lunch finished.

15) The woman struggled to prepare the lunch party.

If "*struggled*" is analyzed as a past tense main verb, the first sentence will be interpreted correctly, whereas, the second will not. If it is analyzed as a past participle, the second sentence will be correctly interpreted, whereas, the first will not.

Similar to the PP attachment ambiguous structure, studies depending on the modularity theory suggested the minimal attachment strategy to account for the preference of a main verb initial interpretation of the verb "*struggled*", which leads to a garden-path effect when the verb is a reduced relative ("*who struggled*"). However, constraint–based approaches proposed that this garden-path effect could be overridden by two contextual factors. The first factor is the plausibility (Trueswell & Tanenhaus, 1994). If the context makes the reduced relative interpretation more plausible than its main verb competitor, the verb will be early interpreted as a reduced relative and the garden path effect in a sentence like (14) will be overridden. The second factor is the occurrence of several potential referents instead of one referent (Crain & Steedman, 1985). If the context established two ambiguous referents one of which needs to be identified by a reduced relative, the garden path effect will be overridden. For example, in sentence (14), if a preceding context presented two women as two potential referents, the specification of "the woman who finished" by a reduced relative doesn't lead to syntactic ambiguity. The first study of this thesis examines whether this syntactic ambiguity can also be overridden through priming. If priming increase the accessibility of reduced relative, the garden-path effect will be overridden.

1.7.3 The construal hypothesis

The construal hypothesis developed by Frazier and Clifton (1996) is an updated version of the modularity theory. The construal hypothesis distinguishes between primary and non-primary phrases. While a primary phrase is an obligatory argument which can be the subject or predicate of a clause or an obligatory complement to a primary phrase, a non-primary phrase is an adjunct. Whereas primary phrases are processed in accordance with the parsing principles specified in the modularity theory such as the minimal attachment principle, non-primary relations allow other non-syntactic sources of information to guide its interpretation. According to the construal hypothesis, an ambiguous PP will initially be interpreted as a primary phrase attached to the verb. If it turns out to be non-primary, then it will be associated, not attached, to the current thematic representation. Non-primary phrases remain unattached until finding a their plausible host. The advantage of the construal hypothesis is that it predicts the

differences in syntactic processing between arguments and adjuncts, which will be revisited later in the third study of the present thesis.

1.7.4 The tuning hypothesis

The Tuning hypothesis proposed by Mitchell and collegues (Brysbaert & Mitchell, 1996; Mitchell, Cuetos, Corley, & Brysbaert, 1995) is an experience-based model that explains syntactic ambiguity resolution. The hypothesis claims that the human syntactic knowledge is exposure-based, that is initial parsing choices of resolving a syntactic ambiguity in one way or another depend on the frequency with which the parser correctly analyzed a similar structure in the past. Accordingly, the initial interpretation assigned to an ambiguous structure is the one that most frequently occurs in language. Frequency of occurrence for different kinds of syntactic ambiguity can be extracted from corpus studies. Indeed, the hypothesis was supported by multiple corpus studies that showed that corpus frequencies can predict attachment preferences in the processing of ambiguous structures (Desmet, Brysbaert, & De Baecke, 2002; Desmet & Gibson, 2003)

The tuning hypothesis was initially proposed to account for cross- language attachment preferences in the relative clause structure such as "*Someone shot the servant of the actress who was on the balcony*". This structure is ambiguous because the relative clause ("*who was on the balcony*") could be attached to either the first noun (i.e. "*the servant*") or the second (i.e. "*the actress*"). It was shown that while there is preference of the low-attachment interpretation in English, other language such as German, Dutch, and Spanish prefer the high-attachment interpretation (Mitchell & Brysbaert, 1998). As predicted by the Tuning hypothesis, it was shown that the low attachment interpretation is more frequent in English corpora, whereas, in German and Spanish, the high-attachment is the prevalent (Cuetos, Mitchell, & Corley, 1996; Mitchell & Brysbaert, 1998; Mitchell et al., 1995).

Nevertheless, contradictory studies showed evidence against the Tuning hypothesis, for example, Gibson and Schütze (1999) examined the processing of the noun phrase that can be attached to three potential conjunctions as in "*The salesman ignored a customer with a baby with a dirty face and a wet diaper / one with a wet diaper / one with a baby*

with a wet diaper". Although corpus analysis showed that middle attachment (i.e. to "*a baby*") is more frequent than high attachment (i.e. to "*a customer*"), reading task results showed that participants more easily processed the high-attachment structure compared to the middle attachment structure, which contradicts with the Tuning Hypothesis predictions. Neverthless, Desmet, and Gibson (2003) argued that this contradiction is the result of the use of the pronoun "*one*" which very rarely occurs in the corpus. Indeed, later examination of similar sentences which doesn't include the pronoun "*one*" showed that the middle attachment was processed more easily than the high attachment.

The assumptions of the Tuning hypothesis go in line with the mechanisms underlying the accumulative priming effect. Both predict that parsing preferences change after repeated exposure to a particular structure, resulting in facilitation in the processing of the structure that was more repeatedly encountered. Nevertheless, the tuning hypothesis was criticized for attributing processing differences to only coarse grained (syntactic) statistics and ignoring the fine-grained (lexical) variables (Desmet, De Baecke, Drieghe, Brysbaert, & Vonk, 2006; Desmet & Gibson, 2003). This was evident in later observations in which empirical data didn't correspond to corpus frequencies (Desmet & Gibson, 2003). Therefore, it was proposed that lexical aspects (e.g. animacy) of the words within the studied syntactic structure must be taken into consideration (Desmet, De Baecke, Drieghe, Brysbaert, & Vonk, 2006). The sensitivity of syntactic priming to fine-grained differences between prime and target sentences is revisited in the fourth chapter of the present thesis. Recent belief-updating Bayesian models (Kleinschmidt, Fine, & Jaeger, 2012; Kleinschmidt & Jaeger, 2015) discussed in the following section included the fine-grained effects component.

1.7.5 Belief updating models

Belief updating Bayesian models (Kleinschmidt et al., 2012; Kleinschmidt & Jaeger, 2015) proposes that language user store information about probability distributions of encountered linguistic features, whether it is syntactic or other features. Based on this knowledge, language users perform predictions of whether and how frequently a given linguistic features occurs in a specific context. If these predictions are not borne out, language users dynamically shift their probabilistic knowledge to align with the

probabilities of the context. For example, repeated exposure led listeners to adapt to syntactic structures that were initially judged as ungrammatical to the extent that they became more easily processed (Luka & Barsalou, 2005) and even produced (Kaschak & Glenberg, 2004). Belief updating models therefore correspond to the implicit learning account of syntactic priming. Similar to the inverse frequency effect proposed by the implicit learning account, the belief updating models suggest that the language user is less able to predict infrequent syntactic structures. Encountering a less predicted structure therefore results in larger shift in the language user's probabilistic knowledge than more frequent structures. Processing of infrequent structures become easier after repeated exposure to an extent that the facilitation in their processing exceeds that of the initially frequent or preferred structures.

Myslin and Levy (2016) examined adaptation to contextual probabilities using a self - paced reading task. Two groups of participants read two-sentence vignettes that included the sentence complement structure (SC) as in "*Her friend whispered the solution was to dispose of evidence*". Although both group were presented with the same number of SC sentences, the SC structure was clustered differently for each group in a training phase. One group was allocated to a clustering condition in which the SC structure was repeated in the two sentences composing the vignette. The other group was exposed to and an anti-cluster condition in which SC structure never occurred with another SC structure in the same vignette. In the test phase, participants in both groups read vignettes of two SC sentences. Results showed that the group with clustered training read the second sentences in the test vignettes more rapidly than the group with anti-clustered experience, indicating that reader's context based predictions change to align with the probabilistic properties of the context.

Kroczek and Gunter (2017) examined adaptation to word order structural frequencies in two different contexts by exposing German listeners to two different talkers. The first talker used the Subject-Object-Verb (SOV) word order in German more often, whereas the second talker more often used the OSV word order. Following exposure, German speakers were presented with sentences in which some parts were replaced with noise as in (Today *has [XXX] man friend [XXX] seen*). The sentences were therefore ambiguous as to their syntactic structures. Then participants were asked questions like

"*Who did see?*" It was inferred that participants would answer with "*man*" if they parsed the sentence as having SOV structure because this noun comes first in the preceding ambiguous sentence. Conversely, participants would answer "*friend*" if they parsed the sentence as OSV structure because this noun comes second in the sentence. Findings showed that participants were biased to parse the sentence as having SOV structure after being exposed to an SOV talker, and vice versa, indicating that participants adapted their predictions to match the syntactic preferences of a particular talker.

1.8 Syntactic processing of ambiguous structures in L2

There is mixed evidence for the similarity of language processing between L1 and L2 speakers, with arguments support the existence of parsing differences between the two populations (Dussias, 2001; Grosjean, 1989, 1997; Kim, Relkin, Lee, & Hirsch, 1997; Perani et al., 1996), and other arguments that advocate the opposite stance (Dekydtspotter, Schwartz, & Sprouse, 2006). Previous research found no differences in parsing between L1 and L2 speakers in the comprehension of either the low attachment ambiguity (Kweon, 2009; Pozzan & Trueswell, 2016; Rah & Adone, 2008) or reduced relative clause structures (Juffs, 1998; Frenck-Mestre, 2005) that are examined in the present thesis. The general finding arising from these studies is that L2 speakers analyze the sentence incrementally and don't wait till the end of the sentences to perform an analysis; therefore, both L1 and L2 speakers show processing difficulty for these syntactic ambiguities; However, the temporal constraints of the task might lead L2 speakers to employ different strategies or be affected by different cues from L1 speakers.

Second language speakers compensate for their lack of automaticity by resorting to a shallow processing to reach a message-level representation while keeping up with the speed of the task, referred to as shallow structure hypothesis (Clahsen & Felser, 2006b). This is achieved through building a message-level representation that is consistent with each incoming word and subsequently employ this higher-level representation to judge the accessibility of the incoming words at a lower level, leading the perceiver to pay more attention to semantic rather than syntactic or thematic representation. This lack of

syntactic activation prevents the L2 perceiver from successfully rebuilding the sentence as soon as one arrives at the disambiguating part. Also, the focus on the semantic message level representation lead the L2 perceiver to respond incorrectly to critical words when they mismatch the structure which hold greater probability of occurrence based on their previous experience with the language (Clahsen & Felser 2006a, 2006b).

The most striking evidence on L2 speakers less sensitivity to syntactic information comes from event-related potentials studies. Electrophysiological response to syntactic processing was found to be limited or absent in L2. For example, Hahne & Friederici (2001) examined brain response to syntactically anomalous structures in German. The study involved Russian and Japanese speakers of L2 German. Compared to native controls, results showed an absence of Left Anterior Negativity response (ELAN) which characterizes word category violations. Furthermore, L2 participants showed weaker P600 response as compared to L1 speakers. In addition, Guo, Guo, Yan, Jiang, and Peng (2008) examined ERP's elicited by sentences with verb subcategorization anomaly as in "*Joe's father didn't show him drive the car*". The study involved L1 speakers of English and Chinese learners of English. Results revealed that L1 speakers gave a positive ERP response (P600) which is normally linked to syntactic processing difficulty. However, L2 learners rather gave a negative ERP response (N400) which characterized the processing of semantic anomalies, indicating L2 speaker's on semantic rather than syntactic processing strategies.

Second language speakers over reliance on semantic representation might hinder or delay the occurrence of syntactic priming, especially for the examined low attachment structure (e.g. "*the worker repaired the ceiling with a leakage*") in which the use of an action verbs such as "*repaired*" in combination with the preposition "*with*" strongly bias towards a high-attachment interpretation as in "*the worker repaired the ceiling with a tool* ". L2 speakers' over-reliance on such semantic features (i.e. use of action verbs and prepositional cues) might render them more resistant to the intended low attachment interpretation (i.e. "*the worker repaired the ceiling which is leaking*").

Contradictory views to shallow structure hypothesis indicate no qualitative differences between L1 and L2 processing (Frenck-Mestre, 2002; Hopp, 2010; Jackson & Dussias,

2009, Rah & Adone, 2010). Instead, lower proficiency and slower processing modulate L2 processing; therefore, the evidence of different parsing mechanisms should be attributed to large processing demands rather than to categorical differences between L1 and L2. Once these processing demands are reduced, L2 speakers become able of applying native-like parsing. For example, Rah and Adone (2010) used an online self-based reading task and an offline grammaticality judgment task to examine German learners of English processing of reduced relative clauses as in (16a-c). The study included two L2 groups with intermediate and advance frequency in addition to a native control group.

16) a) The brown sparrow seen by the hungry cat pecked at an insect. (Unambiguous sentence)
    b) The brown sparrow noticed on an upper branch pecked at an insect. (Ambiguous with good cue)
    c) The brown sparrow noticed almost every day pecked at an insect. (Ambiguous with bad cue).

Sentence (16c) is a bad cue sentence because the reader doesn't realize that "*noticed*" is a reduced relative rather than the main verb until encountering the word "*day*". Findings revealed that advanced learners were faster in recovering from syntactic misinterpretation than intermediate learners. In addition, L2 speakers showed the same parsing mechanisms as L1 speakers for the grammatical judgment structure, whereas, in the online task, intermediate participants showed longer reading time than advanced learners for both good cue and bad cue sentences. Sentence processing behavior in the three groups suggested that differences between them are gradual, not fundamental.

1.9 The effect of dis/similarity between L1 and L2 on syntactic priming

Previous research has shown that second language learners can employ knowledge of their first language syntax to help them in their L2 syntactic processing (Foucart & Frenck-Mestre, 2011; Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016). This result has been confirmed in cross-linguistic syntactic priming research which aimed to examine whether bilinguals can transfer the syntactic priming effect across two different languages that share a similar syntactic structure. Cross-linguistic syntactic priming was demonstrated both in production (Loebell & Bock, 2003; Bernolet,

Hartsuiker, & Pickering, 2013; Hartsuiker, Pickering, & Veltkamp, 2004) and comprehension (Kidd, Tennant, & Nitschke, 2014), indicating that syntactic representations can be shared across languages. Based on these results, it can be inferred that bilinguals' first language might affect the occurrence of priming in L2, especially because it has been demonstrated that syntactic priming in L2 involves cross-language transfer (e.g., Flet, Branigan, & Pickering, 2013; Jackson & Ruf, 2017; Nitschke et al., 2010) and code switching (Frick & Koostra, 2016).

Although no research has yet investigated in one experimental manipulation the effect of the dis/similarity between L1 and L2 on syntactic priming among bilinguals, limited studies attempted to examine the effect of L1 syntax on the occurrence of syntactic priming in L2. For example, Nitschke et al., (2010) investigated how the dissimilarity in processing preferences between two alternative syntactic constructions can affect the occurrence of syntactic priming in L1 and L2 German and Italian speakers (see section 1.6.1 for a detailed explanation of the study). The object relative OR interpretation of the studied relative clause structure RC is the only interpretation available in English whereas in German, a subject relative SR interpretation is preferred over OR. Therefore, it was hypothesized that the baseline data would show more OR responses among L2 German speakers. As hypothesized, the L2 German participants provided more OR interpretations than their L1 counterparts. The OR interpretation of the examined type of RC is rare in Italian, and totally absent in English, which led to a prediction that both L1 and L2 Italian participants would provide less OR responses. The results supported this prediction. The baseline results showed a transfer of L1 preferences; however, the occurrence of syntactic priming in stages following the baseline stage was not affected as participants were more likely to choose OR target interpretation after exposure to OR structure in the prime trial.

Nevertheless, Many languages include aspects of syntax that others don't. The morphological system and word order doesn't only differ from one language to another, but also the same morphological and syntactic systems are used differently in different languages (Aronoff, 1994). One syntactic dissimilarity that was tested in L2 syntactic priming research is the relative clause word order that differs between Chinese and English (Wei et al., 2017,2019). In Chinese, the RC structure is head-final with the

relative clause always preceding the head of the sentence, whereas the English RC is a head-initial construction in which the relative clause comes after the head. Wei et al (2017, 2019) tested the effect of this syntactic dissimilarity on the occurrence of L2 syntactic priming among Chines second language speakers of English (see section 1.6.1 for a full explanation of the study). Results showed the occurrence of lexically dependent syntactic priming in L2 irrespective of the syntactic differences between the two languages.

Therefore, research conducted up to date showed no effect of L1 and L2 syntactic dis/similarity on the occurrence of syntactic priming; however, relevant research conducted so far is limited. The present thesis included L2 English with Arabic as a first language. Arabic and English belong to different language families. There is a wide dissimilarity in the syntactic systems of each language. For example, whereas the sentence structure in English is SVO, Arabic contains both VSO and SVO sentential structures with a greater preference for the VSO structure (Shormani, 2015). In addition, The PP attachment ambiguity studied throughout the present thesis is absent in Arabic because each of the modifier and instrument interpretation of the PP is represented by a different preposition in Arabic, which doesn't lead to an ambiguity similar to that in English where both interpretations are represented with the preposition "*With*". It can therefore be assumed that the significant difference between the two languages would hinder the cross-linguistic transfer and code-switching effects that might have an effect in languages that share similar syntactic systems with English, leading to the occurrence of Priming in English by Arabic first language speakers. Thus Arabic was employed for its linguistic dissimilarity to English to control for cross-language transfer effects.

1.10 Research questions

1.10.1 To what extent is syntactic processing independent of other sources of information?

A long-standing question in psycholinguistics research has been how language users integrate syntactic and lexical information during sentence comprehension especially when the two sources of information are in conflict. Research on the interplay between

syntactic and lexical biases has shown that listeners use syntactic knowledge in word recognition in some, but not all, conditions. Syntactic priming is not merely a mechanism that facilitates particular processes, but rather a reflection of the linguistic syntactic knowledge (Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995). In this way, syntactic priming can be used as a way to investigate the nature of the syntactic information represented during processing, the interplay between syntactic information and other sources of information, and to what extent can syntactic knowledge affect lexical processing. This issue is relevant to the notion of grain size of the information exploited in processing. Altmann and Steedman (1988) defined the fineness of grain as whether the processor can make a processing decision only over large units (clauses) or whether the process can proceed over smaller entities, more frequently at each successive word. The present thesis employs syntactic priming to answer this question by employing PP-attachment ambiguity in which the final word attachment to the preceding linguistic input differ between the NP- and VP- attachment structure alternatives. If the syntactic information transferred from the prime sentence can facilitate recognition of the final word, this would support the coarse-grained (syntactic) effects in word recognition. An absence of an effect would support fine-grained bottom-up processing.

Chapter 2 uses trial-to-trial priming to examine whether syntactic information that transfer between prime and target sentence can play a role in lexical processing. Previous research has demonstrated that the syntactic knowledge transferring across the prime and target sentences can facilitate the interpretation of the target; however, this goes in contrast to a huge bulk of previous research which showed superiority of the effect of lexical bottom-up processes over top-down syntactic effects in word recognition. Chapter 2 revisits this long-standing question using both a lexical decision task and masked word identification. Whereas lexical decision is intended to tap into the fluency of lexical processing, the masked word identification task was used to examine whether degrading the lexical input would make listeners more sensitive to the top-down input.

Chapter 3 examines the syntactic-lexical interplay using accumulative priming paradigm. Repeated exposure to a syntactic structure in an accumulative priming

paradigm leads to allocating higher statistical regularity to the primed structure. This entails assigning the primed structure higher probability distribution (i.e. preference) which exceeds that produced in the trial-to trial priming. This is hypothesized to render the course-grained (syntactic) information more capable of directing lexical processing. According to the belief-updating syntactic models, the language user exploits a number of contextual information to come up with the intended interpretation from among a number of possible interpretations, so comprehension proceeds in an incremental probabilistic fashion. The possible interpretation for a given structure is ranked according to its plausibility and the amount of cognitive resource allocated based on this rank. If the interpretation undergoes higher plausibility and less directed mental resources as a result of accumulative priming, processing facilitation will occur. Chapter 4 extends the investigation of syntactic processing independence by examining the effect of thematic role dis/similarity between primes and targets on the occurrence of syntactic priming.

1.10.2 Do listening and reading involve the same syntactic representations in L1 and L2?

Chapter 3 employs both visual and auditory lexical decision tasks to examine whether syntactic priming effect in either reading or listening can transfer to the other modality. In a within-modality priming experimental manipulation, the processing of a particular item (i.e. prime) affects the processing of another item (i.e. target). This effect could be attributed to a shared abstract mental representation between the two linguistic items, or the sharing of perceptual features of the modality in which both items are presented. Bock and Loebell (1990) suggested that the facilitation in comprehension in syntactic priming studies might be caused from facilitation in the perceptual procedures involved in listening comprehension or reading comprehension rather than from a syntactic priming effect. Therefore, the occurrence of cross modal priming would enable attributing the resulting facilitation to the underlying shared representations rather than to the perceptual strategies related to any of the two modalities. Previous visual-world paradigm studies showed that syntactic priming can transfer from reading to listening (Arai et al., 2007; Arai, Nakamura, & Mazuka, 2015; Scheepers & Crocker, 2004); however, full modality-independence of syntactic priming cannot be assumed unless a

bidirectional effect (i.e. from reading to listening and from listening to reading) is examined. Chapter 3 employs an accumulative priming paradigm to examine whether modality-specific aspects can interfere in the occurrence of the priming effect in L1 and L2.

1.10.3 How do syntactic and thematic representations interact in sentence processing in L1 and L2?

Previous research has found syntactic priming in PP-attachment structures where prime and target sentences share not only the syntactic structure but also the thematic role assigned to the PP (Branigan et al., 2005; Boudewyn et al., 2014; Traxler, 2008). This can lead to the assumption that the observed facilitation in processing may be attributed, even partially, to the shared thematic, and not syntactic, representation between prime and target sentences. Chapter 4 aims to disentangle the syntactic and thematic sources of influence by varying between thematic roles while keeping the PP syntactic attachment the same.

If the priming facilitatory effect results from shared thematic role of the sentence constituents rather than shared syntactic structure, then varying the thematic role across prime and target sentences while keeping the syntactic structure (i.e. NP attached PP) the same would yield no cross-role priming. This would indicate that the grain size of the thematic role assignment has the largest influence on processing these types of sentences. Alternatively, the processor sensitivity to the function played by thematic role might be overridden by the strong expectation for an NP attachment resulting from accumulative priming. This, in turn would indicate a maximization of the role played by syntax, indicating the effectiveness of priming in modifying the grain size of the effect played by different sources of information. Thus the occurrence of cross-role priming would indicate that the priming in this sentence type happens, at least in most part, on a syntactic rather than thematic basis.

1.10.4 What are the causes of the difference between L1 and L2 syntactic processing?

As syntactic priming can mirror the representation, integration, and interpretation of syntactic input (Branigan et al., 1995), it is used in the present thesis as a method to understand the sources of differences between L1 and L2 syntactic processing. Previous research showed that L2 are similar to their L1 counterparts in semantic processing; however, differences arise between the two groups in the syntactic domain of language comprehension (Weber-Fox & Neville, 1996; Hahne, 2001; Hahne & Friederici, 2001). While a number of previous studies claimed the existence of qualitative dissimilarities in the parsing mechanisms employed by each group (Dussias, 2001; Grosjean, 1997; Kim, Relkin, Lee, & Hirsch, 1997; Perani et al., 1996), other studies attributed the differences to the lack of automaticity and fluency among L2 speakers (Frenck-Mestre, 2002; Hopp, 2010; Jackson & Dussias, 2009, Rah & Adone, 2010). In the present thesis, the absence of a L2 syntactic priming effect that is independent of other sources of information would give support to the former account, whereas, the absence of L2 priming only in condition in which automaticity constraint are imposed on L2 participants would support the latter account.

Chapter 2 employs trial-to-trial priming to investigate L1 and L2 differences in the interplay between syntactic and lexical processing. Limited previous research has demonstrated that L2 speakers can integrate syntactic knowledge in word recognition (Chrabaszcz & Gor, 2014, 2017). In addition, comprehension syntactic priming research showed, in some but not all cases, a greater syntactic priming effect among L2 speakers (Nitschke, Kidd, & Serratrice, 2010; Weber & Indefrey, 2009). Therefore, it can be predicted that syntactic priming in L2 would facilitate word recognition. However, contradictory results might rises because of the nature of the employed lexical decision and masked word identification tasks. Lexical processing that is a preliminary requirement for syntactic integration might be hindered by the temporal constraint imposed by the lexical decision task as well as the degradation in the signal in the masked word task. The resulting difficulty in retrieving the final word in the experimental sentences might hinder the occurrence of syntactic priming among L2 participants. This is supported by previous results which suggested that part of L2

inefficiency in syntactic integration results from difficulties in lexical processes which feed into syntactic processing (Dekydtspotter & Renaud, 2014; Hopp, 2016).

Chapter 3 further investigates L1 and L2 differences in the interplay between syntactic and lexical processing using an accumulative priming paradigm. Repeated exposure to multiple examples of the studied PP-attachment structure alternatives is predicted to improve L2 syntactic integration despite the temporal constraint imposed by the lexical decision task. The improved syntactic integration could in turn lead to the occurrence of an accumulative syntactic priming in L2; however, it can be predicted that L2 participants might still show weaker accumulative priming compared to their L1 counterparts. The accumulatively of priming refer to the well-established result that the more instances of the studied structure an individual is exposed to, the stronger the system converge to the primed structure. Lexical retrieval difficulties and temporal constraints affecting L2 speakers might prevent them from benefiting from all of the prime sentences, which leads to a more limited exposure to the studies structure among L2 participants as compared to their L1 counterparts.

Chapter 4 employs a self-paced reading task which imposes no temporal constraint when compared to the lexical decision task used in Chapters 1,2,3 and 4. Therefore, if syntactic priming occurred using this task and not the lexical decision task, this would support the claim that differences between L1 and L2 syntactic processing results from lack of fluency and automaticity among L2 speakers, at least in the processing of PP-attachment ambiguity structure examined in the present thesis.

1.11 Thesis overview

The aim of the present thesis is to compare between first and second language speakers with regard to syntactic priming. The first study will look at the role of syntactic priming in word recognition among both first and second language speakers of English. In addition to enhancing the syntactic knowledge, the first study predicts that syntactic priming may help in word recognition as well. As syntactic priming makes the target structure more accessible for the perceiver, it is hypothesized that it will be useful in contributing to fluency and accuracy of word recognition, specifically for second language speakers who face problems in word recognition. The second study will

examine syntactic priming from reading to listening and listening to reading among first and second speakers of English. Previous research showed syntactic priming from reading to listening modalities in L1 speakers (Scheepers & Crocker, 2004). However, this cross-modal syntactic priming hasn't been examined in L2 before. The third study aims to investigate thematic-independence of syntactic priming with prepositional phrase structure. To exclude out the effect of the similarity in thematic role between prime and target pairs, the study will vary between thematic roles while keeping the syntactic attachment preposition the same to see whether shared thematic role between prime and target contribute to the occurrence of priming in comprehension. A general discussion of the main findings is presented in Chapter 5.

Chapter 2

The Role of Syntactic Priming in Auditory Word Identification

2.1 Introduction

There is a large line of research in sentence comprehension examining the processing of temporarily ambiguous syntactic structures by language users. In particular, many previous studies investigated how language users use various sources of information in the on-line incremental processing of sentences, including lexical and semantic information, discourse context, plausibility, and prosody (see section 1.7.2). Although many studies demonstrated the effect of syntactic information in the online processing of ambiguous structures, such an effect was not examined on the identification of words presented in ambiguous structures. The current study addresses this issue by using syntactic priming as a method to separate the syntactic information from other contextual effects and examine its sole influence on the processing of critical final words in ambiguous structures. If the syntactic knowledge produced by priming can facilitate the fluency and accuracy of identifying the critical words, then syntactic processing can guide interpretation independently of semantic information sources. If not, then other interacting sources of information are required to take effect in the online spoken word identification.

2.2 Research on the effect of syntactic information on word recognition in first language

The syntactic context effect in word recognition has been demonstrated in early studies that have examined the processing of simple sentences. In these studies, experimental sentences included words that are either grammatically congruent with its preceding syntactic context or incongruent because of a phrase structure violation, for example, words that are imbedded in congruent syntactic context as in "*The man spoke but could **compete***" elicit faster response times than words in incongruent contexts as in "*The man spoke but could **entries***" (Deutsch & Bentin, 1994; Stanovich & West, 1983; West & Stanovich, 1986; Wright & Garrett, 1984). In addition, the recognition of the word "*to*"

is easier when it precedes a verb (e.g. "*He tried **to** go*") than when it precedes a noun (e.g. "*He tried **to** gold*") (Isenberg, 1980). However, in these studies, violating the syntactic context also entailed a semantic implausibility, for example, a sentence like "*The man spoke but could **entries***" causes difficulty not only because it is syntactically erroneous, but also because it is semantically implausible. The study of syntactic context effects, therefore, requires a method that separates the effect of syntactic context from other contextual semantic effects. Syntactic priming includes pairs of sentences that are semantically and lexically different, but share the same syntactic structures. This makes it a successful paradigm in testing syntactic effects apart from semantic contextual effects.

Later research on the contextual effects relied on the common assumption that hearing a word spontaneously activates a set of related words "*competitors*" that share similar lexical characteristics, for example, hearing the word "*part*" activates similar competitors such as "*party*" and "*park*". Accordingly, The existence of preceding syntactic cues was shown to facilitate early stage of word recognition by eliminating word competitors that are incongruent with the current syntactic context, for example, in French, Dahan, Swingley, Tanenhaus, and Magnuson (2000) showed that gender-marking determiners (i.e. the masculine article "*le*" vs. the feminine article "*la*") facilitate the recognition of a subsequent target word through eliminating competitors that mismatch the gender of the preceding article. Moreover, response times are faster when a congruent gender-marked determiner precedes the target word (Cole & Segui, 1994; Jakubowicz & Faussart, 1998), or when the target word is preceded by a possessive adjective (Gurjanov, Lukatela, Lukatela, Savic, & Turvey, 1985) than when preceeded by an incongruent syntactic cue. This suggests that syntactic context activated only compatible lexical competitors.

The majority of previous research has focused on local syntactic effects derived by single syntactic cues rather than the wider (global) sentential syntactic structure attachments. Support for the global structure constraint comes only from studies investigating eye movements in reading (Morris, 1994; Staub, 2011). For example, Staub (2011) examined eye movements using eye-tracking on words embedded in

sentences when the sentence varied by structure only (i.e. content words remain the same). An example is shown below:

1) The airport manager heard that the employees hurried across the open field.
2) The airport manager heard the employees hurried across the open field.

In sentence (2), the noun phrase "*the employees*" is ambiguous between a direct object and a sentence complement. The target word "*hurried*" is, therefore, difficult to be attached to the sentence as it resolves the ambiguity towards the non-preferred analysis (i.e. sentence complement). Findings showed increased regressive gazes on the verb "*hurried*" from later parts of the sentence in (2). However, in sentence (1), the presence of the word "*that*" facilitated the syntactic attachment of the verb "*hurried*" into its wider sentential context, which supports the effect of the prior syntactic context in word processing.

Evidence against the syntactic context effect on word recognition comes mainly from studies that examine the interpretation of lexical ambiguity. Findings of these studies have established that lexical access can in most cases proceed, independent of the preceding syntactic context (Tanenhaus, Leiman, & Seidenberg, 1979; Seidenberg, Tanenhaus, Leiman, Bienkowski, 1982). In Tanenhaus et al., (1979), category ambiguous words that are ambiguous between a verb and a noun (e.g. "*saw*", "*trip*") were embedded in contexts that either bias towards a noun or a verb (e.g. "*He bought a new saw*", "*They began to trip*"). Cross-modal priming results showed that both syntactic categories are initially activated irrespective of the preceding syntactic context, which suggests that syntactic context couldn't constraint access to inappropriate meanings of the ambiguous word. A contradicting finding was shown by Folk and Morris (2003) using an eye tracking reading task. Similar target words that were ambiguous between two meanings were embedded in contexts which bias towards a noun meaning. Reading time results showed difficulty in reading target words that were ambiguous between two noun meanings such as "*calf*", but not on target words which were ambiguous between noun and verb meanings "*duck*". This finding suggests that the assignment of a word class precedes the assignment of a meaning. Therefore, when a word has two meanings that each belong to a different syntactic category, and only one of these categories fits with the preceding syntactic context, the competition

between the two meanings disappears. Clifton, Staub, and Rayner (2007) reported that it is not clear how to reconcile findings observed by Folk and Morris (2003) with cross-modal priming results provided by Tanenhaus et al., (1979) which contradicted the effect of context on word recognition. Thus further examination of the syntactic information effect on word identification is necessary.

The maximized sensitivity to the grammatical category constraints is also supported by the speed-accuracy trade-off task (McElree & Griffith, 1995). In this task, participants made grammatical acceptability judgments to both grammatical category and thematic violations (e.g. "*some people were agreed by books*" and "*some people were loved by books*", respectively). By examining the level of judgment accuracy over multiple response times (100 ms - 3000 ms), it is possible to detect which type of violation affects processing sooner. Findings showed that participants started integrating information about word category accuracy (230 ms after word presentation) earlier than integrating information about thematic accuracy (279 ms). In addition, neurophysiological studies found an Early Left Anterior Negativity (ELAN) for word category violations (Friederici & Weissenborn, 2007; Hastings & Kotz, 2008) that occurs 100 ms – 200 ms post item onset, which was earlier than other neural indices related to other types of violations such as the false assignment of semantic relations (N400), suggesting an earlier accessibility of word category contextual constraints.

In summary, research on syntactic context effect on word recognition has shown that language users use grammatical context in word recognition in some, but not all, conditions. The research discussed above suggests that the integration of the syntactic context in word recognition is made possible when the syntactic context constraint for word category. Words belonging to different grammatical category compete for lexical selection less than words with the same grammatical category (Dell, Oppenheim, & Kittredge, 2008; Levelt, Roelofs, & Meyer, 1999; Pechmann & Zerbst, 2002). Another factor is the existence of a syntactic cue which enhance contextual effects if it eliminates much of the word's competitors and, therefore, narrowing the field of lexical selection.

2.3 Research on the effect of syntactic context on word recognition in second language

The effect of syntactic context on word recognition has been much less extensively studied in L2 than in L1. Most of the relevant research examined the contextual effects on words that overlap across first and second languages in orthography, phonology, and semantics, referred to as cognates. It was found that bilinguals process cognates more rapidly and accurately than their matched control words. Research concentrated on the effect of the semantic context on the cognate effect. The disappearance of the cognate facilitation effect in a highly constraining context means that the context constrains the target word by suppressing L1 activation that would have otherwise led to facilitation. Gullifer, Dussias, and Kroll (2010) provided evidence on the syntactic context effect on the processing of cognates by using a word-naming task. In this study, English-Spanish bilinguals read either high- or low- syntactically constraining sentences whereby syntactic structure is specific to one language (high-constraining), or non-specific because it exists in both languages (low-constraining). Findings revealed an absence of the cognate facilitation effect in the high-constraint syntactic context, suggesting that bilinguals, similar to L1 speakers, integrate the syntactic context in word recognition.

Additionally, previous research demonstrated that the syntactic context has a significant effect on the recognition of phonological ambiguities in L2 (Chrabaszcz & Gor, 2014, 2017). Phonological ambiguities are linguistic segments that are phonologically distinct in L2, but not in L1. For example, although "*rock*" and "*lock*" are two distinct words in English, Japanese speakers find it difficult to discriminate between these words as the sounds "l" and "r" are perceived as the same phoneme in Japanese. Chrabaszcz and Gor (2014) examined the effect of semantic, syntactic, and morphological context on the recognition of phonologically ambiguous words between both first and second language speakers of Russian. The study employed a listening comprehension task in which participants listened either to a congruent sentence in which the target word match the sentence context as in "*My elder sister and younger brother are coming to see me tomorrow*" or an incongruent sentence in which the target word mismatch the sentence context either semantically (e.g. "*My elder system and younger brother are coming to see me tomorrow*"), syntactically (e.g. "*seam*", "*seize*"), or morphologically (e.g.

"*seen*", "*sees*"). After listening to each sentence, participants performed a forced choice task in which they identified which of two words presented on a screen was heard in the preceding sentence. Results showed that both syntactic and morphological sentences were more effective in constraining for the critical word and guiding the word choice of L2 listeners. It is worth noting that in the syntactic conditions in Chrabaszcz and Gor (2014), the two phonologically ambiguous target words differed in their grammatical category. The semantic condition involved noun-noun ambiguities. Similar to findings from L1 research, syntactic effects in L2 might be, therefore, maximized when they constraint for word grammatical category.

Nevertheless, L2 speakers' ability to integrate syntactic information in word recognition is not supported by the shallow structure hypothesis (Clahsen & Felser, 2006a, 2006b) (see section 1.8 for a detailed explanation). According to the shallow structure hypothesis, L2 syntactic context is characterized by shallow parsing. The representation resulting from sentence processing in L2 lack syntactic detail, which cause L2 speaker to rely more on lexical and semantic information in processing structure ambiguities. Over reliance on semantic and lexical information among L2 speakers could affect their accessibility of the syntactic knowledge produced in a syntactic priming paradigm.

Other evidence suggest that L2 speakers are able to perform native-like syntactic representations; however, difficulties emerging from online processing such as limited working memory capacity, lack of automaticity, and reduced speed of processing cause them difficulties in integrating the syntactic context in the on-line processing of sentences. Supporting evidence emerges from the finding that L2 speakers don't perform less efficiently than L1 speakers when responding to off-line tasks as compared to on-line tasks (Ellis, 2005; Lopez Prego & Gabrielle, 2014). For example, Lopez Prego and Gabrielle (2014) examined Spanish L1 and L2 speakers' sensitivity to number and gender agreement violations in Spanish. L2 speakers with advanced, intermediate, and low proficiency were tested. The study employed both an on-line speeded grammaticality judgment task and an off-line untimed grammaticality judgment task. Results showed that advanced learners performed like L1 speakers in both gender and number agreement, but only in the untimed off-line task. Temporal constraints imposed in on-line task affects syntactic integration in slower L2 speakers.

Unlike L1 speakers, low speed of processing in L2 could hinder the integration of the primed syntactic knowledge in the on-line processing of target sentences.

2.4 Speech perception in noise

Previous research found a positive effect of semantic context on comprehension in noise for L1 but not for L2 speakers of English. Golestani, Rosen, and Scott (2009) tried to examine the semantic effect of the context separately from other effects (syntactic and phonological), In a semantic priming experiment that included pairs of either semantically related or unrelated words, they found that words that are semantically primed are more easily identified through different levels of noise in first language, but not in second language participants. This goes in line with previous research that used whole sentences instead of pairs of words and found that first language participants are better able to identify the sentences in predictable contexts, but second language speakers failed to show this context advantage (Florentine, 1985). It was concluded that L2 speakers can make use of the semantic context in speech recognition in quite, but not in noise. The effect of syntactic knowledge on word recognition in noise hasn't been examined in previous research. This raises the question of whether L1 and L2 participants are better able to perceive speech in noise in syntactically primed rather than in non-primed sentences.

