

PROCESSING SYNTACTICALLY AMBIGUOUS SENTENCES

PROCESSING SYNTACTICALLY AMBIGUOUS SENTENCES

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1. Introduction¹

Language is a complex system of patterns and rules. Research in different areas of linguistics has been dedicated to understand language and give an account for its systematic nature. Second language experts argue that the best way to learn a language is to be exposed to it, and the more exposed learners are to a language, the better they become in learning and perceiving it. Psycholinguistic research has been concerned with how the human mind copes with different sentence structures that language users may encounter either by reading or listening. Such sentence structures might be less complex while others can be more intricate. First and second language research gives credit to context which is a key element in understanding and processing any complex or ambiguous structures including learning new vocabulary and inferencing word meanings. Research has shown different strategies employed by different L1 and L2 speakers to process words and sentences in order to infer their meaning with or without a context (e.g., Sturt et al., 2000). Research has also focused on the different cues native speakers and language learners use in sentence processing. These cues are thought to facilitate language processing (e.g. Kilborn, 1989). Native speakers as well as second language learners do not usually need to resolve sentence ambiguity in isolation when exposed to it by reading or listening. They rely highly on given contextual cues that serve to disambiguate such structures when encountered. Although such structures might not be recognized as ambiguous and might not be taught explicitly in second language classrooms, different theories have approached sentence processing strategies in different ways, either from a syntactic or pragmatic and semantic perspective.

¹ I would like to thank the anonymous reviewers for their constructive feedback and genuine evaluation. Any errors or oversights are my own.

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1.1 Aims and significance

By focusing on the reading time expended, the present study seeks to examine how native speakers and Arabic learners of English process ambiguous sentences in isolation without any antecedent context. The ultimate goal is to examine whether reading and processing such sentences, including making a decision of a preferred prepositional phrase attachment, influence the reading and processing of normal sentences that do not exhibit any prepositional phrase ambiguity. The ambiguous type studied in this paper is that with ambiguous prepositional phrase. In a sentence like *the cop saw the spy with binoculars*, the prepositional phrase can be either attached to the verb or the noun phrase. Another aim is to examine if the time spent on processing ambiguous sentences delays the processing of simple and unambiguous ones. Finally, it aims at expanding the literature of first and second language processing by focusing on a new unstudied group of English language learners whose first language background is Arabic (experimental group).

As a studied group, Arabic L1 learners of English have not been studied per se, though participants from L1 Arabic background have been included in experimental groups in many sentence processing studies. Very often language learners have difficulties learning and processing new language patterns when these do not exist in their L1 languages. Such patterns can be hard to learn as they might seem opaque to learners following the fact that they are not used to them in their L1 system.

It has been shown that there are differences across languages in the cues people use to interpret sentence structure (Cuetos & Mitchell, 1988). Given this, the significance of choosing Arabic speaking participants for this study is that the majority of ambiguous cases resolved in the literature of sentence processing might not apply to Arabic, so Arabic L1 parsers are not aware

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of the nature of ambiguous prepositional phrases. With regards to prepositional phrase differences, Arabic allows the possibility of using several prepositions with the same verb while preserving the meaning. The approaches used to resolve prepositional phrase ambiguity in English are different in Arabic; thus, the English examples are not ambiguous in Arabic (Daimi, 2001). Therefore, *a whip* in sentence (a) can only be attached to the verb phrase:

(a) The kid hit the girl with a whip (Spivey-Knowlton & Sedivy, 1995).

Arabic is a Semitic language that allows SVO and VSO word order. Arabic L1 learners of English were chosen as an experimental group for this study because the Arabic language does not typically exhibit the same prepositional phrase ambiguity the way the English language does:

(b1) Sam [hit [the girl]] [with a book]].

[VP [NP]] [PP]

(b2) [Daraba Sam] [Al-Binta] [*b-il* Kitab]].

VP NP PP

Hit-3rd sing. ms. Sam the-girl *with*-the book

Sam hit the girl with a book

Sentence (b1) allows two possible interpretations. The prepositional phrase *with a book* might be a constituent of the verb phrase, or the noun phrase. In (b2), the prepositional phrase *bi* cannot be a constituent of the noun phrase because the sentence conveys the meaning of an instrument used to hit, which in the Arabic example is possessed by the subject, and cannot be associated with the object.

The ambiguity of the preposition *with* is triggered by the variety of meanings it has, so it can indicate an instrument, an attribute, or an accompaniment. In (b1), the duality in meaning (a

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tool vs. possession) leads the preposition to be possibly attached to the verb phrase or the noun phrase. This distinction in the meaning of the preposition is not found in Arabic since the preposition itself serves to disambiguate the subject-object relationship with the prepositional phrase, hence such prepositional phrase can only be attached to the verb phrase in Arabic:

(c1) The cop [saw [the spy]] [with binoculars].

[VP [NP]] [PP]

(c2) [Raʔa Razulu Al-ʃurtati [Al-ʒasuusa] [b-il Minḏar]].

VP NP PP

saw 3rd sing. ms. man the-police the spy in-the binoculars

The cop saw the spy with binoculars.

