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The Interplay of Memory and Sentence Structure on the Resolution of Persian Pronouns

by

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A THESIS

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Abstract

One of the most prominent hypotheses in the realm of pronoun resolution in pro-drop languages is the Position of Antecedent Hypothesis (PAH) according to which null pronouns are more likely to select subject antecedents whereas overt pronouns are more likely to be linked with non-subject antecedents. A plethora of studies attempts to examine the extension of PAH to several pro-drop languages. However, none has taken the differences between individuals into account. It has been claimed that the working memory capacity of individuals as one measure of individual difference might affect processing pronouns by native speakers of a language.

I will show that the memory load has a facilitative role in the resolution of Persian pronouns whereas working memory of individuals is not a predictor variable. Moreover, overt pronouns behave more consistently with predictions of PAH especially when the memory load is low.

Keywords: Pronouns, Pro-drop, PAH, Working Memory, Persian

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List of Symbols, Abbreviations and Nomenclature

ø	Null Pronoun
1SG	First Person Singular
2SG	Second Person Singular
3SG	Third Person Singular
ANOVA	Analysis of Variances
DEF	Definite Marker
DUR	Durative Marker
ERP	Event-Related Potentials
Fem.	Feminine
LMER	Linear Mixed-Effect Regression
Mas.	Masculine
NP	Noun Phrase
OPP	Overt Pronoun Penalty
PAH	Position of Antecedent Hypothesis
PL	Plural Marker
PP	Prepositional Phrase
REL	Relativizer
RRT	Residual Reading Time
RT	Reading Time
WMC	Working Memory Capacity

Chapter One

Introduction

1.1 Overview

Many languages like Persian differ from English in their pronoun inventories in that it is possible for the subject position to be phonetically empty as in (1.1a), but still detectable because of the subject agreement marker attaching to the end of the verb. This feature is referred to as the pro-drop parameter and languages with this feature are called pro-drop languages. There are two types of pronouns in a pro-drop language: overt pronouns which are pronounced and null or empty pronouns shown with ø which are phonetically unpronounced. As can be seen, the dropping of the subject in a pro-drop language is permitted whereas this is not acceptable in a non-prodrop language.

(1.1) a. ø diruz raft-am madrese

ø yesterday went-1SG school

'I went to school yesterday.'

b. * ø went to school yesterday

Previous studies suggest different functions for overt and null pronouns in pro-drop languages (Cardinalleti & Stark, 2001; Montalbetti, 1984; Papadopoulou, 2015). Overt pronouns are generally used when the discourse topic needs to be shifted in these languages whereas null pronouns are used when the topic is going to be maintained. Thus, overt pronouns are more likely to refer to non-subject antecedents which, in most cases, are not the topic of the sentence as in (1.2) taken from Persian. Likewise, null pronouns tend to refer to subject antecedents which are generally considered as the topic as well.

(1.2) pirezan$_i$ be doxtar$_j$ [vaqti ø$_{i>j}$/u$_{i<j}$ az xiyābān rad mi-shod] salām
old woman$_i$ to girl$_j$ [when ø$_{i>j}$/she$_{i<j}$ from street cross DUR-became] hello
kard
did

'The old woman said hello to the girl when she was crossing the street.'

As can be seen, the null pronoun in the subject position of the embedded clause is more likely to refer to the subject of the matrix clause whereas the overt pronoun tends to refer to the object of the matrix clause.

A large number of studies are aimed at investigating how pronouns are interpreted in ambiguous contexts like (1.2) and what factors if there are any might probably affect their interpretation in both pro-drop and non-prodrop languages. One of the most prominent hypotheses proposed for the resolution of pronouns in pro-drop languages is the Position of Antecedent Hypothesis (Carminati, 2002, henceforth PAH), based on which null pronouns are more likely to refer to syntactically more prominent antecedents in the subject position whereas overt pronouns are more likely to refer to less prominent antecedents in non-subject positions.

Despite some discrepancies in findings, the extension of this hypothesis to several pro-drop languages has been confirmed (Haznedar, 2010 in Turkish; Kweon, 2011 in Korean; Lezama & Almor, 2011 in Spanish; Mayol & Clark, 2010 in Catalan; Ovalle, Solera, Frazier & Clifton, 2002 in Spanish; Papadopoulou et al., 2015 in Greek; Sorace & Filliaci, 2006 in Italian; Yang, Gordon, Hendrick & Wu, 1999 in Chinese).

Other factors which are believed to have an impact on the processing of pronouns are the memory load and working memory capacity of individuals, based on which pronouns might be processed differently when the memory load or working memory capacity of speakers change.

1.2 The Issue

Currently, there is no consensus in how memory load and working memory affect the resolution of pronouns. Traditionally, some believe that increasing the memory load on speakers by adding to the distance between pronouns and their antecedents might make the sentence more complex and result in reading pronouns more slowly (Clark & Sengul, 1979; Streb, Hennighausen, & Rosler, 2004). Thus, those with higher working memory capacity process the sentences better. Others, though, claim that adding to the memory load might make individuals not understand linguistic constraints such as gender mismatches between pronouns and antecedents or ambiguity of the context and process the pronouns more easily (Hammer, Jansma, Lamers and Münte, 2008; Nieuwland & Van Berkum, 2006; Qiu, Swabb, Chen, & Wang, 2012). Thus, those with higher working memory capacity will be more sensitive to the constraints or ambiguity which will result in processing sentences more slowly. The first aim of this study, therefore, is to see which of these claims applies to the relation between pronouns and their antecedents. In other words, whether the memory load and working memory of individuals have a deterring or facilitative role in the resolution of pronouns regardless of the pronoun type.

Moreover, previous studies in pro-drop languages have used a method of data analysis which is not robust enough to unbalanced number of observations per condition (ANOVA) which has made their findings less generalizable to other groups. Thus, the second aim of this study is to

replicate previous studies using a different data-analysis method (Linear Mixed-Effect Regression Method) which is robust enough to deal with uneven observations per condition to see if Persian speakers make use of PAH in the interpretation of pronouns in Persian through an online methodology.

1.3 Plan of the Study

As discussed above, the present study is aimed at: 1) investigating whether and how the distance between pronouns and their antecedent on the one hand and working memory capacity of individuals on the other play a role in the resolution of pronouns, and 2) checking whether PAH extends to Persian when the distance between pronouns and their antecedents is held constant. To do so, a set of sentences is constructed. Each sentence is divided into four regions as in (1.3) in which slashes represent different regions. As can be seen, the null or overt pronoun in the subject position of the embedded clause is forced to refer to the antecedent in the subject or object position of the matrix clause.

(1.3) pirezan$_i$ samimāne/be doxtar-hā$_j$ / [vaqti ø$_i$|u$_i$ az xiyābān rad mi-shod]
old woman$_i$ cordially /to girl-PL$_j$ / [when ø$_i$|she$_i$ from street cross DUR-became]
/ salām kard
/ hello did
'The old woman cordially said hello to the girls when she was crossing the street.'

A set of similar sentences is also constructed where the distance between the pronoun and the antecedent is being manipulated as in (1.4).

(1.4) pirezan$_i$ samimāne dar pārk / be doxtar-hā$_j$ / [vaqti ø$_i$|u$_i$ az xiyābān rad
old woman$_i$ cordially in park / to girl-PL$_j$ / [when ø$_i$|she$_i$ from street cross
mi-shod] / salām kard
DUR-became] / hello did
'The old woman cordially in the park said hello to the girls when she was crossing the street.'

48 native speakers of Persian are asked to read sentences using a moving window region-by-region self-paced reading task (Just, Carpenter, & Wooley, 1982). In this task, in order to read the whole sentence, participants keep pressing a pre-defined button on the keyboard for each region to appear on the screen while the other regions are hidden with dashes. It is believed that regions with higher complexity require higher processing times. The reading time of regions is, then, used as an indicator of their complexity. The reading time of each region of the stimuli developed for the current study is recorded and compared across different conditions (subject antecedent-null pronoun; subject antecedent-overt pronoun; object antecedent-null pronoun; object antecedent-overt pronoun) which will be elaborated in detail in Chapter 3. In a separate session, the working memory capacity of individuals is also measured.

In this way, the effect of memory load, working memory of individuals and pronoun type on the reading time of pronouns can be tested on the resolution of pronouns at the same time. To check if PAH extends to Persian, two subsets of data are selected such that the memory load or the distance between pronouns and antecedents is held constant.

In line with the purpose of the study, the following research questions are developed to see how null and overt pronouns are processed in Persian and how the distance between pronouns and antecedents and working memory capacity of participants come into play:

RQ1: Does the distance between pronouns and their antecedents play a role in the resolution of Persian pronouns?

RQ2: Does the WMC (Working Memory Capacity) of Persian monolinguals play a role in the resolution of Persian pronouns?

RQ3: Does PAH (Position of Antecedent Hypothesis) extend to Persian as a pro-drop language?

RQ4: Will there be any interactions between these factors?

The following null hypotheses are developed for each research question above:

$H_0$1: The distance between pronouns and antecedents does not play a role in the resolution of Persian pronouns.

$H_0$2: The working memory capacity of Persian speakers does not play a role in the resolution of Persian pronouns.

$H_0$3: PAH does not extend to Persian; participants show no significant tendency in selecting either of the antecedent in the subject or object position in the resolution of null or overt pronouns.

$H_0$4: There are no interactions between factors.

1.4 Thesis Outline

Chapter 2 will provide a general overview of previous research in the field. In Chapter 3, the design and methodology of the experiments will be discussed in detail along with results of

each experiment. Chapter 4 discusses the findings of the study and is aimed at explaining the outcomes of the study. In Chapter 5, conclusion of this study as well as some suggestions for future research will be given.

Chapter Two

Previous Research

2.1 Introduction

This chapter discusses previous research in the field of pronoun resolution. The findings of these studies, in general, determine four different factors which might affect the interpretation of pronouns in any language. The first factor is the syntactic salience of the antecedent or whether the antecedent of the pronoun is placed in a syntactically salient position of the sentence or not which is discussed in section 2.2 in detail. The second factor is the pronoun type factor based on which speakers of a pro-drop language have a different tendency in the resolution of null vs. overt pronouns within a sentence. This is discussed in detail in section 2.3. A third group of factors deals with investigating the role of individual differences such as working memory capacity of participants on the interpretation of pronouns which is discussed in section 2.4. There are also some purely pragmatic factors which will not be discussed here as they are beyond the scope of this thesis.

2.2 Syntactic Salience of Antecedents

According to Ariel (1988), each entity in the discourse is assigned a degree of accessibility in the speaker's minds. The extent to which an entity is accessible in the mind determines how it should be referred to later (Burmester, Sauermann, Spalek, & Wartenburger, 2017). For instance, the more accessible an entity is, the more reduced the form of a referring expression (e.g. pronoun) linked with it it should be (Ariel, 2001). For the purpose of this study, the term *salience* is used to refer to the degree of accessibility an entity has in the speaker's mind.

Many factors have been proposed to influence the salience of an entity one of which is the subjecthood factor. It is claimed that the subject position in the sentence evokes higher accessibility for an entity (Gordon, Grosz, & Gillion, 1993; Gordon & Hendrick, 1998; Walker, Joshi, & Prince, 1998). Thus, it is more likely for the subject of a sentence to be considered as a potential antecedent for the following pronoun. This is generally referred to as Subject Rule Hypothesis (Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000; Crawley & Stevenson, 1990; Gordon et al., 1993; Stevenson, Nelson, & Stenning, 1995, among others).

Another factor which might affect the salience of entities is more related to their topicality, or information structure. For instance, topics are claimed to have a higher degree of salience or activation in the mind (Ariel, 1988; Givón, 1983). Thus, language users tend to attribute pronouns to the topic of the sentence which has higher information status and salience.

It should be mentioned, though, that highly salient entities are preferred to come in the initial position in the sentence (Burmester et al., 2017). In languages such as English where the subject and topic of a sentence usually co-occur in the same place, it is difficult to tease apart which factor plays a more significant role in the resolution of following pronouns.

Matthews and Chodorow (1988) conduct a study using sentence pairs. In one sentence of the pair, the antecedent is placed in the subject position of the adverbial clause as in (2.1a) and it is placed in the object position in the other sentence of the pair as in (2.1b).

(2.1a) When the $food_i$ was prepared by the $owner_j$ of the restaurant, it_i was always delicious.

(2.1b) When the $owner_i$ of the restaurant prepared the $food_j$, it_j was always delicious.

As can be seen, the only candidate antecedent for the pronoun, *it*, in both (2.1a-b) is the noun phrase, *the food*. The results of their study show that participants read the pronoun much faster when it refers to the antecedent in the subject position.

A group of studies claim that not only do pronouns prefer subject-positioned antecedents within the sentence, but also they are more likely to select subject-positioned antecedents in the prior discourse. In a study, Hudson-D'Zmura and Tanenhaus (1998) conduct a study to examine how pronouns are processed when they refer to the centre of attention which is also in the subject position in the previous sentence. In the first experiment of their study, participants are first presented with a context sentence with two same-gender proper nouns in the subject and indirect object positions, which is followed by a target sentence in four conditions. In two conditions, the subject position of the target sentence is either a pronoun or proper noun which is forced to refer to the subject antecedent as in (2.2a-b) and in the other two conditions the subject position of the target sentence is forced to be anchored with the object antecedent as in (2.2c-d).

(2.2) Jack apologized profusely to Josh.

a. He had been rude to Josh yesterday.

b. Jack had been rude to Josh yesterday.

c. He had been offended by Jack's comment.

d. Josh had been offended by Jack's comment.

Having read the context and one of the four conditions as listed in (a-d) above, they see a question mark on the screen and are asked to determine if the context can be rationally followed by the condition sentence. The results confirm that sentences in which the pronoun

refers to the subject antecedent (2.2a) are read faster (2158ms) and decided to be more coherent (97%) compared to those in which the pronoun refers to the object antecedent (2644ms & 78%) (2.2c). Moreover, when proper nouns are repeated to refer to the subject antecedent as in (2.2b), it will take longer to comprehend the sentence (2475ms vs. 2158ms) but the rate of coherence is much closer to the condition where the pronoun refers to the subject antecedent (94% vs. 97%). They conclude that pronouns are more favoured to refer to the preceding topic which is usually the subject in English whereas proper nouns are used to change the topic. However, as mentioned earlier, it should be noted that topics and subjects usually co-occur in the same position in English and the sole effect of subjecthood and topichood in English cannot be easily teased apart. In other words, it is very difficult to distinguish the salience of the entity due to its syntactic position within the sentence and the salience associated with its information status such as topicality or other discourse-related factors.

From another perspective, individuals tend to attribute pronouns to the first-mentioned antecedents which are usually in the subject position in English in almost all cases (Carreiras, Gernsbacher, & Villa, 1995; Gernsbacher & Hargreaves, 1988; Gernsbacher, Hargreaves, & Beeman, 1989). To tease apart first-mention hypothesis and subject-rule hypothesis, Järvikivi, van Gompel, Hyönä and Bertram (2005) design an eye-tracking study in Finnish. They include a set of two-sentence ministories in Finnish where the subject is placed before the object in the first sentence of half of the ministories as in (2.3a) and after the object in the remaining half of

ministories as in (2.3b)[1]. The second sentence includes a neutral pronoun which could refer to either the subject or object of the first sentence.

(2.3) a. Tony Blair$_i$ kätteli George Bush$_j$-ia valkoisessa talossa. Hän$_{i/j}$ halusi keskustella Irakin tilanteesta.

Tony Blair (subject) shook hands with George Bush (object) in the White House. He wanted to discuss the situation in Iraq.

b. George Bush$_j$-ia kätteli Tony Blair$_i$ valkoisessa talossa. Hän$_{i/j}$ halusi keskustella Irakin tilanteesta.

George Bush (object) shook hands with Tony Blair (subject) in the White House. He wanted to discuss the situation in Iraq.

They conclude that after hearing the pronoun, participants fixate their eyes significantly more on pictures of the subject character than on pictures of the object character regardless of the order of mention. Interestingly, their eyes are also fixated more on the first-mentioned than the second-mentioned antecedent regardless of the antecedent's role. Combining two findings, they conclude that participants' eyes are fixated the most on subjects which also happen to come initially (35.8%) and the least on the objects which come as the second-mentioned antecedent (14.9%). The intermediate ranks are associated with fixations on the first-mentioned subjects (24.5%) and first-mentioned objects (24.8%). The results of this study suggest that both subject rule hypothesis and first-mention account affect the resolution of pronouns and the sole effect of each must be interpreted with caution.

[1] - The objects in all trials are identified with Partitive Case Marker (-ia) attaching as a suffix to the end of the object

2.3 The Pronoun-type Factor

One of the most prominent hypotheses applicable to pro-drop languages is Position of Antecedent Hypothesis (PAH) proposed by Carminati (2002) in Italian. PAH is rooted from Ariel's accessibility theory (1990) which is a more general discourse-related theory according to which the more salient the antecedent is, the more reduced form of a pronoun it might be referenced with. However, PAH uses accessibility theory to predict the behaviour of pronouns intra-sententially or within a sentence. Carminati assigns different degrees of salience to hierarchical syntactic positions in a given sentence such that the SpecIP position (i.e. preverbal subject) has the highest salience followed by the direct object, indirect object and other entities' positions respectively (Carminati, 2002). She then proposes that as the subject of the sentence has highest salience and most accessiblity, it is more sensible to be linked with a weaker and less informative reduced form of the pronoun (Papadopoulou, 2015).

Based on this, null pronouns are more likely to co-refer with an antecedent in a more syntactically salient position within the sentence, i.e. the subject position, whereas overt pronouns would be more likely to refer to an antecedent in a less salient position, i.e. the non-subject position as in (2.4) which has been taken from Persian.

(2.4) Ali_i bā Hasan_j [vaqti $\text{ø}_{i>j}$ / $\text{u}_{i<j}$ dāsht nāhār mi-xord] sohbat kard

Ali_i with Hasan_j [when $\text{ø}_{i>j}$/ $\text{he}_{i<j}$ was lunch DUR-ate.3SG] talk did.3SG

'Ali talked to Hasan when he was eating lunch.'

As can be seen, both pronoun types in the subject position of the adverbial clause can grammatically select the matrix clause subject, *Ali*, or the matrix clause object, *Hasan,* which makes the sentence globally ambiguous. However, in terms of preference, the null pronoun

tends to refer to the subject-positioned antecedent, *Ali*, due to its higher prominence whereas the overt pronoun is more biased toward the object-positioned antecedent, *Hasan*.

Prior to the introduction of PAH, various hypotheses attempted to explain different behaviours of null and overt pronouns in pro-drop languages. For instance, Lujan (1985, 1986) claims that null pronouns act more like unstressed pronouns and overt pronouns are more like stressed pronouns in a non-prodrop language. Another hypothesis is that overt pronouns are used as a means of avoiding ambiguity, as they carry more informational content such as number, gender or animacy features. Another hypothesis proposed by Chomsky (1981) and Cardinaletti and Starke (1999) is that because null pronouns are more economical, there is a general preference in pro-drop languages toward using null pronouns rather than overt pronouns. In her thesis, Carminati runs some experiments to argue against all previous hypotheses; instead, she proposes that null and overt pronouns select their antecedents based on their syntactic positions in the sentence.