2.5 Aim of the study

Although several studies have employed numerous tasks to examine syntactic priming effect in facilitating the processing of ambiguous syntactic structures (see sections 1.5 and 1.6 for a detailed review), it is unclear how these effects are reflected in word recognition. The present study aim to examine whether trial-to-trial syntactic priming could play a role in the recognition of spoken words embedded in complex structures for both L1 and L2 speakers. Based on previous findings, the contextual syntactic effects are maximized when they constrain the grammatical category of the critical word. Given that the final word has a different grammatical category in the reduced relative structure (verb) and its main clause (noun) counterpart, trial-to-trial syntactic priming is predicted to be stronger in the relative-clause ambiguity than in the low-attachment ambiguity.

Lexical decision task was used to assess the priming effect on the fluency of target word recognition. Targeting fluency would enable comparisons with previous research that demonstrated the priming effect on the processing fluency of the PP-attachment structure. Also, The lexical decision task includes a non-word option, which encourages the participants to rely on the syntactic sentential information to discriminate words from non-words, and prevent them from developing the strategy of detaching the word from its context and attending to its perceptual aspects only. This serves the present research purpose of detecting the effect of the primed syntactic context on the recognition of words.

A masked word identification task is used to examine whether the syntactic priming effect occurs in a noise situation. Thus the present study would provide the first investigation of the effect of syntactic information on speech perception in noise. The choice of the masked word identification task was intended as previous research suggested that the degradation of stimulus intelligibility motivates participants to engage the context to come up with the word (Cutler, Garcia Lecumberri, & Cooke, 2008). Similar to the lexical decision, this serves the current purpose of assessing the primed context effects.

2.6 Pilot study

A pilot study was conducted to estimate the noise level that results in 50 % correct responses. This noise level acted as a mask to the target words in the masked word identification task employed in the main study. The masked word identification task was used to examine the facilitatory effect of syntactic priming on the identification of words that are masked by white noise and presented in target sentences final position.

The signal to noise ratio for a fixed 50% response is defined in the literature as the speech reception threshold. In the present study, the speech reception threshold is the signal to noise ratio at which 50% of the words are identified correctly without any error. Two distinct speech reception thresholds will be examined for native and non-native listeners. This is because previous evidence has shown that non-native listeners are less able to perceive a message in masking noise than native listeners (Florentine, 1985). Non-native listeners performance declines more sharply than native participants'

performance on speech perception tasks with increasing level of signal distortion. Relevant previous studies employed a range of tasks such as word identification (Nabeelek & Donahue, 1984), sentence intelligibility (Bradlow & Bent, 2002; Cooke, Garcia Lecumberri, & Barker, 2008), and phoneme identification (Cutler et al., 2008). Therefore, two distinct speech reception thresholds of the word stimuli used in the main study will be identified for L1 and L2 listeners separately.

2.6.1 Participants

Participants are 10 first language and 10 second language postgraduate students from the University of Leeds. The age of the participants ranged from 20 to 35 (M = 19.3). All participants have normal hearing and a normal or corrected vision. Before the experiment, L2 participants were asked to complete a Language History of Use questionnaire (Appendix A) that revealed that participants started to learn English at an average age of 11.4 years old. All L2 participants were regularly exposed to their L2 through popular media, and English university textbooks. Six participants reported never speaking English at home, and all of them reported speaking English every day at work or study related activities. On a 7-point Likert scale (ranging from very poor to very good), participants were asked to rate their L2 (English) proficiency with respect to reading, writing, speaking, understanding and general proficiency. Mean self-reported proficiencies were 6.85, 6.45, 6.55, 5.97, and 7.58 for reading, writing, listening, speaking, and general proficiency in order.

2.6.2 Stimuli

The stimuli were a list of 96 experimental target words (Appendix B) (see section 2.7 and 2.8). The list consisted of all the single words that appeared in the final position of the target sentences in the different conditions of the main study.

2.6.3 Procedure

Individual experimental words were adjusted to be equally intelligible. The duration of the mask equaled the duration of the longest target word and was also equal in all sentences. The first word was presented at 70 dB with the accompanying noise mask presented at 65 dB. The noise level which resulted in 50% correct identification was

specified through a simple top-down adaptive 'staircase' method (Levitt, 1971). Participants listened to the recorded words through loudspeakers. If the first word in the list was not identified, it was repeated at -5 dB noise level with each repetition until the listener was able to identify it correctly. The rest of the words in the list were presented only once. If a word is identified correctly, the noise level was increased by 2dB for the next word; otherwise it was decreased by 2dB. The average noise presentation level from the 4th to the 96th word was taken as the speech reception threshold.

2.6.4 Results

The average noise levels (speech reception thresholds) were 73.2 dB (*SD* = 2.93) for L2 participants, and 76.8 dB (*SD* = 2.02) for L1 participants. Independent samples t test yielded no significant differences between both groups $p = .13$.

2.7 Experiment 1: The role of syntactic priming in L1 word recognition

Experiment 1 examines the role of syntactic priming in word recognition among L1 speakers of English. The rationale behind this experiment raises from the assumption that lexical decision latency and masked word identification will be affected by priming the context in which the word occurs. Two ambiguous syntactic structures are tested alternating with their unambiguous counterparts: 1) low attachment ambiguity and its high attachment counterpart as in (3a) and (3b), and 2) reduced relative clause and its main clause counterpart structure as in (4a) and (4b) (see section 1.7 for a detailed explanation of the cause of ambiguity in both structures):

3)	a) The man fixed the wall with a hole	Low-attachment ambiguity
	b) The man fixed the wall with a tool	High-attachment structure
4)	a) The salesman decided to abandon the company left	Reduced relative ambiguity
	b) The salesman decided to abandon the company job	Main clause structure

The low/high attachment structure was employed in the present experiment as it includes a final word that differs in its syntactic attachment between the two alternatives (i.e. high/low attachment) of the studied PP-attachment structure. More importantly, the disambiguation of the structure occurs at the final critical word, which results in difficulty in processing the final word in the low attachment structure. This serves the

research purpose as it allows testing the facilitation of processing in the priming condition at the word level. This is unachievable with other PP-attachment structures in which the disambiguation occurs before the final word as in "*The maid dropped the ball on the corner into the closet*" in which the disambiguation occurs at the preposition "*into*". Moreover, the studied ambiguous low-attachment has a more familiar counterpart structure (high-attachment structure) which matches it in length. The high-attachment, therefor, is used as a control (baseline) to which the processing of the ambiguous low attachment structure can be compared. Other PP-attachment structures do not provide this advantage, for example, in the above example, "on the corner" is a low-attachment PP, so its counterpart structure would be "*The maid dropped the ball on the corner*" in which "*on the corner*" is a high-attachment PP. Both sentences don't match in length, which makes it a less reliable control as the load on the working memory resources will not be the same for both sentences.

Similarly, the reduced relative structure employed was chosen as its final word has a different category (verb vs. noun) in each alternative structure (reduced relative vs. main clause. In addition, the disambiguation occurs on the final word in both structure alternatives, allowing detection of the priming effect at the word level, and both syntactic alternatives match in length.

In half of the trials, participants listened to low-attachment or high-attachment target sentence after listening to another low-attachment or high-attachment prime sentence. In the other half, participants listened to a reduced relative or main clause target sentence after listening to another reduced relative or main clause prime sentence. The high-low attachment and main/relative clause structures were both shown to produce a syntactic priming effect[2] that facilitated target sentence comprehension in previous research (e.g. Branigan et al., 2005; Fine et al. (2013), respectively). However, the effect of the produced facilitating priming effect on the recognition words impeded in the target has not been examined yet.

[2] Trial-to-trial priming

2.7.1 Method

2.7.1.1 Participants

Forty-eight participants from the University of Leeds took part in the experiment. All were between the ages of 18 and 30 (M = 21.2), first language speakers of English, and naïve as to the aim of the study. All participants reported normal vision and hearing and hadn't participated in the pilot study.

2.7.1.2 Design and material

The stimuli consisted of 48 prime-target pairs, 24 pairs in the reduced relative/main clause structure, and 24 pairs in the low /high attachment structure (experimental items presented in Appendices C.1 and C.2). The experiment had 2x2 factorial design with the independent variables of 1) prime structure, and 2) target structure resulting in four conditions of prime-target pairs for each of the reduced relative (RR) structure and its main clause (MC) counterpart, and low attachment structure and its high-attachment counterpart. Experimental conditions are presented in Table 2.1. The main verb was repeated between prime and target pairs to create a lexical boost effect that would maximize the generated priming effect. Items were allocated to eight lists of sentences so that each sentence served once as a prime and once as a target, and each participant saw only one version of each sentence. Each of the eight lists contained six items in each of the four experimental conditions. Two groups of participants were assigned to each list. For the first group in each condition, half of the target sentences were presented in the lexical decision task and half were presented in the masked word identification task. For the second group, this was reversed.

Each list included the same 120 filler sentences (Appendix C.3). Between one and three filler sentences were inserted between the prime and target sentences. The filler sentences had randomly chosen structures and occupied different list position for each participant. To reduce interference from the syntactic structure of the fillers, the filler sentences had structures other than the experimental target structures. Because of the nature of the lexical decision task, 24 of the filler sentences ended with a non-word. Non-words were generated by a stimulus generation program presented by the English lexicon project that generates list of non-words according to specific lexical

characteristics (Balota et al., 2007). Six practice items preceded the experiment to allow participants to ask questions about the procedure.

To make sure that the final critical word couldn't be predicted by its context, the experimental sentences were piloted by means of a cloze test. The cloze test was a sentence completion task in which 20 participants were asked to fill in the first word that comes to mind. The experimental words produced an average cloze probability of 5% (range 0% - 20%); however, one experimental word was replaced because of its high cloze probability (60%). To control for the lexical characteristic of the target words, the four groups of words embedded in each of the four experimental sentence structures were matched with respect to response time latencies which were calculated by the use of the British Lexicon Project (Keuleers, Lacey, Rastle, & Brysbaert, 2012).

Table 2.1 Experimental conditions of the first study presented with example sentences in both reduced relative / main clause structure and high/low attachment structure.

Structure type	Sentences	Condition
Reduced relative clause ambiguity (RR) vs. main clause structure (MC)	The baker intended to prepare the cake topping. The burglar intended to rob the bank safe.	MC prime – MC target
	The burglar intended to rob the bank safe. The baker intended to prepare the cake finished.	MC prime – RR target
	The burglar intended to rob the bank escaped. The baker intended to prepare the cake topping.	RR prime – MC target
	The baker intended to prepare the cake finished. The burglar intended to rob the bank escaped.	RR prime – RR target
Low-attachment ambiguity (LA) vs. high-attachment structure (HA)	The thief opened the safe with a wire. The man opened the door with a hammer.	HA prime – HA target
	The man opened the door with a hammer. The thief opened the safe with a diamond.	HA prime – LA target
	The man opened the door with a sign. The thief opened the safe with a wire.	LA prime – HA target
	The thief opened the safe with a diamond. The man opened the door with a sign.	LA prime – LA target

2.7.1.3 Procedure

The stimuli in this experiment were presented using DMDX (Forster & Forster, 2003). A female speaker with a standard British English accent recorded all sentences using Audacity software (SourceForge; https://sourceforge.net/). Each participant was tested individually in a silent room. The experimenter and the participant listened to the stimuli simultaneously through loudspeakers. In the masked word identification task, critical final words in target sentences were masked with white noise at the level determined by the pilot study. Prime and filler sentences were preceded with "----------" which indicated that participants are required to only listen to the whole sentence whereas target sentences were preceded by "++++++++++" which indicated that the final word will be accompanied with noise and the participant is required to identify the masked word. No time constraint was imposed. Participants were instructed to press a key to move through the stimuli and were therefore self-paced. After listening to each prime sentence, participants were asked to provide an oral paraphrase of the sentence meaning. No paraphrase task followed target items. Vocal responses were recorded by both the software and the researcher.

In the lexical decision task, participants were instructed to listen to the sentences and to state, as quickly and accurately as possible, whether the last word was a real word or a non-word in the silence interval at the end of each sentence by pressing one of two response keys. The prompt "+" appeared for 500 ms at the middle of the screen before each sentence. Response times were recorded by the software and were measured from the end of the experimental words. Sentences were presented automatically one after the other with a 2500 ms inter-sentential interval. The experiment was preceded by a practice block of six randomized prime target pairs, with three prime target pairs in each of the two word recognition tasks. The experiment took approximately 30 minutes to be completed.

2.7.2 Results

2.7.2.1 Lexical decision data

Trials with incorrect responses or those shorter than 100 ms or longer than 2000 ms (or 2.5 SD from the mean) were excluded from the analysis. This resulted in 14.3% of all

data being excluded. Data on the non-words were considered fillers and are not reported here. Mean lexical decision latencies and error rates for the four experimental conditions for each syntactic structure are presented in Table 2.2.

Table 2.2 Mean lexical decision latencies (in ms) and % error rates of first language speakers for both high/ low attachment structure and main/relative clause structure by condition (SEMs in parenthesis).

Condition	**Latency (ms)**	**Error rate (%)**
High/Low attachment structure		
HA prime/HA target	287.1 (22.4)	6.4 (.03)
LA prime/LA target	311.7 (23.9)	11.2 (.04)
HA prime/LA target	322.3 (26.7)	7.4 (.03)
LA prime/HA target	339.3 (19.2)	10.2 (.03)
Main/ Relative clause structure		
MC prime/MC target	317.8 (23.2)	1.2 (.01)
RR prime/RR target	451.5 (22.7)	27.1 (.05)
MC prime/RR target	545.5 (32.1)	22.5 (.04)
RR prime/MC target	330.9 (19.4)	2.5 (.02)

2.7.2.1.1 Error rates

For the high/low attachment structure, a 2x2 ANOV with prime structure (HA vs. LA) and target structure (HA vs. LA) as the independent variables and error percentages as the dependent variable showed no interaction, $F1_{(1, 47)} = 1.04$, $p = .31$, $F2_{(1, 23)} = 1.04$, $p = .31$. No main effects were found. Target sentences were responded to at equal accuracy regardless of the preceding prime type. For the reduced relative/main clause structure, the same analysis showed no interaction, $F1_{(1, 47)} = 1.2$, $p = .27$, $F2_{(1, 23)} = .08$, $p = .76$ There was a main effect of target structure, $F1_{(1, 47)} = 35.4$, $p < .000$, $F2_{(1, 23)} = 22.03$, $p < .000$. Main clause targets were responded to with higher accuracy than reduced relative targets.

2.7.2.1.2 Reaction times

As for the high/low attachment ambiguity structure, a 2x2 ANOVA crossing prime structure (high attachment vs. low attachment) with target structure (high attachment vs. low attachment) revealed no interaction of prime and target structure, $F1_{(1, 47)} = 2.52$, $p = .11$, $F2_{(1, 23)} = .076$, $p = .784$. Follow-up mean comparisons revealed that low attachment target sentences were processed at equal speed regardless of whether it was following a low-attachment prime or a high attachment prime. No main effects were found. High attachment structures were also processed at equal speeds irrespective of whether they were preceded by a high attachment target or a low attachment target.

To examine the occurrence of priming with the relative vs. main clause structure, a 2x2 ANOVA crossing prime structure (relative clause vs. main clause) with target structure (relative clause vs. main clause) was conducted, revealing an interaction of prime and target structure, $F1_{(1, 47)} = 5.27$, $p < .02$, $F2_{(1, 23)} = 4.13$, $p < .05$. Final words in an ambiguous relative clause structure were processed more rapidly following another relative clause structure than following a main clause structure (see Figure 2.1). However, final words in a main clause structure were processed at equal speed whether it followed another main clause structure or a relative clause structure. There was a main effect of target structure, $F1_{(1, 47)} = 67.3$, $p < .000$, $F2_{(1, 23)} = 14.7$, $p < .001$. Main clause targets were responded to more rapidly than reduced relative targets.

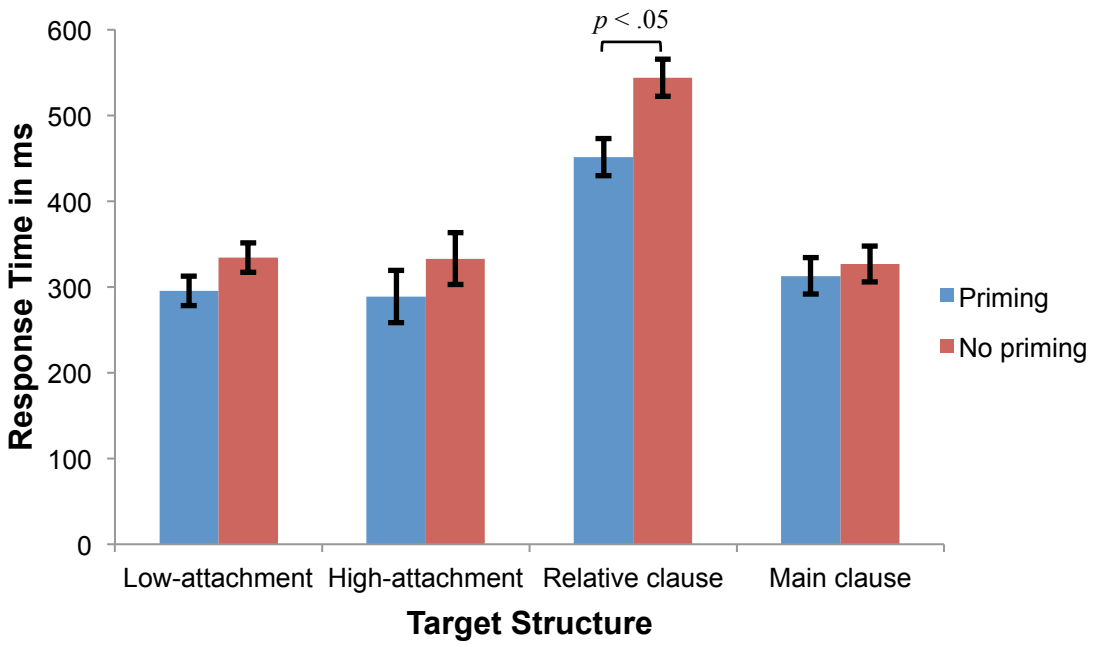

Figure 2.1 Response time in ms as a function of prime structure and target structure for L1 participants. Targets preceded by a congruent structure are shown as blue bars, and targets preceded by incongruent structure as red bars. The error bars represent SEM.

2.7.2.2 Masked word identification data

All responses were first categorized into correct responses (correct identification of the masked word) and errors as presented in Table 2.3. Trials in which participants provided an incorrect paraphrase to the prime sentence were excluded from the analysis (15.14% of all data).

Table 2.3 Percentages of correct identification by first language speakers for both high/ low attachment structure and main/relative clause structure targets by condition (SEMs in parenthesis).

Condition	Correct Identification (%)	Condition	Correct Identification (%)
HA prime/HA target	70.88 (.05)	MC prime/MC target	60.25 (.06)
LA prime/LA target	55.12(.06)	RR prime/RR target	26.86 (.06)
HA prime/LA target	59.54(.06)	MC prime/RR target	21.33 (.05)
LA prime/HA target	53.33(.06)	RR prime/MC target	62.79 (.06)

The masked word identification data showed no effect of prime structure on the identification of the final words in the target structure either in the high/low attachment structure or the relative / main clause structure (All *p*s > .10).

2.8 Experiment 2: The role of syntactic priming in L2 word recognition

To examine the role of priming in word identification in L2, Experiment 2 was identical to the first experiment, except that participants were L2 English speakers.

2.8.1 Method

2.8.1.1 Participants

Thirty-two L1 Arabic speakers with L2 English from the University of Leeds took part in the experiment. The age of participants ranged from 18 to 30 (M = 24.7). Participants responded to the English History of Use questionnaire (Appendix A). They started to learn English at the mean age of 9.3 years and are regularly exposed to English through media and textbooks. Participants were asked to rate their proficiency in reading, writing, speaking, listening, and general proficiency on a 7-point Likert scale ranging from very poor to Native-like. Means are presented in Table 2.4

Table 2.4 Mean self-reported ratings of L2 proficiency (7 Points) for Experiment 2 (SEMs in parenthesis).

Skill	**Mean Proficiency (7 points)**
Listening	6.31 (0.60)
Reading	6.44 (0.56)
Writing	6.00 (0.70)
Listening	6.54 (0.56)
General Proficiency	5.94 (0.55)

2.7.1.2 Material and procedure

Design, material, and procedure are identical to Experiment 1.

2.8.2 Results

2.8.2.1 Lexical decision data

Trials with RTs with incorrect response and those with reaction times shorter than 100 ms or longer than 2000 ms (or 2.5 SD from the mean) were excluded from the analysis (13.58% of all data). Data on the non-words were considered fillers and are not reported here. Mean lexical decision latencies and error rates of the four experimental conditions for each syntactic structure are presented in Table 2.5.

Table 2.5 Mean lexical decision latencies (in ms) and % error rates of second language speakers for both high/ low attachment structure and main/relative clause structure by condition (SEMs in parenthesis).

Condition	**Latency (ms)**	**Error rate (%)**
High/Low attachment structure		
HA prime/HA target	538.02 (38.5)	10 (.05)
LA prime/LA target	609.40 (48.5)	14.70 (.06)
HA prime/LA target	664.98 (52.3)	8.10 (.04)
LA prime/HA target	523.63(52.6)	3.12(.05)
Main/ Relative clause structure		
MC prime/MC target	472.73 (33.8)	12.90 (.05)
RR prime/RR target	664.14 (54.1)	13.51 (.07)
MC prime/RR target	663.74 (52.3)	17.14 (.06)
RR prime/MC target	580.56 (72.4)	3.44 (.03)

2.8.2.1.1 Error rates

Error percentages data showed no effect of prime structure on the identification of the final words in the target structure either in the high/low attachment structure or the relative/ main clause structure (All *p*s $> .10$).

2.8.2.1.2 Reaction times

Reaction time data showed no effect of prime structure on the identification of the final words in the target structure either in the high/low attachment structure or the relative/ main clause structure (All *p*s $> .10$).

2.8.2.2 Masked word identification data

Trials in which participants provided an incorrect paraphrase to the prime sentence were excluded from the analysis (8.15 % of all data). Table 2.6 presents the percentages of correct word identification.

Table 2.6 Percentages of correct identification by second language speakers for both high/ low attachment structure and main/relative clause structure targets by condition (SEMs in parenthesis).

Condition	Correct Identification (%)	Condition	Correct Identification (%)
HA prime/HA target	64.10 (.04)	MC prime/MC target	36.15 (.03)
LA prime/LA target	36.11 (.08)	RR prime/RR target	33.33 (.06)
HA prime/LA target	37.83 (.07)	MC prime/RR target	20.58 (.07)
LA prime/HA target	55.55 (.05)	RR prime/MC target	33.33 (.06)

As for the high/low attachment structure, no interaction was found between prime type and target type for both low-attachment and high-attachment structure, $F1_{(1, 47)} = .05$, $p = .8.$, $F2_{(1, 23)} = 2.6$, $p = .1$.

For the relative/main clause structure, a 2x2 ANOVA crossing prime structure (relative clause vs. main clause) with target structure (relative clause vs. main clause) was conducted, revealing an interaction of prime and target structure, $F1_{(1, 47)} = 7.2$, $p < .05$, $F2_{(1, 23)} = 9.7$, $p < .05$ Final words in an ambiguous relative clause structure were processed more accurately following another relative clause structure than following a main clause structure. However, final words in a main clause structure were processed at equal speed whether it followed another main clause structure or a relative clause structure. Also, There was a main effect of structure, $F_{(1, 47)} = 6.6$, $p < .05$. Main clause target sentences elicited more correct identification responses than reduced relative target sentences.

2.9 Discussion

The aim of the present study was to examine the effect of trial-to-trial syntactic priming on the identification of words embedded in the target sentences. The study of word recognition requires an analytic approach that distinguishes between different types of context such as lexical, intra-lexical, syntactic, semantic, and interpretative contexts (Frauenfelder & Tyler, 1987). Such an approach is necessary to understand the relationship between a specific type of contextual information and the phase(s) of word

recognition at which it has its impact. Although the current findings don't distinguish between the three phases of word recognition(i.e. access, selection, and integration), it still provided a method to distinguish syntactic information from other types of semantic effects, to study the sole effect of syntax on word recognition.

Unpredictably, a huge error rate (more than 50%) was found for both L1 and L2 participants' responses to the reduced relative structure in the masked word identification task. A closer revision of the stimuli resulted in the realization that reduced relative stimuli in the present study are anomalous. The composition of this type of stimuli was inspired by the classical garden-path sentence "*The horse raced past the barn fell*". Despite the large line of research that examined syntactic processing of this type of structure, the grammaticality of that structure was challenged by Mckoon and Ratcliff (2003). Mckoon and Ratcliff (2003) argued that an unergative (manner-of-motion) verbs like "*raced*" have an internal control by the entity in the head position "*horse*", which grammatically contradicts with the passive meaning of the reduced relative. Based on a large-scale corpus study, Mckoon and Ratcliff (2003) concluded that reduced relatives of that type rarely occur with internal cause change of state verbs. All six verbs used in the present study have an internal control (declined, promised, hoped, volunteered, agreed, and intended), which renders the reduced relative sentences grammatically unacceptable.

Despite its ungrammaticality, lexical decision results showed that L1 speakers processed final words in reduced relative targets more rapidly following another reduced relative prime than following a main clause prime, indicating a priming effect. This aligns with previous research which showed that anomalous structures can be primed by L1 speakers of English (Ivanona, Branigan, Mclean, Costa, & Pickering, 2017; Ivanova, Pickering, Branigan, Mclean, & Costa, 2012; Ivanova, Wardlow, Warker, & Ferreira, 2017). For example, Ivanova et al., (2012) used a picture description task to examine L1 speakers' production of ditransitive structure (prepositional-object vs. double-object datives) as in "*The waitress gives the book to the monk*" after listening to a similar ditransitive structure with anomalous verb subcategorization as in "*The waitress brunks the book to the monk*" and "*The waitress exists the book to the monk*". Results showed that participant were able to produce

prepositional-object or double-object dative structures following primes that have the same structure regardless of whether the prime carried an anomalous or acceptable verb subcategorization. Later research also showed successful priming after exposure to anomalous primes with a missing verb as in "*The waitress ####the book to the monk*" and "*The waitress #### the monk the book*" (Ivanova et al., 2016).

The huge error rate found for L2 masked word identification data suggests that L2 speakers found the reduced relative structure unacceptable, similar to their L1 counterparts. Despite the high error rates, L2 speakers processed final words in a reduced relative clause structure more accurately following another relative clause structure than following a main clause structure, suggesting that L2 speakers are able to show priming of anomalous structure; however, this notion hasn't been examined in previous research

The primary purpose of employing reduced relative in the present study was to examine whether the effect of syntactic context on word recognition is maximized when it acts as a constraint for grammatical category (noun vs. verb). Therefore, reduced relative was chosen as it contains a final word that differ in category with the final word of the alternative main clause structure (verb vs. noun) which best serves the purpose of the present study; however, given its ungrammaticality, reduced relative data cannot be interpreted or generalized. In what follows, only results based on the high/low attachment structure are discussed.

Experiments 1 and 2 demonstrated no effect of syntactic priming on word recognition for both L1 and L2 participants either in the lexical decision task or the masked word identification task. Preceding sentences in both structures with another that shared the same global syntactic structure was hypothesized to affect target accessibility, which in turn could have led to faster response latencies, a hypothesis that was based on multiple previous comprehension priming studies in which the processing of a low-attachment structure prime led to facilitation in the processing of the disambiguation area (i.e. the prepositional phrase) of a target sentence that share the same low-attachment structure within a trial-to-trial paradigm. The present results suggest that, at the word level, syntactic knowledge was not strong enough to guide the recognition of the final word in

low-attachment structure.

Most research on the interplay between lexical and syntactic constraints demonstrates that the syntactic context can facilitate word recognition when it constraints for the critical word grammatical category. The syntactic context in the high/low attachment rather constrains the thematic role of the critical word, and not its grammatical category. It appears that the encoding of word category is part of the syntactic representation of language and can therefore be encoded in syntactic priming, whereas the thematic role encoding is part of a semantic representation that is not captured by syntactic priming. This is supported by previous evidence that priming of syntactic structure is not enhanced when thematic mappings or semantic features are repeated between prime and target sentences (Bock & Loebell, 1990; Huang et al., 2016; Messenger, Branigan, & McLean 2011), suggesting that semantic information such as thematic role is not incorporated into syntactic structure. This notion will be revisited in Chapter 4 of the present thesis.

The absence of priming in the high-low attachment structure supports a constraint-based approaches of syntactic processing (see section 1.7.2) (McDonald et al., 1994) that opposed the full independence of the syntactic processor and argued that different sources of information may interfere to help syntactic interpretation in early stages of processing and lead sentence processing. According to this approach, semantic information, discourse context, and even non-linguistic information interact with the syntactic processor to guide processing. Therefore, isolating syntactic information from other contextual effects by means of syntactic priming didn't contribute to word recognition in the low attachment structure. Accordingly, the present finding that syntactic information is not sufficient to prime low-attachment structure suggests that other sources of information underlie the processing of prepositional phrase-attachment ambiguities. This assumption is revisited in Chapter 4 of the present thesis.

Despite the main verb being repeated in our prime and target pair sentences, results showed an absence of a trial-to-trial priming effect in most conditions. This contrasts with most previous comprehension syntactic priming research that showed that the use of the same main verb in both the prime and target sentences helped in directing the

processing of the target sentences to apply the same parsing routine as the priming sentences (for a review, see Pickering & Ferreira, 2008). The enhanced effect of repeating the verb in both the prime and target sentence was referred to by the 'lexical boost effect' (see section 1.2). Studies that found trial-to-trial syntactic priming effect in comprehension without verb repetition are limited. Low- attachment PP structure was among the very few syntactic structures that showed lexically- independent priming that can occur without lexical boost. Previous evidence established a distinction between lexically independent and lexically dependent priming effect. While the former is a long lasting effect, the latter is a short-lived effect that relies on lexical boost. It was therefore suggested that different mechanism underlie each type of syntactic priming. While the lexically-dependent priming relies on residual activation that transfer across prime and target sentences, lexically-independent priming relies on an implicit learning mechanisms that is enhanced through repeated exposure to the prime structure. Given that the priming of low-attachment structure occurred without lexical boost in previous research (i.e. through lexically-independent priming), it is predicted that low-attachment structure can be primed through an accumulative priming paradigm rather than trial-to trial priming employed in the present study, which accounts for the absence of low-attachment priming in the present study (accumulative priming of low-attachment structure will be revisited in Chapter 3 and 4 of the present thesis).

Previous evidence showed that L2 speakers can benefit more from syntactic context than from semantic and moroho-syntactic context in word recognition (Chrabaszcz & Gor, 2014). Additionally, syntactic priming results acquired so far showed that L2 speakers indeed show more syntactic priming than native speakers (Nitschke et al., 2014). Therefore, it was predicted that L2 speakers might be more able to benefit from syntactic priming than their L1 counterparts. This is not evident here, as L2 speakers resembled their L1 counterparts in showing no effect for priming on word recognition. The present results support the accounts of shallow parsing mechanisms among L2 speakers (Felser, Roberts, Marinis, & Gross, 2003; Papadopoulou & Clahsen, 2003) and the "Good Enough" processing among L1 speakers (Ferreira, Engelhardt, & Jones, 2009; Ferreira & Patson, 2007). Both accounts claim that L1 and L2 over reliance on semantic processing might cause them to be easily misled by semantic context. As their

syntactic representations lack detail and complex structure, semantic information may override syntactic information in online processing. Indeed, in the present study, the use of an action main verb (e.g. repaired, opened, made) with the preposition "with" form a lexical semantic cue that strongly bias a high attachment structure in which the final preposition phrase carry "an instrument" thematic role (Ferretti, Mcrae & Hatherell, 2001). This might have imposed participants' over reliance on the semantic context and led them to stick to the initial interpretation of the thematic role of the critical word as an instrument rather than a modifier, which accounts for the absence of syntactic priming effect in both groups; however, same result might not borne out with other types of syntactic structures that lack similar lexical biases.

The present findings contradict with the interactive-activation model of speech perception (Elman & McClelland, 1984; McClelland & Rumelhart, 1981). This model suggests that higher-level information affect the representation of low-level units. For example, a letter embedded in a real word is better represented than a separate letter or letter embedded in non-word, referred to as word superiority effect. In this way, the behavior of each unit in the system depends on the behavior of other units to which it is connected. Similarly, the representation of a word depends on the representation of the context in which it is embedded. The more plausible and accessible the context, the better its constituents words are represented. In line with this model, many studies have examined the processing of words in congruent, incongruent, and neutral contexts (West & Stanovich, 1986). This is because contexts are informative as they affect choices between alternatives in one or more levels of lexical representation. The present experiment, similarly, examined whether the accessibility of an ambiguous syntactic structure by means of syntactic priming may affect the lexical representation of the words in a way that makes it easily integrated into its context. The present finding revealed no dependencies between the word and the context in which it occurs, at least for the examined low-attachment structure.

Chapter 3

Cross-modal Comprehension Syntactic Priming

3.1 Introduction

The present study aimed to investigate whether accumulative syntactic priming in comprehension can be a shared mechanism between reading and listening in L1 and L2. This is achieved by employing visual and auditory lexical decision tasks to examine whether syntactic priming in either the auditory or the visual modality can transfer to the other modality. The occurrence of bidirectional effect would indicate that syntactic priming effect results from an abstract syntactic representation rather than low-level perceptual strategies related to an individual modality. In addition, L2 speakers' sensitivity to syntactic adaptation will be revisited. L2 speaker's lack of syntactic adaptation in previous research (Kaan et al., 2018) might be attributed to the brief insufficient exposure to a few instances of the syntactic structure, or to the difficulties associated with L2 listening. Therefore, the present study increased the number of experimental items and included both reading and listening condition. So that factors modulating the occurrence of syntactic adaptation in L2 can be inferred.

3.2 Differences between reading and listening

Previous research indicated that there are no absolute differences between oral and written discourse (McCarthy, 2001); however, there is a very wide range of characteristics that are regularly specific to each modality. The following section focuses on particular modality-specific characteristics that might result in differences in the syntactic representation resulting in each modality and subsequently affect the transfer of the priming effect across the two modalities.

3.2.1 Differences in linguistic frequency

Oral and written discourses differ with regard to the frequency of occurrence with which linguistic items appear in each modality. For example, at the lexical level, written discourse has higher level of nominalization, meaning that it includes more nouns than verbs (Biber, 1988). Moreover, the frequency of a word when it is spoken is different

from its frequency in the written form. That is why linguistic corpora like British National Corpus (BNC) have separate entries for the frequency of spoken words and written words. At the level of syntax, written discourse tends to be more formal and more structurally complex than spoken discourse. Accordingly, some syntactic structures such as passive constructions, gerunds, attributive objectives, and participles are encountered more frequently in reading than in listening (O'Donnell, 1974).

Frequency of occurrence of syntactic forms and structures is one aspect which influences the occurrence of syntactic priming. Bock (1986) demonstrated that while the infrequent passive structure produced a priming effect, its frequently occurring counterpart (i.e. active structure) showed no priming effect. This result was extended to a wide range of comprehension priming research which mainly involved complex and ambiguous structures (Ledoux et al., 2007; Scheepers & Crocker, 2004; Sturt et al., 2010; Traxler, Tooley, & Pickering, 2014; Traxler, 2008). This phenomenon was called the inverse frequency effect. As discussed earlier, the implicit learning account of syntactic priming suggested that the prediction error that results from the processing of an ambiguous prime sentence is the cause of the syntactic priming effect. Subsequently, infrequent or ambiguous syntactic structures that result in a larger prediction error can prime more than the more frequent structures. Hence differences in frequency across the written and oral discourse could result in differences in the magnitude of the priming effect produced in each modality.

3.2.2 Prosody of speech vs. punctuation in writing

Speech is characterized by prosodic features such as tones, pauses, stress, and intonation. These features have the advantage of signifying the meaning in a way that facilitates comprehension. For example, prosody can perform functions such as signifying breaks between sentences, signaling the difference between old and new information, and distinguishing between questions and statements. Similarly, written discourse is characterized by the punctuation marks (e.g. period, question mark, semi colon), which might, or might not fulfill the same functions as prosody. For example, period and question mark signal the difference between statements and questions similar to the intonation in prosody; however, written discourse doesn't have marks that

signal different emotions and attitudes similar to what intonation does in speech. Most relevant research considers prosody more effective in facilitating comprehension than punctuation (Miller & Weinert, 1998, p.198; Townsend, Carrithers, & Bever, 1987). Accordingly, much research has been conducted to examine the role of prosody in facilitating comprehension (see Dahan, 2015, for a review).

As for the low-attached vs. high-attached prepositional phrase structures employed in the present study (e.g. "*the teacher fixed the essay with a marker*", and "*the teacher fixed the essay with an error*", respectively), it was shown that native speakers use distinct prosodic features to distinguish between the two counterpart structures (Price, Ostendorf, Shattuck-Hufnagel, & Fong, 1991; Straub, 1997) with a greater duration of the word preceding the preposition along with a lengthened pause before the preposition for the high-attached prepositional phrase. Conversely, Low- attached PP structure is not pronounced with such prosodic boundaries, which was shown to lead to the disambiguation of the low-attachment PP structure (Warren, Schafer, Speer, & White, 2000). Such prosodic features might subsequently facilitate the disambiguation of the low-attachment structure in listening compared to in reading, meaning that a greater prediction error would be associated with the processing of that structure in reading, which subsequently, as predicted by the error-based implicit learning account of syntactic priming, lead to stronger priming of that structure in reading.

3.2.3 Long lasting written discourse vs. transient speech

In reading, the entire discourse is simultaneously present, meaning that the reader might retreat back at any point to the beginning of the sentence, whereas listening disappears instantaneously, so listeners cannot backtrack. Accordingly, reading is a self-paced process in which the reader has the opportunity to attend to peripheral details along with the central idea. Conversely, with the time constraint imposed in listening, listeners are forced to disregard minor details and focus on the main idea, which might result in a misinterpretation of the intended message. Moreover, there is evidence that monolingual listeners tend to perform shallow and partial syntactic processing to be able to keep up with the rapidly incoming linguistic input (Christianson, Hollingworth, Halliwell, & Ferreira, 2003; Ferreira, Christianson, & Hollingworth, 2001). This issue

goes in line with the 'Good Enough' approach to comprehension (Ferreira, Engelhardt, & Jones, 2009; Ferreira & Patson, 2007), which proposes that the system compensate for the limited processing resources by abandoning detailed and accurate syntactic analysis and relying more on semantic representations.

The 'Good Enough' approach was shown to affect the occurrence of syntactic priming in oral production (Christianson, Luke, & Ferriera, 2010). Christianson et al., (2010) used a picture description task in which participants first listened to implausible passive and active sentences such as "*The dog was bitten by the man*", and "*the man bit the dog*", and then described simple drawings depicting transitive actions. Results revealed that both plausible passives and implausible actives primed passive constructions. When faced with ambiguity, participants adopted the semantically plausible interpretation rather than the accurate, but implausible, syntactic representation, which hindered the occurrence of syntactic priming. Such 'Good Enough' mode of processing weakens the syntactic priming effect in the oral modality as compared to the written modality.