In the English version, the prepositional phrase can be attached to the verb phrase or the noun phrase. In the Arabic version, there is no ambiguity as the prepositional phrase can only be attached to the verb phrase indicating that *the binoculars* represent a tool.

2. Literature Review

In recent decades, strenuous effort has been devoted to understanding the nature of language processing when it occurs in context or isolation (e.g., Frazier, 1979; Rayner et. al., 1983; Ying, 1996; Felser & Roberts, 2007). A major question in the research of sentence comprehension is how a parser deals with ambiguous structures that allow more than one interpretation. Such structures can include a relative clause ambiguity as exemplified in (d), in which the relative clause *who was reading a book* could be attached to the first noun phrase *the secretary* (high attachment), or could be constructed with the second noun phrase *the professor* (low attachment):

(d) The dean liked the secretary of the professor who was reading a book.

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For example native speakers of English have shown a general preference for low attachment e.g. (Frazier & Clifton, 1996), but L2 learners have shown a tendency to attach the relative clause to the first noun phrase (high attachment) e.g. (Bidaoui et al., 2016).

Another type of ambiguity concerns the embedded clause of *that*, which could possibly be interpreted as a complement clause or a relative clause in sentences like (e).

(e) The receptionist informed the doctor that the journalist had phoned about the events.

Native speakers of English as well as L2 learners tend to interpret the *that-clause* as a complement clause e.g. (Ying, 2004).

A third type of ambiguity, which is the focus of the present paper, concerns prepositional phrase attachment. In sentences like (f), the prepositional phrase *with a book* could be interpreted as a noun phrase attachment (NP) or a verb phrase attachment (VP):

(f) Sam hit the girl with a book.

Many studies have explored how L1 English children and adults process such ambiguous sentences (e.g. Frazier & Rayner, 1982; Rayner & Carlson & Frazier, 1983; Joseph & Liversedge, 2013). Other studies have examined the processing of native speakers as well as second language learners of English (e.g. Ying, 1996; Felser et al., 2003; Ying, 2004; Marinis & Roberts & Felser & Clashen, 2005; Felser & Roberts, 2007). These studies have examined the processing and processing strategies of different types of ambiguities by a variety of L1 and L2 speakers from different language backgrounds.

Jegerski (2014) describes how ambiguity arises when the grammar allows more than one syntactic interpretation of a phrase (or a word) and processing strategy occurs when a parser is

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inclined to favor one interpretation over the other. She divides structural ambiguity into local and global. The former refers to temporary ambiguity that occurs during reading but is resolved within the same sentence. The latter refers to the continuation of ambiguity even after the whole sentence has been read. She explains the notion of *garden path* which has been widely used in the literature of language processing:

Local or temporary ambiguities are also referred to as garden path phenomena because such sentences are designed to initially lead the reader in the wrong direction with regard to the structure of the sentence. Garden path effects are evident in increased self-paced reading times at or after the point in the sentence where it becomes evident to the reader that the initial interpretation was incorrect (Jegerski, 2014: 23).

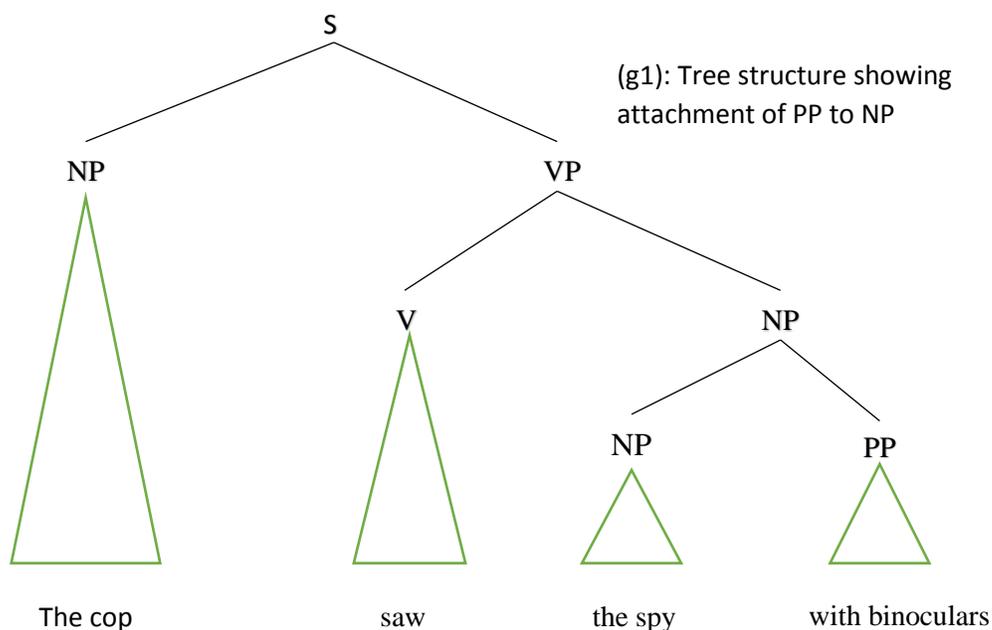
2.1 General syntactic approaches to sentence ambiguity

The main aim of different theories and principles that have been developed in the literature of sentence processing is to comprehend the different types of information people need and use when they come across different sentence structures, either when reading or hearing them, and to identify the principles language users follow in using the information at their disposal (Clifton & Ferreira, 1989). There have been several structure-based approaches to structural ambiguity resolution. These syntactic approaches can be narrowed down to two main and general principles that offer two opposing syntactic accounts for the attachment of ambiguous phrases in complex sentences (e.g., Kimball, 1973; Frazier, 1979). This is illustrated in the literature by different syntactic tree diagrams:

1. Right association: A constituent is attached to another constituent that is immediately on its right (Kimball, 1973).
2. Minimal attachment: Attach incoming constituent into the phrase marker using the fewest syntactic nodes (Frazier, 1979).