It should be noted that PAH, as originally formulated, does not predict the behaviour of pronouns when they refer to antecedents beyond the sentence in preceding contexts. However, a group of studies are aimed at expanding the application of PAH beyond one sentence and conclude that PAH is not only applicable intra-sententially, but also it runs when pronouns refer to antecedents in the previous sentence.

Ovalle et al. (2002) run an offline study to investigate if PAH extends inter-sententially to Spanish. In the first part of their study, they form a set of two-sentence contexts. The second sentence of each context includes a null or overt pronoun which could potentially refer to the subject or object of the first sentence as in (2.5). The results of their study show that 73.2% of

participants, consistent with the prediction of PAH, prefer subject antecedents for null pronouns whereas only 50.2% select subject antecedents for overt pronouns.

(2.5) Juan$_i$ pegó a Pedro$_j$. ø$_{i/j}$|Él$_{i/j}$ està enfadado

Juan hit Pedro. ø/he is angry

'Juan hit Pedro. He is angry.'

In the second part of their study, they evaluate the extension of PAH to non-ambiguous contexts. They speculate that not only does PAH apply in ambiguous sentences but also it is applicable to disambiguated contexts. To do so, participants are presented a group of two-sentence items as in (2.6) and asked to rate the acceptability of the second sentence containing either an overt or a null pronoun on a five-point Likert scale.

(2.6) Teresa$_i$ llegóal aeropuerto tarde. ø$_{i/k}$|Ella$_{i/k}$ esta bacansada.

'Teresa arrived at the airport late. She was tired.'

As can be seen, if PAH extends inter-sententially, participants are more likely to attribute the null pronoun to the subject of previous sentence, *Teresa*. Expectedly, the results show that the mean rating of null pronoun continuation is significantly greater than that of overt pronoun continuation. This confirms that in Spanish, PAH applies even to non-ambiguous contexts because the only factor which has a determining role, based on PAH, is the syntactic position of the antecedent. However, it should be noted that the original predictions of PAH are limited to the sentence boundaries where hierarchical positions within a sentence are assigned different degrees of salience and it does not predict how pronouns are processed beyond the sentence in which some other factors such as the information status of antecedents and discourse-

related factors might play a role. Moreover, this study has an offline methodology and cannot explain real time processing of pronouns in Spanish.

In another study, Lezama and Almor (2011), through an online methodology in Spanish, show that processing overt pronouns is more difficult when they refer to subject-positioned antecedents. They construct 36 two-sentence passages in which the first sentence contains two proper nouns with different genders in subject and object positions and the second sentence contains a null pronoun, an overt pronoun or a repeated name in the subject position. The results of their study reveal that sentences in which null pronouns co-refer with the subject antecedent are read significantly faster compared to those in which overt or repeated names refer to the subject antecedent. This suggests that when overt pronouns are forced to refer to a highly salient position, i.e., the subject, they are processed more slowly which is referred to as Overt Pronoun Penalty (OPP). The results also show that null pronouns compared to overt pronouns are read significantly more slowly when forced to refer to object antecedents; however, no significant difference is observed between the reading time of overt pronouns and repeated names when forced to refer to either subject or object position. It can be concluded from the results of their study that the default choice for referring to subject antecedents in Spanish is null pronouns whereas the best choice to refer to object antecedents would be overt pronouns. This study, though, uses analysis of variance (ANOVA) for data analysis which is less reliable compared to other methods such as mixed-effect models.

There are several advantages to using a mixed-effect data analysis method to older methods such as ANOVA (Pinheiro & Bates, 2000 as cited in Vasishth & Lewis, 2006) two of the most important ones are discussed here. First, mixed-effect models have a better power in

comparing different treatments and thus makes obtained results more generalizable to other groups. This is because ANOVA method deals with averages across conditions whereas mixed-effect methods generally deal with all raw data points which makes them more powerful and generalization of results to other groups more reliable.

Second, one of the most fundamental requirements of ANOVA method is to have equal number of observations per condition or participant. As the number of observations is not usually equal across conditions in the analysis of reaction times due to removal of outliers or including only those trials which have been comprehended correctly, researchers used to replace missing data with the average reaction time for that condition to fulfill the ANOVA requirement. Mixed-effect models, however, better account for unbalanced or uneven repeated-measures data as there is no need to have equal number of data points in each condition.

A plethora of studies has explored the extension of PAH inter-sententially to other pro-drop languages (Keating, VanPatten & Jegerski, 2011 (Spanish); Sorace & Filiaci, 2006 (Italian); Papadopoulu et al., 2015 (Greek); Marefat & Samadi, 2017 (Persian); Kweon, 2011 (Korean); Yang et al., 2006 (Mandarin)).

Keating et al. (2011) investigates how Spanish monolingual adult speakers resolve pronouns and compare these with Spanish heritage speakers and advanced learners of Spanish. According to both Subject Rule Hypothesis and PAH, all groups are expected to behave similarly selecting subject antecedents in the null pronoun condition. In the overt pronoun condition, however, heritage speakers and English L2 learners of Spanish are expected to be more observant to Subject Rule Hypothesis in English and attribute Spanish overt pronouns to the subject of the preceding clause due to their extensive exposure to English whereas monolingual

Spanish speakers are expected to select non-subject antecedents for overt pronouns under the influence of PAH.

The materials of their study include 40 ambiguous sentences with a main clause followed by a subordinate clause. The main clause contains two referents and the subordinate clause includes a null pronoun in the subject position in half of the items and an overt pronoun in the remaining half as in (2.7).

(2.7) Daniel$_i$ ya no ve a Miguel$_j$ desdeque ø$_{i/j}$|Él$_{i/j}$ se casó.

'Daniel no longer sees Miguel ever since he got married.'

After each item, participants are required to answer a question eliciting their preference in attributing the given pronoun to one of the possible antecedents as in (2.8).

(2.8) ¿ Quién se casó?

'Who got married? A. Daniel B. Miguel'

The findings suggest that both heritage speakers and L2 learners of Spanish, unlike the monolingual Spanish group are under the influence of Subject Rule Hypothesis as they behave similarly in selecting subject-positioned antecedent for both null and overt pronouns. Monolingual Spanish speakers, though, behave more in line with predictions of PAH in the sense that they prefer subject antecedents for null pronouns more than overt pronouns. However, for the attribution of overt pronouns, the difference is not very significant. The study also uses an offline methodology which cannot explain how individuals process pronouns in real time.

In Italian, Sorace and Filiaci (2006) conduct a study to investigate the pattern of pronoun resolution by native and near-native Italian speakers. Their study includes a monolingual Italian

group with no exposure to English (non-prodrop language) and one near-native Italian group with English as their L1. The stimuli include 20 experimental items all consisting of a main clause with two same-gender noun phrases in subject and object positions and a subordinate clause containing an overt pronoun in ten items and a null pronoun in remaining items. Moreover, to check the effect of the antecedent position with respect to pronouns, the main clause precedes the subordinate clause in half of the stimuli and follows the subordinate clause in the other half. In other words, the pronouns precede the antecedents in half of the items (forward anaphora condition) and follow the antecedents in the other half (backward anaphora condition). The English translation of a sample item is given in (2.9a-b):

(2.9) a. While $she_{i/j}|ø_{i/j}$ is wearing her coat, the $mother_i$ kisses her $daughter_j$.

b. The $mother_i$ kisses her $daughter_j$, while $she_{i/j}|ø_{i/j}$ is wearing her coat.

Through a picture verification task, the interpretation of null and overt pronouns in both forward and backward conditions by native and near-native speakers of Italian is investigated. Putting the results obtained from near-native speakers aside, the findings show that in the forward anaphora condition, (2.9a) above, when the pronoun is overt, native speakers prefer non-subject antecedents. In the null pronoun condition, though, they select subject-positioned and object-positioned antecedents quite equally.

In the backward anaphora condition, (2.9b) above, the results suggest that native speakers of Italian are biased toward extra-sentential antecedents for the resolution of overt pronouns whereas they are more biased toward subject-positioned antecedent for attributing null pronouns. It can be concluded that in both forward and backward anaphora conditions, overt pronouns behave more consistently with the prediction of PAH in that they prefer to select

non-subject antecedents in both conditions whereas null pronouns prefer subject antecedents only in backward anaphora condition.

As more supporting evidence for the extension of PAH, Papadopoulu et al. (2015) conduct a study to examine the tendency of monolingual Greek speakers in the resolution of null and overt pronouns. The main stimuli include a main clause with two animate entities in subject and object positions, followed by a subordinate clause with either a null or overt pronoun in the subject position. The pronoun in the subordinate clause can potentially refer to both subject or object of the matrix clause making the whole sentence ambiguous. Each sentence is divided into different regions which are displayed on the screen region-by-region followed by a picture depicting each antecedent performing the embedded verb action. Participants are, then, required to decide whether the picture matches the sentence or not. It is hypothesized that in the null pronoun condition, participants select pictures in which subject antecedent is performing the embedded verb action. Likewise, an opposite trend is expected for the overt pronoun condition such that participants might select those pictures in which the object antecedent is performing the embedded verb action. Analyzing the reaction time and final decision for picture selection task, they conclude that participants tend to select those pictures in which the doer of the action is the subject of the main clause significantly more for null pronouns, which in general suggests that null pronouns tend to co-refer with subject antecedents. Similarly, participants prefer more object-positioned antecedents for the overt pronoun condition. With regard to the reaction time to match the shown pictures with the sentences, in the null pronoun condition, the reaction time is significantly greater when the doer of the action in the picture is not the subject of the main clause whereas in the overt

pronoun condition, the reaction time is significantly greater when the doer of the action in the picture is the subject of the main clause. Thus, both online and offline measures confirm predictions of PAH in Greek.

The extension of PAH to non-European languages such as Persian, Korean and Chinese has been also investigated. In Persian, Marefat and Samadi (2017) explore the effect of pronoun position relative to their antecedents on the resolution of Persian null and overt pronouns. In some items, an adverbial clause including the pronoun is placed after the antecedents (backward anaphora) as in (2.10a), and in some items, it is placed before the antecedents (forward anaphora) as in (2.10b). Moreover, since Persian allows for adverbial clauses to occur between the subject and object of the matrix clause, the adverbial clause is placed between the subject and object antecedent in the remaining items as in (2.10c).

(2.10)a. pirezan$_i$ be doxtar$_j$ salām kard [darhālike ø$_{i>j=k}$/u$_{i<j=k}$ dāsht az xiyābān rad
old woman to girl hello did [while ø /she was from street cross
mi-shod]
DUR-became]
'The old woman said hello to the girl while she was crossing the street.'

b. [darhālike ø$_{i>j=k}$ /u$_{i<j=k}$ dāsht az xiyābān rad mi-shod] pirezan$_i$ be
[while ø /she was from street cross DUR-became] old woman to
doxtar$_j$ salām kard
girl hello did
'While she was crossing the street, the old woman said hello to the girl.'

c. pirezan$_i$ [darhālike ø$_{i<j=k}$ /u$_{i<j=k}$ dāsht az xiyābān rad mi-shod] be
old woman [while ø /she was from street cross DUR-became] to
doxtar$_j$ salām kard
girl hello did
'The old woman, while she was crossing the street, said hello to the girl.'

Because the embedded verb in all items above is third person singular, both antecedents in the matrix clause will be grammatically available for the pronoun. Participants are then shown three pictures together. One of the pictures depicts the subject antecedent performing the embedded verb action. The other two depict the object antecedent and an extra-sentential entity performing the embedded verb actions, respectively. Consistent with PAH, participants are expected to select those pictures in which the subject antecedent is the performer of the embedded verb significantly more for the resolution of null pronouns. Likewise, they are expected to select pictures with an object or extra-sentential antecedent performing the embedded verb action significantly more for resolution of overt pronouns.

The results show that in both overt cataphoric condition where the pronouns precede the antecedents and anaphoric condition where pronouns follow antecedents (2.10a-b), participants behave consistently according to PAH such that they select those pictures in which subject antecedents are also performer of the embedded verb significantly less. In conditions where the overt pronoun is placed between two antecedents (2.10c), though, participants select those pictures in which subject antecedents are performers of the embedded verb actions significantly more which is in contrast to the prediction of PAH.

As for null pronouns, they come to the conclusion that in the cataphoric condition (2.10b), there is no significant difference between subject, object and extra-sentential antecedents, which rejects PAH. Though, in null anaphoric condition and the condition where the pronoun is located between the subject and object (2.10a-c), participants show a tendency to select subject antecedents more which supports PAH. In essence, they conclude that PAH is applicable to all conditions excluding null cataphoric condition and conditions where overt pronouns come

between the subject and object antecedents. Like other offline studies, though, this study does not explain how pronouns are processed in real time. Moreover, the results of the study should be cautiously generalized to other groups since the method authors use for data analysis, ANOVA, is not robust enough to items and participant differences as discussed before.

Verbal agreement marking systems are believed to be a crucial factor to give a language the ability of dropping the subject phonetically. In other words, the distinct agreement markers at the end of verbs in pro-drop languages compensates for the lack of information in reduced forms of pronouns in these languages (Chomsky, 1981). Korean and Chinese, though, are different from other pro-drop languages in that they do not benefit from an agreement marker system despite being pro-drop languages.

There have been some studies aimed at seeing if PAH extends to these languages. In Korean, for example, Kweon (2011) constructs some complex sentences in which both subject and non-subject antecedents in the preposed subordinate clause could be equally regarded as the possible antecedent for the pronoun in the main clause. The results of his study suggest that in the null pronoun condition, participants prefer subject antecedents more (81.1%) whereas in the overt pronoun condition, object antecedents are preferred (68.6%). This finding confirms the extension of PAH to Korean although the preference for the subject antecedent in the null condition is greater than the preference for the object antecedent in overt condition. This latter finding suggests the rigidity of the resolution of null pronouns compared to overt pronouns.

In Mandarin, Yang et al. (1999) study the processing of three types of null, overt and repeated name anaphors. They conclude that repeated names, in Chinese, are processed significantly more slowly when they refer to subject antecedents. However, no significant difference is

observed between the processing time of null and overt pronouns when they refer to the subject antecedent which is in contrast to the prediction of PAH. They suggest that this might be due to the lack of verbal morphology which makes overt pronouns in Chinese carry more information and become less marked than their counterparts in other pro-drop languages in which null pronouns are regarded as default. That is, overt pronouns and null pronouns behave similarly in Mandarin. However, this does not explain the extension of PAH to other similar languages like Korean with a similar agreement system (Kweon, 2011).

To sum up, three general caveats in the findings of previous studies can be found: (i) most of these studies make use of offline methodologies. Previous findings conclude that there are some differences between offline and online processing of sentences in general (Marinis, 2010). Online methodologies provide a better estimate of how language is processed by individuals as they do not let parsers think about the sentence they have read or listened to in order to use their metalinguistic abilities. Instead, these methodologies intend to measure the unconscious processing of the sentence as it unfolds and, (ii) almost all previous studies use repeated-measures ANOVA as their data-analysis method which is believed to have less power compared to more recent data-analysis methods such as LMER. Thus, the findings of these studies should be cautiously generalized to other groups, (iii) they fail to consider individual differences as an independent factor in their design. In other words, they assume that all speakers of a language interpret pronouns similarly. The following section discusses some studies which focus on individual differences on the resolution of pronouns.

2.4 The Individual Difference Factors

The working memory capacity of individuals is considered as a measure of individual variation in language processing (Daneman & Carpenter, 1980; Just & Carpenter, 1992). The overall findings of previous studies suggest a positive correlation between the individuals' working memory capacity scores and their level of language comprehension (Calvo, 2001; Just & Carpenter, 1992; Linderholm, 2002).

Moreover, one of the factors which can influence the language comprehension is how pronouns are linked to their antecedents. One group of studies claims that with an increase in the memory load, the attribution of pronouns to their antecedents would be more difficult, as the process of pronoun resolution requires the availability of the antecedent in the memory (Clark & Sengul, 1979; Streb et al., 2004). The second group, counter-intuitively, claims that increasing the memory load might make individuals process complex sentences more easily (Hammer et al., 2008; Nieuwland & Van Berkum, 2006; Qiu et al., 2012). In this section, some of previous studies from both groups are discussed.

Group I: Memory load as a deterring factor

As mentioned, this group believes that increasing the memory load will make processing the pronouns more difficult. Thus, they are expected to be read more slowly. For example, Clark and Sengul (1979) manipulate the memory load by increasing the distance between pronouns and their antecedents and examine the resolution of pronouns across one, two or three sentences back. The results of their study reveal that individuals have less difficulty and react more quickly when the antecedents are positioned one sentence back compared to the condition when they are stated in two or more sentences back. This finding suggests that the

longer the distance between the pronoun and its antecedent, the more demand it might put on the working memory to comprehend the sentence.

In another study, Streb et al. (1999) assume that non-parallel syntactic structures are more difficult than parallel structures and demand higher memory. The trials of their study are constructed of two-sentence contexts with a pronoun in the subject position of the second sentence which is forced to co-refer with either the subject positioned antecedent (parallel syntactic structure) or object positioned antecedent (non-parallel syntactic structure) as in (2.11 a-b).

(2.11) a. Peter$_i$ visits Julia$_j$ in the hospital. There he$_i$ asked a question to the physician.

b. Peter$_i$ visits Julia$_j$ in the hospital. There she$_j$ asked a question to the physician.

They utilize Event-Related Potentials (ERPs) as their methodology. In the ERP method, electrical activity in the brain is recorded through EEG (electroencephalography) data and then time-locked to the relevant event (e.g. the onset of a critical word on the screen or in the speech signal). The electrical amplitudes exhibit positive or negative shifts with specific latencies. Two of the most important shift tendencies which are commonly used in linguistic studies are known as P600 and N400 effects. Syntactic processing difficulties are believed to elicit left-anterior negativities between 300 and 500ms, and subsequent parietal positivities around 600ms (P600), whereas semantic relations are believed to induce a negativity shift peaking around 400ms after the onset of the stimulus over centro-parietal electrode sites (N400). The results of Streb et al.'s study show that non-parallel structures engender more negativity at parietal sites compared to parallel structures. In other words, more complex structures elicit

more intensity in ERP patterns. This finding also suggests that increasing the memory load can make the process of pronoun resolution more cumbersome.

Group II: Memory load as a facilitative factor

This group claims that the memory load makes individuals miss linguistic constraints or ambiguity and thus read the sentences more easily. In addition, those with higher memory capacity are more sensitive to the anomalies or ambiguities in the sentence and read them more slowly.