In summary, the mechanisms that underlie the syntactic priming effect don't favor one modality over another. Although some features such as prosody and richness of contextual cues are expected to strengthen priming in listening, other features such as the evanescence, reviewability and self-paced aspect of reading are predicted to support the occurrence of priming in reading more than in listening. Hence the superiority of one modality over another with regard to the occurrence and ease of the priming effect is not a clear cut.

3.3 Research on differences between listening and reading processing systems

3.3.1 Lexical access in listening and reading

Lexical access starts with a sensory coding process in which the phonemes received from listening and letters received from reading are transformed into a mental code. Visual items result in a very short-lived iconic code (less than 1000 ms), whereas auditory items produce a relatively long-lasting echoic code (3-4 seconds) (Baddeley, Eysenck, Anderson, 2009). Then for lexical access to occur, the activated code has to match the corresponding word representation in the mental lexicon. The mental lexicon

is a mental store which preserves information about the form and meaning of words. Much evidence supports the fact that the stored word representations in the mental lexicon take three forms: A phonological representation, an orthographic representation, and an amodal semantic representation (Jahandarie, 1999, p.154). Due to these different stored forms, it was hypothesized that sensory codes take two distinct routes to meaning, an orthographic route for visual forms and a phonological route for auditory forms. This dual phonological and orthographic route to meaning is advocated by evidence that visual lexical access reacts differently from auditory lexical access to some variables. For example, the identification of non-words in auditory lexical access depend on the first few phonemes of the word regardless of the syllable structure, whereas in the visual modality, the first syllable forms the code for access (Taft, 1986). In addition, an ERP study by Holcomb and Neville (1990) showed that auditory lexical access takes place before the word is pronounced in full, whereas visual lexical access is more delayed. In addition, auditory lexical access has a larger magnitude, and lasts longer than visual lexical access, implying that lexical access takes place throw distinct phonological and orthographic routes.

3.3.2 Evidence from neurological studies

Moreover, the distinctiveness of phonological and orthographic representations is supported by the neuropsychological studies that showed dissociation between the reading processing system and the auditory system. For example, it was observed that aphasic patients maintain their visual word recognition ability in the presence of a dysfunctional phonological system (Caramazza & Hillis, 1990, 1991). This indicates that adults develop a visual input system that is independent of the oral phonological system. Other modality-specific neurological dysfunctions included deficits in verbal, but not oral, production of abstract words among deep dyslexic patients (Tyler & Moss, 1995); production of verbs among brain damaged patients who responded differently to oral and written tasks (Caramazza & Hillis, 1991); and deficits in performing visual naming task as compared to auditory naming in aphasia (Endo, Makishita, Yanagisawa, & Sugishita, 1996). These findings support the independence of reading and listening systems.

3.4 Cross-modal priming paradigm

Given the distinct phonological and orthographic routes, cross-modal priming can be used as a method to test for modality-independence of mental representations. In the uni-modal priming experiments, the processing of a particular item (i.e. prime) results in facilitation in the processing of another item (i.e. target). This facilitation could be accounted for by a shared abstract mental representation between the two linguistic items, or the sharing of lower-level perceptual features that are specific to the modality in which both items are presented. The occurrence of cross modal priming enables attributing the resulting facilitation to the underlying shared representations. Indeed, cross-modal priming was used as a method to examine shared semantic and morphological representations underlying single words (e.g., Longtin, Segui, & Halle, 2003; Marslen-Wilson, Tyler, Waksler, & Older, 1994; Meunier & Longtin, 2007). In that task, prime words are presented orally, and at its offset, target sentences are presented in a written form, then participants perform a lexical decision task on the target words only. Prime and target words are, therefore, presented cross-modally to control for modality-specific sensory features that could otherwise interfere in a within modality condition.

Marslen-wilson et al., (1994) provided one example of the use of cross-modal priming paradigm in preventing interference from modality-specific features. In a seminal article, cross modal priming paradigm was used to examine the mechanisms underlying the processing of morphologically complex words (e.g. "*dark-ness*" and "*depart-ment*"), specifically, whether morphologically complex words share lexical representation with their stems (i.e. "*dark-darkness*" and "*depart-department*"). Results showed priming only between prime and target pairs in which the meaning of the full form can be derived from the meaning of its stem (e.g. "*dark - darkness*"); however, prime and target words in which the meaning of the whole form cannot be derived from its stem (e.g. "*depart - department*") didn't show priming. Thus the resulting facilitation in the processing of the target word in the former condition can be attributed to higher-level semantic representation shared between the prime and target words. Cross-modal priming task was specifically chosen to control for effects resulting from "lower level overlap in modality-specific access pathways" (Marsle-Wilson et al., 1994, p.6) that

would otherwise obscure the higher-level shared semantic and morpho-syntactic representation. Similarly, it is hypothesized in the present study that shared syntactic representations underlying prime and target sentences can be tested cross-modally to control for low-level sensory features specific to one modality or another.

3.5 The phonological recoding process in reading

Differences between listening and reading are eliminated by the fact that reading involves a phonological recoding process similar to that generated in listening. Upon encountering a written word, both phonological and orthographic representations are activated. This can be inferred from the observation that readers tend to sound out the written words while reading. Supportive evidence comes from findings of priming studies which showed facilitation in naming target words that were primed by related words that are misspelled but phonologically similar (e.g. "*tode*" primes "*frog*"). The size of priming was as equal as the condition in which the correctly spelled primes were used (i.e. "*toad*") (Lukatela & Turvey, 1993, 1994). However, no priming was found when misspelled primes with different sounds were presented (e.g. "*towed*"), indicating an activation of the phonological code for read words. In a different set of studies, homophonic anomalies (such as "*blew*" replacing "*blue*") were shown to be less easily identified by readers than non-homophonic anomalies such as "*blow*" replacing "*blue*" (Coltheart, Patterson, & Leahy, 1994; Rayner, Pollastek, & Binder, 1998).

Therefore, many models of reading involve a phonological recoding component, for example, the Dual Route Cascade model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) proposed that a word is accessed into the mental lexical through applying a set of 'rules' that is used to transform a word from its graphemes into the corresponding phonological representation. In addition to the 'rules' route, there is a direct rout that involves a direct and quicker mapping between the whole word and its whole phonological representation. Another common model of reading is the connectionist triangle models (Harm & Seidenbeg, 2004) which assumed that activation resulting at the input processing unit for the orthographic representation is collected and spread across connections to other output units representing phonological output, so all words are transformed into their phonological representation through a single set of

connections. Thus although different models underlie different mechanism, the general consensus is that the orthographic representation is transformed into a phonological representation, indicating that the same representations underlie listening and reading.

3.6 Differences between listening and reading in sentence comprehension

At the sentence level, comprehension involves integrating the incoming words into the sentence context through combining semantic, syntactic and pragmatic sources of information in both bottom-up and top-down manner. One can expect sentence integration to be similar in both modalities as the same semantic, syntactic, and pragmatic roles are employed in both modalities. In addition, language users who show high proficiency in reading comprehension are likely to be highly proficient in listening comprehension (Townsend, Carrithers, & Bever, 1987), suggesting that the same skills and processes underlie reading and listening comprehension. Moreover, listening and reading don't differ in their effect on comprehension (Moyer, 2011; Rogowsky, Calhoun & Tallal, 2016). Also, early research showed that there are no differences between reading and listening with regard to the contextual effects on comprehension (Cambourne, 1981). Nevertheless, there are some modality-specific characteristics that might hinder comprehension. First, the echoic code resulting from listening lasts for a longer time than the iconic code in reading, which gives privilege to the sentence-level integration in listening rather than reading. This is because maintaining words that exist early in the sentence till later words are perceived is possible in listening than reading. However, this advantage is compensated for in reading by the widely accepted finding that both listening and reading results in a phonological code that is produced along with the naturally generated orthographic code for literate people in reading. Second, the fact that, in reading, The entire discourse is simultaneously present means that the reader might retreat back at any point to the beginning of the sentence, suggesting that the memory code resulting from reading doesn't have to be as long-lasting as in listening. In summary, although different mechanisms seem to underlie reading and listening, such mechanisms are not expected to lead to intrinsic processing difference between the two modalities.

3.7 Shared syntactic priming in previous research

Although different theoretical accounts and mechanisms underlie syntactic processing in comprehension and production (Bock, 1987; MacDonald, 2013), Shared syntactic priming has been detected in studies that investigated syntactic priming from comprehension to production. In comprehension-to-production priming studies, sentence comprehension was shown to affect the production of a subsequent sentence, suggesting that syntactic priming result in an abstract syntactic knowledge that transfer from comprehension to production. Van Gompel, et al., (2006) found comprehension to production priming in a spoken sentence completion task. In this study, subjects were more likely to produce transitive than intransitive sentences after reading an ambiguous prime sentence like "*when the decorator was cleaning the doors that were to go on the new kitchen units were delivered* ", which means that they retained the activation of the wrong initial transitive interpretation of the first clause.

Shared syntactic representation across speaking and writing (i.e. production modalities) was investigated by Cleland and Pickering (2006) who examined cross-modal syntactic priming from speaking to writing and from writing to speaking. Findings showed syntactic priming across both production modalities. In a sentence completion task, the prime sentences were either spoken or written by the participants, whereas the target sentences were only spoken in the first experiment and written in a second experiment. The syntactic structure employed was the prepositional dative structure and its double-object alternative.

In comprehension, cross-modal syntactic priming was shown from reading to listening using a visual world paradigm task (Arai et al., 2007; Arai et al., 2015; Scheepers & Crocker, 2004). For example, Arai et al., (2007) conducted a study in which participants first read prime then listened to a target sentence in either a prepositional object dative structure like "*the pirate will send the necklace to the princess*" or a double object structure like "*the pirate will send the princess the necklace*". Target sentences were presented with pictures that depict the three referents in the sentence, for example, a picture of a pirate, a princess, and a necklace. Eye fixations were recorded using eye-tracking technique. Upon hearing the verb in the target (i.e. "*will send* "), participants

were more likely to gaze (anticipatorily) at the princess after having read a double object prime aloud but more likely to gaze at the necklace after having read a prepositional object prime. Nevertheless, these studies did not investigate the opposite direction (i.e. from listening to reading). In addition, the cross modal (reading–listening) syntactic priming effect was not compared to a control condition of within - modality (listening-listening) priming.

3.8 The accumulative effect of comprehension syntactic priming

The accumulative syntactic priming effect was shown to occur within-modally either in reading (Fine et al., 2013) or in listening (Fine & Jaeger, 2013), however, the persistence of this accumulative effect between the two comprehension modalities hasn't been investigated before either for first language or second language speakers. As discussed earlier, accumulative priming (syntactic adaptation) builds up gradually as the language user is exposed to more items of a particular structure. Comparing syntactic adaptation in the two modalities using the same syntactic structure and task would enable examining how modality-specific aspects interfere in the occurrence of syntactic priming, especially with L2 speakers who were shown to perform differently in each modality as discussed in the coming section.

3.9 Listening difficulties in second language

L2 speakers face more difficulty in listening than in reading. A major cause for the superior listening disadvantage in L2 is L2 speakers' inability to prevent activation of L1 lexica while listening in L2. Word recognition in listening involves the activation of multiple word candidates (Marslen Wilson & Welsh, 1978), referred to as competitors, then competition proceeds between these competitors until the recognition occurs. Thus the difficulty in word recognition increases with larger number of competitors. Upon hearing a word, second language speakers activate not only L2 competitors, but also competitors from their L1. The set of activated competitors is therefore increased by words that are phonologically similar across L1 and L2. For example, Dutch listeners activated the word "*kist*", meaning "*chest*" upon hearing the English word "*kitten*" (Weber & Cutler, 2004) and English listeners activate the word "*pool*" upon hearing the French word "*poul* ", meaning, *"chicken"*.

Another difficulty in L2 listening results from the segmentation of the auditory input. In the written input, boundaries between letters, words, and sentences are clearly separated by spaces, which enables the reader to identify beginnings and ends of letters and words. Conversely, the speech signal is continuous. Prosodic features occur within words as well as between words, which doesn't help in overcoming difficulties in speech segmentation. L1 speakers rather resort to language-specific segmentation strategies to overcome difficulties of speech segmentation. Such segmentation strategies are a type of linguistic knowledge that is acquired from everyday experience with language, which makes L2 learner less efficient in employing such strategies; for example, syllable-based segmentation strategy is employed in French, whereas in English, segmentation is stress-based. However, Cutler, Mehler, Norris, and Sequi (1986) found that French participants tend to perform syllable-based segmentation while listening to English, whereas English listeners don't use the same strategy while listening to French. In addition, Both English and French listeners use their L1 segmentation strategies while listening to Japanese in which segmentation is based on a different sub syllabic unit called "mora", indicating that L2 listeners use their L1 segmentation strategies while listening in L2. Other causes for L2 lack of efficiency in segmentation include their limited lexical knowledge (Mattys, Carroll, Li, & Chan, 2010) and their uncertainty about legal sound sequences (Weber & Broersma, 2012).

Difficulties in L2 lexical access and segmentation cause lack of processing automaticity among L2 listeners (Lim & Godfroid, 2015). Automaticity doesn't merely mean fast processing, but also an increased ability of parallel processing without having to eliminate one of the stages of processing (Segaloitz, 2003, 2005). Sentence processing mainly involves two stages: lexical access of single words, and the integration of these words into its context. Given the temporal constraint imposed in listening, mental resources can be overly consumed in processing the bottom up signal to an extent that hinders the syntactic integration process, and subsequently hinder syntactic adaptation (i.e. accumulative priming) in listening. This is supported by previous evidence that showed L2 difficulties in integrating multiple sources of information when performing time- constrained online tasks (Rah & Adone, 2008).

3.10 Aim of the study

The aim of Experiment 3 was to investigate whether the priming produced in each of the listening or reading modalities would transfer to the other modality in both L1 and L2. According to Bock and Loebell (1990), the facilitation in comprehension in syntactic priming studies might be caused from facilitation in the perceptual procedures involved in listening comprehension or reading comprehension themselves rather than from a syntactic priming effect. However, since no intrinsic processing differences exist between reading and listening, and given the fact that shared syntactic priming was detected in previous research, it is predicted that the syntactic priming effect can transfer cross-modally from reading to listening and listening to reading. As for L2 speakers, difficulties associated with L2 listening in processing ambiguous structures might hinder the occurrence of syntactic adaptation in listening. If accumulative priming occur in reading and not in listening, then its absence will be attributed to difficulties of L2 listening; whereas, the absence of accumulative priming in both reading and listening would indicate that L2 speakers are less able to adapt to the syntactic probabilities of the context. Alternatively, L2 speakers might tend to exploit the grammatical knowledge resulting from syntactic priming to mediate listening difficulties such as segmentation, coping with variation in the acoustic of words, and recognizing novel words. Syntactic priming in this sense would disambiguate the speech signal and guide the processor's analysis to match the syntactic probabilities of the context.

The present study employed an NP-attachment ambiguity[3] as in "*The cook made a birthday cake with a candle*" or the more familiar VP-attachment counterpart structure "*The cook made a birthday cake with a mixer*". To examine modality-independence of syntactic priming, prime and target sentences differed in their modality of presentation such that in the listening-to-reading condition, prime sentences were listened to while target sentences were read whereas in the reading-to-listening condition, participants read the primes then listened to the targets.

[3] Throughout the present thesis, the compound word NP-attachment is used interchangeably with the compound word low-attachment to refer to the same structure. Similarly, VP-attachment is used interchangeably with high-attachment to refer to the same structure

Prior to examining cross-modal priming, within-modal accumulative priming was examined by presenting all sentences in the same modality. This was necessary to act as a baseline to which target sentences in the cross-modal condition can be compared. The first study of the current thesis yielded a priming effect in listening for the same syntactic structure; however, the number of stimuli was increased in the present experiment as it examined an accumulative priming effect that strengthens with repeated exposure to several instances of the syntactic structure. Therefore, more sentences were added to guarantee that an absence of the priming effect in the cross-modal conditions would result from the change in modality rather than to the use of insufficient number of primes. In addition, the first study of the present thesis examined priming in listening, whereas, the present experiment examine the occurrence of accumulative within modal priming in both reading and listening. Similar to the first study, the present study employs a lexical decision task. This is intended to enable comparison with the first study. In addition, lexical decision is employed here for the same reasons as in the first study (see section 2.5 for full explanation).

3.11 Experiment 3: Cross-modal priming in L1

3.11.1 Method

3.11.1.1 Participants

The study included 80 participants who are between 18-35 (M = 18.2) years of age from undergraduate and postgraduate students at the University of Leeds. All reported normal vision and hearing, and no neurological impairment

3.11.1.2 Material

The study has a between-groups design in which participants were assigned to one of four lists, two within modality lists and two cross-modality lists. The two within-modality lists were: 1) a reading list in which participants read all sentences and performed on a visual lexical decision task, and 2) a listening list in which participants listened to all sentences and performed an auditory lexical decision task. The other two lists were between-modality lists. In the reading – listening list, participants read the first four blocks of the list and listen to the fifth block (reading-listening group), whereas in the listening-reading list, participants listened to the first four blocks and

read the fifth (see Table 3.1). Reading blocks were visually presented and included a visual lexical decision task, whereas listening blocks were heard and included an auditory lexical decision task.

Each list included 30 experimental sentences. Fifteen sentences were disambiguated towards low-attachment structure (LA) (e.g. "*the man fixed the box with a whole*") and fifteen disambiguated into the high-attachment (HA) counterpart (e.g. "*the man fixed the box with a tool*") (see Appendix D). Experimental sentences were created from six action verbs that cause syntactic ambiguity in a low attachment structure (*hit*, *cleaned*, *fixed*, *repaired*, *opened*, *made*). The two types of sentences were alternated over five similar blocks, resulting in six sentences per block, three in the low-attachment structure and three in the high-attachment structure. Two versions of each of the four lists were created to counterbalance sentence structure so that low-attachment version of each sentence appears in one list version and its high-attachment counterpart appears in the other. Order of item presentation was counterbalanced so that each six items appeared in the same block for equal number of participants.

Table 3.1 Summary of design and material for the cross-modal conditions in Experiments 3 and 4.

Condition	**Reading-listening list**	**Listening-reading list**
Blocks 1-4	12 LA sentences	12 LA sentences
	12 HA sentences	12 HA sentences
	50 fillers	50 fillers
	All presented visually	All presented auditorily
Block 5	3 LA sentences	3 LA sentences
	3 HA sentences	3 HA sentences
	10 fillers	10 fillers
	All presented auditorily	All presented visually

In addition to the experimental sentences, the study involved 60 filler sentences (Appendices D.3, D.4). Between one and three filler sentences intervene between the

prime and target sentences. The filler sentences are of randomly chosen structures and occupied different list position for each participant. To reduce interference from the syntactic structure of the fillers, the filler sentences had structures other than the experimental target structures. For the purposes of the lexical decision task, some of the filler sentences end with a non-word. Non-words were generated by a stimulus generation program presented by the English lexicon project that generates list of non-words according to specific lexical characteristics (Balota et al., 2007). Non-words were matched with real experimental words with respect to word mean length and mean bigram frequency. Six practice items will precede the experiment to allow participants to ask questions about the procedure. Each experimental and filer sentences were followed by a yes/no comprehension question.

The predictability of the final experimental words was controlled for by a cloze test. The cloze test was a sentence completion task in which all the experimental sentences were presented with the final critical words replaced with a gap. Twenty participants were asked to fill in the gap with the first word that comes to mind. The experimental words produced an average cloze probability of 2.3% (range 0% - 5%). None of the words were found highly predictable. To control for the lexical characteristics of the target words, the two groups of words embedded in each of high-attachment and low-attachment structure sentences were matched with respect to response time latencies values which were extracted from the British Lexicon Project (Keuleers, Lacey, Rastle, & Brysbaert, 2012).

3.11.1.3 Procedure

The stimuli in this experiment were presented by the use of DMDX (Forster & Forster, 2003). A female speaker with a standard British English accent recorded the listening stimuli using Audacity software. Both LA and HA sentences were recorded using a neutral intonation such that a stop before the preposition phrase was avoided to prevent bias to the HA structure. Each subject was tested individually in a silent room. Participants were instructed to listen to or read the sentences and to state whether the last word is a real word or a non-word by pressing one of two keys. In the reading trials (see Figure 3.1), a fixation point first appeared for 500 ms on the screen at the same

place where the first letter of the sentence is to appear. Participants were instructed to keep their fingers on the buttons at all times to encourage quick responding. The 'yes' response key was always pressed with the dominant hand and the 'no' response with the non-dominant hand. After that, sentence context up to the word preceding the final word appeared for 3000 ms with the position of the final target word marked with dashes. Immediately after the sentence context disappeared from the screen, the final target word was displayed for 1000 ms. The participants were given 2500 ms to give a response. Response time is measured by the software from the onset of the target word.

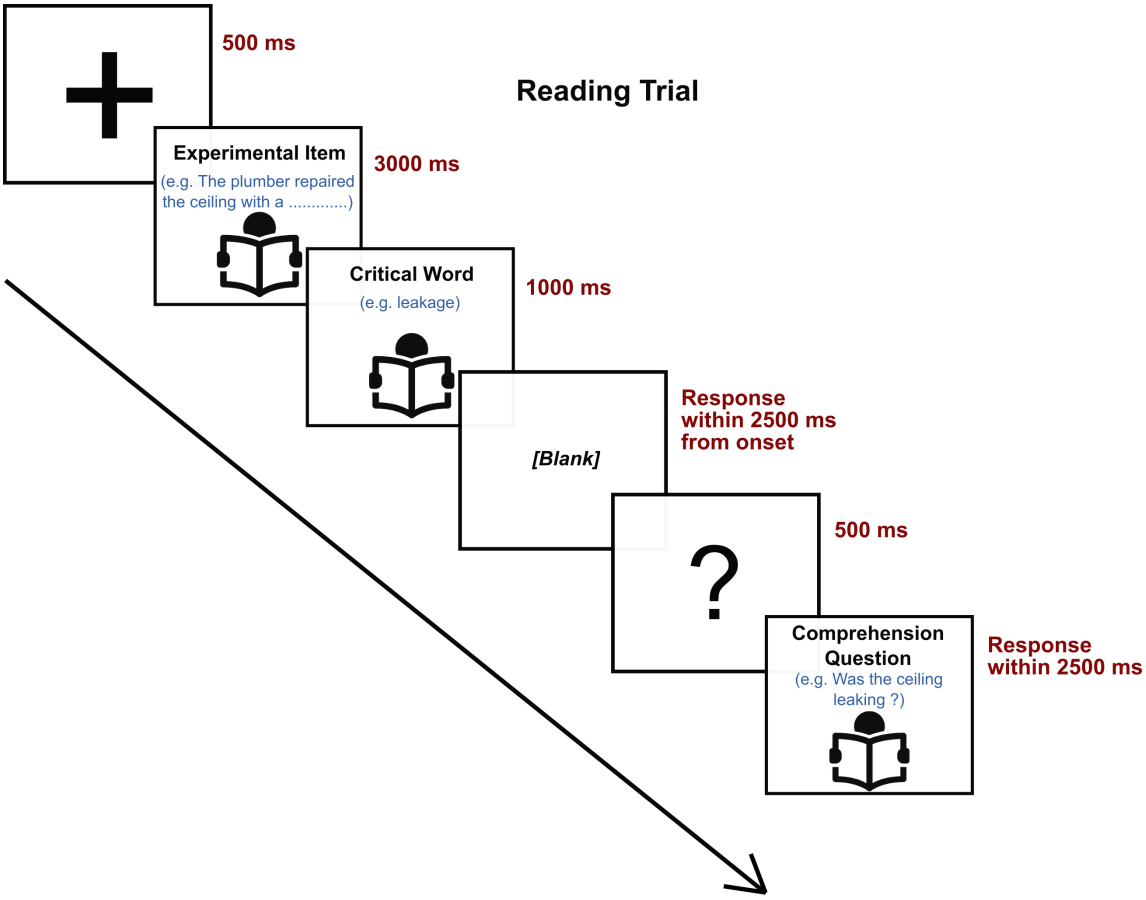

Figure 3.1 Experimental procedure for the reading trials

In the listening trials (Figure 3.2), a fixation point appears on the screen for 500 ms before the sentence is displayed. Participants are allowed 2500 ms to give an answer. Following both reading and listening trials, the probe 'Question' was displayed for 500 ms, then the comprehension question was presented. Participants were allowed 2500 ms to answer the comprehension question.

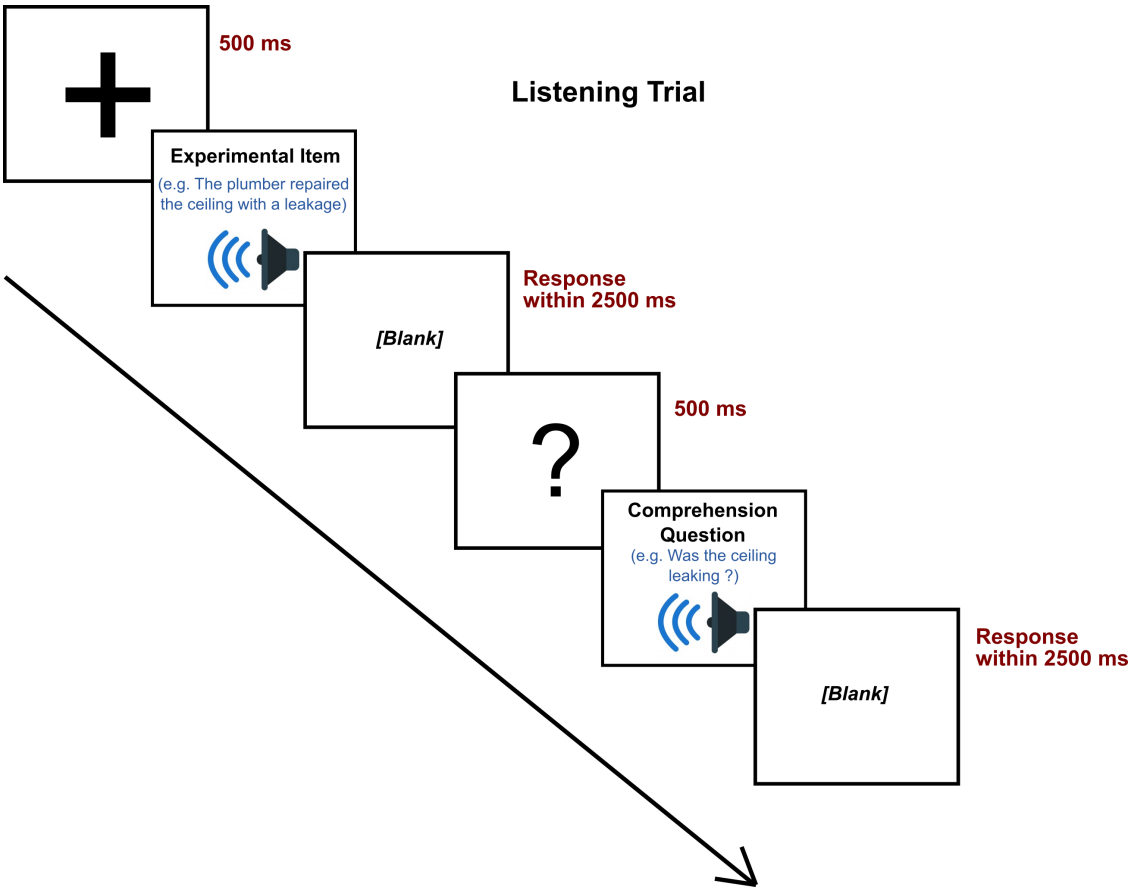

Figure 3.2 Experiment procedure for the listening trials

3.11.2 Results

3.11.2.1 Reading

First, RTs of items to which the following comprehension question was answered incorrectly were excluded from the analysis. The within-modality group made 17.5% errors, whereas the between modality group made 10% errors of all the reading items in the (listening-reading) condition. In addition, erroneous responses, RTs longer than 2000 ms or shorter than 200 ms were also excluded, resulting in the exclusion of additional 4.6% of all data for the within modality group, and 2.5% for the between modality group.

Repeated exposure to the ambiguous low-attachment structure throughout the list is expected to lead to an accumulatively generated priming effect that will eliminate the processing difficulty towards the end of the list, leading critical words in sentences at

the later blocks to be more easily processed than in sentences occurring earlier in the list. The effect is predicted to be observed in the low-attachment ambiguous structure rather than its familiar high-attachment counterpart. Accumulative priming would be attributed to the prediction error resulting from processing the low-attachment ambiguity. Mean RTs and error percentages are presented in Table 3.2.

Table 3.2 Mean RTs (in ms) and errors (%) as a function of block order for both LA and HA structures in reading, first language speakers (SEMs in parenthesis).

	Low-attachment		**High-attachment**	
Dependent measures	**RT (ms)**	**% Error**	**RT (ms)**	**% Error**
Within-modal list (1st block)	995.8 (62.8)	26.6	845 (47.8)	18.3
Within-modal list (2nd block)	906.1 (72.8)	16.6	809.8 (49.3)	20
Within-modal list (3rd block)	808.9 (33.9)	35	843.9 (101.2)	28.3
Within-modal list (4th block)	719.3 (36.7)	20	769.6 (55.2)	16.6
Within-modal list (5th block)	653.6 (23.1)	21.6	729.6 (42.9)	13.3
Cross-modal list (5th block)	716 (39.6)	13.3	750.8 (56.9)	16.5

3.11.2.1.1 Error rates

The most prominent proof of the occurrence of priming would be the finding that the performance is affected by the order of the block in which the sentence occurs. To assess the occurrence of such an accumulative priming effect, a 2x5 repeated measures analyses of variance ANOVA was conducted crossing sentence structure (LA vs. HA) with block order in which the item occurs within the list (i.e. first, second, third, fourth, or fifth block). Results revealed no interaction, $F1_{(1, 19)} = .14$, $p = .7$. All items were responded to with equal accuracy throughout the whole list. Given that error data of the reading condition showed no within-modal priming effect, it cannot be used as a control for a cross-modal condition. Hence, error rates analysis of cross-modal priming in L1 listening is not included.

3.11.2.1.2 Reaction times

A 2x5 ANOVA with structure (LA vs. HA) and block order (i.e. first, second, third, fourth, or fifth block) as independent variables and reaction time as the dependent variable revealed an interaction, $F1_{(1, 19)} = 2.58$, $p < .05$. Mean comparisons showed that LA items in first block elicited longer reaction times than LA items in the third $p < .01$, fourth $p < .000$, and fifth blocks, $p < .000$. Also, there was a main effect of block order, $F1_{(1, 19)} = 7.17$, $p < .000$.

To examine the occurrence of cross modal syntactic priming (from listening to reading), we ask whether critical words read during the last block (reading block) of the cross modality list were processed at the same speed as words included in the same block in the within-modality list. To address this, a 2x2 mixed ANOVA was conducted between groups (cross modal vs. within modal) for each structure (LA vs. HA) on response times. Results revealed no interaction, $F1_{(1, 38)} = .42$, $p = .5$. LA items in the fifth block of the listening-reading list and the reading list elicited equal reaction times, indicating the occurrence of cross-modal priming.

Cross-modal priming was additionally examined by comparing the fifth block of the cross-modal list to the first block of the within-modal list. A difference in processing between the two blocks would indicate that a priming effect was accumulated throughout the cross-modal list leading sentences in the last block to be more easily processed than in the first block of the within-modal list. A 2X2 mixed ANOVA crossing structure (LA vs. HA) with block position (cross-modal list 5th block vs. within modal list 1st block) revealed an interaction, $F1_{(1, 38)} = 5.83$, $p < .05$, which strengthens the evidence supporting the occurrence of priming (see Figure 3.3). Also, there was also a main effect of block position, $F1_{(1, 38)} = 8.6$, $p < .05$., with sentences appearing early in the list processed less rapidly than items appearing in later blocks.

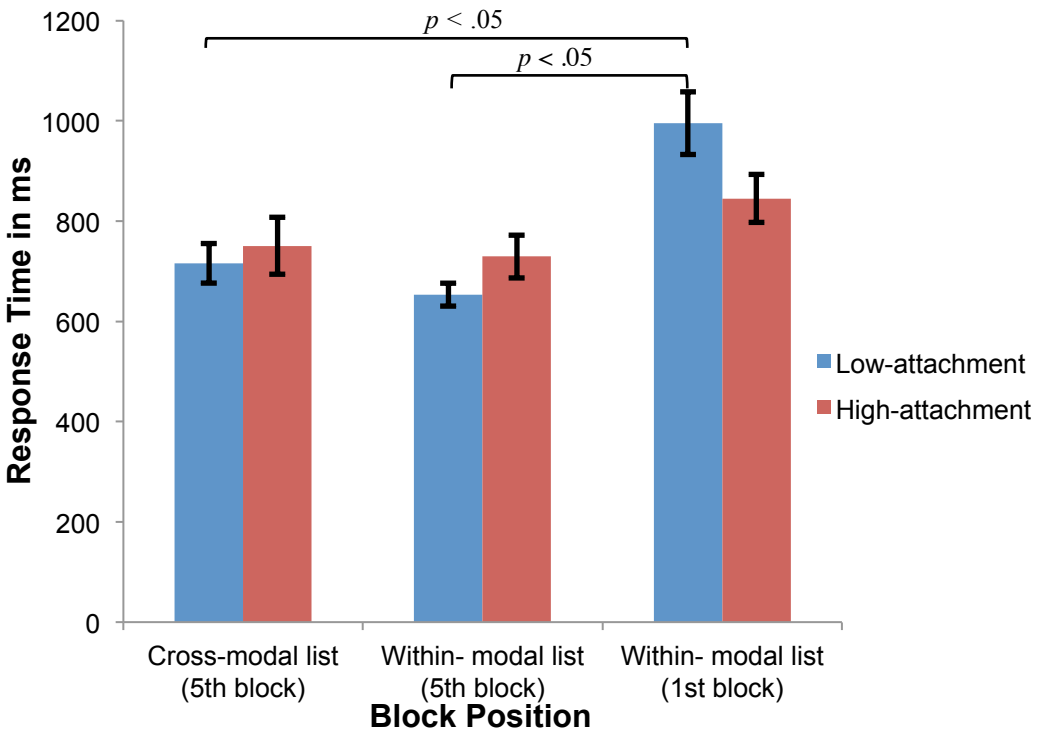

Figure 3.3 Reaction times (in ms) in reading split by structure and block position for first language speakers. Low-attachment target words are shown as blue bars and high-attachment target words as red bars. The error bars indicate SEM.

3.11.2.1.3 Mixed effects analysis

The accumulative effect of syntactic priming was assessed through the use of regression mixed effects model in which RTs are regressed onto the main effects and interactions of sentence structure (high attachment vs. low attachment), and block order (from 1-5). To control for task adaptation, stimulus order was also included as a predictor representing item position among other experimental, filler, and practice items. The difference between block order and stimulus order is that block order is a predictor of the occurrence of syntactic priming as exposure to more items throughout the list is predicted to produce the priming effect in late blocks compared to early blocks, whereas, stimulus order is a predictor of the increased speed of processing resulting from increased adaptation to the task throughout the list (i.e. learning/training effect). Maximum random effects structure justified by the data was included. Table 3.3 presents model estimates. The best fitting random effect structure was determined by

beginning with the maximal version of the model. If the maximal model wouldn't show convergence, random effects were eliminated based on their variance such that random effects causing the least variance were removed first until the model reached convergence. The interaction between structure and block order was significant, β = - 63.27, $p < .05$. Participants adapted to the less frequent low-attachment structure through the occurrence of syntactic priming effect that resulted in faster RTs towards the end of the list.

Table 3.3 Mixed effects model estimates for reaction times[4] in within-modal reading, first language speakers.

Coefficient	**Estimate**	**S.E.**	**t-value**
Intercept	652.5	436.53	1.4
Structure	109	103.15	1.05
Block Order	-22.4	56.11	-0.40
Stimulus Order	81	351.69	0.23
Structure x Block Order	- 63.27	28.38	-2.22

Cross-modal syntactic priming was assessed by comparing performance on the last block between within- and cross- modal groups. Fixed effects included in the structure of the regression model included group (cross-modal vs. within modal), structure (LA vs. HA), and stimulus order (to control for task adaptation). The model also included maximal random effects structure justified by the data. Results revealed no group by structure interaction β = 108, p = .82, revealing no differences in processing the last block between within-modal and cross-modal groups, which confirms ANOVA results.

3.11.2.2 Listening

RTs of items followed by an incorrect response to the comprehension question were excluded from the analysis, resulting in a loss of 19.3% of the data for the within-modality condition and 9.1% for the cross–modality condition (listening block). In addition, erroneous responses, RTs longer than 2000 ms or shorter than 100 ms were

[4] Response time model for the within-modal examination included random by-item and by-subject intercepts for structure, block order and stimulus order.

also excluded, resulting in the exclusion of additional 2% of all data for the within modality group, and 7.5% for the between modality group. Mean RTs and error percentages are presented in Table 3.4.

Table 3.4 Mean RTs (in ms) and errors (%) as a function of block order for both LA and HA structures in listening, first language speakers (SEMs in parenthesis).

	Low-attachment		**High-attachment**	
Dependent measures	**RT (ms)**	**% Error**	**RT (ms)**	**% Error**
Within-modal list (1st block)	633.6 (68.5)	31.6	456.2 (43.3)	21.6
Within-modal list (2nd block)	487.3 (39.1)	28.3	433.9 (51.9)	8.3
Within-modal list (3rd block)	433.8 (49.3)	23.3	443.06 (50.01)	26.6
Within-modal list (4th block)	451.1 (34)	6	485.2 (38.8)	11.6
Within-modal list (5th block)	358 (21.7)	6	442.5 (41.8)	21.6
Cross-modal list (5th block)	451.6 (33.05)	23.3	452.6 (43.7)	10

3.11.2.2.1 Error rates

A 2x5 repeated measure ANOVA with structure (LA vs. HA) and block order (first, second, third, fourth, and fifth) as independent variables and error percentage as the dependent variable was conducted. Results revealed no interaction, $F1_{(1, 19)} = 2.23$, $p = .07$. There was a main effect of block order, $F1_{(1, 19)} = 3.71$, $p < .01$. Both LA and HA items were less easily processed in the first block compared to the fourth block $p < .01$.

3.11.2.2.2 Reaction times

In order to examine the occurrence of an accumulative syntactic priming effect within the listening modality, reaction times were analyzed using 2x5 repeated measures ANOVA crossing structure and block order in which the item occurs within the list (i.e. first, second, third, fourth, or fifth block). Results revealed an interaction of structure and block position $F1_{(1, 19)} = 3.34$, $p < .01$, follow-up means comparisons revealed that

low-attachment sentences in the first block elicited slower response times than sentences occurring third block $p < .05$, fourth block $p < .05$, and fifth block $p < .001$.

To examine the occurrence of cross modal syntactic priming (from reading to listening), A 2x2 mixed ANOVA was conducted between groups (cross modal vs. within modal) for each structure (LA vs. HA) on RT data of the fifth block in both lists. Results revealed no interaction of structure and group $F1_{(1,38)} = 1.59$, $p = .2$. LA Sentences in the last block of the cross modality list were responded to at the same pace as in the within-modality list.