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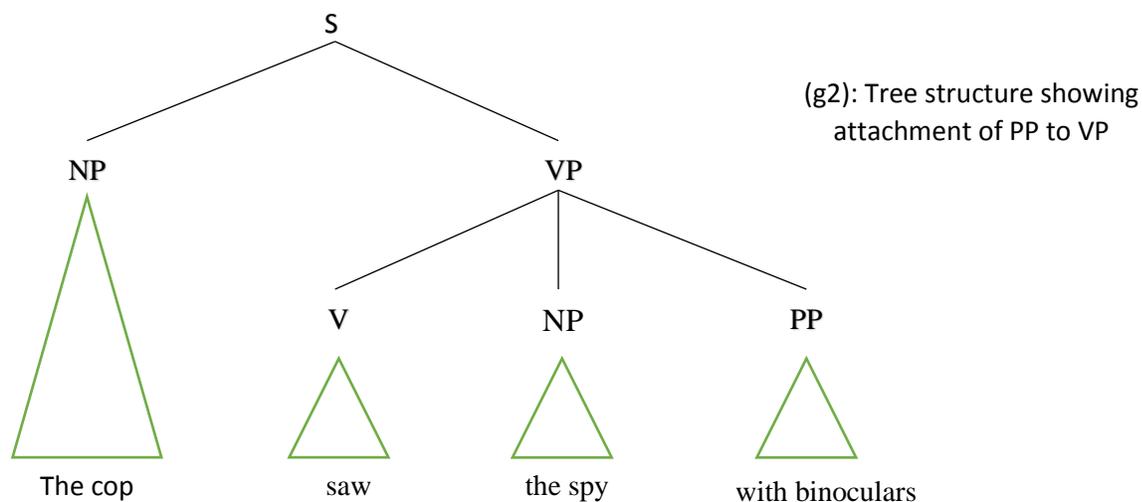
The two principles make two contrastive predictions about the attachment of the ambiguous prepositional phrase *with binoculars* in *the cop saw the spy with binoculars*. Right association suggests that sentences of a given natural language organize themselves into right branching structures. Hence, right association predicts a right attachment, which means the prepositional phrase *with binoculars* will be attached to the noun phrase *the spy*, creating an extra node as in (g1). Kimball suggests that right branching structures are perceptually less complex than center embedded or left branching structures.



In contrast, minimal attachment predicts a verb phrase attachment because it has fewer nodes making the processing load rather reduced (Cuetos & Mitchell, 1988). With the PP being attached to the VP, minimal attachment predicts that the phrase *the spy* and the phrase *with binoculars* will both be minimally attached directly to the VP-node as in (g2). The NP attached version (g1) involves an extra syntactic node and deeper branching of the syntactic structure. Attaching the PP to the VP as predicted by minimal attachment ensures a less complex structure

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where structural complexity is defined by the number of nodes in the syntactic structure (Spivey-Knowlton & Sedivy, 1995).



2.2 A pragmatic account

A third approach to ambiguity resolution is the *principle of referential support* which suggests that contextual cues influence parsing decisions following the fact that attachment preference is highly dependent on a preceding discourse context:

3. An NP analysis which is referentially supported will be favored over one that is not (Altmann & Steedman, 1988).

Within this approach, the decision of whether to attach the prepositional phrase *with binoculars* to the NP or VP is determined by any preceding context which can be a VP-supporting context, or NP-supporting context.

2.3 Relevance theory

Relevance theory proposes that human cognition is relevance-oriented: human beings pay attention to what is relevant to them and they process information in a context that maximizes its

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relevance. In their theory, Sperber and Wilson (1995, 2002) incorporated Grice's cooperative principle of four conversational maxims² into one main principle of cognition and relevance.

Developing the concept, Sperber and Wilson (1995: 125) define it as:

- “Extent condition 1: an assumption is relevant in a context to the extent that its contextual effects in this context are large.
- Extent condition 2: an assumption is relevant in a context to the extent that the effort required to process it in this context is small”.

Extent condition 1 shows how relevant information generates adequate contextual effects to justify the receiver's attention. Extent condition 2 describes how a context is crucial in the course of eliminating extra effort and extra time in processing. This foundation goes with their updated definition in Sperber and Wilson (2002: 252) concerning processing effort:

- “The greater the processing effort expended, the lower the relevance of the input to the individual at that time.”

In other words, the absence of supporting contextual cues contributes to increasing the processing effort of sentences that depend highly on given contextual information to resolve any ambiguity. This increase in the processing effort mirrors an increase in the processing time.