Nieuwland and Van Berkum (2006), through an ERP methodology, explore how the working memory of individuals and contextual biases affect the resolution of pronouns in Dutch. They predict that consistent with previous studies (Van Berkum, 2004), processing pronouns in ambiguous contexts might lead to a frontal negative shift known as Nref in ERPs compared to non-ambiguous contexts. Moreover, they hypothesize that this negative shift is correlated with the working memory capacity scores of individuals on the one hand and the contextual bias of the sentence on the other. That is, individuals with higher working memory elicit more intense Nref whereas the contextual bias might decrease the intensity of Nref.

They construct a set of short contexts where the pronoun in the subject position of the embedded clause could either grammatically refer to both antecedents in the subject and object position of the matrix clause as in (2.12a) or be disambiguated toward one of the antecedents as in (2.12b). They also form contexts with semantic anomalies as in (2.12c) for the pure elicitation of N400 effect and referentially failing pronouns as in (2.12d) to induce P600 effects. As mentioned before, the P600 effect is believed to occur when there is a violation in a

grammatical rule whereas the N400 effect mostly deals with semantic integration of words into the sentence[1].

(2.12) a. Al Pacino$_i$ told Bruce$_j$ Willis that he$_{i/j}$ wasn't a very nice person to be around.

b. Al Pacino$_i$ told Madonna$_j$ that she$_j$ wasn't a very nice person to be around.

c. Al Pacino told Madonna that she wasn't a very friendly sausage to be around.

d. Al Pacino told Bruce Willis that she wasn't a very nice person to be around.

Moreover, the contextual bias is manipulated by selecting different verbs in the matrix clause as in (2.13). The degree of the bias is determined by asking a group of different participants to decide which antecedent the pronoun refers to prior to the main experiment. Based on the results of their selection, the degree of contextual bias is calculated as the absolute value of the difference between NP1% from NP2% where % shows the percentage of participants who select NP1 or NP2 as the antecedent for a given pronoun. For example, in (2.13), 20% of participants select NP1 and 80% select NP2 as the antecedent for the pronoun. Thus, the contextual bias for this trial is 60.

(2.13) The businessman$_i$ called the dealer$_j$ just as he$_{i/j}$ left the trendy club.

Consistent with their predictions, the results of their study reveal that only ambiguous contexts such as (2.12a) cause an Nref whose amplitude is correlated with the working memory capacity scores such that higher working memory scores intensify Nref amplitudes.

Splitting the participants into two low-span and high-span groups and running the statistical analysis in each group again, the authors conclude that the significant negative shift in ambiguous contexts is only observed for the high-span group but not for the low-span group.

1- The paper does not provide the original Dutch examples.

That is, the high-span group seems more sensitive to the ambiguity than the low-span group. Further analysis reveals that the negative shift in ambiguous contexts is only marginally observed for the weakly biased contexts but not for the moderately biased ones as expected because the contextual bias makes participants take one of the two possible antecedents more into account.

Analysis of baseline trials reveals that semantic anomalies such as (2.12c) expectedly lead to N400 and referentially failing pronouns such as (2.12d) lead to P600 effect whose amplitudes are not correlated with the memory scores. Thus, the findings of their study show that (i) ambiguous contexts lead to a significant negative shift in ERP patterns known as Nref, (ii) the amplitude of this negative shift is correlated with the working memory only for individuals with higher working memory capacity, (iii) this pattern shift is expectedly not observed in non-ambiguous contexts or contexts with highly salient anomalies, and (iv) the contextual bias can affect the resolution of pronoun to a lesser degree which is not correlated with working memory scores. Aside from the latter finding, this study has two major implications. First of all, it suggests that individuals with higher working memory scores are more sensitive to ambiguous contexts which leads them to process sentences with more difficulty. Secondly, the working memory affects pronoun resolution only in ambiguous contexts not in non-ambiguous ones.

Hammer et al. (2008) conduct an ERP study to investigate how semantic and syntactic genders and working memory load interact with each other on the resolution of pronouns in German. They construct two-sentence trials with either a masculine or feminine pronoun in the subject position of the second sentence referring to a possible antecedent in the subject position of the

first sentence. Half of the trials include inanimate antecedents in two syntactic genders (masculine vs. feminine) and half of the trials include person antecedents in two biological genders (MALE vs. FEMALE) as in (2.14 a-b). Thus, the pronoun matches the syntactic or biological genders of the antecedents in half of trials and mismatches the antecedent genders in the remaining half. To manipulate the memory load, the distance between the pronoun and the antecedent in half of the trials is longer than the other half as in (2.14 c-d).

(2.14) a. Person antecedent: short distance

Congruent: Der Häuptling$_{MALE/mas}$ ist kriegerisch, weil er$_{MALE/mas}$ gewinnen will.

Incongruent: Der Häuptling$_{MALE/mas}$ ist kriegerisch, weil sie$_{FEMALE/fem}$ gewinnen will.

'The chief is martial, because he/she wants to win.'

b. Inanimate antecedent: short distance

Congruent: Der Apfel$_{mas}$ ist süβ, weil er$_{MALE/mas}$ reif ist.

Incongruent: Der Apfel$_{mas}$ ist süβ, weil sie$_{FEMALE/fem}$ reif ist.

'The apple is sweet, because he/she (it) is ripe.'

c. Person antecedent: long distance

Congruent: Der Häuptling$_{MALE/mas}$ greift bald an und ist kriegerisch, weil er$_{MALE/mas}$ gewinnen will.

Incongruent: Der Häuptling$_{MALE/mas}$ greift bald an und ist kriegerisch, weil sie$_{FEMALE/fem}$ gewinnen will.

'The chief attacks soon and is martial, because he/she wants to win.'

d. Inanimate antecedent: long distance

Congruent: Der Apfel$_{mas}$ ist sehr saftig und ist süβ, weil er$_{MALE/mas}$ reif ist.

Incongruent: Der Apfel$_{mas}$ ist sehr saftig und ist süβ, weil sie$_{FEMALE/fem}$ reif ist.

'The apple is very juicy and is sweet, because he/she is.'

The results of their study show that in the person condition, the mismatch between biological genders of the pronoun and the antecedent leads to an N400 effect only when the distance is short, and fades away when the distance increases. This suggests that memory load interacts

with semantic gender information processing. In the inanimate condition, though, a P600 effect is observed when there is a mismatch between syntactic genders of the pronoun and antecedent only in the short distance condition. This effect is not observed in the long distance condition, however. This finding suggests that the distance as a measure of the memory load interacts with syntactic parsing as well.

In another study, Qiu et al. (2012) examine the effect of the memory load on establishing the gender agreement between pronouns and their antecedents in Chinese. Chinese is unique in that it is a gender-neutral language in speaking as there is only one third-person singular pronoun (pronounced as *tā*) for both genders. However, this pronoun is written differently for two genders in modern Chinese. The sample trial of their study includes a sentence with a proper name in the subject position followed by another sentence with a pronoun in the subject position. As participants read the trials, they can identify the gender of the pronoun. In half of the trials, the gender of the pronoun and the proper name agrees whereas in the other half, their genders are different. To manipulate the distance between the pronoun and its antecedent, a prepositional phrase is placed before the proper name in the short distance condition (2.15 a-b). In the long distance, though, the prepositional phrase is placed after the proper name to make the distance between the pronoun and its antecedent greater (2.15 c-d).

(2.15) a. In the new round of competition for the outstanding individual, **Panzhen** (male name) earned acclaim. **He** won the Model Worker award with an absolute advantage.

b. In the new round of competition for the outstanding individual, **Panzhen** (male name) earned acclaim. **She** won the Model Worker award with an absolute advantage.

c. **Panzhen** (male name) earned acclaim. In the new round of competition for the outstanding individual, **he** won the Model Worker award with an absolute advantage.

d. **Panzhen** (male name) earned acclaim. In the new round of competition for the outstanding individual, **she** won the Model Worker award with an absolute advantage.

The results of the study show an N400 effect only in the short distance condition when there is a mismatch between the pronoun and its antecedent which implies the semantic sensitivity of Chinese speakers in the short distance condition. In the long distance condition, however, they find an unexpected P600 effect. There are two possible explanations for this: First, the long distance between pronouns and antecedents might have decreased the availability of the antecedent for the pronoun to the extent that participants might have failed to find any antecedents for the pronoun in participants' minds and turned the sentences to no-referential contexts which has, in turn, elicited P600 effect (Nieuwland & Van Berkum, 2006). Another possible explanation is that the inserted prepositional phrase is so long that it has added to the complexity of the sentence, leading to a P600 effect. Aside from how an unexpected elicitation of P600 is explained for the long distance condition, they conclude that N400 effect is only observed in the short distance condition and increasing the memory load can wipe out the negativity shift (N400) in ERP patterns.

Fiorentino, Covey and Gabriele (2018) explore the role of working memory and attention control as two measures of cognitive abilities on the processing of the referential ambiguity and failure. Attention control, which is believed to be an important factor in the reference resolution, is the ability to allow the execution of cognitive processes, maintaining attention

and allocating working memory through ignoring redundant but prominent information in the discourse (Arrington, Kulesz, Francis, Fletcher, & Barnes, 2014).

Their study includes two experiments. The trials in their first experiment are constructed of two sentences with a pronoun in the subject position of the second sentence. In half of the items, the pronoun could refer equally to two antecedents which matches the pronoun in gender and in the other half, it refers to only one antecedent which matches in gender (2.16 a-b). In the second experiment, the trials include no-referent and one referent sentences as in (2.17 a-b).

(2.16) a. Tyler$_i$ grabbed Eric$_j$ because he$_{i/j}$ was falling down the stairs (two-referent)

b. Janet$_i$ grabbed Eric$_j$ because he$_j$ was falling down the stairs (one-referent)

(2.17) a. Alice$_i$ astonished Justin$_j$ because she$_i$ was able to sing beautifully (one-referent)

b. Ben$_i$ astonished Justin$_j$ because she$_{??}$ was able to sing beautifully (no-referent)

The findings of their study reveal that some individuals display an Nref effect whereas some others display a P600 effect while processing ambiguous contexts such as (2.16a). Part of this result is consistent with previous findings where referential ambiguity is thought to engender Nref effect (Nieuwland & VanBerkum, 2006). Within the Nref group, the individuals with higher working memory yield more intense Nref effect which is in line with previous studies such as Nieuwland and VanBerkum (2006) in the sense that there is a positive correlation between working memory and Nref intensity. Nref effect is elicited only for those individuals with higher working memory capacity.

Within the P600 group, there is a negative correlation between attention control scores and the intensity of P600 effect. That is, the higher the score in the attention control test, the lower the P600 effect; individuals with higher attention control scores show less P600 effect. These two

findings suggest that individuals with higher cognitive abilities have more problems processing ambiguous pronouns.

The findings of the second experiment reveal that there is an expected P600 effect for the referential failure such as (2.17b). However, no correlation is found between working memory capacity of participants and P600 amplitude, although there is a marginal correlation between the attention control scores and P600 amplitude. Taking the results of two experiments together, it can be concluded that working memory can modulate the reference resolution in ambiguous contexts but not in non-ambiguous contexts or contexts where there are referential failures.

To sum up, the following conclusions can be drawn from previous studies on the role of individual differences in the resolution of pronouns: (i) traditionally, the distance between pronouns and antecedents is believed to have a deterring role in the processing of pronouns because it can increase the memory load. Thus, readers have harder time reading the contexts where there is a great distance between pronouns and antecedents, (ii) some other studies, on the other hand, claim that as the memory load increases through increasing the distance, readers might miss ambiguity or linguistic constraints such as gender disagreement. Thus, they can process the sentences more easily, (iii) as the working memory capacity of individuals increases, the amplitude of the negative shift in ERP patterns increases as well. That is, individuals with better working memory, counter-intuitively, have more difficulty with processing ambiguous or complex sentences, (iv) a group of studies such as Nieuwland and Van Berkum (2006) narrow down the effect of the working memory to ambiguous contexts and suggest that the amplitude of the negativity shift in ERP patterns which is observed in lexical

anomalies, gender mismatches and contexts with no antecedents is not correlated with the working memory.

2.5 Summary

Previous studies discussed in this chapter confirm that: (i) PAH can explain how null and overt pronouns are processed differently in a variety of pro-drop languages based on the salience of the positions in the hierarchical syntax tree. However, previous studies which have tested the extension of PAH to other pro-drop languages either make use of a data analysis method which is not robust enough to consider unbalanced observations per person and condition or have offline methodologies which do not provide us with an insight how individuals process pronouns in real time, (ii) working memory is believed to have an independent role on the resolution of pronouns. The results, though, are mixed such that some studies predict more complexity in processing pronouns when the memory load increases through adding the distance between pronouns and antecedents. On the other hand, there is a second group of studies claiming that increasing the memory load will lead individuals miss the linguistic constraints such as gender matching or ambiguity and predict shorter reading time of pronouns as the memory load increases. A third group of studies limits the role of working memory to ambiguous contexts and predicts that readers with higher working memory have more difficulty reading ambiguous pronouns while this correlation is not predicted in non-ambiguous contexts.

The present study is aimed at: (i) exploring the extension of PAH to Persian and analyzing the data using a more generalizable method, linear mixed-effect method (LMER), and (ii) examining if working memory capacity of individuals plays a significant role in processing pronouns in non-

ambiguous contexts through a different methodology, self-paced reading task. In other words, if individuals follow Nieuwland and Van Berkum's pattern, the working memory and distance might not have a significant effect on the reading time of pronouns. On the other hand, if they are behaving more according to the findings of the opposite groups, the distance should increase the memory load even in non-ambiguous contexts and the reading time of the pronoun should, in turn, either increase consistent with Clark and Sengul (1979), Streb et al. (2004) or decrease consistent with Hammer et al. (2008), Qiu et al. (2012) and Fiorentino et al. (2018). The following chapter discusses the design, methodology and results of the study in detail.

Chapter 3

Research Methodology and Results

3.1 Introduction

This chapter presents a detailed description of the methods used in this study as well as the results obtained. This study involves two phases. The main objective of Phase 1 is to check for any biases in the stimuli, whereas the main objective of Phase 2 is to measure the reading time of the stimuli as well as working memory capacity of participants. First, a detailed description of each phase is provided followed by the findings of each phase. All methods and data collection procedures are approved by the University of Calgary's Ethics Board.

3.2 Overall Design

To study the effect of distance on the resolution of pronouns, three independent variables are defined: pronoun type at two levels – null vs. overt; distance between the pronoun and its antecedent at two levels – short vs. long, working memory capacity (hereinafter WMC) of participants as a between-subject factor in a gradient scale from 0 to 54, and one dependent variable: reading time of different regions. Table 3.1 summarizes the concrete conditions of first part of the study.

Table 3.1

Summary of conditions for studying distance manipulation

Distance	Pronoun Type	
	Null	*Overt*
Short	**Condition 1**	**Condition 2**
Long	**Condition 3**	**Condition 4**

In addition, to see if PAH extends to Persian, the distance variable is held constant and another variable is added to the design of the study which is the antecedent type at two levels: subject vs. object. Thus, the extension of PAH to Persian is studied in two subsets of data – the short-distance subset and the long-distance subset. In sum, the design of the study in this part involves pronoun type at two levels – null vs. overt; antecedent type at two levels: subject vs. object and WMC. Putting the WMC of participants aside due to its gradient nature, it yields the following concrete conditions as summarized in Table 3.2:

Table 3.2

The summary of conditions for PAH extension in short/long distance

Distance	Antecedent Type	Pronoun Type	
		Null	*Overt*
Short / Long	*Subject*	**Condition 1**	**Condition 2**
	Object	**Condition 3**	**Condition 4**

3.3 Phase 1 (Acceptability Judgement Test)

The aim of this phase is to see if there are any biases in items which are developed to be used in the second phase of the study.

3.3.1 Participants.

A group of 20 Persian monolinguals (11 males and 9 females) with an average age of 31 (ranging between 26 and 37) were recruited with a cash incentive equal to 250000IRR (~7CAD). They were only aware of the general purpose of the study, and not debriefed about the detailed research purpose until the end of their participation. They were studying different majors of Arts and Social Sciences at an Applied Science College in Tehran. All of them claimed that they had a lower than intermediate level of English proficiency through a self-evaluation

questionnaire, but they all had passed elementary English courses at high school or university. None of them had contact with English at work or home and none had stayed in an English-speaking country even temporarily.

3.3.2 Instruments.

The test instrument for this phase includes 37 pairs of experimental and 76 filler items in Persian. In the following sections, the detailed description of both item types are explained.

3.3.2.1. Experimental items.

The experimental items developed for the main experiment in Phase 2 contains a matrix clause and an embedded clause as in 3.1:

(3.1) pirezan$_i$ samimāne be doxtar-ha darhālike ø$_i$ / u$_i$ dāsht az xiybān rad
old woman cordially to girl-PL while ø/she was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG
'The old woman cordially said hello to the girls while she was crossing the street.'

The main aim of the acceptability test in Phase 1 is to make sure that the embedded verb is not biased toward any antecedents in the subject or object position of the matrix clause. Otherwise, the pronoun located in the subject position of the embedded clause may be forced to align with a particular antecedent due to semantic bias. If it does not agree in number with the biased antecedent, though, as in (3.2), it leads to an increase in reading time of the sentence.

(3.2) doxtar-hā$_i$ samimāne be pirezan darhālike ø$_i$ / u$_i$ dāsht mi-raqsid

girl-PL cordially to old woman while ø /she was DUR-danced.3SG

salām dād-and

hello gave-3PL

'The girls cordially said hello to the old woman while she was dancing.'

As can be seen, the embedded verb, *dance*, is biased toward the subject of the main clause, *girls*, but as they do not agree in number, it is forced to attribute to the object antecedent, *old woman*. In other words, if there is a semantic bias toward any antecedents, there is no way of teasing apart the delay in the processing time due to semantic bias and the delay due to pronoun resolution.

One way to check the bias of the embedded verb toward antecedents is to develop two items separately for each set of experimental items in Phase 2 as in (3.3a-b).

(3.3) a. pirezan mi-raqsid

old woman DUR-danced.3SG

'*The old woman was dancing.*'

b. doxtar mi-raqsid

girl DUR-danced.3SG

'*The girl was dancing.'*

The problem with this system, though, is that items might be judged as highly acceptable in isolation, but when they are combined together in a single complex structure, they might seem biased.

To solve this problem, for each experimental item developed for Phase 2, two items are developed in which the embedded clause is replaced with a relative clause. In one item, the relative clause modifies the object of the sentence as in (3.4a) and in another item, it modifies the subject as in (3.4b).

(3.4) a. pirezan be doxtar-i ke raqsid salām dād

old woman to girl-DEF REL danced.3SG hello gave.3SG

'The old woman said hello to the girl who danced.'

b. pirezan-i ke raqsid be doxtar salām dād

old woman-DEF REL danced.3SG to girl hello gave.3SG

'The old woman who danced said hello to the girl.'

These two items, together, make up a single experimental set of Phase 1. Participants are asked to decide the acceptability of the items relative to each other on a 7-point Likert scale in which 1 to 3 shows the bias toward the first sentence, 5-7 shows the bias toward the second sentence and 4 shows no bias. Thus, the expectation is the scores land somewhere around [4] for most participants, indicating there would be no bias toward antecedents.