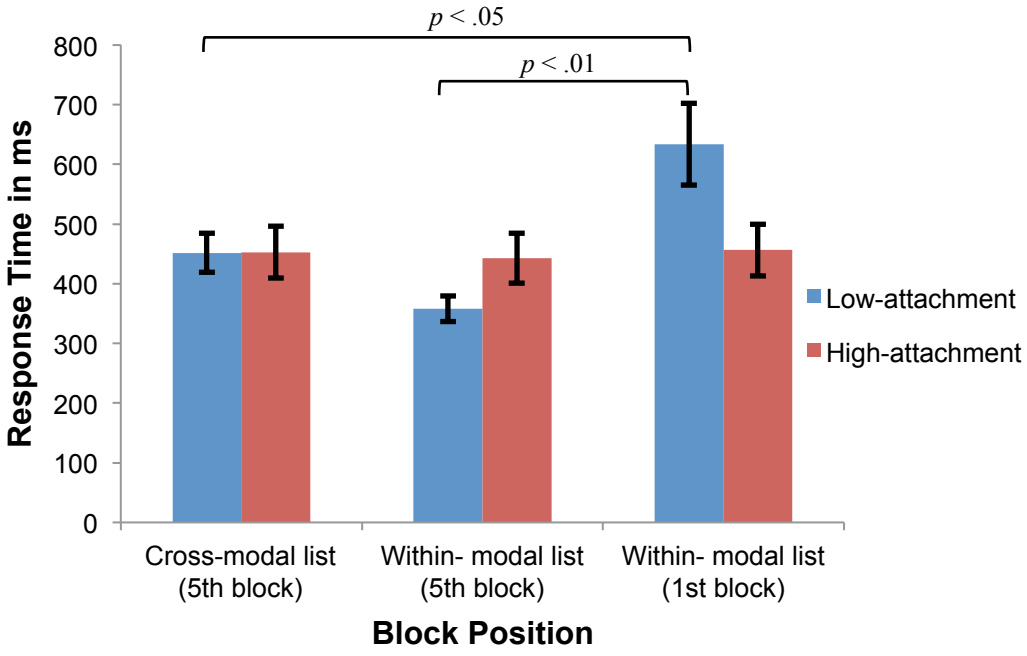

Figure 3.4. Response times (in ms) in listening split by structure and block position for first language speakers. Low-attachment target words are shown as blue bars and high-attachment target words as red bars. The error bars indicate SEM.

Additionally, RTs were compared for the fifth block (listening block) of the cross-modal list and first block of the within-modal listening list using 2x2 mixed ANOVA crossing structure (LA vs. HA) with block position. Results revealed an interaction, $F1_{(1,38)} = 3.83$, $p < .05$. LA sentences in the fifth block (listening block) of the cross-modal list were processed more easily than LA sentences in first block of the within-modal listening list, $p < .05$ (see Figure 3.4).

Similar to the reading analysis, the accumulative effect of syntactic priming was additionally assessed through the use of regression mixed effects model in which RTs are regressed onto the main effects and interactions of sentence structure (high attachment vs. low attachment), block order (from 1-5), and log transformed stimulus order. Maximum random effects structure justified by the data was included. The two way interaction between structure and block order was significant β = -58.4, $p < .05$. Participants adapted to the less frequent low attachment structure through the occurrence of syntactic priming effect that resulted in faster RTs towards the end of the list. Model estimates are presented in Table 3.5.

Table 3.5 Mixed effects model estimates for response times[5] in within-modal listening, first language speakers.

Coefficient	**Estimate**	**S.E.**	**t-value**
Intercept	489.5	148.3	3.3
Structure	202.8	58.7	3.4
Block Order	11.7	25.06	0.4
Stimulus Order	-47.7	128.4	-0.3
Structure x Block Order	-58.4	15.4	3.7

Cross-modal syntactic priming was assessed by comparing reaction times in the last (listening) block between within - and cross - modality groups. Fixed effects included in the structure of the regression model included group (cross-modal vs. within modal), structure (LA vs. HA) and the interaction between group and structure. The model also included maximal random effects structure justified by the data[6], if the model wouldn't converge, random effects were eliminated based on their variance size until convergence is achieved. Results revealed no group by structure interaction β = 65.15, p = .38, revealing no differences in processing last block between within-modal and cross-modal groups.

[5] Response time model for the listening within-modal examination included random by-item intercepts for structure and block order and by-subject intercepts for block order and stimulus order.

[6] The model included by subject and by-item random slopes for structure x group.

3.12 Experiment 4: Cross-modal priming in L2

3.12.1 Method

3.12.1.1 Participants

Eighty native Arabic speakers with English as a second language participated in Experiment 4. Participant ages ranged from 17 to 33 years (M = 21.6 year). All participants reported normal to corrected hearing and vision, and no neurological impairments. Participants responded to a language history questionnaire (Appendix A) prior to participation. All participants started to learn English between the ages 8 and 12, and were exposed to English in media and textbooks on a daily basis. Fifty-two participants (65%) lived in L1-dominant environment. All participants were either undergraduate or postgraduate students and had the minimum English proficiency required for enrollment in the University of Leeds with an IELTS (International English Language Testing System) total score of 6 out of 8 and a TOEFL (Test of English as a Foreign Language) score of 87 out of 120. Five students were enrolled in English language courses in the University of Leeds to improve their language. Table 3.6 presents self-rated proficiency in English for L2 group.

Table 3.6. Mean self-reported ratings (7-point Likert scale) of proficiency in English as a second language for Experiment 4 (Standard deviations are between parentheses).

Skill	Mean Proficiency (7 points)
Listening	5.46 (0.81)
Speaking	6.09 (0.83)
Reading	6.15 (0.97)
Writing	5.65 (0.79)
General proficiency	5.45 (0.53)

3.12.1.2 Material and procedure

Stimulus, materials, and procedures were the same as in Experiment 3.

3.12.2 Results

3.12.2.1 Reading

Reaction time outliers were identified in the same way as in Experiment 3. Participants made 10.1% errors for the within-modal condition, and 8% errors for the fifth trial of the cross-modal condition. Errors, data outliers, and incorrect responses to the comprehension questions resulted in the elimination of 24.5% of the reading data for the within-modal condition and 25.8% for the fifth block (reading block) of the cross-modal condition. Mean RTs and error percentages are presented in Table 3.7.

3.12.2.1.1 Error rates

To examine the occurrence of accumulative priming throughout the reading list, error percentages were analysed using 2x5 repeated measure ANOVA crossing sentence structure LA vs. HA with block order in which the item occurs within the list (i.e. first, second, third, fourth, or fifth block). No interaction was found between structure and block order $F_{(1,19)} = 1.89$, $p = .12$. Although items in the final two blocks elicited correct responses more often than the first three trials, the size of the effect is not significant enough. Given that error data of the reading list showed no priming effect, it is not possible to use it as a control that can be compared to cross-modal priming condition. Hence, error rates analysis of cross modal priming in reading is not included.

Table 3.7 Mean RTs (in ms) and errors (%) as a function of block order for both LA and HA structures in reading, second language speakers (SEMs in parenthesis).

	Low-attachment		**High-attachment**	
Dependent measures	**RT (ms)**	**% Error**	**RT (ms)**	**% Error**
Within-modal list (1st block)	1311.8 (90.3)	28.3	1025.2 (45.5)	11.6
Within-modal list (2nd block)	1143.7 (54.3)	33.3	1042.2 (75.4)	21.6
Within-modal list (3rd block)	1151 (67.3)	40	928.3 (61.5)	23.3
Within-modal list (4th block)	1052.9 (70.5)	25	924.8 (38.9)	16.6
Within-modal list (5th block)	972.8 (43.8)	20	943.1 (63.8)	25
Cross-modal list (5th block)	1072.5 (76)	28.3	917.89 (48.4)	21.6

3.12.2.1.2 Reaction times

To examine the occurrence of within modal priming in reading, a 2x5 repeated measure ANOVA crossing sentence structure (HA vs. LA) with the order of the block in which the item occurs within the list (i.e. first, second, third, fourth, or fifth block) revealed an interaction $F_{(1,19)} = 2.42$, $p < .05$. Pairwise comparisons showed that participants responded to items in the first block more slowly than items in the fourth $p < .005$, and fifth blocks $p < .001$; however, items in the first block were processed at the same speed as items in the second $p = .08$, and third block $p = .11$. There was a main effect of structure as LA structure was processed at lower speed than HA structure, $F_{(1,19)} = 27.67$, $p < .000$, and a main effect of block order, $F_{(1,19)} = 9.08$, $p <. 000$.

Cross-modal priming (from listening to reading) was examined. Response times of the fifth block for the within modal vs. the cross-modal conditions were compared in a mixed 2x2 ANOVA crossing structure (HA vs. LA) block position (5th block in cross-modal group vs. first block in within modal group). Results showed no interaction, $F_{(1,38)} = 1.8$, $p = .17$. Pairwise comparisons revealed that LA items in the fifth block of the within-modal list and cross-modal lists were processed at equal speed, which indicates that participants adapted to the LA structure in the cross-modal condition to the same extent as in the within-modal condition. A main effect was found for structure, $F_{(1,38)} = 4.18$, $p < .05$.

Additionally, a 2x2 mixed ANOVA crossing structure (HA vs. LA) with block position (cross-modal group 5th block vs. within modal group 1st block) revealed no interaction, $F_{(1,38)} = 1.59$, $p = .21$. Items in the fifth block of the cross-modal list were processed at equal speed as item in the first block of the within-modal list, which weakens the evidence supporting the occurrence of cross-modal syntactic priming. This is because a difference in processing between the two blocks would indicate that a priming effect was built up throughout the cross-modal list leading sentences in the last block to be more easily processed than their counterparts in the first block of the within-modal list. Therefore, the absence of difference between these two blocks indicates an absence of accumulative priming. Results showed a main effect of structure

$F_{(1,38)} = 16.89$, $p < .000$ as the processing of LA structure took longer time than the HA structure.

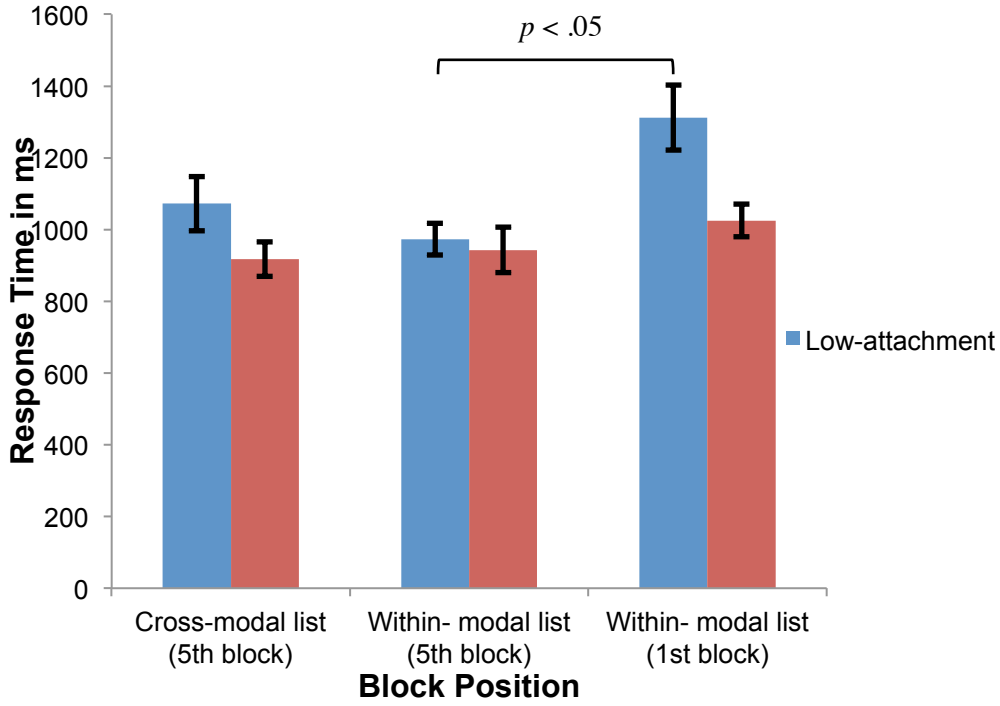

Figure 3.5. Response times (in ms) in reading split by structure and block position for second language speakers. Low-attachment target words are shown as blue bars and high-attachment target words as red bars. The error bars indicate SEM.

3.12.2.1.3 Mixed effects model analysis

Similar to Experiment 3, two mixed effects models were fit for the examination of within-modal and cross-modal priming.

Table 3.8 Mixed effects model estimates for response times[7] in within-modal reading, second language speakers.

Coefficient	Estimate	S.E.	t-value
Intercept	1308.746	182.570	7.168
Structure	299.483	59.784	5.009
Block Order	5.971	26.949	0.222
Stimulus Order	- 213.678	145.690	-1.467
Structure x Block Order	- 48.784	16.580	-2.942

Model estimates for reaction time data (Table 3.8) showed significant interaction between block order and structure, β = -48.7, $p < .001$ in addition to main effects of structure, $p < .000$ and block order, $p < .000$. Thus mixed effects model mirrored ANOVA analysis by revealing the occurrence of accumulative priming within the reading modality for second language speaker participants.

To examine cross-modal priming, reaction times were regressed onto the main effects and interactions of sentence structure (High-attachment vs. Low-attachment) and block position (5th block of cross-modal list vs. 5th block of within-modal list). Supporting the ANOVA analysis, results revealed no interaction,[8] β = 124.17, SE = 81.23, t = 1.52, p = .12.

3.12.2.2 Listening

Reaction time outliers were identified in the same way as in Experiment 3. Participants made 8.3% errors for the within-modal condition, and 12.5% errors for the fifth (listening) block of the cross-modal condition. Errors, data outliers, and incorrect responses to the comprehension questions resulted in the elimination of 27.3% of the listening data for the within-modal condition and 25.8% for the fifth block (listening block) of the cross-modal condition. Table 3.9 shows mean RTs and error percentages.

[7] Response time model for the within-modal examination included random by-item intercepts for structure, block order and stimulus order as well as by-subject intercept for block order.
[8] The model included by-subject and by-item random intercepts for structure and group.

3.12.2.2.1 Error rates

A 2x5 repeated measure ANOVA with structure (LA vs. HA) and block order (from first to fifth block) as the independent variables and error percentages as the dependent variable revealed no interaction, $F_{(1,19)} = 1.25$, $p = .2$. Participants responded with equal accuracy to both structures throughout the whole list, indicating the absence of accumulative adaptation. Given that error data of the reading list showed no within-modal priming effect, it cannot be used as a control for a cross-modal condition. Hence, error rates analysis of cross-modal priming in L2 listening is not included.

3.12.2.2.2 Reaction times

A 2x5 repeated measure ANOVA with structure (LA vs. HA) and block order (from first to fifth block) as the independent variables and reaction times as the dependent variable demonstrated no interaction, $F_{(1,19)} = .61$, $p = .65$, which showed that items throughout the within-modal listening list were processed at equal speed, indicating the absence of accumulative priming. Results revealed a main effect of structure $F_{(1,19)} = 12.9$, $p < .01$ with LA structure eliciting longer reaction times than HA structure.

Table 3.9 Mean RTs (in ms) and errors (%) as a function of block order for both LA and HA structures in listening, second language speakers (SEMs in parenthesis).

	Low-attachment		**High-attachment**	
Dependent measures	**RT (ms)**	**% Error**	**RT (ms)**	**% Error**
Within-modal list (1st block)	978.5 (92.1)	20	782.4 (45.5)	35
Within-modal list (2nd block)	1119.6 (96.3)	21.6	818.5 (96.6)	16.6
Within-modal list (3rd block)	934.9 (78.2)	13.3	793.06 (104.6)	18.3
Within-modal list (4th block)	949.6 (116.1)	35	842.4 (61.7)	21.6
Within-modal list (5th block)	971.5 (98.5)	16.6	752.7 (56.7)	18.3
Cross-modal list (5th block)	799.2 (78.8)	26.6	906.6 (48.4)	21.6

Although cross-modal priming (from reading to listening) cannot be conducted because of the absence of the control within-modal condition, the final listening block was compared for both the within-modal and cross-modal conditions to compare facilitation in processing between the two blocks. Given that accumulative priming occurred in the reading modality, it is predicted that the final listening block in the (reading-listening) condition would be processed more easily than the final block in the (listening-listening) condition. A 2x2 mixed ANOVA with structure (LA vs. HA) as the independent within-subjects variable and block position (5^{th} block of cross-modal list vs. 5^{th} block of within-modal list) as the independent between-subjects variable and RTs to the fifth block in both conditions, as the dependent variable demonstrated an interaction, $F_{(1,38)} = 6.24$, $p < .01$. Showing that LA items in the final listening block were processed more easily after exposure to the first four reading trials in the (reading-listening) condition than after exposure to the first four listening trials in the (listening-listening) condition, $p < .05$.

Although it cannot be concluding that a cross-modal syntactic adaptation occurred in the (reading-listening) condition. However, processing of the LA structure in listening was facilitated after exposure to the same structure in reading than in listening.

3.13 Discussion

Current results demonstrate modality independence of syntactic priming, supporting therefore an account of shared syntactic information in listening and reading comprehension. Although sensory encoding involves phonological and orthographic dual routes for word form representation, a common modality-independent mechanism underlies later integration process of words into their syntactic context. The occurrence of accumulative syntactic priming in both reading and listening modalities using the same task and stimuli strengthens the notion of modality-independence in L1. L2 speakers were found to perform differently from L1 group in the listening modality. Although L2 accumulative priming occurred in reading, no priming was observed in listening. In addition, relatively weak evidence supported cross-modal priming effect from listening to reading and from reading to listening in L2. The occurrence of accumulative priming in reading, and not in listening in the present study supports

previous evidence on the difficulties associated with listening in a second language (For a review, see Weber & Broersma, 2012); however, it doesn't rule out L2 speakers ability to show accumulative priming.

Issues related to listening comprehension in L2 such as segmentation, cross-linguistic interference, and lack of automaticity imposes more difficulty on L2 syntactic integration during online processing. Online language processing involves integrating multiple sources of information. For example, the interpretation of the high-low attachment ambiguity employed in present study requires sorting out verb argument structure, assigning correct thematic roles to the final prepositional phrase and accordingly, sorting out the prepositional phrase attachment. Temporal constraints imposed in listening prevent L2 speakers from effectively performing these parallel processes, forcing them to resort to a shallow processing strategy (Clahsen & Felser, 2006). According to the shallow structure hypothesis, L2 speakers rely solely on lexical-thematic representation to interpret syntactic ambiguities instead of performing structurally detailed syntactic representation. The occurrence of shared syntactic representation in reading, and not in listening in the present study suggests that L2 speakers don't engage in shallow processing all the time. Instead, factors affecting speed of processing such as task demands and modality of presentation contribute to the occurrence of shallow processing. This goes in line with previous evidence suggesting that insufficient processing speed could result in processing difficulties in L2 (Ellis, 2005; Lopez Prego & Gabrielle, 2014).

The employed lexical decision task provides another possible reason for the differences found between L1 and L2. During comprehensions, language users are required to quickly integrate different sources of information such as accessing lexical items, building syntactic structures, and interpreting the intended meaning of the message. While L1 speakers can rapidly accomplish these processes, research indicates that L2 speakers' processing occurs less efficiently (Roberts, 2013). Building a syntactic structure is but one step that follows other non-syntactic processes and relies on them for efficiency. Among these processes is lexical access (Hopp, 2016). In the present study, the lexical decision task contains a non-word options that delays lexical retrieval of the final critical word. This slow down in lexical retrieval might delay the structure

building process that is required for syntactic priming to occur among L2 participants. This slowing-down in lexical access is even maximized in the listening experimental setting more than in reading. This is because in reading, participants are presented with the part of the sentence up till before the final word for 3000 ms before the final word appears for another 1000ms, which exceeds the sentence presentation time in the auditory task. Therefore, participants have more time to perform syntactic integration in the visual task. Current results back theoretical accounts that attributed L2 syntactic difficulties to the delay in the lower level processes that feeds into the syntactic structure building (Dekydtspotter, Schwartz, & Sprouse, 2006). Syntactic processing differences between L1 and L2 don't, therefore, stem from qualitative differences in syntactic structure building, but rather a quantitative speed of processing problem that can be overridden if L2 speakers were given the time sufficient for syntactic processing. One possible explanation for the occurrence of cross-modal priming is that, in reading, language users might activate an auditory syntactic representation in addition to the visual syntactic representation, and similarly, a visual syntactic representation is activated in parallel to the auditory representation in listening. In this way, a unified mental representation underlies both listening and reading. This argument seems plausible as during reading, visual discourse is transformed into its equivalent auditory forms through some type of 'inner voice' (Jahandarie, 1999, p.155). Even with skilled readers, this voicing of written discourse occurs at a sub-vocal level (Huey, 1968). This inner voicing is even supported by the procedure in the current experiment. In the reading trials, the sentence context disappears before the critical word appears on the screen for the participants to respond to. This prevents participants from retreating back to the beginning of the sentence to revise their understanding. To compensate for that difficulty, an alternative strategy would be to use this inner voicing which is an activated auditory representation of the written discourse. This implies that the same sort of representations underlie reading and listening. Therefore, the unity of these representations leads to the transfer of priming effect across modalities.

Current results support the notion that syntactic representations are not affected by the grammatical structure frequency of occurrence in one modality or another. Written discourse tends to be more formal and more structurally complex than spoken

discourse. Accordingly, ambiguous and complex structures like the high/low attachment structure used in the present study occur more frequently in reading than in listening (Donnell, 1973). Then it might be the case that a structure's lack of occurrence in listening would hinder the formulation of an accumulative priming effect within the listening modality. Nevertheless, Low-attachment structure employed in the current study produced a syntactic priming effect both in listening and cross-modally from listening to reading.

Current results support an implicit learning account of syntactic priming. The occurrence of bi-directional syntactic priming (from listening to reading and from reading to listening) reflects an abstract syntactic knowledge that is not tied to lower level modality-specific sensory characteristics. It can be stated therefore that the priming effect leads to long lasting changes in the processing system. This goes in line with the implicit learning account which assumes that syntactic priming results from an experience dependent adjustment which leads to an increased accessibility of a particular sentence structure due to a previous exposure to that structure.

In contrast, current results don't support the residual activation account. According to this account, processing a prime sentence structure lead to a residual activation of the syntactic procedures associated with that structure, for example, processing a passive structure involve the activation of the procedure associated with a passive structure. Syntactic priming effect occurs because the activation of that procedure persist after the prime sentence has been processed, so the tendency of applying the same procedure in producing or comprehending a subsequent sentence is increased. Residual activation is supported by a trial-to-trial experimental manipulation in which prime and target sentences are alternated within trials so that the effect of prime on the immediately following target is measured. Most previous research showed a weak priming effect resulting from the residual activation mechanism that characterizes the trial-to-trial manipulation (see Traxler & Tooley, 2014, for a review). As current study showed strong priming effect that transcends across modalities, residual activation cannot be the underlying mechanisms.

One limitation of the current study is that listening and reading were manipulated in a

way that differs from real life. This has led to a partial exclusion of the natural differences between the two modalities, which would otherwise have led to different results from the present findings. First, the use of prosody in natural speech was not matched in the present experimental manipulation. All experimental items, either carrying a low-attachment or a high-attachment structure, in the listening trials were recorded using a similar neutral prosody. However, in natural contexts, high attachment ambiguity is regularly characterized by a lengthened articulation of the word preceding the preposition in addition to a prolonged stop before the preposition. The absence of these features bias towards the low-attachment ambiguity and are, therefore, informative of sentences interpretation (Warren, Schafer, Speer, & White, 2000). In this way, prosody might decrease the prediction error resulting from processing that type of structure and, therefore, affect the occurrence of accumulative priming in natural contexts.

Another mismatch between the present experimental manipulation and natural settings is that sentences at the reading trials were presented up till before the final critical word, then the sentence context disappeared from the screen and the final target word was displayed. This was done for unifying the timing of the critical word presentation for all participants so that reaction times could be calculated from the onset. However, It might be assumed that high-span readers had the time to engage in context-based predictions about the upcoming input, which might have led to biased results in the reading condition compared to the listening condition in which experimental items were presented as a whole.

Evidence supporting the notion of context – based predictive processing emerges from previous research that showed that the generation of context-based prediction relies on specific task factors such as the speed of stimulus presentation. Delayed presentation of stimulus enhances the processing system to engage in anticipatory preactivation (Antos, 1979; Neely, 1977; Stanovich & West, 1979; Lukatela et al., 1982; Katz, Deutsch & Bentin, 1992). Inserting a long inter-stimulus interval (ISI) or stimulus onset asynchrony (SOA), defined as the time between the onsets of two stimuli, between the context and the target was found to increase context-based prediction. In a recent study, Wlotko and Federmeire (2015) examined the effect of the timing of stimulus

presentation on predictive processing. A self-paced reading task was used in which sentences were presented word by word with a SOA of 500 ms or 250 ms. The last word in the sentence was an implausible sentence continuation that is semantically related to a predictable word. The N400 ERP component whose increased amplitude reflects semantic demands was recorded. Results showed that implausible words that are semantically related, to a predictable word, but not unrelated words, resulted in reduced N400 amplitude. This effect was absent in the SOA 250 ms condition, suggesting that the timing of presentation enhanced the predictive processes that facilitated the processing of the words that are related to predictable words.

Comprehension syntactic priming experiments, which do not manipulate the timing of presentation and delay the presentation of the target might similarly enhance context-based predictions that lead to reduced priming effect. For example, in Arai et al., (2007) (see section 3.7 for a full description of the study), The found syntactic priming effect was only observed when the verb was repeated between the prime and target sentences, suggesting that the resulting priming effect was weak as it was enhanced by lexical boost. In their experimental procedure, there was a 900 ms temporal interval between the verb and the post verbal noun phrase. This might have led to the generation of context-based prediction that biased a more frequent structure than that of the prime sentence, leading to biased results. In contrast, in the present study, no time interval was inserted between the presentation of the sentence and that of the target critical word. It can't be the case, therefore, that participants have engaged in predictive processes that would bias the more frequent high-attachment structure rather than the primed low-attachment ambiguity. In addition, the fact that present findings showed a priming of the low-attachment ambiguity in reading rules out the possibility of predictive-processing effect.

Another factor that might affect prediction is the tuning of visual attention through the use of pictures. Experimental manipulation that examine syntactic priming through the use of picture matching tasks and visual word paradigm sometimes use visual scenes that involve semantic relation between its objects (Branigan et al., 2005; Kidd et al., 2014; Nitschke, Serratrice, & Kidd, 2014). This might indicate that the observed facilitatory effect in fact resulted from the tuning of visual attention rather than

syntactic priming. In these studies, the visual display was even presented before the accompanying auditory input (Nitschke, Kidd, & Serratrice, 2010; Nitschke et al., 2014), which might have enhanced the tuning of attention at the very beginning of the sentence before encountering the verb. This means that the structure of the target will be primed without being affected by the lexical context of the target sentence, leading to a strong comprehension priming effect without the need for lexical boost. This might account for the occurrence of stronger L2 priming in previous research (Nitschke et al., 2010; Nitschke et al., 2014) in contrast to the present findings that showed the same, and sometimes, weaker priming in L2 compared to L1.

Syntactic priming across the two production modalities (i.e. speaking and writing) has been found in previous research. Additionally, the present findings provide an evidence for priming across the two comprehension modalities (i.e. listening and reading). These findings form a good foundation for a next step in which priming is examined from comprehension to production and vice versa across the four underlying modalities, (i.e. from listening to speaking and vice versa, from listening to writing and vice versa, from writing to reading and vice versa and from speaking to reading and vice versa). The resulting findings would give insight into shared mechanisms and representation underlying comprehension and production. Multiple contradictory views are related to the connection between comprehension and production. First, there are views that support the existence of separate modular instantiation of the processes underlying production and comprehension (Chomsky, 1965). Second, Dell and Chang (2014) proposed the P-Chan model in which production is linked to comprehension through predictive processing. Production of a linguistic content provides top-down effects that are needed for the comprehension process of generating predictions about the upcoming input. Therefore, the model predicts the occurrence of facilitation in processing from production to comprehension, but not vice versa. Finally, the interactive alignment model by Pickering and Garrod (2004) relies on the alignment of produced and comprehended utterances within dialogues to account for the connection between comprehension and production. A future examination of bidirectional priming effects across comprehension and production would reconcile between the existing contradictory views. A recent study has indeed supported bi-directional effects across

production and comprehension through trial-to-trial priming (Litcofsky & van Hell, 2019); however, it is still to be seen whether these effects persist across the four underlying sensory modalities (reading, listening, speaking, and writing), and whether these bidirectional effects can be found in accumulative priming as in trial-to-trial priming.

Chapter 4

The Role of Thematic Role Assignment in Processing Prepositional Phrase Attachment

4.1 Introduction

Syntactic priming is an effect that transfers through similar syntactic structures. Previous research has found syntactic priming in sentences where similarities in syntactic structure are accompanied by similarities in thematic roles assigned to sentence constituents. For example, a low-attachment sentence such as "*the man fixed the box with a hole*", was processed more easily after another sentence that share the same low-attachment structure such as: "*The nurse fixed the arm with an injury*". In both sentences, the modifier prepositional phrases (PP) (i.e. "*with a hole*" and "*with an injury*") share not only the syntactic attachment to a preceding noun phrase, but also an attributive thematic role. However, this previous approach doesn't allow for the study of the sole effect of a shared thematic role on the occurrence of syntactic priming. The present study tries to separate out the syntactic and thematic sources of influence by varying between thematic roles while keeping the PP-attachment the same. This approach will allow an investigation of how the thematic role differences between the prime and target sentence can affect priming. If syntactic priming occurs regardless of differences in thematic role, this will ascertain that constituent structures of sentences in syntactic priming are processed without access to the thematic meaning that underlies them.

4.2 The different representations underlying the processing of PP-attachment structure

Early research in prepositional phrase attachment ambiguity suggests that only syntactic information can guide sentence comprehension. In a sentence like "*Sam fixed the box with a hole*", a prepositional phrase like "*with a hole*" after a post verbal noun phrase (NP) like "*the box*" is a grammatical structure that is often ambiguous. This is because the prepositional phrase could be initially interpreted either as a modifier attached to the

NP (low attachment), or as an instrument for the verb (high attachment) as in "*Sam fixed the box with a tool"*. According to the modularity theory (Frazier & Fodor, 1978), the parsing strategy that controls the attachment decision of a PP following a post verbal noun phrase is minimal attachment. Minimal attachment guides the syntactic processor to make a PP attachment decision that leads to the minimal number of parsing nodes (see section 1.7.1 for a detailed explanation). Because the modifier interpretation of the PP leads to an additional higher noun phrase (NP) node (see Figure 1.3), PP is rather interpreted as an instrument (high attachment). Response time studies found that participants indeed take less time to process the high attachment of the PP both in first language (Ferreira & Clifton, 1986) and second language (Fujita, 2016).

However, over the past 30 years, there has been a shift in the view of syntax from a set of rules to a set of structural probabilities that are guided by different sources of information. For example, in a sentence such as "*The spy saw the cop with the binoculars*", the PP can either be attached to the verb and interpreted as "*the spy used binoculars to see the cop*", or attached to the noun and interpreted as "*The cop holding binoculars was seen by the spy*". Following the minimal attachment hypothesis, this syntactic ambiguity will be interpreted by initially assigning the PP to the verb. However, corpus studies (Hindle & Rooth, 1993) revealed that in 67% of such sentences, the PP is attached to the NP rather than the verb. In addition, Collins and Brooks (1995) showed that attaching the PP to the verb results in a correct interpretation only 41% of the time. Building the attachment decision on the structure's overall frequency bias as proposed by the tuning hypothesis resulted in a 59% accuracy (Mitchelle, Cuetos, Corley, & Brysbaert, 1995). Another source of information that was found to contribute to this ambiguity resolution is the frequency of the preposition. Prepositions differ in the frequency with which they are used with different grammatical structures. In the above example, the attachment decision that is most likely (given the preposition frequency) results in 72% of correct responses (Collins & Brooks, 1995). Also, verb sub-categorization preferences play a role. Perception verbs such as "*see*" are less likely to be attached to an instrument. Most PP following a perception verb holds the role of (manner) rather than an instrument, which can bias against a high-attachment interpretation, whereas, action verbs such as "*make, hit, mended*" occur more frequently

with an instrument, which bias towards a high-attachment. Another constraint is the definiteness of the PP. Corpus analysis showed that definite NP are more likely to occur with VP attachment than with a NP attachment, however, the influence of NP definiteness can be overridden by verb lexical biases (Spivey-Knowlton & Sedivy, 1995). While definite NP can induce VP attachment with perception verbs, indefinite NP cannot effect attachment decision. With indefinite NP, only verb bias can affect attachment decision.

A relevant issue here is the grain size of the information that the processor is sensitive to during the online processing of PP-attachment ambiguity. Some information is more effective than others and it is the job of the processor to represent the most effective predictors and discard irrelevant predictors. For example, apart from the above influences, the processor evaluates the thematic role of each constituent within a structure. If it plays a role within the event, it undergoes a representation. Taraban and McCleland (1988) proposed that, in the low attachment structure, it is not the ultimate attachment to the NP that poses difficulty, but the plausibility of the final word thematic role. An example of this is in a sentence like "*The hospital admitted the patient with cancer*" which was read at the same pace as "*The janitor cleaned the room with a broom*". In this example, PP is attached to NP in the first sentence and to VP in the second, suggesting that thematic role expectation of the upcoming constituents can guide sentence interpretation independent of the attachment to the verb. To examine this, Taraban and McCleland (1988) performed a sentence completion and rating task to determine the predictable thematic role for the object of the preposition phrase in each verb and preposition pair. Findings showed that the expectation for a specific thematic role biased against one of the syntactic attachments. In a subsequent self-paced reading experiment, findings showed that the PP with a thematic role that is not compatible with VP attachment resulted in a facilitated processing when the PP modified NP rather than VP. These findings show the larger grain size of the effect of thematic role assignment on the disambiguation of such ambiguities.

4.3 The processing of arguments vs. adjuncts

Alternatively, the function of thematic role assignment in processing might be

dependent on whether the phrase is an argument, or an adjunct. Arguments are obligatory components of the event reported by the verb. These components refer to participants in the event. For example, in "*Mike fell outside*". The verb "*fell*" reports an event involving one participant, the person who fell. Mike is the participant in the event of falling, and is therefore the argument of the event of falling. In contrast, adjuncts are not obligatory constituents of the event and don't therefore refer to individuals within the event. The word "*outside*" is an adjunct as it is an optional constituent of the event of falling. Unlike arguments, adjuncts are weakly attached to the verb (Pollard & Sag, 1987). An example of this is: "*John put the file on the desk*", the locative prepositional phrase on the desk has a location thematic role, but this is defined by the preposition *on* rather than by the verb.

Two aspects characterize verb arguments: (i) verb sub categorization, which defines the syntactic category of verb arguments, and (ii) the thematic grid which is composed of a number of slots that each correspond to a specific thematic role. For example, in "*John put the files*", the verb put accepts two thematic roles in its grid: (i) the agent in the event of putting the files (i.e. *John*), and (ii) the act of putting (i.e. *the files*). Both roles are obligatory, as the absence of any of them would make the sentence grammatically incorrect. By contrast, adjuncts don't correspond to slots in the verb's grid and their omission doesn't affect the sentence grammaticality, therefore a verb might be accompanied by a number of adjuncts which hold the same or different thematic roles.

Linguistic differences between arguments and adjuncts are accompanied by processing differences as well. In contrast to arguments, there is weak link between a verb and the accompanying adjuncts. This is supported by evidence from syntactic priming research that shows the occurrence of syntactic priming across NP-attached adjunct PP structures, such as the one employed in the present study "e.g. *The vendor tossed the peanuts on the box into the crowd during the game*" (Traxler, 2008). In most comprehension syntactic priming research, priming does not occur unless the verb is repeated between the prime and target sentence, which is not the case in the above sentence as priming did occur in the absence of verb overlap. This contradictory result is reflected in the distinction between arguments and adjuncts. While the priming across arguments seems to be lexically dependent, priming of adjuncts is less dependent on the

verb overlap due to the fact that they are less linked to the verb. Therefore, it is clear that thematic expectancy plays a role in PP-attachment structure processing and that this role might be eliminated due to the fact that the thematic role is held by an adjunct rather than an argument.

4.4 Syntactic priming is not always purely syntactic

Although syntactic priming has long been considered as syntactic phenomenon resulting from similarities in the sentence constituent structure, recent language production research has demonstrated that syntactic priming can result from various types of shared representation between two sentences other than syntax (Bock & Loebell, 1990; Scheepers, Raffray, & Myachykov, 2017; Gamez & Vasilyeva, 2015; Ziegler & Snedeker, 2018). Accordingly, syntactic priming can be used as a method to examine the relative contribution of not only syntactic representation, but also other types of shared representations in sentence processing. Indeed, in a language production study, Ziegler, Snedeker, and Wittenberg (2018) showed that both light verb sentences ("*The mother is giving her son a hug*") and idioms ("*Miss Piggy gives Kermit the cold shoulder*") can prime compositional datives like ("*The mother is giving her son an apple*"). Light verb sentences and idioms differ thematically from datives in that they do not communicate a real transfer of theme from an agent to a recipient, but rather they convey an interaction between an agent and a patient, (e.g. "*Miss Piggy ignoring Kermit and the mother hugging her son*"). The occurrence of priming in spite of these thematic differences indicate that it occurred across these sentences on syntactic basis solely. However, in a second experiment, a larger priming effect was found across compositional dative primes and targets which share both the thematic and syntactic representation, indicating that thematic overlap can contribute to the priming effect.

In comprehension, Ziegler and Snedeker (2019) conducted a study that showed priming based on a type of representation that is different from syntax. The aim of their experiment was to examine the occurrence of priming in the absence of verb overlap using the visual world paradigm. Participants viewed four toys displayed visually on a visual stage while listening to prime and target sentences in either the DO or PO dative structures. Based on the influence of shared syntax, participants were supposed to fixate

more on the inanimate objects following a DO sentence and on animates following a PO structure. Results revealed the opposite. More fixations were directed to inanimate following a DO and to animates following PO structure. This was attributed to the priming of the information structure in which the old known information tends to occur early in the sentence, whereas the new information tends to appear last. Accordingly, a DO structure focuses the perceiver's attention onto the theme, whereas PO structured focuses more attention onto the recipient. This effect led the participants to fixate more on the animates (recipients) in the target sentences following a PO prime, and on inanimates (themes) in the target following a DO prime. This pattern of results indicates a priming of the sentence information structure.