These sentences may be complex in their structure, and need more processing effort and time than regular and normal sentences with no such ambiguity involved between their constituents.

² Grice's four conversational maxims which describe the shared rules that speakers use in interactions are the maxim of quantity, quality, relevance, and manner. These four maxims are said to promote a collaborative conversational contribution.

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2.4 An overview of some of the related studies

Rayner et al (1983) explores the integration of semantics and pragmatics with the syntactic processing of ambiguous sentences. They hypothesize that reading times are longer when the most plausible analysis does not correspond to the analysis selected by the processor's structural preference. That is, sentences in which the minimal attachment condition is the most plausible take less time for subjects to read (h1) than do sentences in which the non-minimal attachment is the most plausible (h2). They propose that ambiguous sentences that are structurally non-preferred but pragmatically more plausible take a longer time to process than sentences that are structurally preferred on pragmatic grounds:

(h1) The spy saw the cop with binoculars, but the cop didn't see him. (Structurally preferred on pragmatic grounds)

(h2) The spy saw the cop with a revolver, but the cop didn't see him. (Structurally non-preferred but pragmatically plausible).

Their results support their hypothesis that a processor adopts structurally preferred analysis of a sentence even if the analysis is less plausible on pragmatic grounds. Following this, they suggest there are two independent processors that are active during sentence comprehension: the syntactic processor that processes syntactically preferred analysis of a sentence, and the thematic processor which selects the semantically and pragmatically most plausible interpretation based on the thematic structures. They call it the *thematic selection hypothesis*, which predicts that the ultimate result when processing an ambiguous sentence is to arrive at the pragmatically most plausible analysis, which should involve a reanalysis of the syntactic structure if the preferred pragmatic analysis does not correspond to the structurally preferred analysis of the sentence. The thematic selection hypothesis suggests that:

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“the processor could consider whether a set of relations including just an experiencer and a theme, or a set of relations including an experiencer, a theme, and an instrument, is more plausible on the basis of pragmatic factors.” (Rayner et al. 1983: 367)

The thematic selection principle predicts that it should take longer to read (h2) than (h1) because arriving at the most plausible analysis of (h2) will involve reanalysis of the syntactic structure initially assigned to the sentence.

Ying (1996) investigated the type of ambiguous sentences in which the prepositional phrase could be attached to the verb phrase or the noun phrase in sentences like (i):

(i) The man talked to the girl with a sense of humor.

The methodology of this study involves only non-native speakers of English. Two groups were involved in the first experiment; the researcher got one group of his subjects to listen to the target sentences, while the other group read them without any preceding context. The second experiment was conducted to see if favoring contextual (j1) or prosodic cues (j2) could lead learners to the intended interpretation. The researcher manipulated his sentences to favor the noun phrase attachment. He also aimed at examining the effect of both cues on the decisions his subjects made.

(j1) There were two girls. One of them had a sense of humor, and the other did not. The man talked to the girl with a sense of humor.

(j2) The man talked (pause) to the girl with a sense of humor.

His results show a preference for verb phrase attachment when sentences are not preceded by a context, which supports the prediction of the minimal attachment principle that an ambiguous prepositional phrase will be constructed with the verb phrase, resulting in fewer syntactic nodes. His results for the other experiment show that although both contextual and prosodic cues can

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guide learners towards the intended interpretation, contextual cues appear to be more robust than prosodic cues.

Nicol and Pickering (1998) focus on the role of intonation in the processing of sentences that involve *that-clause* ambiguity attachment e.g., *the receptionist informed the doctor that the journalist had phoned about the events*, in which *that-clause* could indicate a complement clause interpretation, or a relative clause interpretation. Each sentence was recorded on a player by a female speaker who read them at a normal speech rate but with two different intonations: one produced with an intonation that favored the complement clause reading, and another that favored the relative clause reading. The difference in intonation occurred after *that* within the following NP and VP. Once respondents had heard the sentences, they were required to make a lexical decision on their favorable interpretation by clicking a “yes” or “no” button on a screen in front of them. Responses and response times were automatically recorded during the experiment. The researchers argue that the difference in intonation can lead to different processing. They suggest when parsers come across ambiguity, multiple attachments are attempted and evaluated in the process of what they call *attach*, *assess*, and *select*. The researchers claim that when their subjects made their decisions, they had gone through this process which enabled them to construct multiple representations of the possible and plausible attachments.

Ying (2004) addresses whether relevance theory can provide an account for how adult L2 learners process ambiguous sentences. He sought to examine if a preceding referential context would constrain the comprehension of ambiguous sentences. Similar to many other studies, the main concern is how the parser copes with ambiguous sentences that allow more than one interpretation and in which *that* could function as a complement or a relative clause. His results show that L2 learners’ inferential processing is constrained by the contextual effects of relevance

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theory. In other words, his L2 learners showed a strong preference for the interpretation that was favored by a preceding context. This suggests that this context had posed constraints on processing the other interpretation, which was not aimed for by the same preceding context. Moreover, he argues that the level of proficiency seems to affect the inferential processing of his intermediate and advanced groups. According to him, advanced learners do better in inferential processing due to developing better inferential processing capacities than those of intermediate learners.