For the complete list of experimental items in Phase 1, refer to Appendix A.

3.3.2.2. Filler items.

The study includes a total of 76 filler items. The main purpose of their inclusion in the study is to force individuals to use extreme ends of the scale on the one hand and distract them from guessing the main purpose of the study on the other. The filler items are also constructed such that they test some other theoretical issues which are unrelated to the main purpose of this study. For the complete list of filler items, refer to Appendix B.

3.3.3 Procedure.

Participants are asked to rate the acceptability of 113 items (37 experimental and 76 filler) on a 7-point Likert scale on the researcher's laptop which is located in a quiet room for the purpose of conducting research. They are first given a consent form on which the general purpose of the research is described and asked to declare their consent by signing the form.

Each participant sits in front of the laptop. The procedure of the test is then explained to them by the researcher orally. The same explanation appears on the screen in Persian. They first go through two practice items and ask any questions they have. The main test starts by pressing SPACE bar on the keyboard. Each trial includes a sentence pair as discussed above. One sentence is positioned on the right part of the screen and the other sentence on the left. Participants are asked to rate the relative acceptability of sentences in each pair. They would press one of labelled keys (1-3) if they believe the left-located sentence in the pair is more acceptable and (5-7) if they believe the right-located sentence in the pair is more acceptable. If they think both sentences are equally acceptable, they would press labelled key (4) on the keyboard. They take a short one-minute break after running half of the test. The whole test takes 30 minutes. Figure 3.1 and 3.2 show the original trial sample and English equivalent respectively.

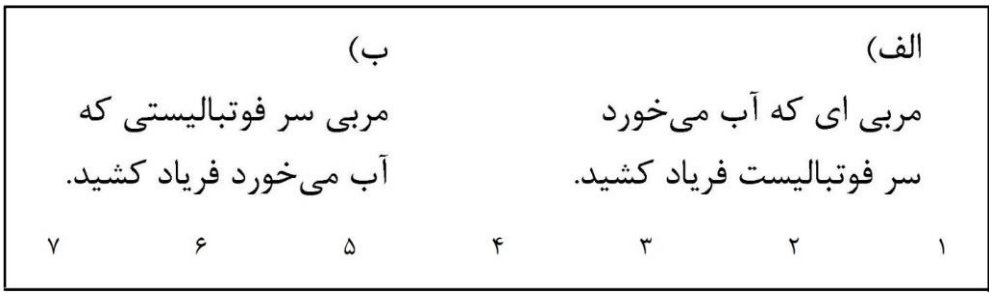

Figure 3.1. A trial sample from Phase 1 (The Acceptability Judgement Test) of the study

a) The coach who was drinking water shouted at the football player.				b) The coach shouted at the football player who was drinking water.		
1	2	3	4	5	6	7

Figure 3.2. The translated version of the trial sample given in Figure 3.1

3.3.4 Data analysis.

The data analysis for this phase of study includes two stages. All analyses are conducted in the R software package (R Core Team, 2013). At the first stage, those participants whose ratings are either below or above two standard deviations from the mean rating for each item are identified and regarded as outliers. Then, the data of two participants whose ratings are regarded as outliers more frequently than others are excluded from data. At the second stage, a two-sided t-test is applied on remaining participants for each item. The desired expectation is that the mean would not be significantly different from 4 for experimental sets which would be an indicator of neutrality of the set.

As can be seen in Table 3.3, the ratings for 25 experimental sets are not significantly different from 4 which demonstrates their neutrality. From the remaining 12 items, five items with the lowest p-values are excluded from Phase 2. The remaining 7 items undergo some minor modifications after discussing the issue with a group of Persian native speakers in order to identify possible reasons why ratings have been biased. To make sure about the plausibility of modified items, a paper-and-pencil acceptability judgement test is developed and given to a different group of 20 native speakers of Persian. The new test includes seven modified experimental sets mixed with 13 previously developed filler items. The results of the new test

confirm the neutrality of modified items. Table 3.4 shows data analysis of modified items. None of participants are considered as outliers in this test.

Table 3.3

Primary results of acceptability judgment test

Item Number	Mean	p-value	Decision	Item Number	Mean	p-value	Decision
1	2.8824	.0209*	Modified	25	4.1176	.5434	Included
2	3.4706	.1662	Included	26	3.4706	.0239*	Modified
3	4.4706	.1037	Included	27	3.5882	.0299*	Modified
4	2.8824	.0022**	Excluded	28	4.1176	.5434	Included
5	4.1176	.6515	Included	29	3.8824	.6082	Included
6	3.2941	.0093**	Excluded	30	3.9412	.3322	Included
7	2.4118	.0005***	Excluded	31	4.3529	.2102	Included
8	3.7647	.1037	Included	32	3.7647	.2156	Included
9	3.8235	.1876	Included	33	3.8824	.3322	Included
10	3.6471	.3028	Included	34	4.1176	.3322	Included
11	4.1176	.4309	Included	35	3.0588	.0051**	Excluded
12	3.8235	.1876	Included	36	3.9412	.8867	Included
13	3.4706	.0342*	Modified	37	4.5294	.0343*	Modified
14	3.6471	.1635	Included				
15	4.8235	.0144*	Modified				
16	5.4118	.0006***	Excluded				
17	4.2353	.1037	Included				
18	4.0588	.7909	Included				
19	3.2353	.0228*	Modified				
20	3.7059	.2636	Included				
21	3.5294	.0573	Included				
22	4.1176	.6082	Included				
23	3.9412	.3322	Included				
24	4	1	Included				

Table 3.4

Secondary results of acceptability judgment test

Modified Item Number	Mean	p-value	Decision
1	4.0625	.3332	Included
13	3.9474	.7162	Included
15	4.1053	.4291	Included
19	4	1	Included
26	4	1	Included
27	4.25	.5142	Included
37	3.9444	.6676	Included

3.4 Phase 2

Phase 2 of the study involves two parts in itself: a working memory test and a self-paced reading task. The main aim of the working memory test is to measure the working memory capacity of individuals. The main aim of the self-paced reading task is to measure the reading time of stimuli which are developed based on the results of Phase 1 (Acceptability Judgement Test). Each part will be discussed in detail in the following sections. It should be mentioned, though, that participants went through the self-paced reading task first and then did the working memory test.

3.4.1 Working memory test.

The aim of this part is to measure the working memory capacity of participants who take part in Phase 2 of the study. Because this task generates one of the independent variables in the analysis of the self-paced reading task, it is discussed first.

3.4.1.1. Instruments.

The test used for this part is the modified version of the test developed by Daneman and Carpenter (1980) translated to Persian. The reliability and validity of the translated version have been checked by Iranian universities (Mojtabazadeh, 2006). The test contains two sections. In the first section (auditory stimuli), participants listen to six sets of sentences about the real world. The size of each set ranges from 2 to 7 sentences yielding a total of 27 sentences. After listening to each sentence, participants decide whether the fact stated in the sentence is TRUE or FALSE by pressing 'P' or 'Q' buttons labelled with red [YES] and [NO] stickers in Persian. After hearing the final sentence in each set, they are asked to recall the final word of each sentence and write them down in specific places provided on the paper answer sheet. If they do not

remember the word, they mark the third option "I don't remember". Table 3.5 shows the sample translated sentences they hear in the two-sentence set as well as the expected response at the end of each. Figure 3.3 shows a translated section of the answer sheet for the two-sentence set.

In the second section (visual stimuli), six sets of sentences which are different from previous section are shown on the screen. Instead of hearing sentences, participants read them silently to judge their truth value and recall the final word of each sentence at the end of each set.

Table 3.5

A sample of the two-sentence set in working memory test

Sentences	Expected Responses
Fish and rooster stay alive only if they live in water.	False
Owls are awake during the day and sleep overnight like other birds.	False

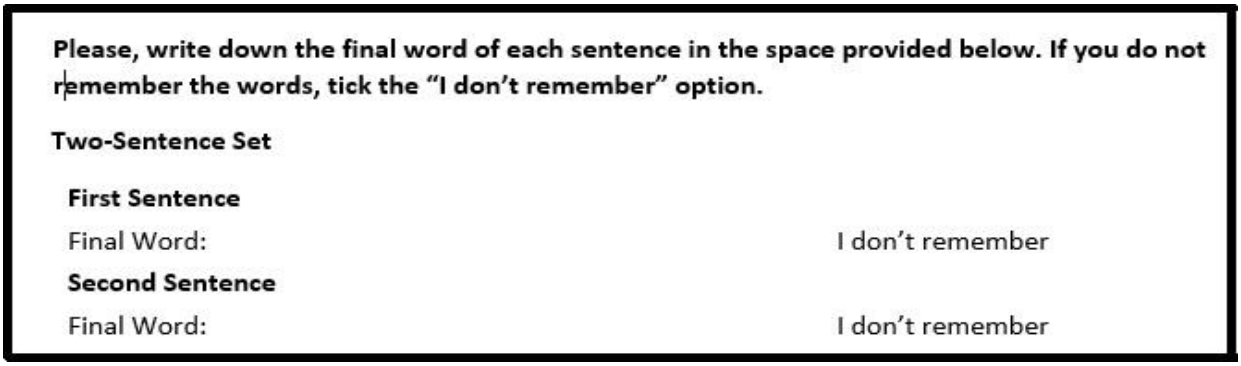

Figure 3.3. A sample of working memory test's answer sheet

For a complete list of sentences in both sections refer to Appendix C.

3.4.1.2. Procedure.

Participants are seated in front the same laptop as in self-paced reading part. They are given instructions how to do the test by the experimenter. At the same time, they read the same instructions on the screen which are followed by some practice trials during which they can ask any questions they have. The main test starts by pressing SPACE bar on the keyboard. The sentence number appears and remains on the screen for one second. Then, the sentence would be either played back or displayed on the screen. After each sentence, they are given time to decide on the truth value of the sentence. At the end of each set, an instruction on the screen asks participants to write the final word of each sentence in the set onto their answer sheet. For half of the participants, the audio section precedes the visual section whereas for the second half, the visual section comes first.

3.4.1.3. Data analysis.

For each participant, two sets of scores are obtained. The first set of scores, *verification*, is obtained by checking if the participant has correctly judged the truth value of sentences. Those whose verification scores are above 42 (80% of all sentences) are included for further analysis. None of participants' data is excluded at this stage.

The second set of scores, *recalling*, is obtained to measure the extent to which individuals are able to recall the final word of all sentences in each set in a perfectly correct order; they are assigned a credit which is weighted according to the size of set. For instance, if they recall all final words of three-sentence set perfectly, they are given the score of 3. The score span of participants, thus, ranges between 0 for those who are not able to recall any words in the correct order in any sets and 54 for those who recall all final words in a perfectly correct order

in all sets. This method of scoring a WMC test is based on previous studies (Ackerman, 2002; Cantor & Engle, 1993; Colom, Molina, Shih, & Santacreu, 2010; Oberauer, Schulze, & Wittmann, 2000).

3.4.2 Self-paced reading task.

In this part, the reading times of a group of Persian sentences the acceptability of which have been ensured in Phase 1 of the study, are measured.

3.4.2.1. Participants.

32 Persian monolinguals (15 males and 17 females) with an average age of 31.28 (ranging between 18 and 38) were asked to participate in this part. None of participants had taken part in Phase 1 of the study. All participants were given cash incentives equal to 250000IRR (~7CAD) and unaware of the detailed purpose of the study; the general purpose of the research, though, was explained to them in advance. They did not have contact with English at work or home and none had lived in an English-speaking country even temporarily. Additionally, 16 participants (6 males and 10 females) with an average age of 29.1 (ranging between 22 and 36) were recruited from 1st-year graduate students studying at University of Calgary all of whom had taken a band score of at least 6 in IELTS exam to get admission into their programs. They were given 10CAD as cash incentives to take part in the study. Thus, a total of 48 participants (21 males and 27 females) with an average age of 30.19 from two pools were recruited in the study.

3.4.2.2. Instruments.

The material used in this part includes 32 experimental sets and 66 filler items. The items are selected from Phase 1 of the study as discussed in Data Analysis section of Phase 1 (For review,

refer to section 3.3.4). In this section, the characteristics of experimental items will be delineated.

As can be seen in (3.5), each item includes a matrix clause followed by an embedded adverbial clause. The matrix clause is constructed of two animate entities in the subject and object positions. The subject of the embedded clause is either null or overt third-person singular pronoun [*u=s/he*] which uniquely refers to either the subject or object antecedent in the matrix clause based on the number agreement between the pronoun and the antecedent. Because the embedded verb is always singular, both pronoun types can only refer to the singular antecedent in the matrix clause.

(3.5) pirezan$_i$ samimāne be doxtar-hā darhālike $ø_i$ /u$_i$ dāsht az xiyābān rad
old woman cordially to girl-PL while ø/she was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG
'The old woman cordially said hello to the girls while she was crossing the street.'

In half of the items, the subject of the main clause is singular and the object is plural whereas in other half, the subject of the main clause is plural and the object is singular as indicated in (3.6a-d).

To manipulate the distance between the pronoun and its antecedent, a locative prepositional phrase (PP) is inserted between the subject and the object of the matrix clause as in (3.7) in half of the items. It is worth mentioning that in some cases, these PPs could be considered as subject modifiers. To avoid this, an adverb of manner is inserted directly between the subject of

the matrix clause and the PP in all conditions so that it could only modify the matrix verb of the sentence.

(3.6) a. *Null Pronoun/Subject Antecedent*

pirezan$_i$ samimāne be doxtar-hā darhālike $ø_i$ dāsht az xiyābān rad
old woman cordially to girl-PL while ø was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

b. *Overt Pronoun/Subject Antecedent*

pirezan$_i$ samimāne be doxtar-hā darhālike u_i dāsht az xiyābān rad
old woman cordially to girl-PL while she was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

c. *Null Pronoun/Object Antecedent*

pirezan-hā samimāne be doxtar$_i$ darhālike $ø_i$ dāsht az xiyābān rad
old woman-PL cordially to girl while ø was from street cross
mi-shod salām kard-and
DUR-became.3SG hello did-3PL

'The old women cordially said hello to the girl while she was crossing the street.'

d. *Overt Pronoun/Object Antecedent*

pirezan-hā samimāne be doxtar$_i$ darhālike u_i dāsht az xiyābān rad
old woman-PL cordially to girl while she was from street cross
mi-shod salām kard-and
DUR-became.3SG hello did-3PL

'The old women cordially said hello to the girl while she was crossing the street.'

(3.7) pirezan$_i$ samimāne dar pārk be doxtar-hā darhālike u_i dāsht az xiyābān
old woman cordially in park to girl-PL while she was from street
rad mi-shod salām kard
cross DUR-became.3SG hello did.3SG
'The old woman cordially in the park said hello to the girls while she was crossing the street.'

Each item is divided into four regions. The subject of the matrix clause and the adverb of manner, along with the locative PP (if present), make up the first region. The object of the matrix clause comes in the second region. The third region contains the whole embedded clause which is regarded as the critical region as it includes the pronoun. The matrix clause verb is placed in the fourth region accordingly. The fourth region is also regarded as the region in which a spillover effect might be observed. To make sure participants have been fully attentive to the item, a comprehension-check statement is also developed for each item. For the complete list of experimental sets in this phase, refer to Appendix D.

Filler items are identical to those developed for the first phase of the study. The only difference is that they are also divided into four regions.

Eight lists are developed in a Latin-square design. Each includes four items from each condition yielding a total of 32 (4*8) experimental items. Table 3.6 shows a sample experimental set. Each participant sees only one item from each set. These items are mixed with filler items in a pseudo-randomized way such that not any two experimental items from one condition are placed one after another and each list begins with two filler items. The final eight lists are

presented in a non-cumulative moving window paradigm using PsychoPy software (Peirce, 2007).

From each set, only those items which are forced to refer to the subject antecedent are later selected to investigate the effect of distance manipulation. The number of stimuli in each condition is summarized in Tables 3.7 and 3.8.

Table 3.6

A sample experimental set in eight conditions

Short/Overt Pronoun/Subject Antecedent

pirezan$_i$ samimāne be doxtar-hā darhālike u_i dāsht az xiyābān rad

old woman cordially to girl-PL while she was from street cross

mi-shod salām kard

DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

Short/Overt Pronoun/Object Antecedent

pirezan-hā samimāne be doxtar$_i$ darhālike u_i dāsht az xiyābān rad

old woman-PL cordially to girl while she was from street cross

mi-shod salm kard-and

DUR-became.3SG hello did-3PL

'The old women cordially said hello to the girl while she was crossing the street.'

Short/Null Pronoun/Subject Antecedent

pirezan$_i$ samimāne be doxtar-hā darhālike $ø_i$ dāsht az xiyābān rad

old woman cordially to girl-PL while ø was from street cross

mi-shod salām kard

DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

Short/Null Pronoun/Object Antecedent

pirezan-hā samimāne be doxtar$_i$ darhālike $ø_i$ dāsht az xiyābān rad

old woman-PL cordially to girl while ø was from street cross

mi-shod salām kard-and

DUR-became.3SG hello did-3PL

'The old women cordially said hello to the girl while she was crossing the street.'

Table 3.6 Continued

Long/Overt Pronoun/Subject Antecedent

pirezan$_i$ samimāne dar pārk be doxtar-hā darhālike u_i dāsht az xiyābān rad
old woman cordially in park to girl-PL while she was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG

'The old woman cordially in the park said hello to the girls while she was crossing the street.'

Long/Overt Pronoun/Object Antecedent

pirezan-hā samimāne dar pārk be doxtar$_i$ darhālike u_i dāsht az xiyābān rad
old woman-PL cordially in park to girl while she was from street cross
mi-shod salām kard-and
DUR-became.3SG hello did-3PL

'The old women cordially in the park said hello to the girl while she was crossing the street.'

Long/Null Pronoun/Subject Antecedent

pirezan$_i$ samimāne dar pārk be doxtar-hā darhālike $ø_i$ dāsht az xiyābān rad
old woman cordially in park to girl-PL while ø was from street cross
mi-shod salām kard
DUR-became.3SG hello did.3SG

'The old woman cordially in the park said hello to the girls while she was crossing the street.'

Long/Null Pronoun/Object Antecedent

pirezan-hā samimāne dar pārk be doxtar$_i$ darhālike $ø_i$ dāsht az xiyābān rad
old woman-PL cordially in park to girl while ø was from street cross
mi-shod salām kard-and
DUR-became.3SG hello did-3PL

'The old women cordially in the park said hello to the girl while she was crossing the street.'