4.5 Thematically-independent syntactic priming

The transfer of priming across different thematic roles was studied by Traxler (2008). The aim was to examine whether syntactic priming would withstand difference among prepositional phrases carrying different thematic roles. The study employed an ambiguous prime and a target sentence that contained either an agentive by-prepositional phrase as in ("*the director watched by the cop was in a bad part of the town*") or an instrument with-prepositional phrase ("*the director watched with the binoculars was in a bad part of town*"). Using eye-tracking measures, results revealed that both agent and instrument PPs can be used to prime agent targets, whereas agent PPs couldn't prime instrument PP. The results were attributed to the participants' tendency to activate an agent role while reading a prime sentence with an instrument role (Traxler, 2008). Given that arguments are obligatory constituents that are specified by the verb, they are activated once the verb is encountered. Given that agentive PP is an argument, it was activated at instrument PP primes, leading to the facilitation in the processing of agentive PP targets. In this study by Traxler (2008), differences in thematic roles (i.e. agent vs. instrument) were accompanied by differences in argumenthood (arguments vs. adjuncts), which did not allow for the study of whether syntactic priming could withstand differences in thematic roles. Therefore, it still remains to be ascertained if syntactic priming across a PP structure results in a shared thematic representation between a prime and target sentence. To achieve this varying the thematic role across prime and target sentences while maintaining both syntactic

structure and argumenthood is needed.

The current study addresses this issue by employing an accumulative priming paradigm in which participants are exposed repeatedly to an a priori ambiguous structure, thus leading to facilitation in processing after repeated exposure. The accumulated priming effect creates a gradual facilitation in the processing of ambiguous NP-attachment structures. This new attachment preference should be tied to the PP semantic role with which it co-occurred throughout the course of the experiment. We hypothesize that varying the thematic role while keeping the syntactic structure (i.e. NP attached PP) the same, should result in no cross-role priming if the created facilitation in processing taps into the thematic role of the constituents rather than on syntactic structure. This would indicate that the grain size of the thematic role assignment has the largest influence on processing these types of sentences.

Alternatively, the processor sensitivity to the function played by thematic role might be overridden by the strong expectation for an NP attachment resulted from accumulative priming. This, in turn would indicate a maximization of the role played by syntax, indicating the effectiveness of priming in modifying the grain size of the effect played by different sources of information. Thus the occurrence of cross-role priming would indicate that the priming in this sentence type happens, at least in most part, on a syntactic rather than thematic basis.

4.6 Processing of PP-attachment structure in L2

Research conducted on L2 processing of PP attachment ambiguity shows that L2 speakers show the same pattern of results as L1. Not only are L2 speakers sensitive to PP attachment syntactic ambiguities in L2, but also to the more fine-grained lexical and sub categorization information which guide the analysis of such ambiguities. In an eye-tracking study, Frenck-mestr and Pynte (1997) examined the effect of verb lexical constraints in guiding the interpretation of PP lexical ambiguities in both L1 and L2. The aim of their study was to examine whether French speakers and English-French bilinguals would show differences in syntactic ambiguity resolution while reading sentences like:

1) Il rate le train de peu/ de midi et decide alors de chercher un hotel.

He missed the train by little / of noon and decided to look for a hotel.

2) Il avertit la police du quartier / du crime puis se félicite de son action.

He warned the police of the district / of the crime and congratulated himself for it.

In 1, the main verb is a transitive verb that regularly takes one argument to fulfill its thematic grid, whereas in 2, the main verb is a ditransitive verb that needs two arguments to fulfill its thematic grid. Findings revealed that both native and bilingual participants showed the same attachment preferences. Both groups of participants prefer low attachment of PP following mono-transitive verbs. This was indicated by faster reading times of the disambiguation PP phrase in the low attachment structure ("*de midi"* as compared to "*de peu*" in sentence 1), compared to ditransitive verbs. The results showed a high attachment preference ("*du crime"* as compared to "*du quartier*" in sentence 2), indicating that L2 learners show similar attachment preferences to L1 speakers. Later research that examined L2 processing of ambiguous PP attachment structure also supported the fact that L2 speakers are affected by the same factors as L1 speakers' and have VP-attachment preference (Kweon, 2009; Pozzan & Trueswell, 2016; Rah &Adone, 2008). Following ditransitive verbs, L2 speakers prefer VP high-attachment over NP low-attachment of PP to satisfy the thematic grid.

4.7 Aim of the study

The aim of the present study was to examine whether priming in adjunct NP attached PP sentences is caused by shared thematic representations, and not only on syntactic basis. Priming refers to a facilitation of the response to an item following exposure to the same or similar items, thus priming occurs when two items share a common representation. An example of this is when words sharing similar phonological representation might prime each other, such as "*part*" and "*party*". This can also occur with words sharing similar meaning such as "*nurse*", "*doctor*", and "*surgery*". If one sentence is a better prime than another, this means that the prime has more shared representations with the target than the other. The present study employed this as a method to examine whether priming of NP attachment in prepositional phrases is driven by thematic similarities in this kind of syntactic ambiguity. To examine this, priming was investigated across two thematic roles of PP. It is hypothesized that the absence of cross-role priming would indicate that the priming in this type of ambiguity is derived,

at least in part, by shared thematic representation. However, if priming was derived by both syntactic and thematic shared representations, we would predict the occurrence of a cross-role priming that is weaker than the within-role priming. An equal priming of the two conditions would indicate that the priming effect is mainly driven by shared syntactic representation, and that the two types of PP are treated by the processor as interchangeable.

The present study employs a self-paced reading task in which participants' eye fixations are recorded by an eye-tracking technique. This task was chosen as it provides a natural setting that resembles real-life reading. It allows participants to use button press to present sentences in a pace that correlates with the time course of comprehension processes involved in real-life reading. It, therefore, avoids the temporal constraint imposed by the lexical decision task in Chapters 2 and 3. This time constraint was argued to hinder the occurrence of priming among L2 speakers (see section 3.13 for full explanation)

4.8 Experiment 5: Cross-role priming in L1

The aim of the current experiment was to examine whether priming produced from an NP attachment ambiguity in which PP has an attribute thematic role would transfer to another NP attachment with a locative PP. To examine this, the processing of a target sentences like "*The child copied the drawing on the book into the paper*" will be assessed after exposure to multiple prime sentences like "*Jane tossed the apple on the plate into the fridge*" compared to sentences like "*The worker repaired the wall with a hole*". Although the prepositional phrase (PP) in the latter prime sentence shares the same attachment with the target sentence (low attachment), the thematic role of the PP is different. While "*on the book*" and "*on the plate*" have a "locative" thematic role, "*with a hole*" has an "attribute" thematic role.

Before examining the occurrence of cross-role priming, within-role accumulative priming was examined in sentences that are similar in both syntactic structure (NP-attachment and its VP attachment counterpart) and thematic role (locative thematic role). This structure has been studied in a trial-to-trial manipulation (Boudewyn et al., 2014; Traxler, 2008). As we are using an accumulative priming paradigm that is

different from that used before, it is crucial that we validate the present experimental manipulation and low-attachment stimuli, and to provide a baseline to which cross-role priming can be compared. To achieve this, the occurrence of within-role priming in PP locative sentences was examined first.

4.8.1 Method

4.8.1.1 Participants

Forty-eight native English speakers from the University of Leeds participated. All were naïve as to the aim of the study. The mean age was 21.7 (range: 18-30). Participants had no reported neurological impairments and normal or corrected-to-normal vision and hearing.

4.8.1.2 Material

Participants were assigned to one of two groups, a within-role group and a cross-role group. In the within-role list, thirty-two sentences were created from four verbs. Sixteen sentences were disambiguated towards the modifier PP analysis and the other sixteen were disambiguated towards the goal PP analysis. The two types of sentences were alternated over four similar blocks, resulting in eight sentences per block, four in the goal structure and four in the modifier structure (Appendix E). This was done by including each of the four verbs once in a modifier structure and once in a goal structure within each block. The order of presentation of the blocks was randomized across four lists. Two versions of each list were created to counterbalance sentence structure so that a modifier sentence in one list version appears as a goal sentence in the other, resulting in eight experimental lists in total. Thirty-two filler sentences of matched length intervened.

The cross-role lists included 32 experimental sentences with the first three blocks consisting of 24 sentences, 12 of which were in the low-attachment attributive PP structure and 12 in its high-attachment instrument counterpart. The last block contained four sentences in the modifier PP analysis and four sentences in the goal PP analysis. Four cross-role lists were created in which the last block included sentences that replicated those in the last block in each of the four within-role lists. Of each of the four

lists, two versions were created to counterbalance sentences structure so that a sentence that has a low attachment in one version appears with a high attachment in the other. Similarly for the final block, a modifier sentence in one list appears as a goal sentence in the other.

4.8.1.3 Procedure

The experiment was run using an Eyelink 1000 eye-tracker (SR Research Ltd, Canada) with a temporal resolution of 1000 Hz. Data was recorded from the right eye only. Participants sat approximately 40 cm away from a 17”computer monitor and experiments took place in a darkened room. Chin and head rests were used to minimize head movements throughout the experiment. A brief five-point calibration procedure was performed at the beginning of each block of trials followed by a validation of this calibration to ensure accuracy of eye position of <0.25. Stimuli were presented using Experimental Builder software (SR Research Ltd, Canada) and participants first reviewed instructions on the screen before the experiment began with 4 practice items to ensure correct performance. Individual sentences appeared centered horizontally on the screen. After reading the sentence, participants pressed a button on a keyboard to move on. A yes/no comprehension question was then displayed on the monitor with participants pressing one of two pre-specified keys on the keyboard as a response (z = yes, m = no). At the end of the experiment, participants were asked what they thought the study had examined to make sure they were naïve as to the main aim of the study

4.8.2 Data analysis

Three standard eye tracking measures were analyzed: a) *First run dwell time* which is the sum of all fixations in the trial that were within predefined areas of interest until a fixation was made outside of the areas of interest, b) *First run regressions* was defined as the number of fixations that were made from the current interest area to earlier regions of interest, and c) the *Total dwell time* was defined as the summation of the duration of eye fixations across all current interest area.

These measures were recorded from two interest areas: a) the disambiguation region which included the second post-verbal PP (e.g. “*Anna put the photo in the album **onto***

the table *this morning*"). This is the critical region as it is the phrase at which the difficulty in processing occurs when the reader adopts an initial false goal analysis, and it is the region at which previous studies have found differences in processing between a modifier structure and a goal structure (Rayner, Carlson, & Frazier, 1983; Spivey, Tanenhaus, Eberhard, & Sedivy, 2002); b) the post disambiguation region which included the sentence completion that immediately followed PP (e.g. "*Anna put the photo in the album onto the table* ***this morning***"). This region is included to examine any delayed effects.

4.8.3 Results

First run dwell times less than 120 ms or greater than 3000 ms or 2.5 *SD* from the mean of the by-subject condition were excluded from the analysis, eliminating 6.5% of the data. Total times less than 120 ms or greater than 2.5 *SD* from the mean of by-subject condition were excluded from the analysis, eliminating an additional 2.3% of the data. No upper limit was specified for the total times as participants performed self-paced reading in which they were told to take their times in carefully reading and comprehending the sentences. Many participants read the sentences more than once before moving to the following yes/no questions, which extended the total reading time to more than 3000 ms in many cases. Thus, specifying a cut-off point (e.g. 3000 ms) for total times would lead to the loss of valuable data. Data from sentences after which participants responded incorrectly to the comprehension question were excluded from the analysis, resulting in the elimination of an additional 9.8% of the data.

Our prediction was that the difficulty associated with the processing of the ambiguous modifier structure would gradually decrease throughout the whole list leading sentences at the end of the list to be more easily processed than sentences occurring earlier in the list. Therefore, sentences occurring on the fourth block should be more easily processed than sentences occurring in earlier blocks. This is because repeated exposure to a priori ambiguous structure throughout the list should lead to an accumulatively generated priming effect that will eliminate the processing difficulty towards the end of the list. This priming effect should be evident on the modifier rather than the goal structure as the former is a priori ambiguous structure whereas the latter is a familiar structure. To

assess the occurrence of such an accumulative priming effect for sentences holding a modifier structure, a 2x4 repeated measures analyses of variance ANOVA was conducted crossing sentence structure (modifier vs. goal) with block order in which the item occurs within the list (i.e. first, second, third, or fourth block). The 2x4 ANOVAs were calculated for each dependent eye-tracking measure for each interest area. Follow-up means comparisons were calculated to examine differences between experimental conditions. Table 4.1 shows mean values of the three dependent measures for each structure in each interest area.

4.8.3.1 Within-role syntactic priming

4.8.3.1.1 ANOVA analysis

Disambiguation interest area

The most prominent proof of the occurrence of priming is the finding that the reading on the disambiguation area is affected by the order of the block in which the sentence occurs. First-run time results revealed an interaction between block order and sentence structure, $F_{(1,23)} = 4.56$, $p < .05$. Pairwise comparisons revealed that noun-attached PP in the fourth block was more easily processed than noun-attached PP in earlier blocks, $p < .01$. Verb-attached PPs were processed at equal speed irrespective of the order of the block in which they occur. There was a main effect of structure as noun-attached PPs were more difficult to process compared to verb-attached PPs, $F_{(1,23)} = 10.42$, $p < .05$, This replicates the common finding that noun-attached PP is harder to process than verb attached PP. There was also a main effect of block as items lying in the fourth block were more rapidly processed than items in earlier blocks, $F_{(1,23)} = 9.86$, $p < .000$.

Total time data showed no interaction between structure and block order. There was a main effect of structure, $F_{(1,23)} = 7.85$, $p < .01$, and another main effect of block order $F_{(1,23)} = 15.66$, $p < .000$. Items presented in fourth block were more easily processed than items in earlier blocks. There were no significant effects in first-run regressions in this interest area.

Post-PP interest area

There were no significant effects in first-run time, total times, and first-run regressions

in this region.

Table 4.1 Mean values of the three eye-tracking dependent measures by condition and interest area for first language speakers (Standard errors appear in parenthesis).

	Condition	**Interest area**	
		PP	**Post-PP**
First-run time (ms)	Verb-attachment in first block	370 (30.8)	560 (52.4)
	Verb-attachment in second block	381 (35.2)	535 (58.1)
	Verb-attachment in third block	396 (40.2)	513 (53.1)
	Verb-attachment in fourth block	338 (27.6)	483 (53.1)
	Noun-attachment in first block	540 (38.03)	510 (46.9)
	Noun-attachment in second block	475 (41.26)	518 (42)
	Noun-attachment in third block	425 (38.51)	419 (32.4)
	Noun-attachment in fourth block	292 (25.3)	451 (33.6)
Total time (ms)	Verb-attachment in first block	3118 (319.11)	1431 (188.6)
	Verb-attachment in second block	2900 (286.28)	1469 (202.4)
	Verb-attachment in third block	2783 (281.31)	1359 (206.8)
	Verb-attachment in fourth block	2196 (280.16)	1309 (254.5)
	Noun-attachment in first block	3089 (285.37)	1073 (130.4)
	Noun-attachment in second block	2661 (293.18)	976 (95.7)
	Noun-attachment in third block	2328 (238.31)	847 (103)
	Noun-attachment in fourth block	1741 (239.38)	712 (110.2)
First-run regressions	Verb-attachment in first block	11.7 (1.57)	10.3 (1)
	Verb-attachment in second block	12 (1.78)	9.8 (1.3)
	Verb-attachment in third block	11.7 (1.77)	10.7 (1.2)
	Verb-attachment in fourth block	9.8 (1.52)	8.3 (1.6)
	Noun-attachment in first block	12.3 (1.24)	7.4 (.7)
	Noun-attachment in second block	11.5 (1.68)	5.6 (.7)
	Noun-attachment in third block	10.7 (1.53)	7.1 (.6)
	Noun-attachment in fourth block	9.8 (1.6)	7.8 (.8)

Table 4.2 Model estimates for first run times, total times, and first-run regressions at the PP and post-PP regions for first language speakers.

	Coefficient	Interest area					
		PP			Post-PP		
		Estimate	S.E.	t-value	Estimate	S.E.	t-value
First-run time (ms)	Intercept	342.84	61.77	5.55	539.04	96.18	5.60
	Structure	234.62	48.41	4.84	-46.03	56.73	-0.81
	Block Order	-18.99	22.78	-0.83	-32.95	36.7	-0.89
	Stim. Order	57.25	68.74	0.83	28.89	112.22	0.25
	Structure x Block Order	-74.41	17.30	-4.3	-1.11	19.82	-0.05
Total time (ms)	Intercept	3837	503	7.6	1106.2	317.61	3.48
	Structure	7.29	352	0.02	-207.7	172.58	-1.20
	Block Order	-204.4	111.2	-1.83	-67.56	121.90	-0.55
	Stim. Order	-269.4	364.3	-0.7	310.75	362.99	0.85
	Structure x Block Order	-142.3	124.2	-1.14	-126.94	65.49	-1.93
First-run regressions	Intercept	3.59	0.64	5.59	2.84	0.61	4.63
	Structure	0.72	0.44	1.61	-0.58	0.32	-1.81
	Block Order	0.086	0.15	0.54	0.12	0.20	0.59
	Stim. Order	-0.51	0.46	-1.11	-0.28	0.57	-0.50
	Structure x Block Order	-0.25	0.15	-1.68	-0.11	0.12	-0.96

4.8.3.1.2 Mixed effects model analysis

The accumulative effect of syntactic priming was assessed through the use of regression mixed effects models calculated in r with random intercepts and slopes (Baayen, Davidson, & Bates, 2008). Separate models were fit for each dependent measure at each interest area. First run times[9], total times[10], and first-run[11] regressions were regressed onto the main effects and interactions of sentence structure (high attachment vs. low attachment), and block order (from 1-4). To control for task adaptation, log transformed stimulus order was also included as a predictor representing item position among other experimental, filler, and practice items. The difference between block order and stimulus order is that block order in which a stimulus occurs is a predictor of the occurrence of syntactic priming as exposure to more items throughout the list is predicted to produce the priming effect. Stimulus order, on the other hand, is a predictor of the increased speed of processing resulting from increased adaptation to the task throughout the list. Maximal models justified by the design were fit. If a model wouldn't converge, random effects causing smaller variance were eliminated first until the model achieves convergence. Model estimates are presented in Table 4.2.

Disambiguation area

First run time data revealed a significant effect of the interaction between structure and block order in addition to a significant effect of structure (all p values < .05) The two way interaction between structure and item order was significant β = -9.21, p < .05. Participants adapted to the less frequent low attachment structure through the occurrence of syntactic priming effect that resulted in faster RTs towards the end of the list.

[9] PP region model includes by item and by subject intercepts and random by-item slope of structure and block order and by-subject slope for structure, block order, and stimulus order. Post-PP region includes all random intercepts and slopes except by-subject and by-item slope for structure x block order.

[10] PP region model includes all by-subject and by-item intercepts and slopes. Post-PP region model included all by-subject and by-item random intercepts and slopes except for by-item slope for structure x block.

[11] Disambiguation region model included all by-subject and by-item random intercepts and slopes. Post-PP region model included all by-subject and by-item random intercepts and slopes except for by-subject slope for structure x block.

The mixed effects model data became consistent with ANOVA. The accumulative priming effect was evident by the shorter first run time at the disambiguation region for NP attachment structure as compared to VP attachment structure.

4.8.3.2 Cross-role syntactic priming

Throughout the cross-role list, the removal of outliers followed the same method as with the within-role list, eliminating 4% of the data. Incorrect responses to comprehension questions resulted in the elimination of additional 13.5% of the data.

To examine the transfer of the syntactic priming effect across different thematic roles (from an attributive PP to a modifier PP), we compared the last blocks of the NP attachment sentences for the within-role versus the cross-role conditions. Given that syntactic priming in the within-role list was only evident in the first run time data at the disambiguation PP area, first run times at this area were used as the dependent measure here. If the disambiguation area of the sentences included in the fourth block was processed at equal speeds in both lists, this would indicate that a syntactic priming effect was transferred from attributive PP sentences in the first three blocks to the modifier PP sentences in the fourth block of the cross-role list.

Table 4.3 Mean values of first-run time in ms by structure and condition, first language speakers (SEMs in parenthesis).

Structure	**Condition**		
	Cross-role list (4^{th} block)	**Within role list (4^{th} block)**	**Within role list (1^{st} block)**
NP-attached PP	304 (23.7)	292 (25.3)	540 (38.03)
VP-ttached PP	348 (26.7)	338 (27.6)	370 (30.8)

Mixed ANOVA was conducted between groups (cross-role vs. within-role) for each structure (LA vs. HA) on first run time data at the disambiguation area of the sentences included in the last block in both lists. Results revealed no interaction of structure and group, $F1_{(1,47)} = .002$, $p = .9$. Sentences in the last block of the cross–role list were processed at the same pace as their counterparts in the within-role list. Mean first run times are shown in Table 4.3.

In addition, the fourth block of the cross-role list was compared to the first block of the within-role list. A difference in processing between the two blocks would indicate that a priming effect was accumulated throughout the cross-role test leading sentences in the last block to be more easily processed than their counterparts in the first block of the within-role list (see Figure 4.1). A 2x2 mixed ANOVA crossing structure with group (Cross-role list 4th block vs. within role list 1st block) was conducted. Results revealed an interaction $F_{(1,47)}$= 10.87, $p < .01$ that showed that LA items in the fourth block of the cross-role list were more rapidly processed than in the first block of the within-role list, $p < .01$

In the mixed effects model analysis, first run times were regressed onto the main effects and interactions of sentence structure (VP-attachment vs. NP-attachment) and group (4th block of cross-role list vs. 4th block of within role list). Similar to ANOVA analysis, results revealed no interaction, $\beta = 171.78$, $p = .1$. Another model was fit including the main effects and interactions of sentence structure (high attachment vs. low attachment) and group (Cross-role list 4th block vs. within role list 1st block). For this model, an interaction was found, $\beta = 240.33$, SE=108.7, $t = 2.2$, $p < .05$. This confirms the ANOVA analysis, indicating the occurrence of cross-role priming that transferred from attributive PP in the first three blocks to the modifier PP in the fourth block.

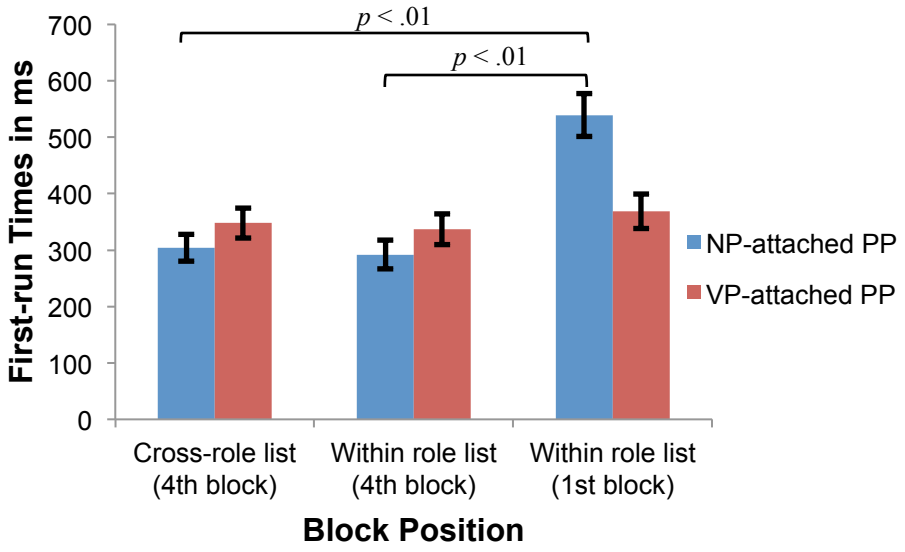

Figure 4.1 First-run times (in ms) split by structure and block position for first language speakers. NP-attached PPs are shown as blue bars and VP-attached PPs as red bars. The error bars indicate SEM.

In summary, results revealed the occurrence of cross-role priming effect that transferred from "attributive" PP to "locative" PP in NP-attached structure. This effect was captured by first-run times. Participants showed facilitation in the processing of NP-attached PP after being repeatedly exposed to either another locative NP-attached PP or an attributive NP-attached PP. Results suggests that syntactic riming generated from this type of sentence structure occurs on syntactic rather than thematic basis.

4.9 Experiment 6: Cross-role priming in L2

4.9.1 Method

4.9.1.1 Participants

Forty-eight students from University of Leeds participated for a monetary reimbursement. They were all native speakers of Arabic. The mean age was 25.2 (range 22-31). All of them reported normal to corrected vision and hearing, and no neurological impairments. Participants responded to the Language History of use Questionnaire (Appendix A) before participation. Mean proficiency ratings are reported in Table 4.4. All participants started to learn English between the ages of 9 and 14, and were regularly exposed to English through media and textbooks, however all of them

lived in L1-dominant environment. Practically, all university students in Leeds are sufficiently proficient in English as a second language, so proficiency in English was not mentioned as an inclusion criterion in recruitment. Two participants made more than 50% errors in responding to comprehension questions within the cross-role list and were excluded from the analysis.

Table 4.4. Mean self reported ratings (7-point Likert scale) of proficiency in English as a second language for Experiment 6 (SDs in parenthesis).

Skill	Mean Proficiency (7 points)
Listening	6.64 (0.85)
Speaking	6.12 (0.96)
Reading	5.64 (0.82)
Writing	5.03 (0.69)
General proficiency	5.07 (0.63)

4.9.1.2 Material and procedure

Stimulus, materials, and procedures were the same as in Experiment 5.

4.9.2 Results

The method of identifying outliers was similar to that of Experiment 5, resulting in the elimination of 7.5 % of the data and an additional 14.5 % of the data for incorrect responses to comprehension questions. First-run regressions data from one participant data was removed to reach normality. Table 4.5 shows mean values of the three dependent measures for each structure in each interest area.

Table 4.5 Mean values for three dependent measures by condition and interest area for second language speakers (Standard errors appear in parenthesis).

	Condition	Interest area	
		PP	**Post-PP**
First-run time (ms)	Verb-attachment in first block	534 (54.15)	701 (72.53)
	Verb-attachment in second block	482 (55.01)	683 (3.2)
	Verb-attachment in third block	554 (46.26)	606 (64.49)
	Verb-attachment in fourth block	716 (44.19)	545 (76.8)
	Noun-attachment in first block	661 (51.8)	684 (53.16)
	Noun-attachment in second block	566 (35.84)	702 (76.78)
	Noun-attachment in third block	536 (47.68)	645 (68.34)
	Noun-attachment in fourth block	432 (35.48)	578 (38.70)
Total time (ms)	Verb-attachment in first block	4462 (270.08)	2285 (291.96)
	Verb-attachment in second block	4006 (302.37)	1921.7 (189.5)
	Verb-attachment in third block	3742 (263.10)	2117 (241.72)
	Verb-attachment in fourth block	4141 (370.95)	1512 (214.04)
	Noun-attachment in first block	4298 (222.47)	1306 (121.58
	Noun-attachment in second block	3601 (282.49)	1278 (130.82)
	Noun-attachment in third block	3367 (321.06)	1042 (80.19)
	Noun-attachment in fourth block	2967 (309.33)	1120 (139.48)
First-run regressions	Verb-attachment in first block	12.04 (1.24)	11.7 (1.1)
	Verb-attachment in second block	10.47 (1.25)	11.08 (1.29)
	Verb-attachment in third block	11.5(2.03)	11.13 (1.29)
	Verb-attachment in fourth block	11.43 (1.19)	9.04 (1.6)
	Noun-attachment in first block	14.95 (.96)	6.47 (.64)
	Noun-attachment in second block	12 (1.80)	5 (.63)
	Noun-attachment in third block	10.21 (1.07)	7.13 (.93)
	Noun-attachment in fourth block	11 (1.25)	7.43 (1.06)

4.9.2.1 Within-role syntactic priming

4.9.2.1.1 ANOVA analysis

Disambiguation area

Similar to L1, first-run time data revealed significant interaction between structure and block order, $F_{(1,23)} = 16.89$, $p < .000$. Follow up mean comparisons showed that NP attached PP structure occurring in the fourth block were processed more rapidly than in the first block of the within-role list, $p < .01$. In contrast, VP-attached PP structure occurring in the fourth block were processed slower compared to VP-attachment structure in the first block. No main effects were observed.

Total times showed a significant interaction between structure and block order, $F_{(1,23)} = 3.39$, $p < .05$. Follow-up mean comparisons revealed that NP-attachment sentences in the fourth block were processed more quickly than NP-attachment sentences in the first block, $t_{(23)} = 4.69$, $p < .000$. In addition, there was a main effect of structure. Surprisingly, participants took longer time to process disambiguation area of VP attachment as compared to NP attachment, $F_{(1,23)} = 19.40$, $p < .000$, however, VP-attachment structure was processed with equal speed throughout the main list. There was also a main effect of block. Items in the first block of the list took longer time to be processed than items in the rest of the three blocks (all p values < .001) irrespective of item structure.

First-run regressions showed an interaction of structure and block order $F_{(1,22)} = 2.81$, $p < .05$. Follow up means comparisons showed more first-run regressions on the PP area of the sentences occurring in first block compared to sentences occurring in third block, $t_{(22)} = 6.99$, $p < .01$, and sentences occurring in the fourth block, $t_{(22)} = 3.4$, $p < .000$. There was a main effect of block order, $F_{(1,22)} = 3.27$, $p < .05$ as PP area in sentences occurring in the first block underwent more regression gazes than sentences in each of the second, third, and fourth blocks (all p values < .05).

Post –PP area

Neither first-run times nor total times data showed interaction. First-run times revealed

a main effect of block order, $F_{(1,23)} = 3.12$, $p < .05$. Items in the fourth block were processed more quickly compared to items in first and second block (all p values <. 05). Total times showed main effect of structure, $F_{(1,23)} = 32.26$, $p < .000$. Post-PP region in VP-attachment structure took longer processing total time than in NP-attachment structure. There was also a main effect of block order, $F_{(1,23)} = 6.10$, $p = .001$. Sentences in the fourth block were more easily processed than sentences in earlier blocks irrespective of sentence structure (all p values < .05).

First-run regressions showed interaction; however, not in the predicted direction. More regression fixations were directed to Post PP region of NP-attachment sentences occurring in fourth block as compared to sentences in earlier blocks, $F_{(1,22)} = 3.63$, $p < .05$., indicating that NP-attachment structure was more difficult to process in the fourth block as compared to the second block. There was a main effect of structure in an unpredicted direction as well as VP-attachment sentences underwent more regressions overall as compared to NP-attachment sentences, $F_{(1,22)} = 43.99$, $p = .000$.

4.9.2.1.2 Mixed effects model analysis

A mixed effects model structure similar to that in Experiment 5 was fit[12, 13, 14]. Model estimates are presented in Table 4.6.

[12] PP region model includes by item and subject intercepts and random by-subject slope of structure x block order. Post-PP region includes all random intercepts except by-subject and by-item intercept for structure x block order.

[13] PP region model includes all by subject and by-item intercepts except for by item intercept of stimulus order and by subject block order intercept by item and by subject slopes for block x structure were included. Post-PP region model included all by-subject and by-item random intercepts except for by-item intercept for stimulus order.

[14] PP region model includes all by subject and by-item intercepts except for by item intercept of stimulus order and by subject block order intercept by item and by subject slopes for block x structure were included. Post-PP region model included all by-subject and by-item random intercepts except for by-item intercept for stimulus order.

Table 4.6 Model estimates for first-run times, total times, and first-run regressions at the PP and post-PP regions for second language speakers.

	Coefficient	Interest area					
		PP			Post-PP		
		Estimate	S.E.	t-value	Estimate	S.E.	t-value
First-run time (ms)	Intercept	392.74	54.76	7.17	390.75	55.15	7.08
	Structure	2.874	42.04	0.06	4.913	38.80	0.12
	Block Order	-11.50	24.42	-0.47	-10.66	23.64	-0.45
	Stim. Order	-16.85	60.56	-0.27	-17.12	59.07	-0.29
	Structure x Block Order	15.62	15.15	2.03	14.8	13.94	1.06
Total time (ms)	Intercept	5512	380.9	14.47	223	351.83	6.35
	Structure	224.9	294.4	0.76	-103	223.15	-4.64
	Block Order	266.0	121.2	2.19	-204.8	90.70	-2.25
	Stim. Order	-1474	342.8	-4.30	202.3	262.16	0.77
	Structure x Block Order	-294	119.5	-2.46	73.46	64.84	1.13
First-run regressions	Intercept	4.108	0.590	6.95	4.38	0.50	8.68
	Structure	1.186	0.367	3.22	-2.72	0.36	-7.51
	Block Order	0.192	0.216	0.88	-0.39	0.19	-2.06
	Stim. Order	-0.545	0.673	-0.80	0.034	0.47	0.07
	Structure x Block Order	-0.392	0.145	-2.69	0.58	0.11	4.95

Disambiguation area

First-run time showed interaction between block order and structure. Total time data revealed an interaction of structure and block, $p < .05$, a main effect of block order, $p < .05$, a main effect of log transformed stimulus order, $p < .001$. First-run regression data showed an interaction between structure and block order $p < .05$. No main effects were observed.

Post PP

First-run times showed no effect of the interaction or any of the three predictors for this interest area. Total times showed main effect of structure $p < .001$. First-run regressions at the post PP showed an interaction between structure and block order in the unpredicted direction. NP attachment structure was more easily processed in the second block as compared to the final fourth block $p < .000$.

4.9.2.2 Cross-role syntactic priming

Analysis was conducted on fourth block of cross-role list. Removal of outliers resulted in the elimination of 7.2% of the data. First-run times, total times, and first regressions were used as dependent measures as these are the measures that showed the occurrence of accumulative priming throughout the within-role list. Mean values of the three dependent measures by condition are displayed in Table 4.7.

Table 4.7 Mean values of the three dependent eye-tracking measures by structure and condition, second language speakers (SEMs in parenthesis).

Measure	Structure	Condition		
		Cross-role list (4th block)	**Within role list (4th block)**	**Within role list (1st block)**
First-run time (ms)	NP-attached PP	607 (30.01)	432 (35.4)	661 (51.8)
	VP-attached PP	635 (26.7)	716 (44.1)	534 (54.1)
Total time (ms)	NP-attached PP	3133 (308.9)	2967 (309.3)	4298 (222.4)
	VP-attached PP	3730 (286.5)	4141 (370.9)	4462 (270.08)
Regressions	NP-attached PP	13.7 (1.2)	11 (1.2)	14.9 (.96)
	VP-attached PP	12.9 (1.2)	11.4 (1.2)	12.04 (1.2)

Mixed 2x2 ANOVA crossing structure x position was conducted. First-run results showed an interaction, $F_{(1,23)} = 3.98$, $p < .05$. NP-attachment PPs in the last block of cross-role list were processed slower than their counterparts in the last block of within-role list (see Figure 4.2), which provides evidence against the occurrence of priming across different thematic roles in the cross-role list, $p < .01$. No interaction was found between fourth block of the cross-role list and first block of the within-role list $p = .3$,

which further confirms the absence of cross-role priming.

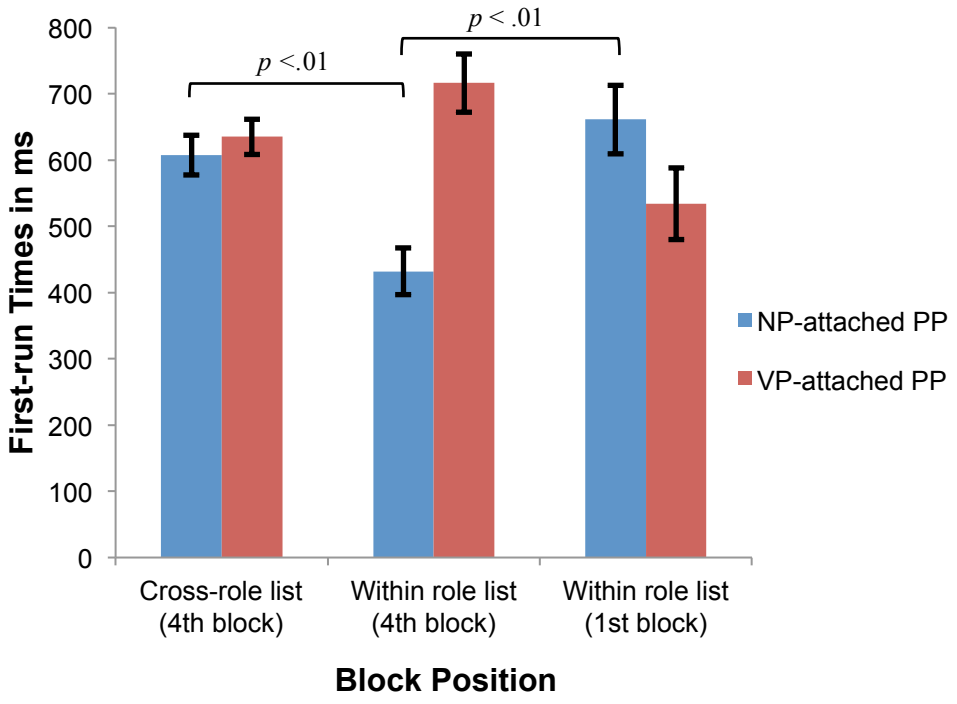

Figure 4.2 First-run times (in ms) split by structure and block position for second language speakers. NP-attached PPs are shown as blue bars and VP-attached PPs as red bars. The error bars indicate SEM.

Total times revealed no interaction between last blocks in both lists, $p = .1$. There was a main effect of structure. VP-attached items took longer total times to be processed than NP-attachment items, $F_{(1,23)} = 18.29$, $p < .000$. No interaction existed between first block in within-role list and fourth block in cross-role list $p = .1$ (see Figure 4.3), which weakens the evidence supporting the occurrence of cross-role syntactic priming. There was a main effect of structure as VP-attached items took longer total times to be processed than NP-attachment items, $F_{(1,23)} = 6.74$, $p < .01$. Regressions showed no structure x group interaction, $p = .4$. Unlike total time data, No main effect of structure was found. The absence of interaction suggests that the number of regression gazes was equal in the last block for both lists which supports the occurrence of a cross-role priming effect that facilitated the processing of items in the last block of cross-role list;

however, similar to first-run and total times data, this evidence is weakened as there was no interaction between first block in within-role list and fourth block in cross-role list, $p = .2$, which supports the absence of cross-role priming effect (see Figure 4.4). There was a main effect of structure as NP-attachment items were less easily processed than VP-attachment items in both blocks, $F_{(1,23)} = 5.01$, $p < .05$.

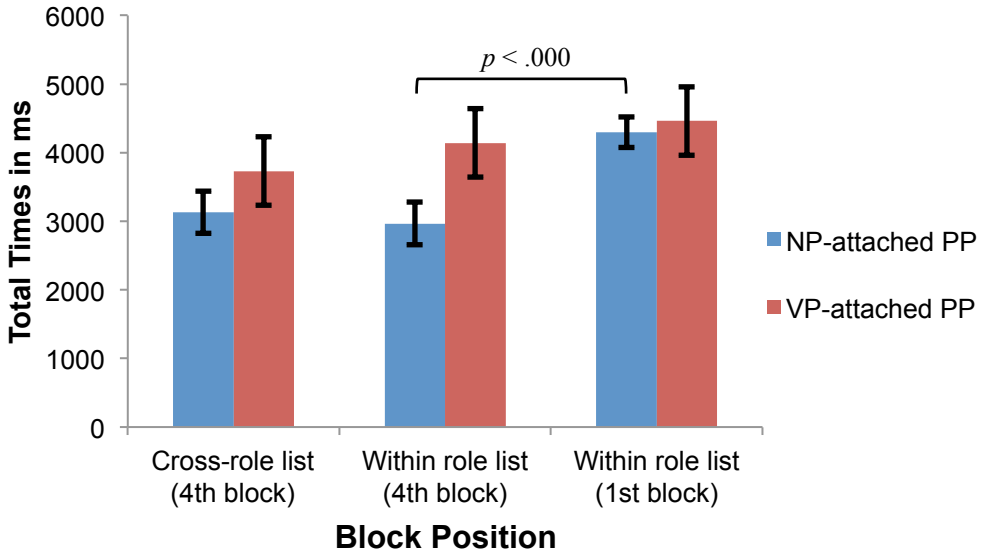

Figure 4.3 Total times (in ms) split by structure and block position for second language speakers. NP-attached PPs are shown as blue bars and VP-attached PPs as red bars. The error bars indicate SEM.