In their research that involves processing ambiguity during text reading in children and adults by monitoring their eye movement, Joseph and Liversedge (2013) examined the attachment preference of ambiguous prepositional phrases for the two groups. They hypothesized that both groups would exhibit a verb phrase attachment and that children would take a longer time than adults to read such sentences. Their results show that the two groups have a preference for verb phrase attachment as proposed by the minimal attachment approach. When presenting the sentences to the two groups, adults made a quick decision to attach the prepositional phrase to the main verb. Although children favored the verb phrase attachment as well, their syntactic decision was made slower. They suggest children and adults have similar mechanisms for syntactic analysis, but that the operation in children is more prolonged.

In their reading time experiments of ambiguous prepositional-phrase sentences, Spivey-Knowlton & Sedivy (1995) argue for lexically specific biases of verbs. They suggest that the PP attachment preference depends on the semantic category of the verb (action verbs vs. perception verbs) and the definiteness of the NP. They claim that in sentences that contain an action verb and a definite NP object, the preference for VP attachment will be strong. On the other hand,

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with a perception-verb sentence and an indefinite NP object, there will be a preference for NP attachment.

3. Research Questions

The present study aims to investigate the processing of English sentences that contain ambiguous prepositional phrases, as well as sentences with unambiguous prepositional phrases. Given that most of the studies in this domain have generally shown a stronger tendency to a verb phrase attachment, this study aims to examine the attachment preference of English sentences with ambiguous prepositional phrases and normal sentences with unambiguous prepositional phrases for native English speakers (control group) as well as Arabic L1 learners of English (experimental group). Three research questions are addressed in this study: 1) Which reading of prepositional phrase ambiguity do native speakers and learners of English favor when there is no referential context? 2) What is the reading time of ambiguous and unambiguous sentences for the two groups? 3) How different is the reading time when dealing with ambiguous vs. unambiguous sentences for the two groups?

The first research question examines the attachment preference of the two groups (e.g. verb phrase attachment vs. noun phrase attachment). The second research question is concerned with the reading time of two sets of target structures: sentences with ambiguous prepositional phrases and sentences with normal prepositional phrases with no potential ambiguity. Friedman (1968) and Fry (1970) claim that longer response times may indicate more complex processing because more complex decision-making would be expected to have longer response time than simpler processing (as cited in Ohala & Jaeger, 1986). The goal of the third research question is to examine time difference when reading ambiguous and unambiguous sentences. By analyzing the reading time of both types of sentences, this paper seeks to explore if processing the

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ambiguous sentences could cause confusion to participants when they read the normal sentences with no ambiguity. In other words, response time may be used to observe the influence of reading ambiguous sentences on reading sentences with no ambiguity. Such influence may include delay in processing the normal sentences, following respondents' need to check whether a prepositional phrase is inclined to be attached to more than one constituent.

4. Method

4.1 Participants

The participants in this study were 20 adult native speakers of English (control group) and 20 adult Arabic L1 learners of English (experimental group) who had been exposed to English as a second language by means of formal education. All participants were linguistically naïve to the experiment. They were randomly chosen to take the experimental survey after completing a background questionnaire. The participants were from different professional backgrounds (e.g., sciences and humanities), and most of them had a language learning experience other than their first L1 including learning French, Japanese, and German. Table 1 details participants with regards to their age range:

Table 1. Age percentage of participants

Age range	NS %	L2 learners %
18-24	52.6	40
25-40	47.4	45
41-64		5
65+		10

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Based on the language background questionnaire, the proficiency level of English for the native Arabic speakers ranges from intermediate to advanced (M= high-intermediate). Nicol and Pickering (1993) found a weak correlation on Kendall tau-b statistical correlations of errors for their group of non-native speakers that included subjects from nine different linguistic backgrounds. They claimed that the difficulty of defining NNS status was due to the variations in their personal backgrounds. They hypothesized that the reason for such weak correlation between their native and non-native subjects was due to the fact that the NNS were less homogeneous in terms of L1 background. To address this gap in the present study, all NNS subjects were chosen from one first language background, i.e Arabic.

4.2 Instrument and procedure

A survey was sent to participants via an anonymous link on Qualtrics. The survey itself was designed on Qualtrics, which allowed participants to choose one answer from a variety of choices for each experimental question. Prior to taking the survey, participants responded to a brief language background questionnaire that contained items such as occupation, age, and any language learning experience (Appendix A). The survey comprised a total of 40 sentences: 12 experimental sentences with prepositional phrase ambiguity (Appendix B), 12 experimental sentences with no prepositional phrase ambiguity (Appendix C) and 16 distractors. The 12 ambiguous sentences were adopted from Ying (1996). The ambiguous and normal sentences were all mixed up so that respondents would not develop a pattern of figuring out the peculiarity of the two sets. Participants were asked to read each sentence and answer a question to indicate their attachment preference, as in (k). Questions were displayed once, and participants were required to choose only one answer without having the option to go back and edit their

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responses. Reading time was recorded by Qulatrics after each one of the 24 experimental sentences.

(k1) The cop saw the spy with binoculars. (Ambiguous prepositional phrase)

Who had binoculars?