Table 3.7

Number of stimuli in each condition for studying PAH extension

Distance	Antecedent Type	Pronoun Type	
		Null	*Overt*
Short	*Subject*	**4**	**4**
	Object	**4**	**4**
Long	*Subject*	**4**	**4**
	Object	**4**	**4**

Table 3.8

Number of stimuli in each condition for studying distance manipulation

Distance	Pronoun Type	
	Null	*Overt*
Short	**4**	**4**
Long	**4**	**4**

3.4.2.3. Procedure.

Participants are referred to a quiet room allocated for the purpose of running research studies based on pre-scheduled timeslots. They receive a consent form on which the general purpose of the study is explained. Having agreed to take part in the study, they are seated in front of the experimenter's laptop. They read the procedure on the screen in Persian and go through two practice trials during which they can ask any questions. This is to make sure that they have fully understood the procedure of doing the experiment before beginning.

All stimuli and filler items are shown in four regions on the screen as discussed earlier. In order for each region to appear, they are required to press SPACE bar while other regions are hidden

with dashes. After reading the final region in each item, a statement appears on the centre of the screen about what they have read. If it is TRUE, they press 'P' button and if it is FALSE, they press 'Q' button which are labelled with red [YES] and [NO] stickers respectively. After running half of the experiment (49 items), participants take a one-minute break.

3.4.2.4. Outliers.

Since the length of corresponding regions is different across conditions, a normalizing method is used to change raw reading times of each region to normalized reading times. In order to do so, a linear equation is calculated for each participant to estimate the reading time based on the number of characters available in the region. This is done through three stages: First, the total reading time of all items (including fillers) is divided by the accumulated number of characters in all items (including white spaces) for each participant. Then, the estimated reading time for each region is obtained by multiplying the RT/Char ratio by the number of characters in each region (including white spaces). The estimated reading time for each region is, finally, subtracted from the actual reading time of that region to form a Residual Reading Time (RRT) (Clifton, 1986; Philips, 2006; Trueswell, 1991). Negative values of RRTs show that participants are reading the given region faster than expected.

In order to check for outliers, the mean of RRTs only for those experimental items which have correct comprehension responses is calculated and those items with RRTs above or below 2.5 standard deviations from the mean of each condition are regarded as outliers and excluded from further analysis.

3.5 Predictions

In this section, different probable findings of the study are delineated. To review, Table 3.9 replicated from Table 3.1 shows the summary of conditions for studying distance manipulation.

Table 3.9

Summary of conditions for studying distance manipulation

Distance	Pronoun Type	
	Null	*Overt*
Short	**Condition 1**	**Condition 2**
Long	**Condition 3**	**Condition 4**

The following predictions can be made based on Table 3.9:

- If there is a main effect of distance, then RRT for sentences in conditions 3 and 4 will be different from conditions 1 and 2. If the memory load or distance plays a facilitative role, then long-distance conditions should be read faster. On the contrary, if the memory load or distance plays a deterring role, the long-distance conditions should be read more slowly. It should be noted that pronouns in all conditions for this portion of the analysis are forced to refer to subject antecedents [Compare (3.8a) & (3.8b)].

(3.8) a. pirezan$_i$ samimāne dar pārk be doxtar-hā darhālike u_i dāsht

old woman cordially in park to girl-PL while she was

az xiyābān rad mi-shod salām kard

from street cross DUR-became.3SG hello did.3SG

'The old woman cordially in the park said hello to the girls while she was crossing the street.'

b. pirezan$_i$ samimāne be doxtar-hā darhālike u_i dāsht az

old woman cordially to girl-PL while she was from

xiyābān rad mi-shod salām kard

street cross DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

- If there is a main effect of pronoun type, it is expected that overt pronoun trials should have longer RRTs compared to null pronouns. This is because if PAH extends to Persian, there is a greater tendency for overt pronouns to refer to object antecedents. However, since pronouns are forced to refer to subject antecedents in all of these conditions, it will be contrary to the prediction of PAH, which might lead to longer RRTs of the critical region.
- If the WMC of participants plays a role, then it is predicted that there would be a correlation between RRTs of the critical region and WMC scores of participants in long distance conditions [Conditions 3 & 4]. The direction of the correlation will then show if it has a facilitative or deterring role in the processing of pronouns. In other words, a positive correlation suggests that individuals with higher working memory

will have more difficult time processing pronouns, whereas a negative correlation denotes that with an increase in WMC, the pronouns are processed faster.

Table 3.10 summarizes the predictions made above regarding the effect of distance between pronouns and their antecedents on the resolution of Persian pronouns. As can be seen, if distance has an effect, the RRT of conditions which are in red are expected to be different from conditions in green.

Table 3.10

Distance predictions

Distance	Pronoun Type	
	Null	*Overt*
Short	**Condition 1**	**Condition 2**
Long	**Condition 3**	**Condition 4**

Regarding the extension of PAH to Persian, Table 3.11 shows the summary of conditions for studying PAH extension replicated from Table 3.2.

Table 3.11

The summary of conditions for PAH extension in short/long distance

Distance	Antecedent Type	Pronoun Type	
		Null	*Overt*
Short / Long	*Subject*	**Condition 1**	**Condition 2**
	Object	**Condition 3**	**Condition 4**

Following predictions are made regarding PAH extension to Persian based on Table 3.11:

- It is predicted that items with null pronouns referring to subject antecedents [Condition 1 in both short and long distance subsets] as in (3.9a) should be read faster than those with null pronouns referring to object antecedents [Condition 3] as in (3.9b). This is in line with prediction of PAH which claims that null pronouns are subject-oriented.

(3.9) a. ***pirezan$_j$*** samimāne be doxtar$_i$- hā darhālike ***ø$_j$*** dāsht az
old woman cordially to girl-PL while ***ø*** was from
xiyābān rad mi-shod salām kard
street cross DUR-became.3SG hello did.3SG
'The old woman cordially said hello to the girls while she was crossing the street.'

b. pirezan$_j$-hā samimāne be ***doxtar$_i$*** darhālike ***ø$_i$*** dāsht az
old woman-PL cordially to ***girl*** while ***ø*** was from
xiyābān rad mi-shod salām kard-and
street cross DUR-became.3SG hello did-3PL
'The old women cordially said hello to the girl while she was crossing the street.'

- Additionally, items in which overt pronouns are forced to select subject antecedents [Condition 2 in both short and long distance subsets] as in (3.10a) should be read more slowly than those in which overt pronouns are attributed toward object antecedents [Condition 4] as in (3.10b). This supports the prediction of PAH, but it is expected that this bias be weaker than null pronouns' tendency toward subject antecedents.

(3.10) a. ***pirezan$_j$*** samimāne be doxtar$_i$- hā darhālike ***u$_j$*** dāsht az xiyābān

old woman cordially to girl-PL while ***she*** was from street

rad mi-shod salām kard

cross DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

b. pirezan$_j$-hā samimāne be ***doxtar$_i$*** darhālike ***u$_i$*** dāsht az xiyābān

old woman-PL cordially to ***girl*** while ***u*** was from street

rad mi-shod salām kard-and

cross DUR-became.3SG hello did-3PL

'The old women cordially said hello to the girl cordially while she was crossing the street.'

- Regarding the antecedent type factor, it is hypothesized that if participants are following Subject-Rule Hypothesis, then they should prefer items in which pronouns are attributed toward subject-positioned antecedent [Conditions 1 & 2 in both short and long distance subsets]. In other words, items which violate the prediction of this hypothesis should be read more slowly as in (3.11a) than items which are in line with its prediction as in (3.11b).

(3.11) a. pirezan$_j$-hā samimāne be ***doxtar$_i$*** darhālike ***ø$_i$/u$_i$*** dāsht az

old woman-PL cordially to ***girl*** while ***ø/she*** was from

xiyābān rad mi-shod salām kard-and

street cross DUR-became.3SG hello did-3PL

'The old women said hello to the girl cordially while she was crossing the street.'

b. ***pirezan$_j$*** samimāne be doxtar$_i$- hā darhālike ***ø$_j$/u$_j$*** dāsht az

old woman cordially to girl-PL while ***ø/she*** was from

xiyābān rad mi-shod salām kard

street cross DUR-became.3SG hello did.3SG

'The old woman cordially said hello to the girls while she was crossing the street.'

As can be seen, both null and overt pronouns in the embedded clause are forced to refer to object antecedent in (3.11a) which violates the prediction of Subject-rule Hypothesis whereas they both refer to subject antecedent in (3.11b) which supports the prediction of Subject-Rule Hypothesis.

In a nutshell, if there is a main effect of antecedent type, then the RRTs of critical regions in Conditions 1 and 2 should be significantly different from those in Conditions 3 and 4 for both short and long subsets of data.

Table 3.12(a-b) summarizes the predictions made above. As can be seen, conditions which are in red are expected to take longer reading time compared to conditions which are in green.

Table 3.12a

PAH prediction

Distance	Antecedent Type	Pronoun Type	
		Null	*Overt*
Short / Long	*Subject*	**Condition 1**	**Condition 2**
	Object	**Condition 3**	**Condition 4**

Table 3.12b

Subject rule hypothesis prediction

Distance	Antecedent Type	Pronoun Type	
		Null	*Overt*
Short / Long	*Subject*	**Condition 1**	**Condition 2**
	Object	**Condition 3**	**Condition 4**

3.6 Results

This section explains the results of the study. As discussed before, this study attempts to investigate the role of distance between pronouns and their antecedents and working memory capacity of individuals on the resolution of Persian pronouns on the one hand and the extension of PAH to Persian on the other.

To address the first aim, the study uses three independent variables: pronoun type (two levels: null vs. overt), distance (two levels: short vs. long) and WMC (gradient from 0 to 54), and the residual reading time (RRT) of each region as the dependent variable.

To achieve the second aim of study, holding the distance variable is held constant and two subsets of data are formed. Then, each subset is analyzed separately to see if PAH extends to Persian with pronoun type (two levels: null vs. overt) and antecedent type (two levels: subject

vs. object) as independent variables and RRT of each region as the dependent variable [For review, refer to Section 3.2]

In the following sections, first the results of each dataset will be delineated in detail. Then, a summary of results is provided to highlight key findings for further discussion.

3.6.1 The role of distance and WMC.

In this section, first the means of raw reading times (RT) and residual reading times (RRTs) are given for each region through Figures 3.4 and 3.5 respectively. Then, statistical analyses are run over the dataset to see if the distance and working memory play role in the resolution of Persian pronouns.

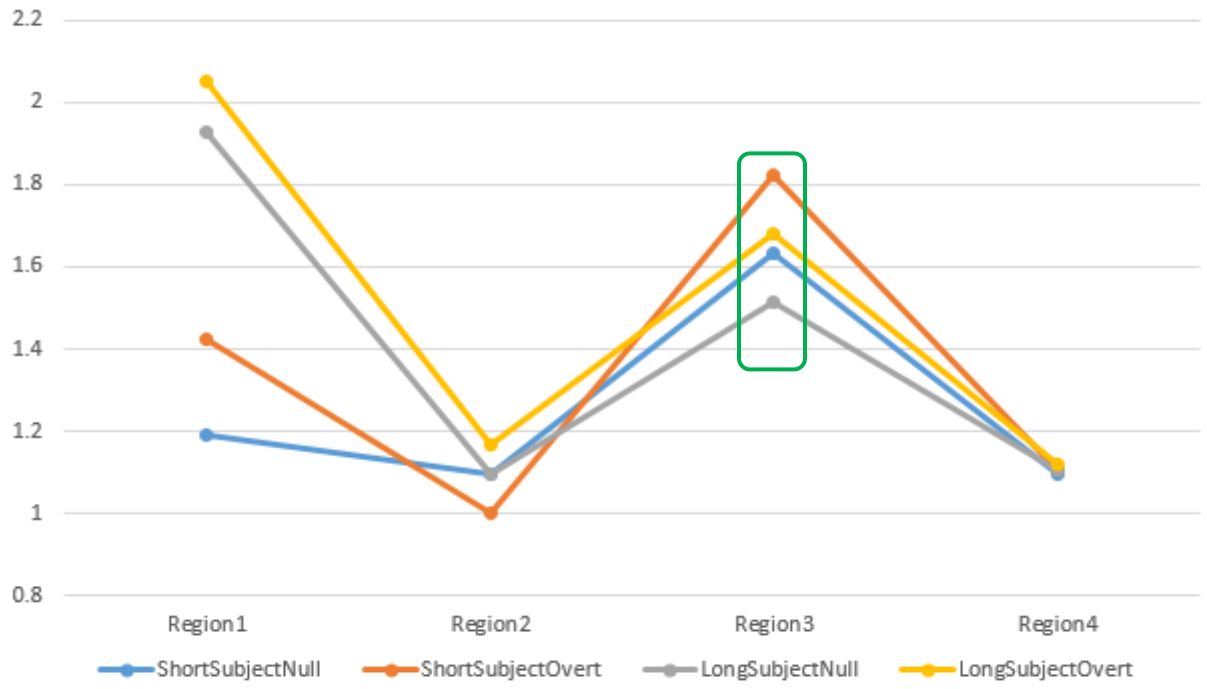

Figure 3.4. The means of raw RTs in different regions to study distance effect

As can be seen in Figure 3.4, the means of raw RT for short-distance trials are much lower in region 1 compared to those of long-distance trials due to a generally shorter length of region 1

for short-distance trials. This is followed by closer means of all conditions in region 2. This is expected since the length of region 2 is similar in all conditions. The means of both regions 1 and 2 show that the task is measuring the reading times correctly in that shorter regions have lower means and longer regions have greater means. In region 3, which is the critical region of the study, the highest mean is associated with short (distance) overt (pronoun) condition whereas the lowest mean belongs to long null condition. In other words, the longer the distance between the pronoun and its antecedent, the faster the critical region is read by participants. This is finally followed by a collapse of all means to the same value in region 4.

However, the difference in reading times across conditions might be just due to the difference in the length of regions and not because of the difficulty in processing sentences. This makes the analysis of raw reading times problematic. To filter out the effect of regions' length, the analysis of residual reading times might be more practical and valid. This way, the length of regions across all conditions is normalized and any differences which are observed between residual reading times in different conditions can be associated with the processing difficulty and not with the length of regions [For review, refer to section 3.4.2.4].

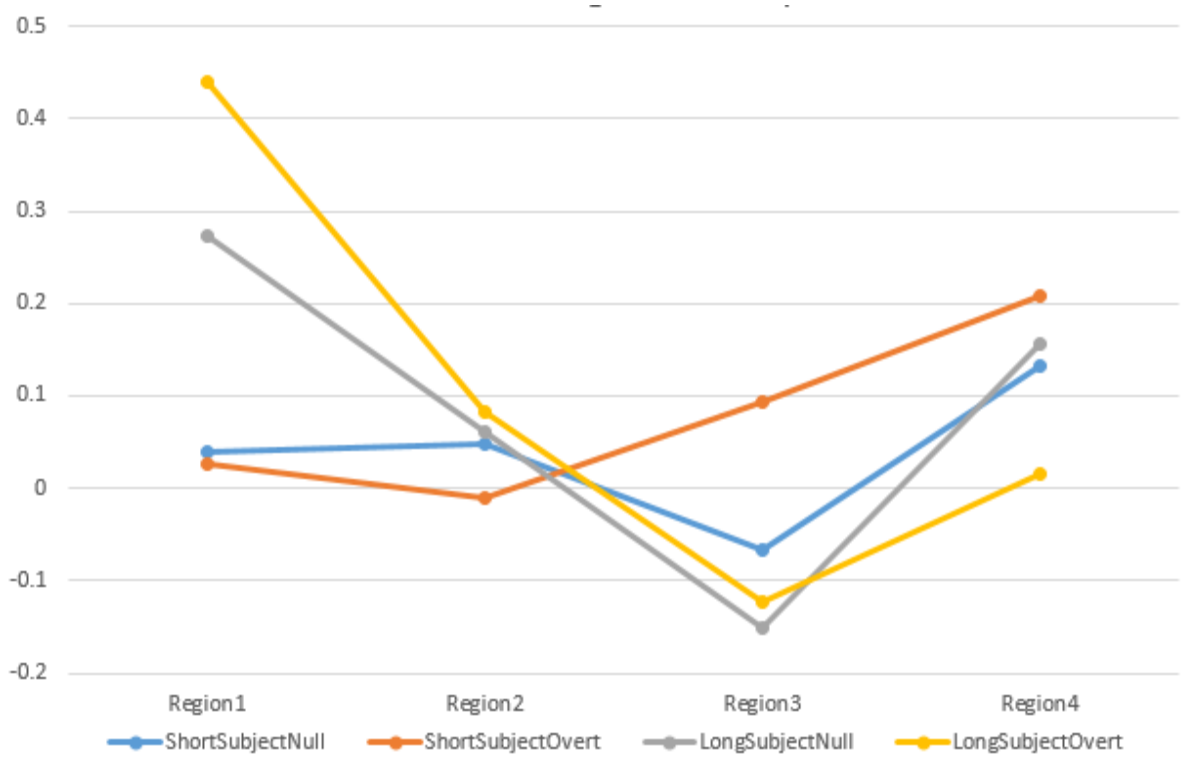

Figure 3.5. The means of RRTs in different regions to study distance effect

As can be seen in Figure 3.5, long distance conditions start with an unexpected higher means of RRTs in region 1 which is corrected in region 2 where all conditions have rather close means of RRTs. Like raw RTs, the highest mean of RRT belongs to the short overt condition in region 3 whereas the lowest mean is associated with long null condition in this region. As the length of region has been filtered out through obtaining residuals, it can be concluded that longer distance between pronouns and their antecedents have led to lower residuals. The same pattern can be seen in region 4 except that the mean of RRT for the long null condition increases sharply and lands below short overt condition.

For statistical analysis, the Linear Mixed-Effect Regression (LMER) method (Bates, Maechler, Bolker, & Walker, 2015) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2017) are used in the R software package (R Core Team, 2013) with participants and items as random effect

factors and the pronoun type, distance and WMC of participants as fixed effect factors. The dependent variable is the RRT of region 3, which contains the pronoun and is assumed as the most critical region. Furthermore, to see if there is a spillover effect, a separate similar analysis is done over the RRT of region 4.

The most complex model is given in (3.12) wherein all independent variables and their interactions as fixed effect factors as well as random effect factors are included.

(3.12) Model1 = lmer(RRT3~PronounType*Distance*WMC+(1|ItemNumber)+(1|Participant))

Table 3.13 shows the summary of Model1.

Table 3.13

The summary of the most complex model in region 3

	Estimate	Std. Error	df	t-value	Pr(>|t|)	
(Intercept)	-0.5064	0.2584	125.178	-1.959	0.0523	.
PronounTypeOvert	0.1240	0.2487	582.595	0.500	0.6169	
DistanceShort	0.3994	0.2522	583.234	1.584	0.1138	
WM	0.0104	0.0073	117.378	1.420	0.1582	
PronounTypeOvert: DistanceShort	-0.4631	0.3476	586.916	-1.332	0.1833	
PronounTypeOvert: WM	-0.0019	0.0071	582.735	-0.272	0.7858	
DistanceShort:WM	-0.0088	0.0072	582.782	-1.210	0.2268	
PronounTypeOvert: DistanceShort:WM	0.0165	0.0099	585.741	1.656	0.0982	.