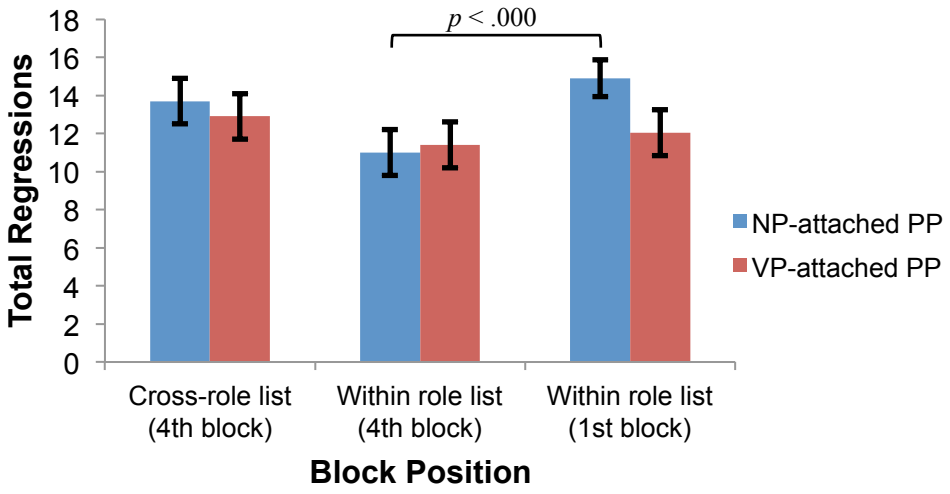

Figure 4.4 Number of total regressions split by structure and block position for second language speakers. NP-attached PPs are shown as blue bars and VP-attached PPs as red bars. The error bars indicate SEM.

In summary, results revealed that cross-role priming in second language speakers is weaker than within role priming. Second language participants showed greater difficulty in processing locative NP-attached PP after the processing of attributive NP-attached PP than after the processing of another locative NP-attachment PP. Results suggest that the generated priming among second language participants for these type of structure is not purely syntactic. Shared thematic representations are required for the priming effect to occur among this group of participants.

4.10 Combined analysis of within-role accumulative priming for both first- and second-language speakers

Language users have the ability to adapt their processing preferences according to the linguistic environment they encounter (Levy, 2008). This ability is the mechanism underlying the occurrence of accumulative priming which involves participants' adaptation to a less frequent syntactic structure after repeated exposure to it in the experimental linguistic environment. This is accounted for by an error-based learning (Chang, Dell, & Bock, 2006). According to error-based learning, the language users invest all their time in prediction about the upcoming linguistic input. If these predictions are not met, the perceiver's linguistic knowledge is adjusted. It is less clear whether L2 participants have the same ability to adapt to the probabilities in their

linguistic environment. This is because L2 speakers are less able to engage in context-based predictions, which might result in differences between both groups in accumulative priming. To examine this, a combined analysis was conducted on within-role lists for both L1 and L2 participants.

Previous research has shown L1 speaker's ability to engage in error-based learning in order to adapt their syntactic preferences according to the probabilities of their linguistic environment (Fine & Jeger, 2016; Fine, Jaeger, Farmer, & Qian, 2013; Myslin & Levy, 2016). For example, in syntactic priming experiments, the frequent exposure to a specific structure was shown to bias the reader's or speaker's prediction for one of two syntactic alternatives. Previous research has shown that the facilitation caused by syntactic priming increases with the number of primes that precede the target and share its syntactic structure. For example, Fine et al., (2013) conducted a syntactic priming experiment to examine the effect of frequent exposure to a less familiar syntactic structure on self-paced reading time. A complex relative clause RC structure like "*the experienced soldiers warned about the dangers conducted the midnight raid* " was presented frequently to the participants as compared to the more familiar main clause MC alternative as in "*the experienced soldiers warned about the dangers before the midnight raid* ". Results showed that although the infrequent RC structure initially produced longer response times, participants became to read the RC structure more quickly when it was presented frequently during the course of the experiment, indicating that L1 speakers adjusted their syntactic expectancy according to the linguistic environment of the experiment.

Studies on second language learners show that predictive processing in L2 is limited (Gruter, Lew-Williams & Fernald, 20012; Hopp, 2013; Martin et al., 2013). L2 speakers don't show predictive processing to the same degree as L1 speakers despite knowing the particular linguistic input used. Because L2 speakers rely more on their attentional resources in L2 processing, they are less likely to allocate enough resources to an attention-demanding predictive processing and instead focus their cognitive resources on conflict monitoring, lexical suppression, construction or revision of contextual representations. Previous studies argued that predictive processing decreases with increasing cognitive control and limited cognitive resources (Slevc & Novick, 2013; but

see Otten & Van Berkum, 2009), which makes L2 speakers less likely to form specific predictions about the upcoming linguistic input. In support of this, Hopp (2013) found that the anticipatory use of gender information is correlated with the speed of lexical access. The reduced predictive processing in language learners is related to their lack of automaticity in lexical access and in performing parsing strategies. Kaan (2014) argued that L2 predictive processing doesn't differ in essence from native predictive processing, but is modulated by factors specific to L2 speakers such as limited experience with linguistic regularities, cross-linguistic competition, and inconsistent lexical representations.

Given that the mechanism that allows L1 speakers to adjust their syntactic preferences and generate an accumulative priming effect is context-based predictions, it is expected that L2 learners are likely to be differently affected by priming than L1 speakers when tested under the same experimental conditions. In the current study we explored this using a maximal mixed effects model was fit. Because first-run times at the disambiguation region is the dependent measure that showed an effect for both L1 and L2 participants, it was used as the dependent measure in the current model. First-run times were regressed onto the main effects and interactions of sentence structure (high attachment vs. low attachment), and block order (from 1-4), log transformed stimulus order, and group (L1 vs. L2). The final random effects structure included by-item and by-subject intercepts in addition to by subject slopes for stimulus order and group and by-item slopes for structure and group.

Findings revealed a 3-way group x block order x structure interaction, β = 0.09, SE = 24.11, p = .01. Mean comparisons showed that first language participants started to more easily process NP-attachment items no earlier than at the fourth block. NP-attached PP items at the fourth block were processed faster than at each of the first block, t = -5.70, $p < .000$, the second block t = -4.66, $p < .000$, and the third block, t = -3.73, $p < .001$. As for second language participants, the accumulative priming effect started to appear as early as the second block as NP-attachment PP items in the second block were more easily assessed than their counterpart items in the first block t = 3.12, $p < .05$. There was also a block order x group interaction, β = 38.28,

SE = 37.94, $p < .000$, and another structure x block order interaction, β = -38.89, *SE* = 17.06, $p < .01$.

As expected, second language participants showed different pattern of accumulative priming from L1 participants. First language participants needed to be exposed to more items than L2 participants in order to adjust their syntactic preferences, whereas L2 participants showed an adaptation to the less frequent NP attached PP structure as early as at the second block.

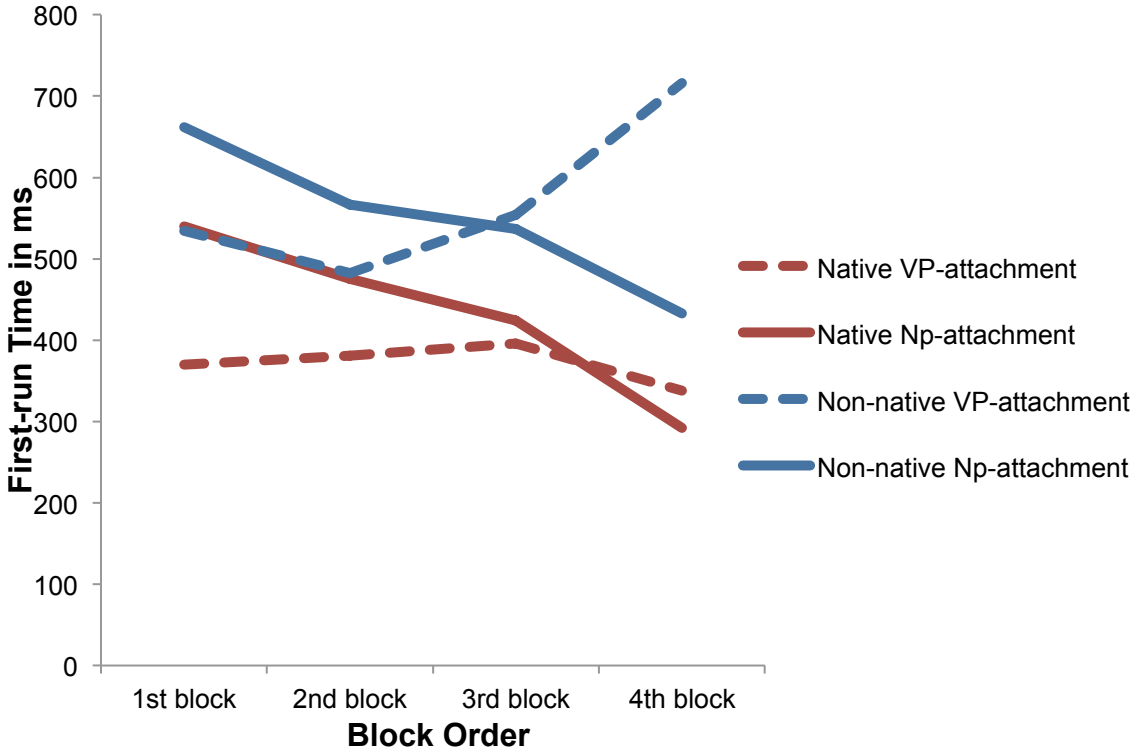

Figure 4.5 First-run time (in ms) split by block order and structure for first and second language participants. VP-attached PPs processed by L1 speakers are shown as a dotted red line, NP-attached PPs processed by L1 speakers as a red line, VP-attached PPs processed by L2 speakers as a dotted blue line, and NP-attached PPs processed by L2 speakers as a red line.

4.11 Discussion

The aim of the present experiments was to examine the resistance of syntactic priming to differences in thematic role in PP-attachment ambiguity, using this as a method to investigate the grain size of the thematic processing in guiding sentence comprehension in this type of syntactic ambiguity. In addition, the study examined differences in accumulative priming between L1 and L2 participants during exposure to NP-attachment PP carrying either same, or different thematic roles. As predicted, NP-attachment PP ambiguity that has initially taken longer first run times was processed more quickly by L1 speaker participants after repeated exposure to this structure throughout the experiment. Moreover, NP-attached PP structure with a locative thematic role was processed at the same pace after repeated exposure to either NP-attached PP with attributive thematic role or another NP-attached PP with locative thematic role, indicating that syntactic priming among L1 speakers can withstand differences in thematic role. L2 participants were able to adapt to the relative probabilities of syntactic structures in the linguistic context. In addition, repeated exposure to sentences with an attribute PP led to facilitation in the processing of sentences containing locative PP. However, unlike L1 speaker participants, the priming effect was weaker than when locative PP followed sentences with the same PP type. Moreover, L2 participants were able to converge their preferences towards the less frequent NP- attachment structure after exposure to fewer instances of the same structure compared to L1 participants.

The occurrence of priming across different thematic roles among L1 participants indicate that priming of NP- attachment ambiguity relied on syntactic, rather than thematic, shared representations. This is attributed to PPs being adjuncts, rather than arguments. Sentential adjuncts are not an independent source of priming that is separate from the effect of syntax. Unlike arguments, adjuncts are optional sentence constituents that are not specified by the verb. Therefore, the assignment of thematic role to adjuncts cannot be affected by the language users experience with verb sub-categorization preferences. Conversely, a preference for one specific PP-attachment or another is tied to the verb. Different verbs have different subcategory preferences. These verb-specific structural biases are supported by the evidence that different verbs with different sub-

categorization frame preferences impose different levels of processing when they appear in a particular ambiguous context (Traxler, 2005; Trueswell, Tanenhaus, & Kello, 1993). As the current study employed action verbs which create a preference for a VP attachment of the post verbal PP, an encounter with a NP-attachment that contradicts with participants' context-based expectations, would result in an adaptation to this less frequent structure. According to the error-based account of syntactic priming, when the perceiver's context-based expectations are not met, their syntactic preferences shift towards the less expected NP-attachment structure (REF error-based account).

Multiple previous studies showed comprehension syntactic priming only when the main verb was repeated between prime and target sentences (REFs). Priming involving this type of lexical overlap has previously been referred to as lexically dependent priming. There are limited studies that showed lexically independent syntactic priming in comprehension, however Traxler (2008) revealed syntactic priming occurred with the prepositional phrase structure both when the verb was repeated and when it was not. In this study by Traxler (2008) reading time showed that participants read a sentence like "*the chemist poured the liquid in the beaker into the flask*" faster after reading a prime sentence with a similar structure and a different main verb like "*the vendor threw the peanut in the box into the crowd*". This indicates that shared syntactic representations were enough for the syntactic priming effect to occur, without the need for the additional contribution of shared lexical representation resulting from verb overlap. The current study supports this finding as our data revealed the occurrence of priming in the absence of thematic overlap was enough for the occurrence of priming in this type of NP-attachment syntactic ambiguity.

There are two competing accounts regarding the processing of arguments and adjuncts. Accounts that oppose differences between arguments and adjuncts argue that information about both arguments and adjuncts syntactic attachment (e.g. either NP-attachment or VP-attachment) are stored lexically at the head (e.g. verb) (MacDonald, Pearlmutter, & Seidenberg, 1994). Upon encounter with a head, the system allows access to syntactic structures that frequently co-occur with that head, either for arguments or adjuncts. For example, a sentence like: "*The teacher gave a paper to*

Peter", the phrase "*to Peter*" is specified as an argument by the dative verb "gave" that regularly takes a recipient argument to-phrase. Conversely, in sentences like "*The teacher stapled a paper to Peter this morning*", the PP "*to Peter*" is an adjunct as the verb "staple" is a transitive verb that more likely refers to an object " *paper*". Thus according to this account, syntactic attachment of both arguments and adjuncts (e.g. NP- or VP- attachment) is lexically specified by their heads. In contrast, accounts which advocate a distinction in processing between arguments and adjuncts suggest that while argument syntactic attachment is lexically specified by the head, adjunct attachment is specified by general grammatical knowledge and global structural principals (Boland & Blodget, 2006). In this way, adjuncts can occur after a number of heads and carry the same thematic role across all those heads. An example of this can be observed in the adjunct phrase like: "this morning" that has the same meaning either after the verb *gave* or *stapled*. Findings from the current study support this latter account. The occurrence of priming across adjunct PPs that carry different thematic roles supports the view of adjuncts as a broad class of members that are not treated differently by the processing system (Boland &Blodget, 2006). Our data suggests that the existence of a specific thematic role or another carried by an adjunct PP is not the source of error-based effects that leads to an accumulation of a syntactic priming effect. This theory is consistent with accounts in which adjuncts are processed differently from arguments.

The finding of a weak priming across different thematic roles among L2 participants suggest that this group of participants depend on both types of shared representations (i.e. syntactic and thematic) for the accumulative priming effect to occur. This occurs in L2 participants without mapping the thematic role on its syntactic attachment. This finding is consistent with the 'Good Enough' model (Christianson, Luke & Ferreira, 2010; Lim &Christianson, 2013), that assumes the existence of two routes to sentence processing: 1) a syntactically-driven algorism route that should be fully functioning along with, 2) a semantics-based heuristic route including world knowledge and lexical/pragmatic information. However, if the syntactic route is weak it can sometimes be suppressed by an overreliance on the semantic knowledge. Accordingly, given the L2 lack of automaticity and cognitive computational constraints that hinder access to full syntactic representations, L2 participants tend to rely on semantic information for

the sake of reaching meaning of the sentence. In our study, the semantic route was chosen over the syntactic route, leading nonnative speakers to represent thematic roles carried by PP without mapping it on its syntactic attachment. Thus due to their dependence of semantic processing (Good Enough model), second language participants exposure to a low-attachment disambiguation phrase might direct the perceiver's attention to the thematic role held by the disambiguation phrase (i.e. attribute of the object). This in turn could increase the attention to potential attributes upon exposure to new sentences. This proves that priming, in some conditions, is not purely syntactic, and can occur on the bases of other types of representation. Furthermore, this would support accounts in which comprehension can occur without syntactic representation (Townsend &Bever, 2001) or proceed with incomplete, contradictory, or globally incoherent syntactic analysis (e.g., Ferreira, Bailey, & Ferraro, 2002; Levy, 2008, 2011; Morgan, Keller, & Steedman, 2010; Tabor, Galantucci, & Richard- son, 2004).

Results from L2 participants showed that the familiar VP-attachment structure took significantly longer times to be processed at the end of the within-role list as compared to at the beginning of the list. Previous research has suggested that the repeated exposure to a less familiar structure along with its familiar counterpart (e.g. NP-attachment vs. VP-attachment) results in an adjustment in the predictions linked to both structures (Fine et al., 2013). After repeated exposure, not only an a priori ambiguous structure becomes familiar, but also the familiar counterpart structure becomes less expected and; therefore, less familiar. This is because participants adapt to the statistical probability of occurrence of different structures throughout the experiment. Structures whose occurrence in the experiment is less than its occurrence in real life (e.g. in corpus) can lead the participants to converge their expectation towards its counterpart. In this study, the ease with which participants process a VP-attachment structure decreased as the number of the sentences in the NP-attachment structure increases throughout the experiment. Participants became more inclined to expect an NP-attachment structure rather than a VP-attachment structure. Although previous studies showed this shift in expectations among L1 participants, the current study showed this effect among L2 participants. This could be because L1 participants needed to be

exposed to more NP-attachment sentences in order to be able to shift their expectation to the extent that a VP-attachment structure. Conversely, L2 participant, as revealed by the combined analysis, could adjust their expectations earlier than L1 participants. Context-based expectations are informed by previous experience with the language. Given than L2 readers have a relatively limited experience with linguistic regularities, they are more prone to converge their expectations to the probability of occurrence of alternative structures. Accordingly, it seems reasonable to assume that the exposure to each structure in the current study was enough to lead to an increased activation of the NP-attachment structure along with a reduced activation of the VP-structure. This ultimately led to an increased difficulty in the processing of VP structure towards the end of the list.

Current results revealed that there is a difference between L1 and L2 participants with regard to eye-tracking measures that detected an accumulative priming effect within locative thematic role (i.e. within-role list). While priming among the L1 group was evident in first run times only, the effect was reflected in first-run times, total times, and total regressions of the L2 group. In support of this finding, measures of on-line comprehension employed in previous research to examine reading of individual sentences also showed a prolonged total processing time for L2 readers as compared to L1 readers (Frenck-mestre & Pynte, 1997; Hoover & Dwivedi, 1998; Seglaowitz & Herbert, 1990). The reason for this relative delay is not clear; however, it is commonly assumed that this is due to the lack of automaticity in the lower level of the orthographic encoding process, leading to a slower lexical access latencies among L2 readers (Favreau & Segalowitz, 1983). Additionally, longer total reading times and increased total regressions for L2 participants was shown to result from a general tendency to re-read sentences (Frenck-Mestre, 2005). By contrast, observed first run times reveal no difference between both groups in the mean length of saccade, mean fixation duration, and regressions within the first run time (Frenck-Mestre, 2005). This is consistent with the pattern of eye-tracking results from the current study. L2 participants showed more regressions from the disambiguation region to earlier regions for the NP-attached PP, this increased number of regression indicate their tendency of re-reading, which in turn increased their total reading times of the disambiguation region as compared to L1

participant.

It could be argued that the priming in the within role condition could, at least partly, be attributed to the overlap in preposition "*on*" and "*onto*". Based on previous research it can be argued that this is unlikely. Findings from previous eye-tracking studies examining different types of ambiguity showed absence of priming in case of overlapping preposition between the prime and target sentences such as (" *The patient visited by the doctor had a bad cough")* and (" *The speaker selected by the student would work perfectly for the program*") (Traxler &Tooley, 2007), In contrast, other cases showed the occurrence of priming although the preposition in the target sentence doesn't exist in the prime, for example, Traxler (2008) found that primes containing agentive by-prepositional phrase (e.g. "*The lifeguard watched by the swimmer had a deep dark suntan"*) primed target sentence containing instrument with-prepositional phrase (e.g. "*The lifeguard watched with the telescope had a deep dark suntan*"). In addition, other sentences types that don't involve prepositions did prime each other "*while the mother was washing the baby cried*". Available evidence reveals that overlapping preposition is not sufficient to cause or maximize the priming effect.

Available syntactic priming findings seem to indicate the fact that content words (especially verbs) boost the priming, whereas function words (such as prepositions) don't contribute to it. Previous evidence showed that content and function words act differently within the processing system. With the exception of head-final languages like Turkish and Korean, it can be suggested that verbs have a larger influence than prepositions in determining links between sentence constituents, and therefore is an essential source of information that guide sentence interpretation. On some occasions information derived from verbs is general, indicating aspects like whether the verb is transitive and is likely to be followed by an object NP or a sentence complement. On other occasions, more fine-grained information can be extracted from the verb as to whether the sentence complement is adverbial as in ("*the man chased the girl waving a stick with his hand*"), or a relative clause complement such as ("*the man noticed the girl waving a stick with his hand*"). The latter sentence was found to result in a "garden path" effect as the verb "chase" doesn't prefer a relative clause complement (Mitchell & Holmes, 1985). Prepositions are used arbitrarily, for example in the present study, the

preposition "*with*" holds an attribute role, whereas, in another sentence it might indicate accompaniment as in "*The manager admitted the student with a bodyguard*". Nevertheless, this doesn't eliminate the possibility that preposition overlap might influence the occurrence of priming but to date, no evidence suggests that it has such influence.

Chapter 5

General Discussion

The process of comprehension, either in reading or listening, involves cognitive representations of the linguistic input. Priming has been extensively used in psycholinguistic research to assess such representations and reflect learning and development. Analogously, syntactic priming has been increasingly used over the past 20 years as a method for investigating the syntactic representation among first language speakers and to a much less extent, among second language speakers. University students with English as a second language often report difficulties related to various syntactical structures in their academic work (Hellstén & Prescott, 2004). Although the majority of international students in the UK don't speak English as their first language, English proficiency is nevertheless a significant predictor of their higher education academic success (Trenkic & Warmington, 2018). The present thesis employed syntactic priming as a method to investigate syntactic processing differences between L1 and L2 speakers. Specifically, this thesis sought to answer four questions: a) To what extent is syntactic processing independent of other sources of information? b) Do listening and reading involve the same syntactic representations in L1 and L2? c) How do syntactic and thematic representations interact in sentence processing in L1 and L2? d) What are the causes of the differences between L1 and L2 syntactic processing? The following section summarizes the main findings.

5.1 Summary of main findings

5.1.1 Chapter 2: The role of syntactic priming in auditory word identification.

The first study sought to examine how the lexical and syntactic levels of representation are interconnected in the online incremental syntactic processing. Specifically, The aim of the study was to examine whether the occurrence of syntactic priming entails facilitation in processing words imbedded in the primed sentence. Previous evidence indicates that listeners are able to identify the word before hearing it in full by employing the information in the unfolding linguistic input (Marslen Wilson, 1984;

Marslen Wilson &Tyler, 2007). It was argued that processing proceeds continuously by combining the speech signal with information derived from previous semantic and syntactic context. Given that syntactic priming involves a transfer of the syntactic knowledge from a prime to a target sentence, it was hypothesized that this syntactic knowledge can contribute to the identification of words imbedded in the target sentence. Previous priming research showed that exposure to a prime sentence with a specific structure increases both the fluency and accessibility of a target sentence with the same structure (for a review, see Pickering & Ferriera, 2008); however, it is not clear whether such improved processing results solely from facilitated integration on the whole sentence level, or also through improving the accessibility of its constituent words. The first study in this thesis employed lexical access and masked word identification tasks to examine L1 and L2 speakers' ability to integrate syntactic knowledge in word identification. The masked word recognition task was employed to examine the priming effect in adverse noise conditions.

For both L1 and L2 participants, high/low prepositional phrase attachment ambiguity failed to yield a trial-to-trial priming effect. The high/low attachment rather yielded an accumulative priming effect in the second study. Such distinction between both types of priming contributes to the dual mechanism account of syntactic priming (Chang et al., 2012; Fitz et al., 2011; Hartsuiker et al, 2008; Tooley & Traxler 2010; see section 1.4.3 for detailed explanation of the model). Hence, different mechanisms underlie (i) the long-lasting accumulative priming, and (ii) the short-lived and less abstract trial-to-trial priming. In the masked word identification task, L1 speakers did not show an ability to integrate syntactic knowledge, despite the previous evidence that support L1 contextual semantic integration in a noise condition (Golestani et al., 2009). Such findings indicate that different types of contexts have different effects on sentence processing in L1 speakers.

5.1.2 Chapter 3: Cross modal comprehension syntactic priming

The second and third studies aimed to examine the abstractness of the accumulative priming effect by investigating the modal- and thematic- independence of the priming effect. This is because an increase in response time that results from repeated exposure

is not a conclusive proof of the occurrence of accumulative priming. As the readers or listeners proceed through the experimental session, they might get quicker or more successful because of the task learning/training effects or via an increased attention. The effect of training on adaptation was shown in previous research (Fine et al., 2010). Conversely, longer response times towards the end of the session might be attributed to fatigue rather than absence of syntactic adaptation. Therefore, this next study sought to examine bidirectional cross-modal priming from listening to reading, and from reading to listening to see whether accumulative priming is abstract enough to persist across the two different modalities.

Second study results supported the abstractness of syntactic priming by showing bidirectional syntactic priming across the two comprehension modalities in L1. Although L2 speakers showed priming in reading, the effect was absent in the listening and weak in the listening-reading condition. Given the observed priming in reading, the absence of priming in listening can be attributed to difficulties in L2 listening rather than an inability to produce abstract priming. This, therefore, rules out the possibility that L2 speakers are less susceptible to syntactic adaptation than L1 speakers. The within-modality results showed the occurrence of accumulative priming, indicating the ability of both L1 and L2 speakers to adapt to the syntactic probabilities of the encountered linguistic environment. This result provides the first empirical evidence of the occurrence of accumulative priming in L2 reading.

5.1.3 Chapter 4: The role of thematic role assignment in processing prepositional phrase attachment

Prepositional phrase attachment structure has always yielded a syntactic priming effect that is more abstract when compared to other structures examined in syntactic priming comprehension research. For example, the general finding from most trial-to-trial priming research is that priming doesn't occur without the lexical boost effect (i.e. co-existence of the same main verb in prime and target sentences). This finding was replicated with numerous syntactic ambiguities except for the PP-attachment ambiguity which was successfully primed without the lexical boost (Traxler, 2008). This evidence has led to the assumption that priming produced from low-attachment structure involves other shared representations in addition to syntax, which results in the augmentation of

the priming effect. Given that prime and target sentences of PP–attachment ambiguity share its thematic role assignment along with its syntax, the third study varied the thematic roles assigned to the prepositional phrase across prime and target trials while keeping syntactic attachment the same. Results refuted that assumption by revealing abstract and thematically independent priming. However, the produced priming effect was less abstract among L2 speakers. L2 speakers were less able to transfer the priming effect across sentences with different thematic roles. Even the within-role condition yielded different results for both groups, which was attributed to processing differences between L1 and L2 participants that is uniquely captured by eye-tracking techniques (see section 4.5.5 for extended explanation).

5.2. Implications of the current findings

5.2.1 Implications for L2 processing

One of the main findings was the occurrence of accumulative priming in L2 speakers. Speakers with English as their second language showed flexible adaptation of their syntactic processing and attachment preferences on the basis of repeated exposure to the noun-attachment structure. Although accumulative priming in L2 has been shown before in production (Kaan & Chun, 2016), this study provides the first evidence of accumulative priming in comprehension in L2 speakers. This was demonstrated through both lexical decision and self-paced reading tasks in Experiments 4 and 6 respectively. Accordingly, L2 speakers are susceptible to the two mechanisms underlying accumulative priming, namely *cumulativity* and *surprisal sensitivity* (Jaeger &Snider, 2007). Cumulativity of syntactic priming refers to gradual increase in the priming effect resulting from repeated exposure to several instances of the same syntactic structure. This accumulation of effect is attributed to error-based implicit learning in which the perceivers generate context-based predictions about the upcoming linguistic input. When these predictions are disconfirmed, knowledge about probability of occurrence for the syntactic structure is updated. This modification in probabilistic syntactic knowledge persists and increases with further exposure, leading the syntactic processing to converge to the more frequently encountered structure. On the other hand, *surprisal* sensitivity of syntactic adaptation refers to the common finding that less predictable and more surprising structures produce a stronger priming effect than more predictable

structures. The occurrence of accumulative priming in L2 indicates, that similar to L1 speakers, L2 speakers can engage in predictive processing that leads to an updated knowledge about the probability of occurrence for different syntactic structures. Additionally, syntactic adaptation in L2 is modulated by the relative frequency of the prime structure, leading less familiar structures to produce stronger priming effects than more frequent structures. This corresponds to the surprisal sensitivity mechanism.

These findings don't support previous evidence that L2 speakers are less able to generate context-based predictions about the upcoming linguistic input (Dussias, Valdes Kroff, Guzzardo Tamargo & Gerfen, 2013; Grüter & Rohde, 2013; Hopp, 2013, Martin et al., 2013). Conversely, the current findings support Kaan's (2014) argument that although L2 predictive processing is modulated by factors such as limited experience with linguistic regularities, cross-linguistic competition, and inconsistent lexical representations, L2 are also capable of performing predictive processing.

Two accounts have been proposed in previous research regarding difficulty of syntactic processing for second language speakers when compared to first language speakers. The first account poses that second language learners employ the same parsing mechanisms used by L1 speakers; however, syntactic processing in L2 differ from L1 in speed of processing (Dekydtspotter, Schwartz, & Sprouse, 2006). The other account, proposes that different parsing mechanisms underlie syntactic processing. Current results support the former account. The occurrence of L2 priming in reading and not in listening indicates that L2 syntactic processing differs from L1, not in the parsing mechanisms, but in the speed of processing. The time constraint imposed in listening prevents slow L2 speakers from coping with the rapidly unfolding input of syntactically ambiguous or unfamiliar structures, leading to a shallow or incomplete processing and overreliance on misleading semantic information. Conversely, reading as a self-paced process allows more time that compensate for the difficulty of processing an unfamiliar structures.

5.2.2 Implications for theories of syntactic processing

Current results cannot be fully explained by modularity theory or the constraint-based approach of syntactic processing. The modularity theory hypothesizes that only syntactic information is taken into consideration in the processing of garden-path

sentences. This assumption can be tested through the use of syntactic priming that act as a method for examining syntactic information contribution apart from other types of information. The trial-to-trial priming manipulation involves alternating between prime and target sentences that share the same syntactic representation, but differ semantically and lexically. Since it is only the syntactic information that transfers from primes to targets, then the sole effect of that shared syntactic information can be studied separately from semantic and lexical information. Results from the first study showed that the shared syntactic representation between prime and target sentences was not strong enough to guide the interpretation of low attachment targets, which negates syntactic knowledge sufficiency in guiding word recognition in the low-attachment structure. In addition, the modularity theory lacks the predictive processing element that contributes to the occurrence of accumulative syntactic priming. Although the constraint-based approach proposes that language user engage in context-based predictions about the incoming input, it doesn't explain how syntactic knowledge is updated when these predictions are disconfirmed.

Current results showed that low-attachment ambiguity was primed by an accumulative priming manipulation, rather than trial-to-trial immediate priming manipulation, which supports the belief update models of syntactic processing (Kleinschmidt & Jaeger, 2015; Qian, Jaeger & Aslin, 2012). According to these models, language users store information about the probability distribution of how or whether a linguistic item (e.g. syntactic item) occurs in the linguistic environment. This knowledge helps language users to form context-based predictions. When they encounter an unexpected feature, this probabilistic knowledge updates to match features in the environment (Levy, 2008). In addition, this experience with the language is dynamic and, therefore, accumulates with repeated exposure to specific syntactic features that prevails in a given environment. Belief-updating models therefore correspond to the implicit learning account of accumulative syntactic priming. Given that the second and third studies presented here showed an accumulative priming effect for the low-attachment structure, then the present findings support the implicit learning account of syntactic priming and its corresponding belief-update models of syntactic processing for this type of structure.

5.2.3 Implication for syntactic adaptation

In the current thesis, adaptation to less familiar low-attachment PP was not simultaneously accompanied by the reversal effect of increased difficulty in processing its counterpart high-attachment PP structure. This contradicts previous finding that repeated exposure to infrequent and non-preferred structures is followed by increased processing difficulty for structures that were initially common and preferred (Fine et al., 2013). According to the implicit learning account, an increased difficulty simultaneously characterizes the processing of an a priori familiar structure as the system converges to the processing of the initially non-preferred structure. However, the present results don't support this account. It can be suggested that the processing system does not diverge from predicting upcoming structures that are common in previous experience. In support of this, study 2 and 3 revealed increased facilitation in processing a priori less familiar structure like low-attached PP, but this was not accompanied by an increased difficulty in processing of the a priori familiar high attachment structure due to its frequent occurrence in language. This indicates that there is a threshold for the susceptibility of syntactic structures to syntactic adaptation. This threshold cannot be overcome for over learnt structures and hence they resist adjustment.

5.2.4 Trial-to-trial vs. accumulative priming

Results from first and second studies showed the occurrence of accumulative priming, and not trial-to-trial priming, despite employing the same task and same syntactic structure. This asserts the claim that different mechanisms underlie both types of priming (Hartsuiker et al., 2008; Tooley & Traxler, 2018). In trial-to trial priming, the underlying mechanism is an increased short-lived activity in the memory system. The primed syntactic knowledge is one of the multiple sources of information that needs to be integrated together to guide interpretation. This justifies the previous finding that trial-to-trial priming was week in comprehension and needed lexical boosting by a verb overlap between prime and target sentence. Accordingly, the absence of priming in the first study is justified by the insufficiency of the primed syntactic knowledge for word recognition. For word recognition to occur, other lexical and semantic information

needs to be incorporated. Given that lexical information was degraded by the task, whereas semantic information was degraded by the ambiguity of the structure, word recognition was not facilitated in trial-to-trial priming. Nevertheless, the need for integrating multiple sources of information can be overridden by the syntactic adaptation inherent in accumulative priming. Increasing the probability of occurrence for a specific structure would render the resulting syntactic knowledge sufficient for guiding the interpretation of complex structures. The underlying belief-updating mechanisms depend on the human's ability to modify their inner probabilistic knowledge to resemble the statistics of the current environment. The third study showed that this probabilistic knowledge changes based on the exposure to a particular syntactic structure irrespective of its semantic and thematic attachments. Accumulative priming doesn't, therefore, have access to the semantic and thematic aspects correlating with a particular syntactic structure in a linguistic environment. Trial-to trial priming is similar to accumulative priming in this respect. It was shown to occur irrespective of differences in semantic and thematic aspects that co-occur with a particular structure (Carminati et al., 2008). The third study provides the first empirical evidence of the thematic independence of accumulative priming.

5.2.5 Contribution to L2 implicit learning research

The current results have novel implications for the role of implicit learning in second language acquisition. Given that syntactic priming is an implicit mechanism, L2 speakers' ability to show priming indicate their ability to benefit from implicit learning in the acquisition of a second language. Previous findings suggest that explicit learning is superior to implicit learning in affecting second language acquisition. Based on the Fundamental Difference Hypothesis (FDH) by Bley-Vroman (2009), implicit or incidental learning processes become unavailable for L2 grammar acquisition by adulthood. L2 syntax should be rather learnt explicitly for a successful acquisition to occur. Evidence supporting FDH hypothesis shows the weak performance of adult L2 learners who have immersed in a second language environment after adulthood, compared to a control group that had been exposed to L2 before adulthood. Additional evidence is found in studies that examined differences between implicit and explicit learning in grammatical knowledge acquisition (Norris & Ortega, 2000). The general

finding was that explicit instruction results in more effective grammatical knowledge acquisition. However, more recently contradictory evidence has emerged from studies in which learners are taught artificial grammar through implicit exposure. Findings showed that learners can acquire grammatical knowledge effectively through implicit exposure without necessarily being taught explicit grammar rules (Rebuschat & Williams, 2012; Williams, 2005). The present findings are in-line with these latter suggestions whereby implicit learning strategies are present in L2 speakers and do form a component of second language acquisition.

5.2.6 Second language acquisition

Results from the second and third study revealed that L2 speakers can implicitly adapt to the linguistic probabilities they encounter in a linguistic environment. Accordingly, in natural learning settings, repeated exposure to several instances of a grammatical structure can help learners draw connections between form and meaning and develop abstract syntactic representations of the encountered structure. This abstract knowledge is what distinguishes between L1 and L2 speakers. Present results confirm that this exposure-based learning occurs implicitly, which necessitates combining between both explicit and implicit instruction in language learning. Although explicit instruction would help learners to master the rule-governed grammar in the initial learning stages, it is the implicit instruction that will help them develop abstract representations similar to those of L1 speakers. Learners should, therefore, be provided with linguistically rich instruction resources that make use of their belief-updating abilities.

5.4 Suggested future research and conclusion

The present findings confirmed the difficulties associated to L2 listening in processing ambiguous or complex syntactic structure; however such difficulty was eliminated in the situation of a facilitated syntactic integration (e.g. in an off line task as well as in reading). This leads to the assumption that syntactic priming in L2 listening could succeed in experiments employing familiar syntactic structures with a more common occurrence in natural language. Familiar syntactic structures have been employed in listening syntactic priming experiments conducted in L1 speakers, but not L2, with the aim of biasing preference for one syntactic structure over another. An example of this is

a recent study by Chun (2018) who presented English listeners with a block of sentences such as "*I saw the cat of the woman that will wear the shoes*" in which the relative clause "*that will wear the shoes*" modifies "*the woman*", followed by a block of sentences such as "*I saw the cat of the woman that will wear the shoes*" in which the relative clause modifies "*the cat*". Before, after and between the presentation of these blocks, participants' attachment preferences for ambiguous sentences such as "*I met the client of the hairdresser who is talking loudly*" were tested by comprehension questions such as "*who is talking loudly?*". Results revealed that participants gave the answer that corresponded to the presentation blocks, indicating that syntactic preferences can be biased. Testing L2 listeners in similar experiments is predicted to lead to similar results to L1, given that the examined syntactic structure is a familiar structure that doesn't overload L2 speakers' mental resources while listening.