The spy

The cop

The teacher

(k2) The spy saw the castle with binoculars. (Unambiguous prepositional phrase)

Who had binoculars?

The castle

The spy

The binoculars

4.3 Data Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS). Scores and means were calculated using SPSS descriptive statistics. The mean of attachment preference and reading times was used for the purpose of interpreting the data.

5. Results

5.1 Attachment preference

The mean for the native English speakers and Arabic L1 learners showed a strong tendency to attach ambiguous prepositional phrases to verbs rather than nouns. This is consistent with similar findings in the literature where ambiguous prepositional phrases are attached to verb phrases as predicted by the minimal attachment approach (e.g. Ying, 1996). The attachment mean for native speakers is 14.8 for VP and 5.1 for NP. L2 learners scored a mean of 15.9 for VP

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attachment and 4 for NP. The attachment mean is not significantly different for the two groups.

Table 2 displays attachment preference mean by group.

Table 2. Attachment preference by group

	NS (N= 20)	L2 learners (N= 20)
Noun Phrase Attachment	M= 5.1	M= 4
Verb Phrase Attachment	M= 14.8	M= 15.9

5.2 Reading time: ambiguous sentences

Reading time results showed native speakers spent less time than L2 learners reading the sentences and deciding on their attachment preference. The total reading time mean for native speakers is 24.25, and the reading time mean for L2 learners is 26.70. The processing time of ambiguous sentences is not significantly different between the two groups due to the relatively high proficiency of the experimental group, which enables better processing capacities (Ying, 2004). Table 3 reports reading time mean for both groups.

Table 3. Reading time mean of ambiguous sentences by group

I am a	Mean	N	Std. Deviation
NS	24.2500	20	14.24919
L2 Learners	26.7000	20	4.73620
Total	25.4750	40	10.55386

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5.3 Reading time: unambiguous sentences

Similar to the reading time of ambiguous sentences, native speakers needed less time than L2 learners to read sentences with unambiguous prepositional phrases ($M = 21.35$). However, unlike the processing difference in ambiguous sentences, unambiguous sentences showed more processing time difference between the two groups ($NS = 21.35$, $NNS = 25.70$). Table 4 shows the results of processing unambiguous prepositional phrases by group.

Table 4. Reading time mean of unambiguous sentences by group

I am a	Mean	N	Std. Deviation
NS	21.3500	20	7.94239
L2 Learners	25.7000	20	3.27832
Total	23.5250	40	6.38904

5.4 Reading time: ambiguous vs. unambiguous

Generally, the two groups spent less time processing normal prepositional phrases. The overall total processing time mean of the 24 experimental sentences is 45.6 for native speakers and 52.4 for L2 learners. The processing time difference between ambiguous and unambiguous sentences for native speakers is more significant than that of L2 learners. This is due to native speakers' confident processing based on the simple nature of the unambiguous sentences. In other words, the normal sentences with no proposed ambiguity are viewed by native speaker processors as simple structures and are taken for granted without being confused by the processing of more complex and ambiguous sentences. In contrast, processing the ambiguous

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sentences caused L2 learners to be puzzled when reading non-ambiguous structures, and thus, spent more time processing them. The results are displayed in table 5.

Table5. Difference between reading time of ambiguous and ambiguous sentences

	NS (N= 20)	L2 learners (N= 20)
Ambiguous sentences	24.25	26.70
Unambiguous sentences	21.35	25.70
Total mean	45.6	52.4

6. Discussion

The results of the attachment preference in the experiment are consistent with similar experiments in the research of prepositional phrase ambiguity. With regards to the first research question (Which reading of prepositional phrase ambiguity do native speakers and learners of English favor when there is no referential context?), the participants in this study showed a strong preference for the VP attachment reading over the NP reading. Generally speaking, it has been found that there is a strong tendency to attach the prepositional phrase in a VP-NP-PP structure to the verb, which functions as the syntactic head of the sentence. This attachment preference is predicted by minimal attachment in which the ambiguous prepositional phrase is preferably attached to the verb phrase rather than the noun phrase in order to not create an extra node. Creating additional nodes forms a processing burden, so parsers resort to disambiguate these structures using minimal attachment strategy which supports the reduction of the processing load and makes the structure less complex for parsers (Cuetos & Mitchell, 1988; Spivey-Knowlton & Sedivy, 1995).

When such ambiguous sentences are presented without context, a main concern is to resolve the ambiguity and make an attachment decision using available resources. With the

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absence of context, the only available resources are the NP and the VP. As predicted by minimal attachment in such structures with ambiguous prepositional phrases, the attachment preference is geared toward the verb phrase, which triggers fewer nodes. The verb phrase which serves as a syntactic head is more dominant over other constituents; thus, it is capable of attracting new incoming constituents, like the prepositional phrases. Both the control and the experimental group in the current study favored the VP attachment. This indicates how central the syntactic head is in the parser's processor. This syntactic head is capable of attracting and bearing incoming materials and new constituents. In sentences that minimal attachment predicts a VP attachment decision, the verb, which is in fact the syntactic head, is what leads to such processing strategy. However, in sentences that cause parsers to reanalyze based on their syntactically preferred analysis and pragmatic grounds, like *the spy saw the cop with a revolver*, the NP, which is the semantic head, prevails over the VP, hence the possible NP attachment decisions.