After reducing factors one at a time and running model comparisons, the best-fitting model is obtained which is given in (3.13). The summary of the model is also shown in Table 3.14.

(3.13) Model6 = lmer(RRT3~PronounType+Distance+(1|ItemNumber)+(1|Participant))

Table 3.14

The summary of the best-fitting model in region 3

	Estimate	Std. Error	df	t-value	Pr(>|t|)	
(Intercept)	-0.1864	0.0904	92.777	-2.06	0.0420	*
PronounTypeOvert	0.1025	0.0560	592.224	1.83	0.0677	.
DistanceShort	0.1513	0.0551	581.327	2.75	0.0062	**

As can be seen, the best-fitting model does not include the working memory capacity of participants as a predictor variable. Moreover, there is a main effect of distance variable (Estimate=0.1513; Pr(>|t|)=.0062) such that regardless of pronoun type when the distance between the pronoun and the antecedent is longer, the RRT is lower which means that the critical region has been read significantly faster. There is also a marginal effect of pronoun type (Estimate=0.1025; Pr(>|t|)=0.0677). This implies that in both distance levels, when the pronoun is overt, the critical region is read more slowly. This is an expected finding because overt pronouns are more likely to refer to non-subject antecedents according to PAH. Thus, when they are forced to refer to subject antecedents as in this case, the sentence might be read more slowly.

Tables 3.15 and 3.16 show statistical analyses of the most complex and reduced models in region 4 respectively. This has been done to see if there is a spillover effect in the region which follows the critical region. As can be seen, the most reduced model does not include any significant results which implies that there is no spillover effect. It should be also noted that none of the intermediary models are significantly different from each other ,which is why the model has been reduced to the simplest one.

Table 3.15

The summary of the most complex model in region 4

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	0.0110	0.1759	150.684	0.062	0.950
PronounTypeOvert	-0.0146	0.1767	583.636	-0.082	0.934
DistanceShort	0.1470	0.1797	584.945	0.818	0.414
WM	0.0039	0.0050	139.500	0.786	0.433
PronounTypeOvert: DistanceShort	-0.0790	0.2478	588.312	-0.319	0.750
PronounTypeOvert: WM	0.0011	0.0051	583.740	0.215	0.830
DistanceShort:WM	-0.0042	0.0052	584.350	-0.809	0.419
PronounTypeOver: DistanceShort:WM	0.0033	0.0071	587.047	0.464	0.643

Table 3.16

The summary of the most reduced model in region 4

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	0.1435	0.0593	73.630	2.422	0.018 *
PronounTypeOvert	0.0371	0.0399	594.293	0.932	.0.352

Since there is a significant random effect of participants in the final model for region 3, first the intercept calculated for each participant is inspected through running the ranef() command in R (Baayen, 2008). Then, the correlation between working memory capacity scores and intercepts is obtained. If these two sets of values are significantly correlated, it may be concluded that the RRTs are also correlated with working memory capacity scores. However, the correlation between these two sets of values is not confirmed to be significant (r=0.104, n=45, p-value=.485). Therefore, despite the fact that individuals are behaving differently from each other in the study, this difference cannot be captured by the working memory test we developed for the purpose of this study.

3.6.2 The extension of PAH to Persian.

To study the extension of PAH to Persian, two subsets of data are formed such that the distance variable is held constant and PAH extension is studied in both of the subsets separately. Like the previous section, the LMER method is used for statistical analyses in each subset with participants and items as random effect factors, pronoun type, antecedent type and WMC of participants as fixed effect factors and RRTs of regions 3 and 4 as dependent variables.

- *Short-distance Subset*

Figure 3.6 depicts the means of raw reading times in different regions for each condition while distance level is held constant to short. As can be seen, all conditions' means except for the subject (antecedent) null (pronoun) condition are close to each other in region 1. It is expected that the means for object conditions be slightly higher than subject conditions in region 1 due to an extra plural morpheme attaching to the subject in region 1. This is seen for the object overt condition which has the highest mean and the subject null condition which has the lowest mean; however, the subject overt mean is unexpectedly higher than the object null mean although the difference is negligible. In region 2, it is expected that subject conditions have higher means in general compared to object conditions due to an extra plural morpheme attaching to the end of object. This is confirmed by the fact that the subject null condition has the highest mean whereas the object overt condition has the lowest mean. The other two conditions, though, collapse over each other in the middle. If PAH extends to Persian, then the subject null mean should be lower than the object null mean in region 3. Likewise, the subject overt mean is expected to be higher than the object overt mean. Both these trends can be observed in region 3. As there is an extra 3PL agreement morpheme attaching to the end of the

matrix verb in object conditions, it is expected that the means of object conditions be higher than those of subject conditions in region 4 which can be observed in the figure such that the means of object null and object overt conditions collapse over one another. Likewise, the means of subject null and subject overt are positioned lower. Moreover, the pronoun type does not affect the means in region 4 as the means of both null and overt pronouns are the same in the subject condition. The same applies to the means of both null and overt pronouns in the object condition. In other words, it is less probable to have a spillover effect in region 4.

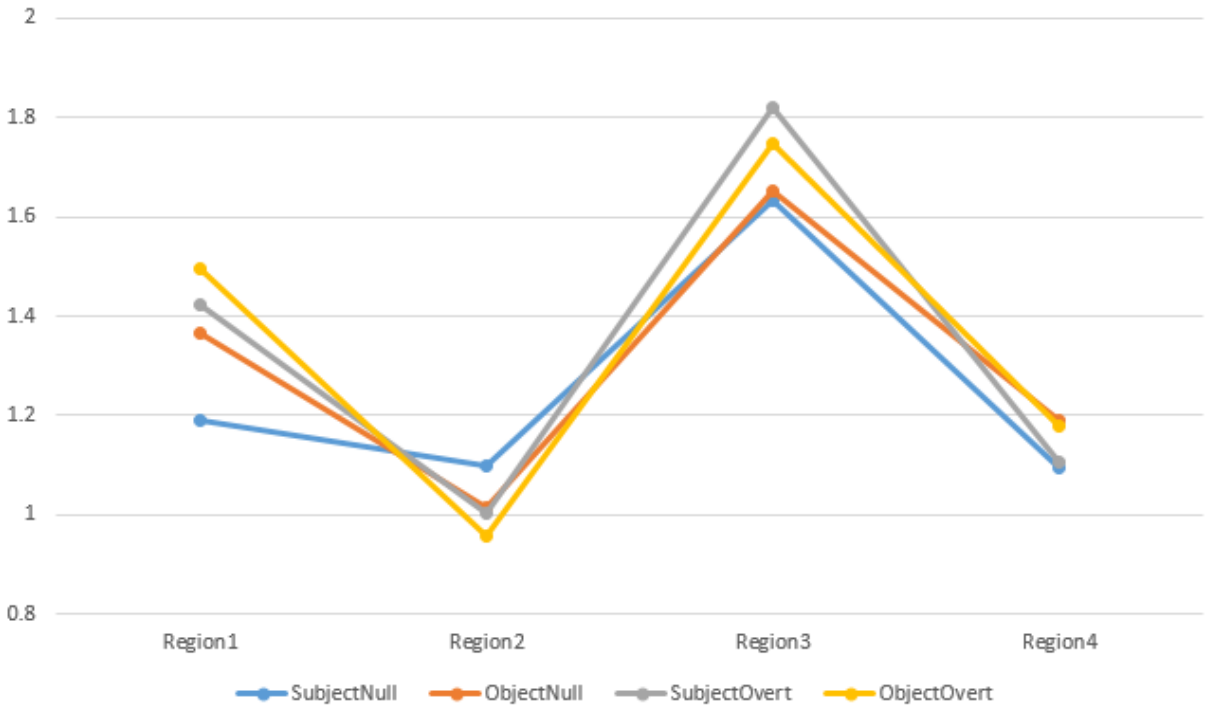

Figure 3.6. The means of raw RTs in different regions to study extension of PAH to short-distance subset of data

To filter out the effect of length of regions on the results, the same analyses are done over RRTs. Figure 3.7 shows the means of RRTs for each condition in different regions.

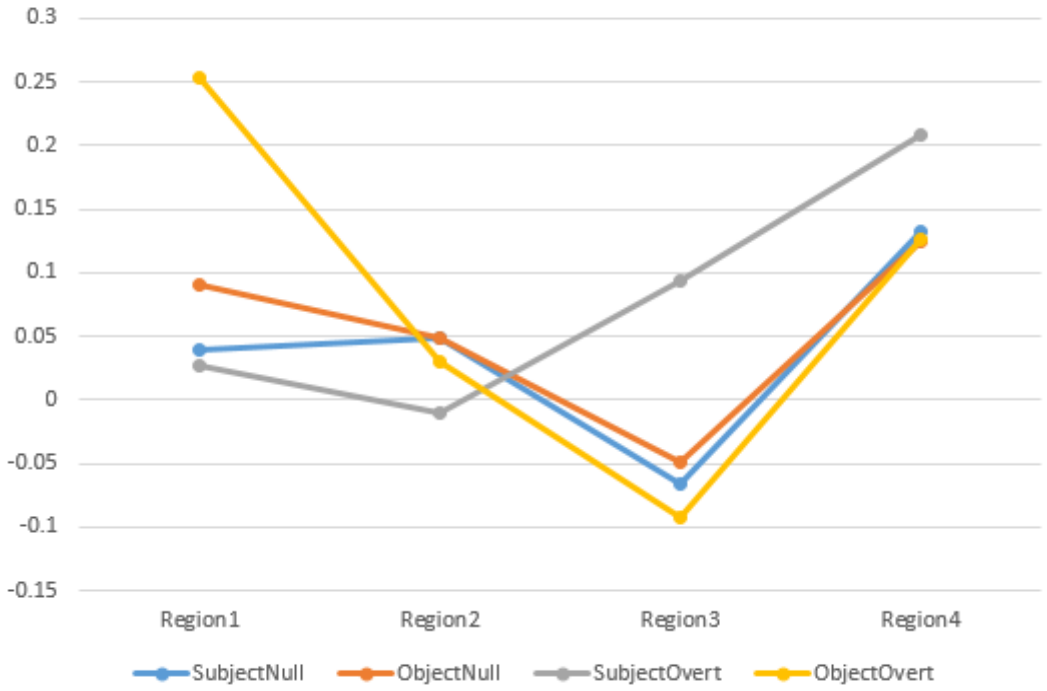

Figure 3.7. The means of RRTs in different regions to study extension of PAH to short-distance subset of data

As shown in Figure 3.7, the means of RRTs in region 1 for object conditions are unexpectedly higher whereas the means of subject conditions are close to each other. The trend disappears in region 2 where the means get much closer to each other. In region 3, though, the mean of the subject overt condition is placed much higher than that of the object overt condition. Likewise, the mean of the object null condition lands slightly above the subject null condition although the difference is not comparable to overt conditions. In region 4, the subject overt condition keeps its difference from other conditions whereas the means of other conditions collapse over each other.

To do statistical analyses, the LMER method is used with pronoun type and antecedent type as fixed effect factors and participant and item number as random effects. The most complex model is given in (3.14). After reducing factors one at a time and comparing models, none of

the models proved to be significantly different from their reduced counterparts. Tables 3.17 and 3.18 illustrate the statistical analyses of the most complex and simplest models respectively.

(3.14) Model1 = lmer(RRT3~PronounType*AntecedentType+(1|ItemNumber)+(1|Participant))

Table 3.17

The summary of the most complex model in region 3 for short subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	-0.0735	0.0977	118.551	-0.752	0.453
PronounTypeOvert	-0.0293	0.0875	576.875	-0.335	0.738
AntecedentTypeSubject	0.0186	0.0871	579.774	0.214	0.831
PronounTypeOvert: AntecedentTypeSubject	0.1593	0.1220	579.786	1.306	0.192

Table 3.18

The summary of the simplest model in region 3 for short subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	-0.0633	0.0866	74.146	-0.73	0.47
PronounTypeOvert	0.0531	0.0608	578.450	0.87	0.38

Two planned comparison tests are then run in region 3. The first test checks if the difference between the subject overt and object overt conditions is significant. The second deals with comparing the subject null and object null conditions. In order to adjust the significance level, the Holm-Bonferroni method (Holm, 1979) is used. In this method, the obtained p-values of post-hoc tests are sorted in an increasing order. Then, the highest p-value is multiplied by 'n' where 'n' is the number of post-hoc tests. The new p-value is then compared with the significance threshold. The second p-value is multiplied by (n-1). This multiplication process is continued until the smallest p-value, which is rationally multiplied by 1 and remained constant.

After applying the correction method, the results reveal that when overt pronouns are forced to refer to subject antecedents, the RRT in region 3 is significantly greater than when they are forced to refer to object antecedents (Estimate=0.1688, Std. Error=0.0830, t(272.88)=2.034, p-value=0.043). However, the difference between the subject null and object null conditions remains insignificant (Estimate=0.0085, Std. Error=0.0925, t(261.61)=0.092, p-value=0.927).

To see if there is a spillover effect in region 4, the same statistical analyses are done in region 4. Tables 3.19 and 3.20 show the summary of the most complex and simplest models in this region. As can be seen, reducing factors does not lead to a significant difference between models. Thus, no significant results are obtained in this region.

Table 3.19

The summary of the most complex model in region 4 for short subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	0.1099	0.0701	114.832	1.569	0.119
PronounTypeOvert	-0.0055	0.0593	577.893	-0.093	0.926
AntecedentTypeSubject	0.0361	0.0591	580.427	0.611	0.541
PronounTypeOvert: AntecedentTypeSubject	0.0615	0.0828	580.279	0.743	0.458

Table 3.20

The summary of the simplest model in region 4 for short subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	0.1291	0.0629	75.780	2.056	0.043 *
PronounTypeOvert	0.0264	0.0412	579.616	0.639	0.523

The same planned comparison tests as in region 3 are applied in region 4. The results show that the difference between the subject overt and object overt conditions is not significant after correction (Estimate=0.0859, Std. Error=0.0600, t(271.66)=1.430, p-value=0.154). Likewise, the

difference between the subject null and object null conditions is proved to be insignificant (Estimate=0.0352, Std. Error=0.0576, t(259.96)=0.611, p-value=0.542).

- *Long-distance Subset*

To study the extension of PAH to the long-distance subset of data, the distance variable is held constant to long. Thus, the independent variables include pronoun type (null vs. overt), antecedent type (subject vs. object) and working memory capacity of participants. Like the short-distance subset, the dependent variable is raw and residual reading times of the critical region (region 3) which contains the pronoun and the following region (region 4) to see if there is a spillover effect.

Figure 3.8 illustrates the means of raw RTs in different regions for all conditions. As can be seen, the means of all conditions in first two regions are close to each other which is in line with expectations although the variation between the means across conditions in region 1 is slightly greater than region 2. Moreover, the mean of each condition in region 1 is much higher than the mean of the same condition in region 2 due to the fact that first region is much longer than the second region for all conditions. In region 3, though, the subject overt condition is positioned higher than the object overt condition which is expected by the prediction of PAH despite not being much different; however, the means of both subject null and object null conditions are unexpectedly collapsed over one another which is in contrast to the expectation that the object null condition should take longer reading time compared to the subject null condition according to PAH. In region 4, the means of all conditions decrease sharply and are positioned very close to each other removing the possibility of the spillover effect.

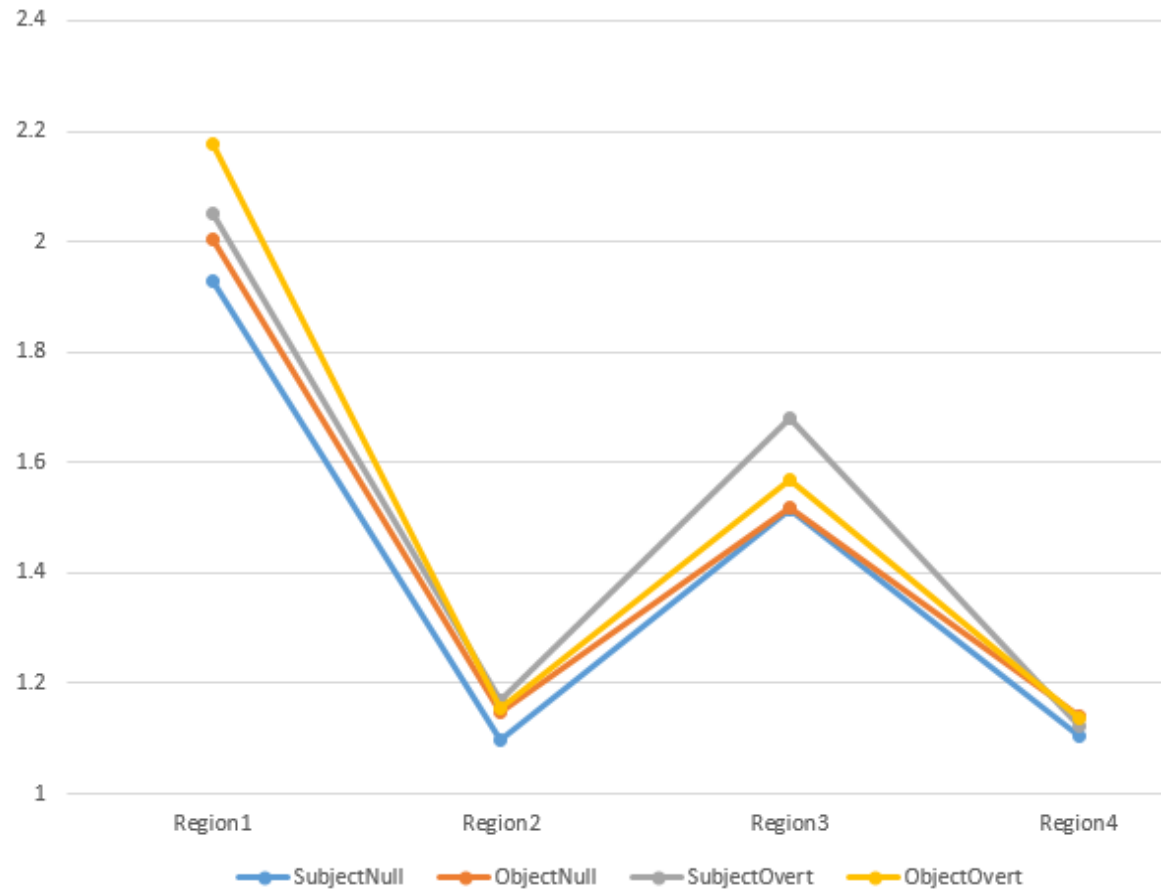

Figure 3.8. The means of raw RTs in different regions to study extension of PAH to long-distance subset of data

Figure 3.9 shows the means of RRTs in different regions for all conditions. As can be seen, the means of RRTs for all conditions in region 1 are unexpectedly much higher compared to other regions although there is not a great variation across conditions. This trends continues in region 2. In the critical region, the subject overt condition expectedly lands higher than the object overt condition whereas the mean for the subject null condition is unexpectedly higher than the mean for the object null condition although the difference between the means of null conditions is much smaller than the difference between means of overt conditions. In region 4, the means sharply increase in the same order and difference.