The present findings provide evidence that syntactic priming has been a successful method in assessing mental representation at the sentence level. Findings of priming in sentence processing can be a foundation for applying priming to the study of text representation, which would contribute to our understanding of mechanisms underlying processing in a wider and more complex contexts like texts. Similar to sentences, different texts can share the same structure as in comparative texts, descriptive texts, problem-solution texts, or cause-effect texts. Findings can show whether text structure can be primed, how knowledge of text structure affects the comprehension of texts constituent subtopics, or whether shared text macrostructure can affect the representation of its microstructure.

As discussed earlier, predictive processing can be a determinant of syntactic priming. Language users use their prior knowledge, linguistic and extra-linguistic cues embedded in the context to form predictions about the upcoming linguistic input. Similarly, the experimental setting of the syntactic priming experiment forms a context for the prime and target sentences. In future studies it may be possible to modify particular experimental factors that could possibly enhance predictive processes to bias a structure in the target that is different from the prime structure. In this way syntactic priming could be eliminated, decreased, or augmented. The occurrence of syntactic priming relies on the degree to which the experimental context and procedures bias against the

primed structure. Features like blocking of items, speed of presentation, and presence of linguistic and extra-linguistic cues could lead to either the augmentation or elimination of the priming effect. These features must be taken into consideration in accounting for contradictory results emerging from syntactic priming research.

In conclusion, accumulative syntactic priming is a useful tool for investigating the mental representation of language in both L1 and L2. The present thesis has provided three potential reasons for that conclusion. First, syntactic priming can be used to examine the interplay between different levels of linguistic representation. This can be achieved by creating a syntactic bias through priming and examining how it affects or is affected by other semantic and lexical levels of representation. Second, syntactic priming is a modality-independent mechanism that mirrors processing without interference from other low-level modality specific perceptual features. Finally, comparing syntactic priming across different ages and different linguistic groups can mirror group-related differences in processing.

List of References

Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, 30(3), 191-238.

Antos, S. J. (1979). Processing facilitation in a lexical decision task. *Journal of Experimental Psychology: Human Perception and Performance, 5,* 527–545.

Arai, M., Nakamura, C., & Mazuka, R. (2015). Predicting the unbeaten path through syntactic priming. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 41(2), 482-500.

Arai, M., Van Gompel. R. P. G., & Scheepers, C. (2007). Priming distransitive structures in comprehension. *Cognitive Psychology, 54*, 218-250

Baddeley, Alan D.; Eysenck, Michael W.; Anderson, Mike (2009). *Memory*. New York: Psychology Press. p. 27.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390 – 412.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., & Treiman, R. (2007). The English lexicon project. *Behavior Research Methods, 3,* 445–459.

Bernolet, S., Hartsuiker, R. J., & Pickering, M. J. (2013). From language-specific to shared syntactic representations: The influence of second language proficiency on syntactic sharing in bilinguals. *Cognition*, 127, 287–306.

Bever, T. G. (1970). The cognitive basis for linguistic structures. In J. R. Hayes (Eds.), *Cognition and the Development of Language*. New York: John Wiley and Sons.

Biber, D. (1988). *Variation across speech and writing*. Cambridge: Cambridge University Press

Bley-Vroman, R. (2009). The evolving context of the fundamental difference hypothesis. *Studies in Second Language Acquisition, 31*, 175-198

Bock, K. (1986). Syntactic persistent in language production, *Cognitive Psychology*, *18*, 355-387

Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. *Cognition, 104*, 437–458

Bock, K., & Ferreira, V. S. (2014). Syntactically speaking. In M. Goldrick, V. S. Ferreira, & M. Miozzo (Eds.), *The Oxford handbook of language production* (pp. 21–46). New York, NY: Oxford University Press.

Bock, J. k., Griffin, Z. M. (2000). The persistence of structural priming: transient activation or Implicit learning, *Journal of Experimental Psychology: General, 129*, 177-192

Bock, K., & Levelt, W. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 945–984). San Diego, CA: Academic Press.

Bock, K., & Loebell, H. (1990). Framing Sentences. *Cognition*, *35*, 1-39

Boland, J. E., & Blodgett, A. (2006). Argument status and pp-attachment. *Journal of Psycholinguistic Research, 35*, 385– 403.

Boudewyn, M. A., Zirnstein, M., Swaab, T. Y., & Traxler, M. J.(2014). Priming prepositional phrase attachment: Evidencefrom eye-tracking and event-related potentials. *The Quarterly Journal of Experimental Psychology*, 67 (3), 424-54.

Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition, 75,* 13-25.

Branigan, H. P., Pickering, M. J., Liversedge, S. P., Srewart, A. J., & Urbach, T. P. (1995). Syntactic priming: Investigating the mental representation of language. *Journal of Psycholinguistic Research*, **24**, 489–506.

Bradlow, A. R., and Bent, T. (2002). The clear speech effect for non-native listeners. *Journal of the Acoustical Society of America, 112*, 272-284.

Branigan, H. P., Pickering, M. J., & McLean, J. F. (2005). Priming prepositional-phrase attachment during language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 468–481.

Britt, M. A. (1994). The interaction of referential Ambiguity and argument structure in the parsing of prepositional phrases. *Journal of Memory and Language 33*, 251-283

Brysbaert, M. & Mitchell, D. C. (1996). Modifier attachment in sentence parsing: Evidence from Dutch. *Quarterly Journal of Experimental Psychology, 49*, 664-695.

Cambourne, B. (1981). Oral and written relationships: a reading perspective. In B. M. Kroll & R. J. Vann (Eds), *Exploring speaking-writing relationships: Connections and contrasts* (pp.82-98). Urbana, IL: NCTE.

Caramazza, A., & Hillis, A. E. (1990). Where do semantic errors come from? *Cortex, 26*, 95–122.

Caramazza, A., & Hillis, A. E. (1991). Lexical organization of nouns and verbs in the brain. *Nature, 349*, 788–790.

Carminati, M. N., van Gompel, R. P. G., Scheepers, C., & Arai, M. (2008). Syntactic priming in comprehension: The role of argument order and animacy. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 1098–1110.

Chang F., Janciauskas, M., & Fitz, H. (2012). Language adaptation and learning: Getting explicit about implicit learning. *Language and Linguistics Compass, 6,* 259–278.

Chambers, C. G., Tanenhaus, M. K., & Magnuson, J. S. (2004). Actions and affordances in syntactic ambiguity resolution. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30* (3), 687–696.

Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological review, 113*(2), 234-272

Chomsky, N. (1965). Aspects of the Theory of Syntax. Cambridge, MA: MIT Press.

Chrabaszcz, A., & Gor, K. (2014). Context effects in the processing of phonolexical ambiguity in L2. *Language Learning, 64*, 415–455.

Christianson, K., Luke, S.G. & Ferreira, F. (2010) Effects of plausibility on structural priming. *Journal of Experimental Psychology*, 36, 538–544.

Christianson, K., Hollingworth, A., Halliwell, J.F., & Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology, 42*, 368-407.

Chun, E. (2018). The role of prediction in adaptation: An evaluation of error-based learning accounts (Ph.D.). Gainesville, FL: University of Florida. Chun, E.

Clahsen, H. & Felser, C. (2006a). Continuity and shallow structures in language processing. (Authors' response). *Applied Psycholinguistics, 17*, 107-126.

Clahsen, H. & Felser, C. (2006b). Grammatical processing in language learners. (Keynote article). *Applied Psycholinguistics, 27,* 3-42.

Cleland, A. A., & Pickering, M. J. (2003). The Use of Lexical and Syntactic Information in Language Production: Evidence from the Priming of Noun-Phrase Structure. *Journal of Memory and Language, 49,* 214-230.

Cleland, A. A., & Pickering, M. J. (2006). Do writing and speaking employ the same syntactic representations? *Journal of Memory and Language, 54,* 185–198.

Clifton, C., Jr., Staub, A., & Rayner, K. (2007). Eye movements in reading words and sentences. In R. P. G. van Gompel, M. H. Fischer, W. S. Murray, & R. L. Hill (Eds.), *Eye movements: A window on mind and brain* (pp. 341-371). Amsterdam, Netherlands: Elsevier.

Colé, P., & Segui, J. (1994). Grammatical incongruency and vocabulary types. *Memory & Cognition, 22,* 387–394.

Collins, M., & Brooks, J. (1995). Prepositional phrase attachment through a backed-off model. *Proceedings of the third Workshop on Very Large Corpora*, 27–38. Cambridge, MA: MIT Press.

Coltheart, V., Patterson, K., & Leahy, J. (1994). When a ROWS is a ROSE: Phonological effects in written word comprehension. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 47A*(4), 917-955.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., Ziegler, J. (2001). DRC: A Dual Route Cascaded model of visual word recognition and reading aloud. *Psychological Review. 108*, 204–256.

Cooke, M. P., Garcia Lecumberri, M. L., and Barker, J. P. (2008). The foreign language cocktail party problem: Energetic and informational masking effects in non-native speech perception. *Journal of the Acouistical Society of America, 123*(1)

Crain, S., & Steedman, M. J. (1985). On not being led up the garden path: the use of context by the psychological parser. In D. Dowty, L. Karttunen, & A. Zwicky (Eds.), *Natural Language Parsing: Psychological, Computational, and Theoretical perspectives*. (pp. 320-358) Cambridge: Cambridge University Press.

Cuetos, F., Mitchell, D., & Corley, M. (1996). Parsing in different languages. In M. Carreiras, J. Garcia-Albea, & N. Sebastian-Galles (Eds.), *Language processing in Spanish* (pp. 145-90). Mahwah, NJ: Erlbaum.

Cutler, A., Garcia Lecumberri, M.L., & Cooke, M. (2008). Consonant identification in noise by native and non-native listeners: Effects of local context. *Journal of the Acoustical Society of America, 124*, 1264–1268

Dahan, D. (2015). Prosody and language comprehension. *Wiley Interdisciplinary Reviews: Cognitive Science, 6*(5), 441–452.

Dahan, D., Swingley, D., Tanenhaus, M. K., & Magnuson, J. S. (2000). Linguistic gender and spoken word recognition in French. *Journal of Memory and Language*, *42*(4), 465–480.

Davis, M. (2013). Cohort model of auditory word recognition. In H. Pashler (Ed.), *Encyclopedia of the mind.* (Vol. 3, pp. 157-159). Thousand Oaks, CA: SAGE Publications

Dekydtspotter, L., & Renaud, C. (2014). On second language processing and grammatical development: The parser in second language acquisition. *Linguistic Approaches to Bilingualism*, 4, 131–166.

Dekydtspotter, L., Schwartz, B.D., & Sprouse, R.A. (2006). The comparative fallacy in L2 processing research. In M. G. O'Brien, C. Shea, & J. Archibald (Eds.), *Proceedings of the 8th Generative Approaches to Second Language Acquisition Conference (GASLA 2006): The Banff Conference.* (pp. 33-40). Somerville, MA: Cascadilla.

Dell,G.S. (1986). A spreading–activation theory of retrieval in sentence production. *Psychological Review, 3*, 283–321.

Dell, G.S., & Chang, F. (2014). The P-Chain: Relating sentence production and its disorders to comprehension and acquisition. *Philosophical Transactions of the Royal Society B, 369*, 1-9

Dell, G., Oppenheim, G., & Kittredge, A. (2008). Saying the right word at the right time: Syntagmatic and paradigmatic interference in sentence production. *Language and Cognitive Processes, 23*(4), 583–608.

Deutsch, A., & Bentin, S. (1994). Attention mechanisms mediate the syntactic priming effect in auditory word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 595–607.

Desmet, T. Brysbaert, M. & De Baecke, C. (2002). The correspondance between sentence production and corpus frequencies in modifier attachment. *The Quarterly Journal of Experimental Psychology, 55*, 879-896.

Desmet, T. & Gibson, E. (2003). Disambiguation preferences and corpus frequencies in noun phrase conjunction. *Journal of Memory and Language, 49*, 353-374.

Desmet, T., De Baecke, C., Drieghe, D., Brysbaert, M., Vonk, W. (2006). Relative clause attachment in Dutch: On-line comprehension corresponds to corpus frequencies when lexical variables are taken into account. *Language and Cognitive Processes. 21*(4):453–485.

Deutsch, A., & Bentin, S. (1994). Attention mechanisms mediate the syntactic priming effect in auditory word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 595–607.

Dussias, P. (2001). Sentence parsing in fluent Spanish–English bilinguals. In J.Nicol(Ed.), *One mind, tow languages: Bilingual language processing* (pp. 159-176). Malden, MA: Blackwell.

Dussias, P. E., Valdés Kroff, J. R., Guzzardo Tamargo, R. E., & Gerfen, C. (2013). When gender and looking go hand in hand: Grammatical gender processing in L2 Spanish. *Studies in Second Language Acquisition, 35*, 353–387.

Ellis, R. (2005). Measuring implicit and explicit knowledge of a second language: A Psychometric study. *Studies in Second Language Acquisition, 27*(2), 141-172.

Elman, J. L., & McClelland, J. L. (1984). Speech perception as a cognitive process: The interactive activation model. In Norman Lass (Ed.), *Speech and Language, Vol. 10*. New York: Academic Press

Endo, K., Makishita, H., Yanagisawa, N., & Sugishita, M. (1996). Modality specific naming and gesture disturbances: A case with optic aphasia, bilateral tactile aphasia, optic apraxia and tactile apraxia. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 32*(1), 3-28.

Favreau, M., & Segaiowitz, N. (1983). Automatic and controlled processes in the first- and second-language reading of fluent bilinguals. *Memory & Cognition, 11*, 565-574.

Felser, C., Roberts, L. (2007). Processing wh-dependencies in a second language: a cross-modal priming study. *Second Language Research, 23*(1), 9-36

Felser, C., Roberts, L., Gross, R., & Marinis, T. (2003). The processing of ambiguous sentences by first and second language learners of English. *Applied Psycholinguistics, 24*, 453-489.

Ferrreira, F. (2003). The misinterpretation of noncanonical sentences. *Cognitive Psycholgoy, 47*, 164-203.

Ferreira, F., Bailey, K. G. D., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science, 11*(1), 11–15.

Ferreira, F., Christianson, K., & Hollingworth, A. (2001). Misinterpretations of garden-path sentences: Implications for models of sentence processing and reanalysis. *Journal of Psycholinguistic Research, 30*(1), 3-20.

Ferreira, F., & Clifton, C. (1986). The independence of syntactic processing. *Journal of Memory and Language*, 25, 347-36.

Flett, S., Branigan, H. P., & Pickering, M. J. (2013). Are non-native structural preferences affected by native language preferences?. *Bilingualism: Language and Cognition*, 16(4), 751-760.

Ferreira, F., & Patson, N. (2007). The good enough approach to language comprehension. Language and Linguistics Compass, 1, 71–83.

Folk, J. R., & Morris, R. K. (2003). Effects of syntactic category assignment on lexical ambiguity resolution in reading: An eye movement analysis. *Memory & Cognition, 31*, 87-99.

Forster, K., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments and Computers*, 35(1), 116–124.

Fine, A. B. & Jaeger, T. F. (2013) Evidence for implicit learning in syntactic comprehension. *Cognitive Science 37*(3):578–91.

Fine, A. B., & Jaeger, T. F. (2016). The role of verb repetition in cumulative structural

priming in comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*(9), 1362-1376.

Fine, A. B., Jaeger, T. F., Framer, T. A., Qian, T. (2013). Rapid Expectation Adaptation during Syntactic Comprehension. *PloS One, 8* (10).

Fine, A. B., Qian, T., Jaeger, T. F., & Jacobs, R. (2010). Syntactic adaptation in language comprehension. *In Proceedings of the 2010 workshop on cognitive modeling and computational linguistics* (pp. 18–26). Uppsala, Sweden: Association for Computational Linguistics.

Fitz, H., Chang, F., Christiansen, M. H. (2011). A connectionist account of the acquisition and processing of relative clauses. In E. Kidd (Ed.), *The Acquisition of Relative Clauses: Processing, Typology, and Function*. Amsterdam pp. 39–60, The Netherlands: John Benjamins.

Florentine, M. (1985). Speech perception in noise by fluent, non-native listeners. *Journal of Acoustical Society of* America, *77, S106*

Foucart, A., & Frenck-Mestre, C. (2011). Grammatical gender processing in L2: Electrophysiological evidence of the effect of L1–L2 syntactic similarity. Bilingual Language Cognition, 14, 379-399

Fodor, J. A., (1983). *Modularity of Mind*. Cambridge, MA: MIT Press.

Frauenfelder, U., & Tyler, L. (1987). The process of spoken word recognition: An introduction, *Cognition, 25*, 1-20.

Frazier, L., (1987). Theories of sentence processing. In J.L. Garfield (Ed.), *Modularity in knowledge representation and natural-language understanding* (pp. 291-307). Cambridge, MA: The MIT Press

Frazier, L. & Clifton, C. (1996). *Construal*. Cambridge, MA: MIT Press.

Frazier, L., & Fodor, J. D. (1978). The Sausage Machine: A New Two-Stage Parsing Model. *Cognition, 6*, 291-325.

Fricke, M., & Kootstra, G. J. (2016). Primed code-switching in spontaneous bilingual dialogue. *Journal of Memory and Language*, 91, 181–201

Friederici, A.D., Weissenborn, J. (2007). Mapping sentence form onto meaning: the syntaxsemantic interface. *Brain Research, 11*(46), 50 –58.

Frenck-Mestre, C. (2002). An on–line look at sentence processing in the second language. In R. Heredia & J. Altarriba (Eds.), *Bilingual sentence processing* (pp. 217–236). New York: Elsevier.

Frenck-Mestre, C. (2005). Eye-movement recording as a tool for studying syntactic processing in a second language: A review of methodologies and experimental findings. *Second Language Research, 21*(2), 175-198.

Frenck-Mestre, C., & Pynte, J. (1997). Syntactic ambiguity resolution while reading in second and native languages. *Quarterly Journal of Experimental Psychology*, *50*, 119–148.

Fujita, H. (2016). Priming effect on automatisation of L2 prepositional-phrase processing ability. *Studies in English Language Teaching, 4(*1).

Gamez, P. B., & Vasilyeva, M. (2015). Exploring interactions between semantic and syntactic processes: The role of animacy in syntactic priming. *Journal of Experimental Child Psychology*, *138*, 15–30.

Garnsey, S. M., Pearlmutter, N. J., Myers, E., & Lotocky, M. A. (1997). The contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language, 37*, 58-93

Giavazzi, M., Sambin, S., Diego-Balaguer, R., Stanc, L., Bachoud-Levi, A. C., & Jacquemot, C. (2018). Structure priming in sentence comprehension : A single prime is enough. *PloS One, 13* (4), e0194959

Golestani, N., Rosen, S., & Scott, S. K. (2009). Native-language benefit for understanding speech-in-noise: the contribution of semantics. *Bilingualism: Language and Cognition. 12,* 385–392.

Gries, S.T.h. (2005). Syntactic priming: A corpus-based approach. *Journal of Psycholinguistic Research. 34*, 365–399

Grosjean, F. (1997). Processing mixed language: Issues, findings and models. In A. de Groot & J. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 225-254). Majwah, NJ: LEA.

Grüter, T., Lew-Williams, C., & Fernald, A. (2012). Grammatical gender in L2: A production or a real-time processing problem? *Second Language Research*, *28*(2), 191-215

Grüter, T., & Rohde, H. (2013). L2 processing is affected by RAGE: Evidence from reference resolution. Talk presented at the 12th conference on Generative Approaches to Second Language Acquisition (GASLA), University of Florida, FL.

Gullifer, J., Dussias, P., & Kroll, J. (2010). Bilingual sentence processing: The role of syntactic constraints in modulating cross-language lexical activity. *Poster presented at the 23rd Annual CUNY conference on Human sentence processing.* March 18-20. New York University, NY.

Guo, J., Guo, T., Yan, Y., Jiang, N., Peng, D. (2008). ERP evidence for different strategies employed by native speakers and L2 learners in sentence processing. *Journal of Neurolinguistics 22*, 123–134.

Gurjanov, M., Lukatela, G., Lukatela, K., Savi´c, M., & Turvey, M. T.(1985). Grammatical priming of inflected nouns by the gender of possessive adjectives. *Journal of Experimental Psychology: Learning,Memory, and Cognition, 11,* 692–701.

Hahne, A. (2001). What's Difference in Second-Language Processing? Evidence from Event-Related Potentials. *Journal of Psycholinguistic Research*, 30, 251-265.

Hahne, A., & Friederici, A. D. (2001). Processing a second language: Late learners' comprehension mechanisms as revealed by event-related brain potential. *Bilingualism: Language and Cognition, 4*(2), 123-141.

Halliday, M. A. K. (1989). *Spoken and written Language*. Oxford: Oxford University

Harrington, M. & Dennis, S. (2003). Structural priming in sentence comprehension. In R. Alterman & D. Kirsh (Eds.). *Proceedings of the Twenty-Fifth Annual Conference of the Cognitive Science Society, Vol. 25 Acquisition* (pp. 510-515). Lawrence Erlbaum Associates.

Harm, M.W., Seidenberg, M. S. (2004). Computing the meaning of words in reading : Cooperative division of labor between visual and phonological processes. *Psychological Review, 111*, 662–720.

Hartsuiker, R. J., Beerts, S., Loncke, M., Desmet, T., & Bernolet, S. (2016). Crosslinguistic structural priming in multilinguals: Further evidence for shared syntax. *Journal of Memory and Language*, 90, 14-30.

Hartsuiker, R. J., Bernolet, S. (2016). The development of shared syntax in second language learning. *Bilingualism: Language and Cognition, 20* (2),219-234

Hartsuiker, R. J., Kolk, H. H. J. (1998). Syntactic persistence in Dutch. *Language and Speech, 41*(2), 143-184

Hartsuiker, R. J., Pickering, M. J., Veltkamp, E. (2004). Is syntax separate or shared between languages? Cross-linguistic syntactic priming in Spanish-English bilinguals. *Psychological science, 15*(6), 409-414

Hartsuiker, R. J., Bernolet, S., Schoonbaert, S., Speybroeck, S., Vanderelst, D. (2008). Syntactic priming persists while the lexical boost decays: Evidence from written and spoken dialogue. *Journal of Memory and Language. 58*, 214–238.

Hasting, A. S., & Kotz, S. (2008). Speeding up syntax: On the relative timing and automaticity of local phrase structure and morphosyntactic processing as reflected in event-related brain potentials. *Journal of Cogniive Neuroscience, 20*(7), 1207-1219.

Hellsten, M. and Prescott, A. (2004) Learning at university: the international students experience. *International Education Journal, 5*(3), 344-351.

Hoover, M.L. & Dwivedi, V.D. (1998). Syntactic processing by skilled bilinguals. *Language* Learning, *48*, 1-29.

Hopp, H. (2010). Ultimate attainment in L2 inflection: Performance similarities between non- native and native speakers. Lingua, 120(4), 901-931.

Hopp, H. (2013). Grammatical gender in adult L2 acquisition: Relations between lexical and syntactic variability. *Second Language Research*, 29(1), 33–56.

Hopp, H. (2015). Semantics and Morphosyntax in Predictive L2 Sentence Processing. *International Review of Applied Linguistics, 53*, 277–306

Hopp, H. (2016). The timing of lexical and syntactic processes in second language sentence comprehension. Applied Psycholinguistics, 37, 1253–1280.

Huang J., Pickering M. J., Yang J., Wang S., Branigan H. P. (2016). The independence of syntactic processing in Mandarin: evidence from structural priming. J. Mem. Lang. 91, 81–98.

Isenberg, D. (1980). A top-down effect on the identification of function words. *The Journal of the Acoustical Society of America*, *68*, S48

Ivanova, I., Branigan, H., McLean, J., Costa, A., & Pickering, M. (2017). Do you what I say? People reconstruct the syntax of anomalous utterances. *Language, Cognition and Neuroscience*, 32, 175–189

Ivanova, I., Pickering, M. J., Branigan, H.P., Mclean, J. F., & Costa, A. (2012). The comprehension of anomalous senences: Evidence from structural priming. *Cognition*, 122, 193-209

Ivanona, I., Wardlow, L., Warker, J., & Ferreira, V. S. (2017). The effect of anomalous utterances on language production. *Memory & Cognition, 45*, 308-319.

Jackson, C.N., & Dussias, P.E., (2009). Cross-linguistic differences and their impact on L2 sentence processing. *Bilingualism: Language and Cognition, 12*, 65–82.

Jackson, C. N., & Ruf, H. T. (2017). The priming of word order in second language German. *Applied Psycholinguistics*, 38(2), 315–345.

Jaeger, T. F., & Snider, N. (2008). Implicit learning and syntactic persistence: Surprisal and cumulativity. In B. C. Love, K. McRae, & V. M. Sloutsky (Eds.), *Proceedings of the 30th Annual Conference of the Cognitive Science Society* (pp. 827–812). Washington, DC: Cognitive Science Society.

Jahandari, K. (1999). *Spoken and written discourse: A multi-disciplinary perspective*. Stamford, Connecticut : Aplex publishing corporation.

Jakubowicz, C., & Faussart, C. (1998). Gender agreement in the processing of spoken French. *Journal of Psycholinguistic Research, 27,* 597–617.

Juffs, A. 1998: Main verb vs. reduced relative clause ambiguity resolution in second language sentence processing. Language Learning 48, 107–47.v

Kaan, E., & Chun, E. (2018). Priming and adaptation in native speakers and second-language learners. *Bilingualism: Language and Cognition, 21*, 228 − 242.

Kaan, E., Futch, C., Fernández Fuertes, R., Mujcinovic, S. and Álvarez de la Fuente, E. (2018) Adaptation to syntactic structures in native and non-native sentence comprehension. *Applied Psycholinguistics, 40,* 3-27.

Kaan, E., Kirkham, J., & Wijnen, F. (2016). Prediction and integration in native and second-language processing of elliptical structures. Bilingualism: Language and Cognition, *19*, 1–18.

Kaan, E. (2014). Predictive sentence processing in L2 and L1. What is different? *Linguistic Approaches to Bilingualism, 42*, 257-282

Kaschak, M. P., & Glenberg, A. M. (2004). This construction needs learned. *Journal of Experimental Psychology: General, 133*, 450–467.

Keuleers, E., Lacey, P., Rastle. K., & Brysbaert, M. (2012). The British lexicon project: Lexical decision data for 28,730 monosyllabic and disyllabic English words. *Behavioral Research Methods*, *44*(1), 287-304

Kidd, E, Tennant, E & Nitschke, S. (2014). Shared abstract representation of linguistic structure in bilingual sentence comprehension. *Psychonomic Bulletin & Review, 22*(4), 1062-1067

Kim, K. H. S., Relkin, N. R., Lee, K. M., & Hirsch, J. (1997). Distinct cortical areas associated with native and second languages. *Nature*, 388, 171-174.

Kleinschmidt, D. F., Fine, A. B., & Jaeger, T. F. (2012). A belief-updating model of adaptation and cue combination in syntactic comprehension. In N. Miyake, D. Peebles, & R. P. Cooper (Eds.), *Proceedings of the 34th annual conference of the cognitive science society* (pp. 599–604). Austin, TX: Cognitive Science Society.

Kleinschmidt, D. F. & Jaeger, T. F. (2015). Robust speech perception: Recognize the familiar, generalize to the similar, and adapt to the novel. *Psychological Review, 122*(2), 148–203.

Kroczek, L. O., & Gunter, T. C. (2017). Communicative predictions can overrule linguistic priors. *Scientific reports, 7, 17581*

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Research, 1146*, 23–49.

Kweon, S. (2009). Resolving PP Attachment Ambiguity in Lexically-Biased Constructions in L2 Sentence Processing. *Korean Journal of Applied Linguistics*, *25*(2), 171-196.

Levelt, W. J. M., Roelofs, A., & Meyer, A. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-75.

Levitt, H. (1971). Transformed up-down methods in psychoacoustics. *Journal of the Acoustical Society of America, 49*, 467-477.

Ledoux K, Traxler MJ, Swaab TY (2007) Syntactic priming in comprehension: evidence from event-related potentials. *Psychological Science 18*, 135–143

Levy, R. (2008). A noisy-channel model of human sentence comprehension under uncertain input. *In proceedings of the 2008 conference on empirical methods in natural language processing* (pp. 234–243). Stroudsburg, PA: Association for Computational Linguistics.

Lew-Williams, C., & Fernald, A. (2010). Real-time processing of gender-marked articles by native and non-native Spanish speakers. *Journal of Memory and Language, 63*, 447–464.

Lim, J. H., & Christianson, K. (2013). Integrating meaning and structure in L1–L2 and L2–L1 translations. *Second Language Research, 29*, 233–256.

Litcofsky, K. A., & van Hell, J. G. (2019). Bi-Directional Evidence Linking Sentence Production and Comprehension: A Cross-Modality Structural Priming Study. *Frontiers in Psychology, 10.*

Loebell, H., & Bock, K. (2003). Structural priming across languages. *Linguistics*, 41(5), 791–824.

Longtin, C. M., Segui, J., & Halle, P. A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes, 18*, 313-334.

López Prego, B., & Gabriele, A. (2014). Examining the impact of task demands on morphological variability in native and non-native Spanish. *Linguistic Approaches to Bilingualism, 4*(2), 192-221.

Luka, B., & Barsalou, L. (2005). Structural facilitation: Mere exposure effects for grammatical acceptability as evidence for syntactic priming in comprehension. *Journal of Memory and Language, 52*(3), 436–459.

Lukatela, G., Moraca, J., Stojnov, D., Savic, M., Katz, L., & Turvey, M. T. (1982). Grammatical priming effects between pronouns and inflected verb forms. *Psychological Research (Psychologische Forschung), 44*, 297-311.

Lukatela, G. & Turvey, M.T. (1993). Similar attentional, frequency, and associative effects for pseudohomophones and words. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 166-178.

Lukatela, G., & Turvey, M. T. (1994). Visual lexical access is initially phonological: 2. Evidence from phonological priming by homophones and pseudohomophones. *Journal of Experimental Psychology: General, 123*(4), 331-353.

MacDonald, M. C.(1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes*, 9, 157–201. MacDonald, M. C., &

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. Psychological *Review, 101*, 676–703.

MacDonald, M. C. (2013) How language production shapes language form and comprehension. *Frontiers in Psychology, 4* (226).

Mahowald, K., James, A., Futrell, R., & Gibson, E. (2016). A meta-analysis of syntactic priming in language production. *Journal of Memory and Language, 91*, 5–27.

Martin, C., Thierry, G., Kuipers, J.-R., Boutonnet, B., Foucart, A., & Costa, A. (2013). Bilinguals reading in their second language do not predict upcoming words as native readers do. *Journal of Memory and Language*, *69*(4), 574–588.

Mattys, S. L., Carroll, L. M., Li, C. K. W., & Chan, S. L. Y. (2010). Effects of energetic and informational masking on speech segmentation by native and non-native speakers. *Speech Communication*, *52*(11-12), 887-899.

McCarthy, D. (2001), Lexical acquisition at the syntax- semantics interface: Diathesis alternatiions, sub-categorizational frames and selectional preferences. Sydney: University of Melbourne

McKoon, G., & Ratcliff, R. (2003). Meaning through syntax: Language comprehension and the reduced relative clause construction. Psychological Review, 110, 490–525.

Meunier, F., & Longtin, C-M. (2007). Morphological decomposition and semantic integration in word processing. *Journal of Memory and Language, 56,* 257-471.

Marslen-Wilson, W. D. (1984). Function and process in spoken wordrecognition. In H. Bouma & D. G. Bouwhuis (Eds.), Attention and performance X: Control of language processes (pp. 125-150). Hillsdale, NJ: Erlbaum.

Marslen-Wilson, W. D., & Tyler, L. K. (2007). Morphology, language and the brain: the decompositional substrate for language comprehension. *Philosophical Transactions of the Royal Society London B: Biological Sciences, 362*(1481), 823-836.

Marslen-Wilson, W. D., Tyler, L., Waksler, R., & Older, L. (1994). Morphology and meaning in the English mental lexicon. Psychological Review, *101*, 3–33.

Marslen-Wilson, W. D., & Welsh, A. (1978). Processing interactions and lexical access during word-recognition in continuous speech. *Cognitive Psychology, 10*, 29-63

McClelland, J. L. & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375-407

McElree, B., & Griffith, T. (1995). Syntactic and thematic processing in sentence comprehension: Evidence for a temporal dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(1), 134-157.

Messenger, K., Branigan, H. P., & McLean, J. F. (2011). Evidence for (shared) abstract structure underlying children's short and full passives. *Cognition, 121*, 268–274.

Miller, J. & Weinert, r. (1998). *Spontaneous spoken language: Syntax and discourse*, Oxford: Clarendon Press

MItchell, D.C., Brysbaert M. Challenges to recent theories of cross-linguistic differences in parsing: Evidence from Dutch. In D. Hillert (Ed.), Sentence processing: A cross-linguistic perspective. CA: Academic Press, San Diego, 1998. 1998.

Mitchell, D. C., Cuetos, F., Corley, M. M. B., & Brysbaert, M. (1995). Exposure-based models of human parsing: Evidence for the use of coarse-grained (nonlexical) statistical records. *Journal of Psycholinguistic Research, 24,* 469–488.

Mitchell, D. C., & Holmes, V. M. (1985). The role of specific information about the verb in parsing sentences with local structural ambiguity. *Journal of Memory and Language, 24*, 542-559.

Morgan, E., Keller, F., & Steedman, M. (2010). A bottom-up parsing model of local coherence effects. In S. Ohlsson & R. Catrambone (Eds.), *Proceedings of the 32nd annual conference of the cognitive science society* (pp. 1559–1564). Austin, TX: Cognitive Science Society.

Morris, R. K. (1994). Lexical and message-level sentence context effects in fixation times in reading.*Journal of Experimental Psychology: Learning, Memory, & Cognition*, *20*, 92–103.

Moyer, J. E. (2011). Teens today don't read book anymore: A study of differences in comprehension and interest across formats (Ph.D. dissertation). University of Minnesota.

Myslin, M., & Levy, R. (2016). Comprehension priming as rational expectation for repetition: Evidence from syntactic processing. *Cognition, 147*, 29–56

Neely, J. H. (1976). Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. *Memory & Cognition, 4,* 648–654.

Nitschke, S., Kidd, E., & Serratrice, L. (2010). First language transfer and long-term structural priming in comprehension. Language and Cognitive Processes, 25, 94–114.

Nitschke, S., Serratrice, L., Kidd, E. (2014). The effect of linguistic nativeness on structural priming in comprehension. *Language, Cognition and Neuroscience, 29*(5)*,* 525-542

Norris, J., and Ortega, L. (2000) Effectiveness of L2 instruction: a research synthesis and quantitative meta-analysis. *Language Learning, 50*, 417–528.

O'Donnell, R. (1974): Syntactic differences between speech and writing. *American Speech 49*, 102–110.

Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language, 31*, 785–806.

Otten, M., & Van Berkum, J. J. A. (2009). Does working memory capacity affect the ability to predict upcoming words in discourse? *Brain Research, 1291*, 92–101.

Papadopoulou, D., & Clahsen, H. (2003). Parsing strategies in L1 and L2 sentence processing: A study of relative clause attachment in Greek. *Studies in Second Language Acquisition, 25*, 501-528.

Pechmann, T., & Zerbst, D. (2002). The activation of word class information during speech production. Journal of Experimental Psychology: *Learning, Memory, and Cognition, 28,* 233–243.

Perani, D., Dehaene, S., Grassi, E, Cohen, L., Cappa, S. E, Dupoux, E., Fazio, E, & Mehler, J. (1996). Brain processing of native and foreign languages. *NeuroReport*, 7, 2439-2444

Pickering, M. J. &, Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory & Language,39*, 633–651.

Pickering, M. J. &, Branigan, H. P. (1999). Syntactic priming in language production. *Trends in Cognitive Sciences, 3*, 136-141

Pickering, M. J., & Ferreira, V. S. (2008). Structural priming: A critical review. *Psychological Bulletin, 134*, 427-459.

Pickering, M. J., & Ferreira, V. S. (2008). Structural priming: A critical review. *Psychological Bulletin, 134*, 427-459.

Pickering, M. J., and Garrod, S. (2013). An integrated theory of language production and comprehension. *Behavioral and Brain Sciences, 36*, 1–19

Pollard, C, & Sag, I. A. (1987). *Information-based syntax and semantics.* Stanford, CA: CSLI.

Pozzan, L., & Trueswell J. C. (2016). Second language processing and revision of garden-path sentences: a visual word study. *Bilingualism: Language and Cognition,19* (3), 636-643

Price, P., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. (1991). The use of prosody in syntactic disambiguation. *Journal of the Acoustical Society of America, 90*, 2956-2970.

Pritchett, B. L. (1992). *Grammatical Competence and Parsing Performance*. Chicago, IL: University of Chicago Press.

Rah, A., & Adone, D. (2008, October). Shallow structures in L2 learners' PP attachment preferences? Paper presented at the conference of Second Language Research Forum, Honolulu, HI.

Rayner, K. Carlson, M. & Frazier, L. (1983). The interaction of syntax and semantics during sentence processing: Eye movements in the analysis of semantically biased sentences. *Journal of Verbal Learning and Verbal* Behavior, *22*, 358-374.

Rebuschat, P., & Williams, J. N. (2012). Implicit and explicit knowledge in second language acquisition. *Applied Psycholinguistics*, *33*, 829–956

Roberts, L. (2013). Sentence processing in bilinguals. In R.P.G. van Gompel (ed.). *Sentence processing* (pp. 221-246). Hove: Psychology Press.

Roberts, L., Felser, C. (2011). Plausibility and recovery from garden-paths in second-language sentence processing. *Applied Psycholinguistics, 32*, 299–331.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. Cognition, 42, 107-142

Roelofs, A. (1993). Testing a non-decompositional theory of lemma retrieval in speaking: Retrieval of verbs. Cognition, 47, 59-87

Rogowsky, B.A., Calhoun, B.M., & Tallal, P. (2016). Does modality matter? The effects of reading, listening and dual modality on comprehension. *SAGE Open, 6(3),* 1-9.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. M., & Bienkowski, M. (1982). Automatic access ofthe meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology*, *14*, 489-537.

Scheepers, C. (2003). Syntactic Priming of Relative Clause Attachments: Persistence of Structural Configuration in Sentence Production. *Cognition, 89*, 179-205

Scheepers, C., & Crocker, M. W. (2004). Constituent order priming from reading to listening: A visual-world study. In M. Carreiras & C. Clifton (Eds.), *The on-line study of sentence comprehension: Eyetracking, ERP, and beyond* (pp. 167–185). New York: Psychology Press.

Scheepers, C., Raffray, C. N., & Myachykov, A. (2017). The lexical boost effect is not diagnostic of lexically-specific syntactic representations. *Journal of Memory and Language, 95*, 102–115

Seglaowitz, N. & Hébert,M. (1990). Phonological recoding in the first and second language reading of skilled bilinguals. *Language Learning, 40*, 503-538.