The fact that Arabic L1 learners of English in this experiment showed a tendency to attach the prepositional phrase to the verb conforms to such patterns in their native language. That is, Arabic speakers are generally geared towards a verb attachment based on their default processing expectation which is originated in their L1. Also the overall general preference for a VP attachment shows that the Arabic L1 participants might not be aware of the nature of the dual attachment of the prepositional phrase. This is observed in the fact that less L1 Arabic respondents have a noun-phrase preference. Noun-phrase attachment choice appears slightly more in the native English speakers' preference which indicates they are more aware of the dual attachment possibility.

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In regards to the second research question, (What is the reading time of ambiguous and unambiguous sentences for both groups?) the reading time of ambiguous sentences is less for native speakers ($M= 24.25$). The processing time mean for L2 learners is not very different ($M= 26.70$). As expected, L2 learners spent more time processing than native speakers. The little difference in reading time among the two groups is based on the good proficiency level of the L2 learners.

As for the processing time of sentences with no prepositional phrase ambiguity, native speakers significantly spent less time than L2 learners. It is not surprising that the two groups spent less time processing the normal sentences, since they did not require much processing effort as did the sentences in the ambiguous set. Longer reading times indicate processing difficulty, while faster reading times indicate facilitation (Jegerski, 2014). The fact that participants did spend less time processing the normal sentences as opposed to the ambiguous ones indicate there was no processing difficulty. However, comparing the processing time gap resulted from processing ambiguous and non-ambiguous sentences for the two groups reveals some nuances about the processing difficulty when the two sets of sentences are combined. This is addressed by the third research question. With regards to the unambiguous sentences, the relatively short reading and processing time follows the fact that they are designed to favor one attachment and one attachment only. In other words, the parser doesn't have to reanalyze the sentence to be able to make a decision of which attachment the prepositional phrase should go with. The attachment choice is unquestionable in these types of normal and less complex sentences.

Moving on to the difference in processing time for the two sets of sentences, research question number three (How different is the reading time when dealing with ambiguous vs.

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unambiguous sentences for all groups?), the difference in processing ambiguous and normal sentences for native speakers is more significant than that for L2 learners. Based on the total mean for native speakers ($M= 45.6$) and L2 learners ($M= 52.6$), reading and processing the ambiguous sentences did not lead the former group to stumble over the unambiguous sentences, hence the considerable difference in the reading time of the two sets of sentences. However, the latter group seemed to have stumbled over the unambiguous sentences following the processing effort expended on the ambiguous sentences, which resulted in the significantly higher time difference. This processing effort expended on the ambiguous sentences causes L2 learners to be puzzled when coming across sentences with unambiguous prepositional phrases thinking that these types of sentences require additional processing effort similar to that needed for the ambiguous sentences. Native English speakers do not seem to have been puzzled by ambiguous sentences when reading and processing normal sentences. The lower mean of the reading time for this group of participants compared to the other group shows they take processing normal sentences for granted, as these types of sentences are simpler and much less complex structures.

The difference between the processing times of both types of sentences suggests there is an independent level of processing activated when needed. Because the sentences in this experiment involve no context, the participants have no cues at their disposal to help them make a decision of favoring an attachment. Given this, an independent processor has to be activated in order to help resolve the attachment ambiguity, yet this particular processor is not activated for all the sentences. As indicated by the longer reading time of ambiguous sentences, the independent processor, which I shall describe as a level 2 processor, is activated on a separate and more advanced level. When dealing with less complex and non-ambiguous sentences whose syntactic structure is simple and does not require any reanalysis of the constituents involved, a

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simple level-1 processor is activated. For these types of sentences, there is no need to activate further processing capacities. When more complex structures are involved, such as the ambiguous sentences intended in this study's experiment in which the participants have to make a choice of which attachment works better, parsers need to activate a level-2 processor, as the level-1 processor is not any more capable of dealing with such complex structures when its usage only pertains to simpler structures that fit into a level one of complexity. When the level of complexity rises as a result of being exposed to more intricate constituent structures, the parser activates the level-2 processor to match the level of complexity and to ultimately be able to resolve any required ambiguity. Once ambiguous and more complex structures have been dealt with and resolved, the parser puts the level-2 processor on hold and reactivates the level-1 processor to process and deal with simpler and normal structures. Once these simple structures have been dealt with and more complex ones are being processed, the level-1 processor is put on hold so that the level-2 processor is activated and so on. The two levels work alternatively and according to the appropriate processing situation. The alternation process involves activating the appropriate-level processor and putting the other on hold, and so on. The determining factor of which processing level should be activated or put on hold is the degree of complexity that the sentence has. In this regard, the disparity between the reading time of ambiguous and non-ambiguous sentences for the native speakers ($M= 45.6$) and L2 learners ($M= 52.4$) in this study indicates a faster alternation between the two levels of the processor for the control group. The longer reading time for the L2 learners is due to the slow paced alternation between the two levels. The more advanced the L2 learners are, the faster the alternation is between the two levels. However, it is still not as fast as it is in native speakers.