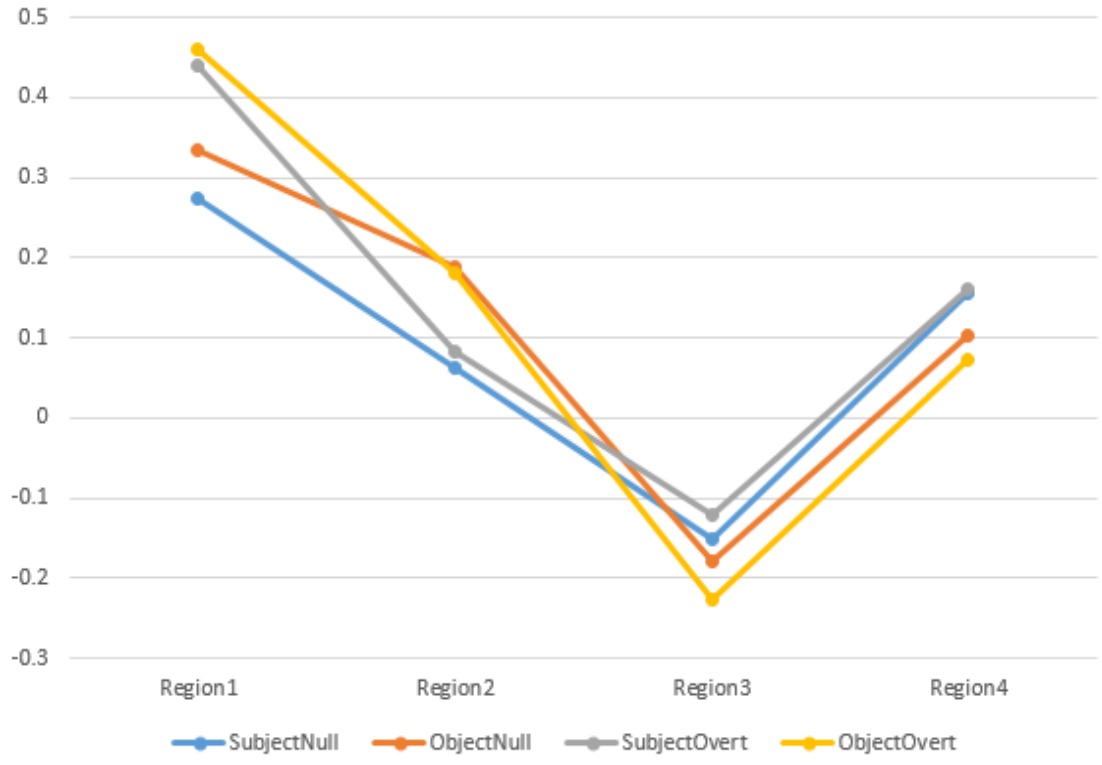

Figure 3.9. The means of RRTs in different regions to study extension of PAH to long-distance subset of data

Like the short-distance subset, the LMER method is selected as statistical method with pronoun type, antecedent type and WMC as fixed effect factors and participants and items as random effects. The most complex model is given in (3.15). Table 3.21 illustrates the summary of the most complex model. After reducing factors one at a time and going through a set of model comparisons, none of the models is significantly different from the other ones which implies that the simplest model should be selected as the best model. Table 3.22 shows the summary of the simplest model in which no significant results are observed. This implies that PAH is not extended to long-distance subset of data.

(3.15) Model1 = lmer(RRT3~PronounType*AntecedentType*WM+(1|ItemNumber)+(1|Participant))

Table 3.21

The summary of the most complex model in region 3 for long subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	-0.2606	0.2456	87.044	-1.061	0.292
PronounTypeOvert	0.1335	0.2068	563.300	0.646	0.519
AntecedentTypeSubject	-0.2433	0.2152	574.741	-1.131	0.259
WM	0.0020	0.0070	81.370	0.282	0.778
PronounTypeOvert: AntecedentTypeSubject	0.0373	0.2933	562.643	0.127	0.899
PronounTypeOvert: WM	-0.0049	0.0060	563.810	-0.819	0.413
AntecedentTypeSubject:WM	0.0087	0.0062	574.480	1.394	0.164
PronounTypeOvert: AntecedentTypeSubject:WM	0.0014	0.0084	563.505	0.169	0.866

Table 3.22

The summary of the simplest model in region 3 for long subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	-0.1760	0.0830	75.178	-2.121	0.037 *
PronounTypeOvert	0.0156	0.0475	567.708	0.329	0.742

To see if there is a spillover effect, the same statistical analyses are done over region 4. None of the models is interpreted as the best-fitting model. Tables 3.23 and 3.24 illustrate the summary of the most complex and reduced models in region 4 respectively.

Table 3.23

The summary of the most complex model in region 4 for long subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	-0.1105	0.1739	142.135	-0.636	0.526
PronounTypeOvert	0.3061	0.1833	568.984	1.670	0.095 .
AntecedentTypeSubject	0.1372	0.1902	583.427	0.721	0.471
WM	0.0062	0.0050	133.191	1.243	0.216
PronounTypeOvert: AntecedentTypeSubject	-0.3302	0.2600	568.490	-1.270	0.205
PronounTypeOvert: WM	-0.0100	0.0053	569.405	-1.882	0.060 .
AntecedentTypeSubject:WM	-0.0026	0.0055	583.186	-0.475	0.635
PronounTypeOvert: AntecedentTypeSubject:WM	0.1112	0.0075	569.594	1.492	0.136

Table 3.24

The summary of the simplest model in region 4 for long subset of data

	Estimate	Std. Error	df	t-value	Pr(>|t|)
(Intercept)	0.1171	0.0557	78.291	2.103	0.039 *
PronounTypeOvert	-0.0020	0.0420	573.906	-0.048	0.962

3.7 Summary

In a nutshell, the following results are obtained from data analysis:

- The working memory capacity of participant is not a predictive variable in the resolution of Persian pronouns.
- There are some interpersonal variations in the resolution of Persian pronouns as the random effect of participants is significant in all models. However, this variation is not correlated with working memory capacity scores.
- There is a main effect of distance between pronouns and their antecedents in Persian such that the greater the distance between the pronoun and its antecedent, the shorter it takes to process the critical region which includes a pronoun.
- There is no main effect of pronoun type, antecedent type or their interactions in any of the datasets suggesting that neither PAH nor the subject rule hypothesis extends to Persian. In the short dataset, though, overt pronouns are processed significantly faster when referring to object antecedents which supports one prediction of PAH.

In the following chapter, the results of the study are discussed and possible explanations for them will be delineated.

3.8 Limitations of the Study

This study faces a number of limitations. First of all, the self-paced reading task and working memory test sessions both occur in the same day. Ideally, these two tests are supposed to happen in separate sessions in two consecutive days; however, due to the time limitations in collecting data from Persian monolinguals in Iran, both tests occur one after another in the same session. The self-paced reading task which is conducted first might affect the working

memory test which is conducted second. This order was chosen because participants would otherwise have to do the main test after being frustrated by doing the demanding working memory test.

Another limitation is collecting data from two separate pools of participants - one pool recruiting Persian monolinguals in Iran and the other pool recruiting Persian-speaking students studying at University of Calgary in Canada. This has also been done because of the shortage of time in collecting data from Persian monolinguals in Iran. However, further investigation of data reveals that both pools show the same results.

Lastly, there might be some prosodic effects on working memory scores, especially in the auditory section such that some sentences might seem more rhythmic, seeming less difficult for participants to recall the final words on those trials, compared to sentences which might have less rhythmic prosodic structures. The possibility for rhythm to interact with the segmentation of the self-paced reading task is also noted, though more consideration of the segmentation appears in the next chapter.

Chapter 4

Discussion

4.1 Introduction

In this chapter, the discussion of the major findings of the study with reference to the literature is provided. To review, the present study is aimed at exploring: (i) whether the distance between pronouns and antecedents and working memory capacity of individuals affect the resolution of Persian pronouns, and (ii) whether PAH (Position of Antecedent Hypothesis) extends to Persian when the distance between pronouns and antecedents is held constant. A set of Persian sentences with a complex structure is constructed. The sentences include a matrix clause followed by an embedded clause with either a null or an overt pronoun in the subject position which is forced to refer to the singular antecedent in the subject or object position of the matrix clause. To manipulate the distance, half of the trials contain a prepositional phrase (PP) between the subject and object of the matrix clause. Each sentence is then divided into four regions. Through a self-paced reading task, participants read different regions and their reading times are recorded and compared across conditions.

To see if PAH extends to Persian, the distance between pronouns and antecedents is held constant. That is, two subsets of data – short vs. long - are formed and the resolution of pronouns is studied in each subset separately. It is hypothesized that, in line with predictions of PAH, the RRT of the critical region is shorter when null pronouns are forced to refer to subject antecedents. Likewise, the RRT of the critical region is expected to be shorter when overt pronouns are linked with object antecedents.

The following sections discuss the findings related to the effect of distance and working memory capacity on the resolution of Persian pronouns and the extension of PAH to Persian respectively.

4.2 The Distance Effect

The results of the study reveal that the distance has a facilitative role in the resolution of Persian pronouns in the sense that the critical region of long distance trials is read significantly faster than that of short distance trials (Estimate=0.1513, Std Error=0.0551, t(581.327)=2.75, p-value=.0062**). In other words, as distance increases, participants read the critical region faster than expected.

This finding contradicts previous studies such as Clark and Sengul (1979) as they conclude that the greater the distance between pronouns and antecedents, the higher the reading time of the region which includes the pronoun. However, the result of this study is in line with previous studies which suggest that the ERP patterns are influenced by manipulating the distance between pronouns and their antecedents (Fiorentino et al., 2018; Hammer et al., 2008; Qiu et al., 2012). These studies generally claim that with an increase in the distance between pronouns and antecedents, the memory load increases, which leads to ERP patterns different from those shown in the short distance condition. For instance, Hammer et al. (2008) in German and Qiu et al. (2012) in Chinese conclude that an N400 is observed in ERP patterns when there is a mismatch between biological genders of pronouns and antecedents only in the short-distance condition which disappears in the long distance condition. Hammer et al. (2008) also find that there is a P600 effect in ERP patterns when the grammatical genders do not match only when the distance between pronouns and antecedents is short. In other words,

participants are more sensitive to the linguistic constraints in the short distance condition and increasing the distance might make them less aware of the mismatch which, in turn, might lead to shifting the ERP patterns or particular to this study, processing pronouns more easily.

Another possible reason why the distance has a facilitative role in this study might be due to the segmentation of regions. The additional prepositional phrase in long distance trials is not presented in a separate region; instead, it is added to the first region of trials along with the subject of the matrix clause [Compare 4.1a-b below].

(4.1) a. pirezan samimāne / be doxtar-hā / ……..

the old woman cordially / to girl-PL / ……..

b. pirezan samimāne dar pārk / be doxtar-hā / ……..

the old woman cordially in park / to girl-PL / ……..

It is possible that the subject of the matrix clause in the long distance condition might have become more salient while participants have been exposed to it compared to the short distance condition. This can be observed in the mean RRT of the first region in Figure 3.5. As can be seen, the RRT for long distance conditions is much greater than that of short distance conditions. As residual reading time analysis cancels out the effect of the region's length, it can be concluded that participants have pondered on the first region more when it is longer. In other words, they have had more exposure to the subject antecedent in long-distance conditions compared to short-distance condition which might have led to increasing its salience. Therefore, participants read pronouns in the third region faster when the distance is long because they are forced to refer to the subject antecedent which has become more salient.

One solution to this methodological issue would be to add the prepositional phrase before the object of the matrix clause by moving the region boundary as in (4.2).

(4.2) pirezan samimāne / dar pārk be doxtar-hā / ……..

the old woman cordially / in park to girl-PL / ……..

However, this type of segmentation seems very odd as the prepositional phrase shows where the event is taking place and has nothing to do with the object of the sentence. This makes processing of the sentence in (4.2) more difficult because participants tend to make a connection between the prepositional phrase and the object in the region on the one hand, but when they do not see a rational link, they try to make a link between the prepositional phrase and another entity in the sentence which might lead to an increase in the complexity of the sentence.

The other way is to introduce a new region between the subject and object of the matrix clause which is constructed of the whole prepositional phrase. This way, trials will include five regions: the subject of the matrix clause as the first region, the manner adverb as well as the prepositional phrase as the second region, the object of the matrix clause in the third region, the whole embedded clause in the fourth region and the matrix clause verb in the final region as illustrated in Table 4.1.

Table 4.1

The revised segmentation

Short	Region 1	Region 2	Region 3
	pirezan *the old woman*	*samimāne* *cordially*	*be doxtar-hā* *to girl-PL*
	Region 4		Region 5
	darhālike ø|u dāsht az xiyābānrad mi-shod *while ø|she was from street cross DUR-became.3SG*		*salām kard* *hello did.3SG*
Long	Region 1	Region 2	Region 3
	pirezan *the old woman*	*samimāne dar pārk* *cordially in park*	*be doxtar-hā* *to girl-PL*
	Region 4		Region 5
	darhālike ø|u dāsht az xiyābānrad mi-shod *while ø|she was from street cross DUR-became.3SG*		*salām kard* *hello did.3SG*

To sum up, the facilitative role of the distance may be attributed to two reasons: (i) the unintended manipulation of the subject salience which has let parsers give more prominence to the subject and process pronouns faster when they are forced to refer to the subject antecedent, (ii) the hypothesis that the memory load makes processing the pronouns easier. If the latter is the case, then there should be an interaction between working memory and the distance such that in the long distance condition, as working memory scores increase, the RRT should also increase. The following section rejects this explanation.

4.3 The Effect of WMC

Regarding the effect of WMC of individuals on the resolution of Persian pronouns, the results of this study show no effect of the working memory, although there is a significant interpersonal variation. As the validity of the working memory test developed for the current study has been previously approved in Iran (Mojtabazadeh, 2006), it is unlikely that the test might not be

measuring what it purports to measure. That is, it can be assumed that the test has exactly measured the working memory capacity of participants.

One possibility which is in line with Nieuwland and Van Berkum (2006) is that working memory effect comes into play only in ambiguous contexts. As they show in their study, participants' ERP patterns does not correlate with individuals' reading span scores in non-ambiguous contexts. In other words, as they conclude "…. differences in language processing skills especially surface in linguistic manipulations that involve subtle constraints (like referential ambiguity) but not in manipulations that involve highly salient anomalies (in this case lexical-semantic anomalies and pronoun gender disagreements." (Nieuwland & Van Berkum, 2006: 162). Thus, the ambiguity of the context is a crucial factor which makes the working memory show its effect.

In this study, though, as pronouns are disambiguated toward their antecedents through number agreement, trials are not ambiguous which, in turn, explains why working memory has not been playing a role. In other words, if trials of this study were totally ambiguous as in (4.3), then the working memory might have been considered as a predictor variable in the RRT of the critical region. In that case, those individuals with higher working memory should be more sensitive to the ambiguity and read the critical region (Region 3) more slowly than those with lower working memory. However, the significant random effects of participants in the best-fitting models suggest that individual differences are significant factor in the processing of pronouns.

(4.3) a. *Short Distance Condition*

pirezan$_i$ samimāne/be doxtar$_j$/

old woman cordially /to girl /

darhālike ø$_{i/j}$|u$_{i/j}$ dāsht az xiyābān rad mi-shod/ salām kard

while ø|she was from street cross DUR-became.3SG/ hello did.3SG

'The old woman cordially said hello to the girl while she was crossing the street.'

b. *Long Distance Condition*

pirezan$_i$ samimāne dar pārk/be doxtar$_j$/

old woman cordially in park/to girl /

darhālike ø$_j$|u$_j$ dāsht az xiyābān rad mi-shod/ salām kard

while ø|she was from street cross DUR-became.3SG/ hello did.3PL

'The old woman cordially said hello to the girl while she was crossing the street.'

The finding of the present study is to some extent contrary to the result of previous studies such as Hammer et al. (2008) and Qiu et al. (2012). As discussed in the previous section, these studies generally claim that as the memory load increases through manipulating the distance between pronouns and antecedents, the ERP patterns change such that N400 or P600 effects which are elicited due to the semantic or structural anomalies are disappearing in long-distance conditions. Thus, those with higher working memory capacity should be more sensitive to linguistic constraints as the memory load increases which means that observed N400 or P600 effects in ERP patterns under no-memory load would reappear under high-memory load for high-span readers. Extending this view to the present study, it is expected that as WMC scores increase, the RRTs are also expected to increase in the long distance condition which the results do not confirm this as there is no correlation between WMC and RRTs.

Therefore, it seems that the results of this study is more in line with Nieuwland and Van Berkum (2006)'s hypothesis that the working memory shows its effect on the resolution of

pronouns only in ambiguous contexts. However, a closer look at the effect of distance and working memory together, it can be concluded that if the results are following purely according to the pattern suggested by Nieuwland and Van Berkum (2006), then no significant change in the RRTs is expected as the distance increases. However, as mentioned in the previous section, the RRT of the critical region significantly decreases as the distance increases. Taken this into account, a likely account for the facilitative role of the distance would be the subject salience manipulation. In other words, as mentioned earlier in chapter 2, having more exposure to the subject in long-distance trials might have increased the accessibility or salience of the subject in readers' minds which has made it a more likely antecedent for the pronoun in next regions.

4.4 The Extension of PAH to Persian

The results show that PAH does not extend to the long distance condition. In the short distance condition, though, participants read the critical region significantly faster when the overt pronoun is referring to the object antecedent, but no difference is found for null pronouns. In other words, the PAH prediction is only observed when the distance between pronouns and antecedents is short and only for overt pronouns but not for null pronouns. In the following sections, the results of the study for each subset of data will be discussed with reference to previous studies.

4.4.1 Short distance.

As for overt pronouns, the findings of this study are consistent with previous online studies such as Lezama and Almor (2011) in Spanish, Nakhaei (2017) in Persian and Papadopoulu et al. (2015) in Greek, in the sense that overt pronouns are processed more slowly when they refer to subject antecedents which is referred to as Overt Pronoun Penalty (OPP) (Lezama & Almor,

2011). These results are also in line with findings of previous offline studies where participants prefer non-subject antecedents for overt pronouns (Kweon, 2011 in Korean; Marefat & Samadi, 2017 in Persian; Ovalle et al., 2002 in Spanish; Sorace & Filiaci, 2006 in Italian).

However, the results contradict those of Yang et al. (1999) in Mandarin in which the processing time of overt and null pronouns is not significantly different from one another when they refer to subject antecedents. In their study, they attribute the results to the lack of verbal morphology in Mandarin which makes overt pronouns more informative compared to other pro-drop languages. In Persian unlike Chinese, though, due to an existence of a distinctive verbal agreement system, overt pronouns are more marked which makes their behaviour different from their null counterparts.