Shormani, M. (2015). Is Standard Arabic a VSO Language? Evidence from Syntax and Semantics. *Al-Qalam Journal,* 3, 1-51.

Sikos, L.,, Martin, H., iersgerald, L., and Grodner, D.J. (2016). Memory-based limits on surprisal-based syntactic adaptation. Talk presented at CUNY Conference on Human Sentence Processing, University of Florida, United States.

Slevc, L. R., & Novick, J. M. (2013). Memory and cognitive control in an integrated theory of language processing. *Behavioral and Brain Sciences, 36*(4), 373–374.

Snider, N. (2008). An exemplar model of syntactic priming. Stanford University.

Spivey-Knowlton, M., & Sedivy, J. C. (1995). Resolving attachment ambiguities with multiple constraints. *Cognition, 55*, 227–267.

Spivey, M. J., Tanenhaus, M. K., Eberhard, K. M., & Sedivy, J. C. (2002). Eye movements and spoken language comprehension: Effects of visual context on syntactic ambiguity resolution. *Cognitive Psychology, 45,* 447– 481.

Stack, C. M. H., James, A. N., & Watson, D. G. (2018). A failure to replicate rapid syntactic adaptation in comprehension. *Memory & Cognition, 46* (6), 1–14.

Stanovich, K. E., & West, R. F. (1983). On priming by a sentence context. *Journal of Experimental Psychology: General, 112*(1), 1-36.

Staub, A. (2011). Word recognition and syntactic attachment in reading: Evidence for a staged architecture. *Journal of Experimental Psychology: General*, *140*, 407–433.

Straub, K.A. (1997). The Production of Prosodic Cues and their Role in the Comprehension of Syntactically Ambiguous Sentences. Unpublished doctoral dissertation, Rochester, NY: University of Rochester.

Sturt, P, Keller, F & Dubey, A (2010). Syntactic priming in comprehension: Parallelism effects with and without coordination. *Journal of Memory and Language*, *62*(4), 333-351.

Swaab, T. Y., Ledoux, K., Camblin, C. C., & Boudewyn, M. A. (2011). ERPs and language pro- cessing. In S. J. Luck & E. S. Kappenman (Eds.), *Oxford handbook of event-related potential components* (chapter 14). New York: Oxford University Press.

Tabor, W., Galantucci, B., & Richardson, D. (2004). Effects of merely local syntactic coherence on sentence processing. *Journal of Memory and Language*, *50*, 355–370.

Taft, M. (1986) Lexical access codes in visual and auditory word recognition, *Language and Cognitive Processes*, *1*(4), 297-308

Tanenhaus, M. K., Leiman, J. M., & Seidenberg, M. S.(1979). Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning and Verbal Behavior*, *18*, 427-440.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M. & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632-1634

Thothathiri, M., & Snedeker, J. (2008). Give and take: Syntactic priming during spoken language compre- hension. *Cognition, 108*, 51–68.

Tooley, K. M., Swaab, T. Y., Boudewyn, M. A., Zirnstein, M., & Traxler, M. J. (2014). Evidence for priming across intervening sentences during on-line sentence comprehension. *Language, Cognition and Neuroscience, 29,* 289–311.

Tooley, K. M., & Traxler, M. J. (2010). Syntactic priming effects in comprehension: A critical review. *Language and Linguistics Compass*, *4,* 925–937

Tooley, K. M., & Traxler, M. J. (2018). Implicit learning of structure occurs in parallel with lexically-mediated syntactic priming effects in sentence comprehension. *Journal of Memory and Language, 98*, 59-76.

Tooley, K.M., Traxler, M.J., & Swaab, T.Y., 2009. Electrophysiological and behavioral evidence of syntactic priming in sentence comprehension. *Journal of Experimental Psychology, Learning, Memory and Cognition. 35*, 19–45

Townsend, D. J., & Bever, T. G. (2001). *Sentence comprehension: The integration of habits and rules.* Cambridge, MA: MIT Press.

Townsend, D., Carrithers, C., & Bever, T. (1987). Listening and reading processes in college- and middle school-age readers. In Horowitz, R. & Samuels, S. (Eds.), *Comprehending oral and written language* (pp. 217–241). London: Academic.

Traxler, M. J. (2005). Plausibility and verb subcategorization prefer- ence in temporarily ambiguous sentences: Evidence from self-paced reading. *Journal of Psycholinguistic Research*, *34*, 1-30.

Traxler MJ (2008) Lexically independent priming in online sentence comprehension. *Psychonomic Bulletin & Review, 15*, 149–155

Traxler, Matthew J. & Tooley, Kristen M. (2008). Syntactic priming in comprehension: Strategic or syntactic?. *Language and Cognitive Processes, 23*, 609-645.

Traxler, M. J. (2008). Structural priming among prepositional phrases: Evidence from eye movements. *Memory and Cognition, 36*, 659-674.

Traxler, M. J., Tooley, K. M. & Pickering, M. J. (2014). Syntactic priming during sentence comprehension: Evidence for the lexical boost. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 40*(4), 905–18.

Traxler, M. J. (2005). Plausibility and verb subcategorization preference in temporarily ambiguous sentences: Evidence from self-paced reading. *Journal of Psycholinguistic Research*, *34*, 1–30.

Trenkic, D., & Warmington, M. (2018). Language and literacy skills of home and international university students: How different are they, and does it matter?. *Bilingualism: Language and Cognition*, *22*(2) 1-17

Trueswell, J. C., & Tanenhaus, M. K. (1994). Towards a lexicalist framework of constraint-based syntactic ambiguity resolution. In C. Clifton, L. Frazier, & K. Rayner (Eds.), *Perspectives on Sentence Processing*. (155-179) Hillsdale, NJ: Lawrence Erlbaum.

Trueswell, J. C., Tanenhaus, M. K., & Kello, C. (1993). Verb- specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *19*, 528-553.

Van Gompel, R. P. G., Pickering, M. J., Pearson, J., & Gunnar Jacob, G. (2006). The activation of inappropriate analyses in garden-path sentences: Evidence from structural priming. *Journal of Memory and Language, 55*(3), 335-362.

Weber, A., & Broersma, M. (2012). Spoken word recognition in second language acquisition. In C. Chapelle (ed.), The Encyclopedia of Applied Linguistics. Hoboken, NJ, USA: John Wiley & Sons, Inc.

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language, 50*, 1−25.

Weber, K., & Indefrey, P. (2009). Syntactic priming in GermanEnglish bilinguals during sentence comprehension. *NeuroImage*, *46*, 1164–1172.

Weber-Fox, C., & Neville, H. (1996). Maturational constraints on functional specializations for language processing: ERP and behavioral evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, 8, 231-256.

Wei, H., Boland, J. E., Brennan, J., Yuan, F., Wang, M., & Zhang, C. (2017). Lexicalized structural priming in second language online sen- tence comprehension. *Second Language Research,* Advance online publication.

West, R. F., Stanovich, K.E. (1986). Robust effect of syntactic structure on visual word processing. *Memory & Cognition, 14*(2), 104-11

Williams, J. N. (2005). Learning without awareness. *Studies in Second Language Acquisition*, *27*, 269–304.

Wright, B., & Garrett, M. (1984). Lexical decision in sentences: Effects of syntactic structure. *Memory & Cognition*, *12*, 31-45.

Ying, H. G.(1996). Multiple constraints on processing ambiguous sentences: Evidence from adult L2 learners. *Language Learning*, *46*(4), 681-711

Ziegler, J., Snedeker, J., (2019). The use of syntax and information structure during language comprehension: Evidence from structural priming. *Language, Cognition, and Neuroscience, 34* (3), 365-384

Ziegler, J., Snedeker, J., & Wittenberg, E. (2018). Event structures drive semantic structural priming, not thematic roles: Evidence form idioms and light verbs. *Cognitive Science*, *42*(8), 2918-2949

List of Abbreviations

BNC	British National Corpus
DO	Double-object structure
ERPs	Event-related potentials
FMRI	Functional magnetic resonance imaging
FDH	Fundamental Difference Hypothesis
IELTS	The International English Language Testing System
ISI	Inter-stimulus interval
L1	First language
L2	Second language
LDT	Lexical decision task
MC	Main clause
NP	Noun phrase
OSV	Object-subject-verb
PO	Prepositional object structure
PP	Prepositional phrase
RC	Relative clause
RR	Reduced relative
RT	Reaction time
SC	Sentence complement
SD	Standard deviation
SEM	Standard error of the mean
SOA	Stimulus onset asynchrony
SOV	Subject-object-verb
TOEFL	Test of English as a Foreign Language
VP	Verb phrase

Appendix A

L2 Language History of Use Questionnaire for Experiments 2, 4 and 6

1- Age:

2- What is your second language?

3- Please specify the age at which you started to learn English in the following situation (write age next to any situation that applies).

At home _____

At school _____

After arriving in the second language speaking country _____

4- How did you learn English up to this point? (Check all that apply)

Mainly through formal classroom instruction _____

Mainly through interacting with people _____

A mixture of both _____

Other (specify) _____

5- Write down the name of the language in which you received instruction in school, for each school level.

Primary/ Elementary School _____

Secondary/ Middle School _____

High School _____

College/ University _____

6- Estimate, in terms of percentages, how often you use your native language and English per day (in all daily activities combined).

Native language_____%

English _____%

Other languages _____% (specify: _____)

(Total should equal to 100%)

7- Estimate, in terms of hours per day, how often you watch TV or listen to radio in your native language and English per day:

Native language __ (hrs)

English __ (hrs)

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

Native language __ (hrs)

English __ (hrs)

Other languages __ (hrs) (specify: _____)

9- Rate your English proficiency in each of the skills listed below. Please rate according to the following scale.

	1 Very Poor	**2 Poor**	**3 Fair**	**4 Functi-onal**	**5 Good**	**6 Very Good**	**7 Native-like**
Reading Proficiency							
Writing Proficiency							
Speaking Fluency							
Listening Comprehension							
General Proficiency							

10- Please indicate the score you received for each of the following tests (if applicable).

Test	Score
IELTS	
TOEFL	
University Language Test	

Appendix B

Experimental Words for the Pilot Study of Chapter 2

Final word in low-attachment structure	**Final words in high-attachment structure**	**Final words in reduced relative structure**	**Final words in main clause structure**
balcony	tractor	landed	route
frame	knife	arrived	size
swing	axe	went	job
curtain	stone	failed	test
pocket	sponge	lied	issue
pillow	brush	came	profit
stain	tissue	replied	format
stink	broom	forgot	review
mistake	marker	practiced	show
scratch	tape	raced	title
injury	device	tried	kit
lining	pin	stayed	report
leakage	paste	lost	plan
hole	tool	closed	wheel
crack	spray	resigned	value
cut	patch	ran	floor
diamond	wire	passed	leader
sign	hammer	called	button
handle	explosive	started	party
treasure	mixer	died	topic
filling	bowl	escaped	safe
sail	rag	left	staff
dress	log	finished	topic
window	stick	smiled	speech

Appendix C

Experimental Stimuli for Experiments 1 and 2

C.1 High-Low attachment ambiguity sentences

1- a. The landlord damaged the house with a tractor.
   b. The landlord damaged the house with a balcony.

2- a. The man damaged the picture with a knife.
   b. The man damaged the picture with a frame.

3- a. The farmer damaged the garden with an axe.
   b. The farmer damaged the garden with a swing.

4- a. The boy damaged the window with a stone.
   b. The boy damaged the window with a curtain.

5- a. The housekeeper cleaned the shirt with a sponge.
   b. The housekeeper cleaned the shirt with a pocket.

6- a. The housewife cleaned the chair with a brush.
   b. The housewife cleaned the chair with a pillow.

7- a. The maid cleaned the blouse with a tissue.
   b. The maid cleaned the blouse with a stain.

8- a. The janitor cleaned the storeroom with a broom.
   b. The janitor cleaned the storeroom with a stink.

9- a. The teacher fixed the essay with a marker.
   b. The teacher fixed the essay with a mistake.

10- a. The apprentice fixed the mirror with a tape.
    b. The apprentice fixed the mirror with a scratch.

11- a. The nurse fixed the leg with a device.
    b. The nurse fixed the leg with an injury.

12- a. The tailor fixed the jacket with a pin.
    b. The tailor fixed the jacket with a lining.

13- a. The plumber repaired the ceiling with a paste.
    b. The plumber repaired the ceiling with a leakage.

14- a. The worker repaired the box with a tool.
b. The worker repaired the box with a hole.

15- a. The caretaker repaired the glass with a spray.
b. The caretaker repaired the glass with a crack.

16- a. The mechanic repaired the tire with a patch.
b. The mechanic repaired the tire with a cut.

17- a. The thief opened the safe with a wire.
b. The thief opened the safe with a diamond.

18- a. The man opened the door with a hammer.
b. The man opened the door with a sign.

19- a. The builder opened the bucket with a stick.
b. The builder opened the bucket with a handle.

20- a. The archaeologist opened the tomb with an explosive.
b. The archaeologist opened the tomb with a treasure.

21a. The cook made a cake with a mixer.
b. The cook made a cake with a filling.

22- a. The child made a boat with a bowl.
b. The child made a boat with a sail.

23- a. The girl made a doll with a rag.
b. The girl made a doll with a dress.

24- a. The scout made a tent with a log.
b. The scout made a tent with a window.

C.2 Reduced relative sentences

1- a. The pilot declined to change the plane landed.
b. The pilot declined to change the plane route.

2- a. The astronomer declined to assess the comet arrived.
b. The astronomer declined to assess the comet size.

3- a. The salesman declined to abandon the company went.
b. The salesman declined to abandon the company job.

4- a. The student declined to change the module failed.

b. The student declined to change the module test.

5- a. The politician promised to discuss the treaty lied.
b. The politician promised to discuss the treaty issue.

6- a. The businessman promised to donate the cash came.
b. The businessman promised to donate the cash profit.

7- a. The secretary promised to find the letter replied.
b. The secretary promised to find the letter format.

8- a. The journalist promised to send the book forgot.
b. The journalist promised to send the book review.

9- a. The dancer hoped to perform the dance practiced.
b. The dancer hoped to perform the dance show.

10- a. The athlete hoped to win the competition raced.
b. The athlete hoped to win the competition title.

11- a. The worker hoped to buy the equipment tried.
b. The worker hoped to buy the equipment kit.

12- a. The lawyer hoped to examine the witness stayed.
b. The lawyer hoped to examine the witness report.

13- a. The trainer volunteered to develop the game lost.
b. The trainer volunteered to develop the game plan.

14- a. The mechanic volunteered to repair the car closed.
b. The mechanic volunteered to repair the car wheel.

15- a. The banker volunteered to conceal the transaction resigned.
b. The banker volunteered to conceal the transaction value.

16- a. The child volunteered to clean the room ran.
b. The child volunteered to clean his room floor.

17- a. The employee agreed to help the staff passed.
b. The worker agreed to help the staff leader.

18- a. The tailor agreed to fix the suit called.
b. The tailor agreed to fix the suit button.

19- a. The woman agreed to prepare the lunch started.
b. The woman agreed to prepare the lunch party.

20- a. The professor agreed to teach the course died.

b. The professor agreed to teach the course topic.

21- a. The burglar intended to rob the bank escaped.
b. The burglar intended to rob the bank safe.

22- a. The minister intended to visit the hospital left.
b. The minister intended to visit the hospital staff.

23- a. The baker intended to prepare the cake finished.
b. The baker intended to prepare the cake topping.

24- a. The manager intended to prepare the party smiled.
b. The manager intended to prepare the party speech.

C.3 Filler sentences (non-words are underlined)

1- The neighbors are selling their house.
2- Mary got married last week.
3- The vendor signed the contract in the presence of two gakes
4- The mother should set a better example.
5- Emily finally found her bakm.
6- The situation is getting worse.
7- You must hurry if you want to catch the train.
8- Sally performed a great dance.
9- The officials reported their observations to the rozgar.
10- Michael can join us for dinner.
11- The child has broken the cub.
12- The farmer thought the land would be good for rasting
13- His brother will disgrace the blomp
14- The tornado is destroying the seef
15- The lost child was found by a mand
16- The building is not designed very well from the point of view of the gops.
17- Emily was singing while she was kearing.
18- Peter is speaking to the manager.
19- The plan was not supported by the mass of the people in the ning.
20- The written complaints were very effective in bringing futs.
21- The customer was surprised by the good quality of the bime.
22- The article must have a brab.
23- John cooked the dinner for his children.
24- The road had to be closed after the proy.
25- The school admitted pupils from many different cultural hodes.
26- The student has come a long way.
27- The soldiers carried out a successful attack on the fost.
28- The girl is laughing at the gend.
29- The tourist is trying to speak Spanish.
30- The witness said that the accident makes him feel very moted.

31- John appreciates his teacher's support.
32- Andrew and Sam play football every afternoon.
33- Mary went to the movie with her friend.
34- The students have a test tomorrow.
35- A crowd of demonstrators will protest against cuts in slaring.
36- Bananas are a good source of vitamin C.
37- If the woman knew his address, she would write to him.
38- Sara returned from the beach.
39- Tom enjoyed his stay in the resort.
40- The institution is criticized for its failure to limit banting.
41- Gary uses chemicals to kill insects inside his rilt.
42- The report urges the government to support the use of zearing.
43- The moon goes through eight phases.
44- He was promoted to General Manager.
45- Most of the snakes are harmless.
46- The children were laughing.
47- The measures taken by the government should help reduce the nipe.
48- The victim can report the accident.
49- Peter was caught in traffic and missed the tander.
50- The lawyer has no time to see the witness.
51- The police car chased the gangster.
52- The door is not opened.
53- The farmer works very hard.
54- The taxes are rising.
55- George learned to ride a bike when he was six.
56- The real estate agent apologized for the delay.
57- The politician takes precautionary steps.
58- Cooperation is essential for success.
59- The client suddenly disappeared from the office.
60- The problem is well understood.
61- The boss is complaining about the messy reports.
62- The hairdresser is holding a mirror.
63- The little girl misses her mother.
64- The prices are swinging up and down.
65- The car broke down in the desert.
66- The government evacuates the embassy.
67- The union leader supported the demands of the workers.
68- The computer isn't working properly.
69- The electronic file is corrupted by the virus.
70- One of the fans punched the player for his bad performance.
71- The cook is preparing a tray of appetizer.
72- The grandfather is going to the dentist.
73- The composer is writing a song for his wife.
74- His teacher is disappointed with the grades.
75- The wind is blowing off the woman's hat.
76- A monument has been discovered by the museum staff.
77- The little boy is feeding the rabbit.
78- The poor man owes 6-month rent to the landlord.

79- A mouse is hiding behind the wall.
80- The report will be submitted next week.
81- The pharmacist will sell the drug to the gangster.
82- The gardener is watering the tree.
83- The children are scared of a spider.
84- The diplomat is suggesting a compromise.
85- The robbery was observed by the neighbors and reported to the police.
86- The woman was scratched by a cat.
87- The study has several limitations.
88- The judge is examining the evidence before giving a final decision.
89- Baby animals are too weak to survive in the open air.
90- Researchers have a long way to go to understand more about asteroids.
91- Working parents need a place where their children can be cared for.
92- The brain produces electrical waves when a person is awake or asleep.
93- The company has a budget of one thousand million dollars.
94- The fish will survive as long as water temperature remains normal.
95- Ninety percent of the coral reefs have died in the Indian Ocean.
96- My friend is known for her skillful playing of music.
97- Interesting facts about left-handedness can be found on the Internet.
98- Golf costs more money to play than many other sports.
99- Our neighbors encourage their son to seek an excellent education.
100- The bank cut the interest rate by one-quarter percent.
101- Young children may feel better at nursery if they bring a toy from home.
102- Scientists come from all over the world to share their research.
103- The boys sat close to their parents when the sky became dark.
104- Emily says that eating healthy food makes her active.
105- A united nation’s program was expanded to include four more countries.
106- The university increased the number of students it admitted last year.
107- Children acquire language at an amazing rate.
108- The piano player interlude with a beautiful improvisation.
109- The rugby player moved from one team to another.
110- The student didn’t know the poem well enough to recite it.
111- Residents were evacuated after the earthquake.
112- Foods which contain a lot of fat must be avoided.
113- The victims were encouraged to talk freely about their experience.
114- The government announced its plan to reform the transportation.
115- The scientist is trying to keep the chemical at the right temperature.
116- After the birthday party, toys were collected from all over the house.
117- The parliament discussed the problem but failed to come up with a solution.
118- The teacher realized that it is impractical to have the students all use the lab at the same time.
119- Maize and beans were cultivated by the villagers.
120- The girl cheated in the test by copying from the boy in front.

C.4 Practice items

1- The chemical waste is polluting the river.
2- There was a lot of debate before the elections.
3- A taxi is waiting outside the skeady.
4- The TV presenter is absent today.
5- The patient mother is teaching her son the alphabet.
6- Flowers began to appear when the snow melted.

Appendix D

Experimental Stimuli for Experiments 3 and 4

D.1 Low-attachment ambiguity with comprehension questions

1- The landlord hit the house with a balcony
Was a barn hit by the landlord?

2- The child hit the painting with a frame.
Is the picture frameless?

3- The driver hit the entrance with a fountain
Have the entrance had a statue?

4- The boy hit the window with a sticker
Was the window hit by a boy?

5- The warrior hit the crown with a gem
Was the crown hit by a king?

6- The housekeeper cleaned the shirt with a collar.
Did the housekeeper clean a jacket?

7- The housewife cleaned the table with a vase.
Was there a vase on the table?

8- The maid cleaned the carpet with a stain.
Was a carpet cleaned by the maid?

9- The janitor cleaned the storeroom with a stink.
Did the storeroom have a bad odor?

10- The mother cleaned the shoe with a buckle
Did the mother clean a dirty shoe?

11- The teacher fixed the essay with a mistake.
Did the teacher correct the essay?

12- The apprentice fixed the mirror with a scratch.
Did the apprentice scratch the mirror?

13- The nurse fixed the arm with an injury.
Was the injury handled by a nurse?

14- The engineer fixed the software with a virus.
Did the engineer remove a virus?

15- The fashion designer fixed the jacket with a lining.
Did the fashion designer fix a shirt?

16- The plumber repaired the ceiling with a leakage.
Was the ceiling leaking?

17- The worker repaired the wall with a hole.
Did the worker repair a damaged wall?

18- The contractor repaired the glass with a crack.
Did the contract damage the glass?

19- The mechanic repaired the tire with a cut.
Was a damaged tire mended?

20- The dentist repaired the tooth
Did the dentist damage the tooth

21- The thief opened the safe with a diamond.
Was the safe empty?

22- The man opened the gate with a lock
Was the gate locked?

23- The builder opened the bucket with a handle.
Did the bucket have a handle?

24- The archaeologist opened the tomb with a treasure.
Did the archaeologist open an empty tomb?

25- The gangster opened the door with a sign
Was there a mark on the door?

26- The cook made a birthday cake with a candle.
Did the cook add a candle?

27- The child made a boat with a sail.
Was a sail made by the child?

28- The child made a sand castle with a tower.
Was the tower made of sand?

29- The fashion designer made a hat with a feather.
Did the designer add a feather to the hat?

30- The scout made a tent with a window.
Did the scout build a tree house?

D.2 High-attachment ambiguity with comprehension questions

1- The landlord hit the house with a tractor.
Was the house hit by a van?

2- The child hit the painting with a ball.
Did the child have a ball?

3- The driver hit the entrance with a van
Did a tractor hit the entrance?

4- The boy hit the window with a stone
Was a toy thrown at the window?

5- The warrior hit the crown with a sword
Was the crown hit by a king?

6- The housekeeper cleaned the shirt with a tissue.
Did the shirt have a stain?

7- The housewife cleaned the table with a towel.
Was a towel used to clean a cupboard?

8- The maid cleaned the carpet with a sponge.
Was a sponge used in cleaning a fridge?

9- The janitor cleaned the storeroom with a broom.
Did the man clean an office?

10- The mother cleaned the shoe with a rag
Did the mother clean a dirty shoe?

11- The teacher fixed the essay with a marker.
Did the teacher correct the essay?

12- The apprentice fixed the mirror with a tape
Was the mirror broken?

13- The nurse fixed the arm with a bandage
Was the injury handled by a scout?

14- The engineer fixed the software with an antivirus.
Did the engineer damage the software?

15- The fashion designer fixed the jacket with a pin.
Was the jacket fixed by a salesman?

16- The plumber repaired the ceiling with a paste.
Was the ceiling mended by a plumber?

17- The worker repaired the wall with a tool.
Was the wall mended by the worker?

18- The contractor repaired the glass with a sticker.
Was the glass fixed by a mechanic?

19- The mechanic repaired the tire with a patch.
Have the tire had a cut?

20- The dentist repaired the tooth with a device.
Was the tooth damaged by the dentist?

21- The thief opened the safe with a wire.
Was the safe robbed?

22- The man opened the gate with a hammer.
Was a screwdriver used by the man?

23- The builder opened the bucket with a stick.
Was the bucket closed?

24- The archaeologist opened the tomb with an explosive.
Did the archaeologist open a closed tomb?

25- The gangster opened the door with a knife.
Did a mother use a knife?

26- The cook made a birthday cake with a mixer.
Did the cook use a mixer in cooking?

27- The child made a boat with a bowl.
Did the child use a bowl?

28- The child made a sand castle with a bucket.
Was the tower made of sand?

29- The fashion designer made a hat with a fabric.
Was the hat made of fabric?

30- The scout made a tent with a log.
Did the scout build a tree house?

D.3 Word-item fillers with comprehension questions

1- One of the fans punched the player for his bad performance.
Did the player play well?

2- The cook is preparing a tray of appetizer.
Did the tray contain dessert?

3- His teacher is disappointed with the grades.
Were the grades high?

4- The bank cut the interest rate by one-quarter percent.
Was the interest rate increased?

5- Children acquire language at an amazing rate.
Is it easy for children to acquire language?

6- The rugby player moved from one team to another.
Did the player remain at the same team?

7- Michael can join us for dinner.
Will Michael attend a dinner?

8- Peter is speaking to the manager.
Is Peter talking to someone?

9- Mary went to the movie with her friend.
Did Mary watch a movie with a friend?

10- Tom enjoyed his stay in the resort.
Did Tom like the resort?

11- The lawyer has no time to see the witness.
Will the lawyer be able to see the witness?

12- George learned to ride a bike when he was six.
Can George ride a bike?

D.4 Non-word item fillers

1- Someone stole a painting from the vounce.
2- Environmentalists regard overpopulation as a danger to manal.

3- A group of small fish was attracted to the louncy.
4- Excessive smoking is harmful to one's arod.
5- The school keeps parents informed about its cancon.
6- In the summer, tourists flock to the galleries and bengels.
7- The manager delayed the meeting for a gancel.
8- Hanna must hurry to the station to meet her tarber.
9- The majority voted in favour of the sanning.
10- Emily stood at the window and watched the basart.
11- In poetry, the rose is often a metaphor of basp.
12- The river divides the country into two dats.
13- Ben succeeded in reaching the top of the vead.
14- Debts increase the budget deficit and the need for extra marps.
15- The teachers counted the students as they got on to the neta.
16- Current methods of production are expensive and firch.
17- The company is focusing on developing new suff.
18- The driver found a parking space close to the mand.
19- The lost child was found by a mulb.
20- The vendor signed the contract in the presence of two gakes.
21- Emily finally found her bakm.
22- The officials reported their observations to the rozgar.
23- The farmer thought the land would be good for rasting.
24- His brother will disgrace the blomp.
25- The tornado is destroying the seef.
26- The lost child was found by a mand.
27- The building is not designed very well from the point of view of the gops.
28- Emily was singing while she was kearing.
29- The plan was not supported by the mass of the people in the ning.
30- The written complaints were very effective in bringing futs.
31- The customer was surprised by the good quality of the bime.
32- The article must have a brab.
33- The road had to be closed after the proy.
34- The school admitted pupils from many different cultural hodes.
35- The soldiers carried out a successful attack on the fost.
36- The girl is laughing at the gend.
37- The witness said that the accident makes him feel very moted.
38- A crowd of demonstrators will protest against cuts in slaring.
39- The institution is criticized for its failure to limit banting.
40- Gary uses chemicals to kill insects inside his rilt.
41- The report urges the government to support the use of zearing.
42- The measures taken by the government should help reduce the nipe.
43- Peter was caught in traffic and missed the tander.
44- The real estate agent apologized for the tuzzing.
45- The politician takes precautionary breen.
46- Cooperation is essential for traim.
47- The client suddenly disappeared from the smeep.

48- The problem is well toin.
49- The fish will survive as long as water temperature remains goil.
50- Ninety percent of the coral reefs have died in the Indian joil.
51- My friend is known for her skillful playing of grench.
52- Interesting facts about left-handedness can be found on the thrist.
53- Golf costs more money to play than many other zait.
54- The poor man owes 6-month rent to the chaim.
55- A mouse is hiding behind the jaul.
56- Amy is collecting the maunch.
57- The report will be submitted next chog.
58- The pharmacist will sell the drug to the byrof.
59- The gardener is watering the lunshel.
60- The children are scared of a fursar.
61- The diplomat is suggesting a gunsen

Appendix E

Experimental Stimuli for Experiments 5 and 6

E.1 Experimental list 1

1- Anne put the photo in the album onto the table this morning.
Did Anna place the album on a shelf?

2- George put the jug into the basket for the picnic.
Is George going on a picnic?

3- Sally put the dress on the bed into the basket to wash it.
Did sally put a shirt in the basket?

4- Leslie put the hat onto the display to sell it.
Did Leslie place a hat on the display?

5- Sam put the boxes on the cart into the van to take them home.
Did Sam move the boxes inside a tractor?

6- The clerk put the receipt into his pocket after the transaction.
Did the clerk put a voucher in his pocket?

7- The child copied the drawing in the story onto the paper before tearing it.
Was the drawing copied onto paper?

8- She copied the notes into her diary after the session.
Were the notes written in a diary?

9- The worker copied the quote in the paper onto the flyer because he liked it.
Did the paper include a quote?

10- The agent copied the photos into the brochure for the customers.
Did the agent copy instructions?

11- The journalist copied the names on the screen into his notebook before leaving.
Did the journalist copy a phone number?

12- The engineer copied the design onto a poster before printing it.
Did a carpenter copy the design?

13- The housekeeper threw the rags in the closet out of the house to tidy up.
Who did throw the rags?

14- Sam threw the ball into the corner when he was angry.
Did Sam drop a bucket?

15- Jane threw the frog in the park on to the towel because she was scared.
Was the frog taken from the park?

16- She threw the cheese out of her bag that was messy.
Was the cheese taken from inside the bag?

17- Kim threw the gift in the shop out of the package to see it.
Did Kim keep the gift in the cover?

18- The housekeeper threw the dust into the bin after the party.
Was the dust thrown in the bin?

19- Mary placed the flowers on the ground into the room as a decoration.
Did Mike place the flowers in the room?

20- Emily placed the note onto the board for the students to read.
Was a poster hung on the wall?

21- Jane placed the apple on the plate into the fridge before it went off.
Did Jane put a banana in the fridge?

22- He placed the box behind the wall to hide it.
Was a box set behind the wall?

23- Peter placed the plant in the pot into the soil that was damp.
Was the plant moved into the soil?

24- The scientist placed the telescope onto the balcony to watch the stars.
Did a scientist move the telescope out of the balcony?

25- Sara put the report in the book into the box before sending it.
Was the report kept inside a box?

26- Karen put the document into the file for her boss to sign.
Did Emily put a document in a file?

27- The lady copied the address on the card into the invitation before handing it.
Was an address added to the invitation?

28- The secretary copied the contacts into a record that was lost.
Did a student add the contacts?

29- He put the ring on her hand into the sea this morning.
Was the ring dropped in a swimming pool?

30- The lady threw the shirt into the laundry to clean it.
Was a shirt added to the laundry?

31- The secretary placed the disc in the laptop into the cover after the meeting.
Was the disc taken out of a laptop?

32- Mike placed the substance into the bowl to study it.
Did Kim place a substance in a bowl?

E.2 Experimental list 2

1- Anne put the photo onto the table.
2- George put the jug on the shelf into the basket for the picnic.
3- Sally put the dress into the basked
4- Leslie put the hat on the rack onto the display.
5- Sam put the boxes into the van
6- The clerk put the receipt in the record into his pocket.
7- Sara put the report into the box
8- Karen put the document in the drawer into the file.
9- The child copied the drawing onto the paper.
10- She copied the notes on the sheet into her diary.
11- The worker copied the quote in the paper onto the flyer.
12- The agent copied the photos in the page into the brochure.
13- The journalist copied the name into his notebook.
14- The engineer copied the design in the manual onto a poster.
15- The lady copied the address into the invitation.
16- The secretary copied the contacts in the phone into a record.
17- The housekeeper threw the rags out of the house.
18- Sam threw the ball on the floor into the corner.
19- Jane threw the frog on to the towel.
20- She threw the cheese in the pack out of her bag.
21- Kim threw the gift out of the package.
22- The housekeeper threw the dust under the table into the bin.
23- He threw the ring into the sea.
24- The lady threw the shirt on the floor into the laundry.
25- Mary placed the flowers into the room.
26- Emily placed the note on the desk onto the board.
27- Jane placed the apple into the fridge.
28- He placed the box by the door behind the wall.
29- Peter placed the plant into the soil.
30- The scientist placed the microscope in the lab into the balcony.
31- Anna placed the disc in the laptop into the cover.
32- Mike placed the substance in the jar into the bowl.

E.3 Attribute vs. instrument PP structure used in the cross-modal list

E.3.1 Attribute PP items

1- The landlord hit the house with a balcony
Was a barn hit by the landlord?

2- The child hit the painting with a frame.
Is the picture frameless?

3- The driver hit the entrance with a fountain
Have the entrance had a statue?

4- The boy hit the window with a sticker
Was the window hit by a boy?

5- The housekeeper cleaned the shirt with a collar.
Did the housekeeper clean a jacket?

6- The housewife cleaned the table with a vase.
Was there a vase on the table?

7- The maid cleaned the carpet with a stain.
Was a carpet cleaned by the maid?

8- The janitor cleaned the storeroom with a stink.
Did the storeroom have a bad odor?

9- The teacher fixed the essay with a mistake.
Did the teacher correct the essay?

10- The apprentice fixed the mirror with a scratch.
Did the apprentice scratch the mirror?

11- The nurse fixed the arm with an injury.
Was the injury handled by a nurse?

12- The engineer fixed the software with a virus.
Did the engineer remove a virus?

13- The plumber repaired the ceiling with a leakage.
Was the ceiling leaking?

14- The worker repaired the wall with a hole.
Did the worker repair a damaged wall?

15- The mechanic repaired the tire with a cut.
Was a damaged tire mended?

16- The dentist repaired the tooth
Did the dentist damage the tooth

17- The thief opened the safe with a diamond.
Was the safe empty?

18- The man opened the gate with a lock
Was the gate locked?

19- The archaeologist opened the tomb with a treasure.
Did the archaeologist open an empty tomb?

20- The gangster opened the door with a sign
Was there a mark on the door?

21- The cook made a birthday cake with a candle.
Did the cook add a candle?

22- The child made a boat with a sail.
Was a sail made by the child?

23- The child made a sand castle with a tower.
Was the tower made of sand?

24- The fashion designer made a hat with a feather.
Did the designer add a feather to the hat?

E.3.2 Instrument PP items

1- The landlord hit the house with a tractor.
Was the house hit by a van?

2- The child hit the painting with a ball.
Did the child have a ball?

3- The driver hit the entrance with a van
Did a tractor hit the entrance?

4- The boy hit the window with a stone
Was a toy thrown at the window?

5- The housekeeper cleaned the shirt with a tissue.
Did the shirt have a stain?

6- The housewife cleaned the table with a towel.
Was a towel used to clean a cupboard?

7- The maid cleaned the carpet with a sponge.
Was a sponge used in cleaning a fridge?

8- The janitor cleaned the storeroom with a broom.
Did the man clean an office?

9- The teacher fixed the essay with a marker.
Did the teacher correct the essay?

10- The apprentice fixed the mirror with a tape
Was the mirror broken?

11- The nurse fixed the arm with a bandage
Was the injury handled by a scout?

12- The engineer fixed the software with an antivirus.
Did the engineer damage the software?

13- The plumber repaired the ceiling with a paste.
Was the ceiling mended by a plumber?

14- The worker repaired the wall with a tool.
Was the wall mended by the worker?

15- The mechanic repaired the tire with a patch.
Have the tire had a cut?

16- The dentist repaired the tooth with a device.
Was the tooth damaged by the dentist?

17- The thief opened the safe with a wire.
Was the safe robbed?

18- The man opened the gate with a hammer.
Was a screwdriver used by the man?

19- The archaeologist opened the tomb with an explosive.
Did the archaeologist open a closed tomb?

20- The gangster opened the door with a knife.
Did a mother use a knife?

21- The cook made a birthday cake with a mixer.
Did the cook use a mixer in cooking?

22- The child made a boat with a bowl.
Did the child use a bowl?

23- 26- The child made a sand castle with a bucket.
Was the tower made of sand?

24- 27-The fashion designer made a hat with a fabric.
25- Was the hat made of fabric?

E.4 Filler sentences

1- John appreciates his teacher's support.
Is John supported by his teacher?

2- Andrew and Sam play football every afternoon.
Do Andrew and Sam play basketball every afternoon?

3- Mary went to the movie with her friend
Did Mary go alone to the movie?

4- The students have a test tomorrow.
Will the student have an exam tomorrow?

5- Jane cleaned the whole house.
Did Jane clean the house?

6- Bananas are a good source of vitamin C.
Do bananas include vitamin C?

7- If the woman knew his address, she would write to him
Do the woman know his address?

8- Emily will come late
Will Emily arrive on time?

9- Sara returned from the beach.
Did Sara come back from the beach?

10- Tom enjoyed his stay in the resort.
Did Tom like the resort?

11- The farmer works very hard.
Does the farmer work well?

12- The taxes are rising.
Are the takes reduced?

13- George learned to ride a bike when he was six.
Did George learn to ride a bike when he was a child?

14- The politician takes precautionary steps.
Does the politician take precaution?

15- Cooperation is essential for success.
Do success require cooperation?

16- The manager is complaining.
Is the manager happy?

17- The hairdresser is holding a mirror.
Is the hairdresser holding a comb?

18- The coach flings the Frisbee.
Do the coach have a Frisbee?

19- The prices are swinging up and down.
Are the prices changing?

20- The car broke down.
Is the car working?

21- The janitor cleans the floor every day.
Does the janitor clean the floor every week?

22- The union leader supports the workers.
Does the union leader ignore the workers?

23- The computer isn't working.
Did the computer break down?

24- The electronic file is corrupted.
Is the electronic file safe?

25- One of the fans punched the player.
Did the plater play well?

26- His teacher is disappointed with the grades.
Were the grades low?

27- The children are scared of a spider.
Did a spider frighten the children?

28- The article includes many errors.
Is the article faultless?

29- The diplomat is suggesting a compromise.
Does the diplomat seek a compromise?

30- The woman was scratched by a cat.
Was a man scratched by the cat?

31- The judge is examining the evidence.
Is the evidence examined by a policeman?

32- The chemical waste is polluting the river.
Is the river clean?