7. Conclusion

This study uses reading time to examine the processing effort of native English speakers (control group) and Arabic L1 Learners of English (experimental group) spent on reading and analyzing two sets of sentences: the first set involves sentences with ambiguous prepositional phrases that participants needed to decide on whether to attach them to the noun or verb phrases. The second set contained simple sentences with obviously attached and non-ambiguous prepositional phrases.

Consistent with most studies in the literature that involve prepositional phrase attachment preference, the participants in this study show a strong preference for a verb phrase attachment over a noun phrase attachment. This strong attachment preference which is predicted by minimal attachment strategy mirrors the dominance of the verb phrase as a prevalent syntactic head that is capable of attracting incoming constituents, such as prepositional phrases in ambiguous prepositional phrase sentences. Unless semantic cues are provided to favor the noun phrase attachment, the syntactic head that is manifested by the verb phrase remains dominant.

The reading time shows how less time is spent by native speakers to read and analyze the two sets of sentences. The reading time of the ambiguous sentences is not significantly different for the two groups of participants due to the high proficiency of the experimental group which plays a role in faster reading and processing abilities. However, although the two groups spent less time reading the unambiguous sentences, the time gap between them reveals how the L2 learners were influenced by the ambiguous sentences when dealing with the normal ones. Because reading the ambiguous sentences required more processing effort, the L2 learners were puzzled when they read normal sentences thinking they would also need more processing effort. This result is not evident in native speakers as their reading time of normal sentences is

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significantly less than that of ambiguous sentences, so there is no reason to suggest that they stumbled over the normal sentences as a result of being influenced by the processing effort of ambiguous sentences.

The total reading time of ambiguous and normal sentences for the two groups suggests there is an alternation going on between a processor that consists of two levels of processing: a level-one that is concerned with processing simple and unambiguous structures, and a level-two that is activated when a parser comes across more intricate and complex structures that could allow multiple interpretations. When the parser deals with such structures, a hold is placed on the level-1 while level-2 is activated. Once ambiguity has been resolved, level-2 is put on hold again until further ambiguities or complexities are met, and the level-1 processor is reactivated to deal with normal and simple structures. This process alternates based on the situation the parser faces. The total less time spent by native speakers on the two sets of sentences suggests a faster alternation between the processor's two levels. On the other hand, the longer time expended by L2 learners on working out the two sets of sentences indicates a more prolonged alternation.

For further studies, it would be interesting to redo the same experiment after a period of being taken to observe any time difference in the alternation of the two-level processor on the long term, relating it to some factors such as, proficiency level and language learning experience. Due to time limitation, this study only included one type of ambiguity, which involves the preposition *with*. It could be further improved by including a variety of ambiguous prepositional phrases and combining them with normal and unambiguous ones. Besides time, another limitation is that there was no clear cut classification of participants based on their English proficiency. A proficiency language test might overcome this limitation and provide a more accurate description of the proficiency of the non-native speakers. Another area is to see how

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parsers deal with lexical ambiguity. A listening experiment can be further used to support or contrast the findings obtained from the reading results. These issues merit further research.

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List of Appendices

Appendix A

Background questionnaire for native speakers (control group)

1. Major/ Occupation:

.....

2. Age: 18-24 25-40 41-64 65 or older

3. Have you learned any other languages?

Yes No

4. If yes, please list here

.....

5. How would you describe your proficiency in the foreign language(s)?

.....

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Background questionnaire for non-native speakers (experimental group)

1. Major/ Occupation:

.....

2. Native language is

.....

3. Age: 18-24 25-40 41-64 65 or older

4. What kind of experience do you have in English language education?

Elementary school Middle school High school

College/university Informal

5. How would you describe your proficiency in the English language?

- Elementary
 Pre-intermediate
 Intermediate
 High-intermediate
 Advanced

6. Have you learned any other foreign languages?

Yes No

7. If yes, please list here

.....

8. How would you describe your proficiency in the foreign language(s)?

.....

Appendix B**Experimental sentences: ambiguous prepositional phrases**

1. The cop saw the spy with binoculars.
2. The woman looked at the man with no hope.
3. The girl talked to the man with a good sense of humor.
4. The student looked at the man with no emotion.
5. The girl hit the man with a book.
6. The girl saw the man with a special pair of glasses.
7. The waiter served the customer with a smile.
8. The man talked to the girl with no sense of shame.
9. The man hit the girl with a notebook
10. The waitress served the man with a bad attitude.
11. The man talked to the girl with a sense of humor.
12. The man looked at the girl with a deep sense of regret.

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Appendix C**Experimental sentences: unambiguous prepositional phrases**

1. The spy saw the castle with binoculars.
2. The woman looked at the situation with a deep sense of regret.
3. The girl sang the song with a stutter.
4. The student looked at the wall with no emotion.
5. The server served the meal with a bad attitude.
6. The girl read the book with a special pair of glasses.
7. The man looked at the stars with a telescope.
8. The boy opened the door with a key.
9. The student asked a question with a smile.
10. The man told a joke with no sense of shame.
11. The woman spoke French with an accent.
12. The woman told the story with patience.