As for null pronouns, the finding of this study does not support previous studies as no pattern is found in the processing of null pronouns. This is, in fact, in contrast with the original prediction of PAH (Carminati, 2002) in two ways. First of all, according to PAH, individuals should tend to attribute null pronouns toward subject-positioned antecedents in the sentence. Secondly, null pronouns are expected to be more rigid in selecting their antecedents. That is, overt pronouns might show more flexibility in selecting either subject or object antecedents, but null pronouns are strictly linked with subject antecedents. The results of the present study, however, reveal that not only do null pronouns not show a tendency toward subject antecedents, but overt pronouns show more rigidity in selecting their antecedents compared to null pronouns.

Comparing the mean RRTs of Region 3 in all conditions, it can be concluded that the mean RRTs for both subject null (-0.0667ms) and object null conditions (-0.0485) are closer to the expected situation, i.e. object overt condition (-0.0927ms), than to the unexpected situation, i.e. subject

overt condition (+0.0938ms). This shows that null pronouns are more inclined to be read generally faster regardless of their antecedent positions which, in turn, suggests that null pronouns should be considered as a default option in Persian although this does not support the prediction of PAH regarding null pronouns.

4.4.2 Long distance.

The results of the study reveal that none of the predictions of PAH is applied in the long distance dataset such that there is no significant preference for attributing null or overt pronouns to either subject or object antecedents. However, through checking the RRT means in the critical region (Region 3), it can be found out that, similar to the short distance dataset, the RRT mean for the subject overt condition is higher than that for the object overt condition (-122ms vs. -225ms). Although the difference is not significant, the overall trend is in line with the prediction of PAH which suggests higher reading time for overt pronouns when they refer to subject antecedents.

As for null pronouns, though, the RRT mean for the object null condition is lower than that for the subject null condition (-178ms vs. -151ms). Although the difference is not significant, even the trend is not conformed to the prediction of PAH which predicts higher reading time for null pronouns when they are forced to refer to object antecedents. As can be seen, the trend shows that the RRT mean for the object null condition is lower than the subject null condition.

Taking these results together, it can be concluded that overt pronouns, similar to the short distance dataset, seem to show more rigidity in selecting their antecedents compared to null pronouns.

At first glance, the results of the long distance dataset seem to contradict those results obtained from the effect of distance. On the one hand, the segmentation of regions might have resulted in an increase in the salience of the subject antecedent in the long distance condition which, in turn, predicts more difference between RRTs of the object overt and subject overt conditions of the PAH analysis. The disappearing of the significant results in the long distance dataset, actually, suggests that the subject antecedent might have become less salient.

However, it should be noted that the study is designed in a way that in order to study the effect of distance, only those trials where pronouns are disambiguated toward subject antecedents are selected. The results, then, show that subject antecedents might have become more salient in the long distance condition compared to subject antecedents in the short distance condition which have resulted in the shorter RRTs of the critical region. To study the extension of PAH, though, all trials are considered when the distance variable is held constant. That is, half trials are disambiguated toward the subject and the other half are disambiguated toward the object. This way, the elimination of the significant results in the long-distance dataset might be due to cancelling out the effect of subject salience by the object antecedent.

Taking together the results of PAH extension to Persian, it can be concluded that null pronouns are more flexible in selecting their antecedents in Persian which is surprisingly in contrast to the original prediction of PAH. Other studies have concluded that the resolution of null pronouns is more consistent with the prediction of PAH compared to the pattern shown by overt pronouns behaviour. In the present study, however, this pattern is reversed such that overt pronouns seem to be more strict in Persian which needs further investigation. This is, in fact, supported by Marefat and Samadi's study (2017) in Persian in which they conclude that overt pronouns

behave more consistent with predictions of PAH in both cataphoric and anaphoric conditions; however, null pronouns do not behave in accordance with PAH when they precede antecedents. Although their study is more focused on the pronoun position relative to antecedents, their conclusions suggest that null pronouns behave differently from overt pronouns.

4.5 Summary

In this section, the main research questions of the study are restated and final conclusion is provided regarding each one.

RQ1: Does the distance between pronouns and their antecedents play a role in the resolution of Persian pronouns?

Yes. The distance between pronouns and antecedents has a facilitative role such that as the distance increases, the processing time of pronouns will decrease which might be due to the inadvertent manipulation of the antecedents' salience in trials.

RQ2: Does the WMC (Working Memory Capacity) of Persian monolinguals play a role in the resolution of Persian pronouns?

No. The working memory capacity of individuals does not seem to play a role in the resolution of Persian pronouns which might be due to the non-ambiguous contexts of trials not letting working memory effect come into play

RQ3: Does PAH (Position of Antecedent Hypothesis) extend to Persian as a pro-drop language?

Not clearly. When the distance between pronouns and antecedents is short, overt pronouns are read significantly faster when they refer to object antecedents which is

in line with the prediction of PAH. When the distance is long, though, the significant results disappear while the trend of means is in line with PAH. The Position of Antecedent Hypothesis does not apply to null pronouns in Persian because there is no difference between reading times of null pronouns when they refer to the subject or object antecedents although they are more inclined to be processed vary fast in both short and long distance conditions.

RQ4: Will there be any interactions between these factors?

No statistically significant interactions are found between factors.

In the following chapter, the final remarks as well as suggestions for future research are provided.

Chapter Five

Conclusion & Future Directions

5.1 Conclusion

To recapitulate, this thesis is aimed at investigating whether the working memory capacity of individuals plays a role in the resolution of Persian pronouns. The second aim of this thesis is to see if Position of Antecedent Hypothesis (PAH), which has been confirmed to extend to other pro-drop languages is also applied to Persian when the memory load is held constant.

In Chapter 2, previous studies in the realm of pronoun resolution generally confirm that PAH extends to a range of pro-drop languages. According to PAH, null pronouns are more likely to refer to the subject-positioned antecedent whereas overt pronouns are more preferred to be linked with the non-subject antecedents. This is because different positions of a hierarchical syntax tree for a given sentence is associated with a specific degree of salience such that the SpecIP position has the highest salience. Thus, it is expected that entities which are placed in this position to be referred with the most reduced form of pronouns, i.e. null pronouns. According to this, it is hypothesized that the same pattern should be observed in Persian as it is a pro-drop language.

I have also included a second group of studies in Chapter 2 which claims that the memory load and working memory of individuals are factors which might affect the processing of pronouns even within speakers of a language. However, I show that the results are mixed such that some studies predict more complexity of the sentence with an increase in the distance between pronouns and antecedents as one way to manipulate the memory load which is resulted in higher reading time of pronouns. Other studies, through, suggest that increasing the distance

might lead participants not to understand the complexity of the sentence such as ambiguity or linguistic constraints. Thus, they predict shorter reading time of pronouns for complex sentences. The third group of studies, moreover, limits the scope of working memory to ambiguous contexts and suggest that memory-related issues come into play whenever the context is ambiguous. Thus, they predict no change in the reading time of pronouns in non-ambiguous contexts.

Chapter 3 discusses the detailed methodology and results of the thesis. It is predicted that under the constant memory load or distance between pronouns and their antecedents, null pronouns are read faster when they are forced to refer to subject antecedents. Likewise, overt pronouns are read faster when they refer to the object antecedents. A closer look at the change in the reading time with an increase in the memory load and working memory scores sheds light on the effect of these two factors on the resolution of Persian pronouns.

The results of the study reveal that PAH does not apply to Persian in overall. However, under no-memory load condition when the distance is short, overt pronouns are read significantly faster when referring to object antecedents, but no trend is observed for null pronouns. Moreover, when the memory load increases, the same trend is observed only for overt pronouns despite removing the significant results.

Regarding the effect of memory load and working memory, I show that as the distance increases, the pronouns are read faster but working memory is not confirmed to be a predictor variable in the final model although there is a significant random effect of participants.

In Chapter 4, I discuss the obtained results. I attribute the facilitative role of the memory load or distance to the incidental manipulation of the subject salience which has made subject

antecedents more accessible in readers' minds and I argue that non-ambiguous context has made the working memory not play a role. The original formulation of PAH does not consider this potential variation of salience.

5.2 Future Directions

A number of ideas can be suggested for furthering research in this area. One of the caveats of the present study is the segmentation of trials as it has manipulated the salience of the subject antecedent which is discussed in detail in Chapter 4. Thus, revised segmentation is recommended to control the possible effect of the salience manipulation in this study. To so do, it is suggested that the adjunct phrase be inserted as a new region between the subject and object of the matrix clause rather than being added to the first region. This way, the trials of the study are constructed of five regions as shown in Table 5.1 replicated from Table 4.1.

Table 5.1

Recommended Segmentation replicated from Table 4.1

Short	Region 1					Region 2			Region 3
	pirezan					*samimāne*			*be doxtar-hā*
	the old woman					*cordially*			*to girl-PL*
	Region 4								Region 5
	darhālike	*ø|u*	*dāsht*	*az*	*xiyābān*	*rad*	*mi-shod*		*salām kard*
	while	*ø|she*	*was*	*from*	*street*	*cross*	*DUR-became.3SG*		*hello did.3SG*
Long	Region 1					Region 2			Region 3
	pirezan					*samimāne*	*dar*	*park*	*be doxtar-hā*
	the old woman					*cordially*	*in*	*park*	*to girl-PL*
	Region 4								Region 5
	darhālike	ø|u	dāsht	az	xiyābān	rad	mi-shod		salām kard
	while	ø|she	was	from	street	cross	DUR-became.3SG		hello did.3SG

Another area which is worth testing is whether the salience of an antecedent in the prior discourse dominates over the syntactic salience of the competing antecedent within the

sentence in the resolution of Persian pronoun or not. This can be addressed through forming a mini-story context which precedes a complex structure similar to this study. The subject of the matrix clause is introduced in the context as the second-mentioned NP whereas the object of the matrix clause is mentioned first and repeated in the context to boost its information status or topicality as in (5.1).

(5.1) **doxtar** va **morabbi-hā** be hayāt raft-and. **doxtar** shoru kard be bāzi.

girl and **instructor-PL** to yard went-3PL. **girl** start did to play.

Vaqti zang xord, **doxtar** dar saf istād.

When bell hit, **girl** in line stood.

Dar kelās, **morabbi-hā** be **doxtar** vaqti **ø/u** dāsht salām mi-kard labxand zad-and.

In class, **teacher-PL** to **girl** when **ø/she** was hello DUR-became smile hit-3PL.

'The girl and the instructors went to the yard. The girl started to play. When the bell rang, the girl stood in the line. In the class, the instructors smiled at the girl while she was entering.'

If syntactic salience of the antecedent dominates over the discourse salience of the antecedent, null pronouns will be read faster when referring to the subject antecedent and overt pronouns are processed faster when referring to the object antecedents regardless of their discourse salience. In (5.1), as the pronoun is forced to refer to the object antecedent, then the overt pronoun should be read faster compared to the null pronoun.

If the higher discourse salience of the object antecedent, on the other hand, dominates over the syntactic salience of the subject antecedent, then it is expected that the less reduced form of the pronoun, i.e. null, be more likely to refer to more salient antecedent, i.e. the object and

more informative form of the pronoun, i.e. overt, is more likely to be linked with the subject as it is lower in salience in the discourse. In (5.1), therefore, the overt pronoun is expected to be processed more slowly as it is forced to refer to a highly salient antecedent.

Another area which is recommended for further investigation is to replicate the study through a different methodology, i.e. eye-tracking method and ambiguous sets of stimuli. Eye-tracking is advantageous to the self-paced reading method in that it can make a profile for each participant showing that which antecedent the participant's eyes are fixated more from the onset of the pronoun to the end of the sentence. The fully ambiguous stimuli also enable the researcher to study what the final interpretation of pronouns is. This way both real time and offline information is obtained and can be compared.

References

Ariel, M. (1990). *Accessing noun-phrase antecedents*. London: Routledge.

Ariel, M. (2001). Accessibility theory: An overview. In T. Sanders, J. Schilperoord, & W. Spooren (Eds.), *Text Representation: Linguistic and psycholinguistic aspects.* (pp. 29-87) Philadelphia: John Benjamins.

Arnold, J. E., Eisenband, J. G., Brown-Schmidt, S., & Trueswell, J. C. (2000). The rapid use of gender information: evidence of the time course of pronoun resolution from eyetracking. *Cognition, 76,* B13-B26.

Arrington, C. N., Kulesz, P. A., Francis, D. J., Fletcher, J. M., & Barnes, M. A. (2014). The contribution of attentional control and working memory to reading comprehension and decoding. *Scientific Studies of Reading*, *18*(5), 325-346.

Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R*. Cambridge University Press.

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., ... & Rcpp, L. (2015). Package 'lme4'. *Convergence*, *12*(1).

Burmester, J., Sauermann, A., Spalek, K., & Wartenburger, I. (2017). Sensitivity to salience: linguistic vs. visual cues affect sentence processing and pronoun resolution. *Language, Cognition and Neuroscience*, *33*(6), 784-801.

Calvo, M. G. (2001). Working memory and inferences: Evidence from eye fixations during reading. *Memory*, *9*(4-6), 365-381.

Cantor, J., & Engle, R. W. (1993). Working-memory capacity as long-term memory activation: An individual-differences approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(5), 1101.

Cardinaletti, A. (2001). La traduzione: un caso di attrito linguistico [A case of linguistic attrition]. In A. Cardinaletti, & G. Garzone (Eds.), *L'italiano delle traduzioni*. Milano: FrancoAngeli (pp. 59–84).

Cardinaletti, A., & Starke, M. (1999). The typology of structural deficiency. On the three grammatical classes. In van Riemsdijk (Ed.), Clitics in the Languages of Europe (Vol 8 of Language Typology). Berlin: Mouton.

Carminati, M.N. (2002). *The processing of Italian subject pronouns* (PhD Thesis, University of Massachusetts Amherst). Retrieved from scholarworks.umass.edu/ETDS/DISSERTATIONS/AAI3039345.

Carreiras, M., Gernsbacher, M. A., & Villa, V. (1995). The advantage of first mention in Spanish. *Psychonomic Bulletin & Review*, *2*(1), 124-129.

Chomsky, N. (1981). *Lectures on government and binding*. Dordrecht: Foris.

Clark, H. H., & Sengul, C. J. (1979). In search of referents for noun phrases and pronouns. *Memory & Cognition, 7*, 35-41.

Colom, R., Martínez-Molina, A., Shih, P. C., & Santacreu, J. (2010). Intelligence, working memory, and multitasking performance. *Intelligence*, *38*(6), 543-551.

Crawley, R., Stevenson, R., & Kleinman, D. (1990). The use of heuristic strategies in the interpretation of pronouns. *Journal of Psycholinguistic Research, 4*, 245-264.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of verbal learning and verbal behavior*, *19*(4), 450-466.

Ferreira, F., & Clifton Jr, C. (1986). The independence of syntactic processing. *Journal of memory and language*, *25*(3), 348-368.

Fiorentino, R., Covey, L., & Gabriele, A. (2018). Individual differences in the processing of referential dependencies: Evidence from event-related potentials. *Neuroscience letters*, *673*, 79-84.

Frederiksen, J. (1981). Understanding anaphora: Rules used by readers in assigning pronominal referents. *Discourse Processes, 4,* 323-347.

Gernsbacher, M. A., & Hargreaves, D. J. (1988). Accessing sentence participants: The advantage of first mention. *Journal of memory and language*, *27*(6), 699-717.

Gernsbacher, M. A., Hargreaves, D. J., & Beeman, M. (1989). Building and accessing clausal representations: The advantage of first mention versus the advantage of clause recency. *Journal of memory and language*, *28*(6), 735-755.

Givón, T. (1983). *Topic continuity in discourse: A quantitative cross-language study*. Amsterdam/Philadelphia: John Benjamins.

Gordon, P. C., Grosz, B. J., & Gilliom, L. A. (1993). Pronouns, names and the centering of attention in discourse. *Cognitive Science, 17*, 311–347.

Gordon, P. C., & Hendrick, R. (1998). The representation and processing of coreference in discourse. *Cognitive Science, 22*, 389–424.

Hammer, A., Jansma, B. M., Lamers, M., & Münte, T. F. (2008). Interplay of meaning, syntax and working memory during pronoun resolution investigated by ERPs. *Brain research*, *1230*, 177-191.

Hazendar, B. (2010). Transfer at the syntax-pragmatics interface: Pronominal subjects in bilingual Turkish. *Second Language Research, 26*(3), 355–378.

Hobbs, J. (1978). Resolving pronoun references. *Lingua, 44*, 311-338.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian journal of statistics*, 65-70.

Hudson-D'Zmura, S., & Tanenhaus, M. K . (1998). Assigning antecedents to ambiguous pronouns: The role of center of attention as the default assignment. In M. A. Walker, A. K. Joshi, & E. F. Prince (Eds.), *Centering theory in discourse* (pp. 199-226). Oxford: Oxford University Press.

Järvikivi, J., van Gompel, R. P., Hyönä, J., & Bertram, R. (2005). Ambiguous pronoun resolution: Contrasting the first-mention and subject-preference accounts. *Psychological Science*, *16*(4), 260-264.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: individual differences in working memory. *Psychological review*, *99*(1), 122.

Just, M., Carpenter, P. A., & Wooley, J. D. (1982). Paradigms and processes in reading comprehension. *Journal of Experimental Psychology: General, 111*(2), 228-38.

Keating, G. D., VanPatten, B., & Jegerski, J. (2011). Who was walking on the beach? Anaphora resolution in Spanish heritage speakers and adult second language learners. *Studies in Second Language Acquisition, 33,* 193– 221.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13).

Kweon, S. (2011). Processing null and overt pronoun subject in ambiguous sentences in Korean. *International Journal of Linguistics, 3*(1), 1-13.

Lezama, C. G., & Almor, A. (2011). Repeated names, overt pronouns, and null pronouns in Spanish. *Language and Cognitive Processes, 26*(3), 437-454.

Linderholm, T. (2002). Predictive inference generation as a function of working memory capacity and causal text constraints. *Discourse processes*, *34*(3), 259-280.

Lujan, M. (1985). Binding Properties of overt pronouns in null pronominal languages. In W. H. Eilforth, P.D. Kroeber, & K.L. Peterson (Eds.), *Proceedings of the Chicago Linguistic Society, 21*, 424-438.

Lujan, M. (1986). Stress and binding of pronouns. In A.M. Farley, P.T. Farley, & K.E. McCullough (Eds.), *Proceedings of the Chicago Linguistic Society, 22*, Part 2, 248-262.

Marefat, H., & Samadi, E. (2017). Processing null and overt pronouns in Persian. *Journal of Language Researches, 7*(2), 97-115.

Marinis, T. (2010). Using on-line processing methods in language acquisition research. *Experimental methods in language acquisition research*, 139-162.

Matthews, A., & Chodorow, M. (1988). Pronoun resolution in two-clause sentences: Effects of ambiguity, antecedent location and depth of embedding. *Journal of Memory and Language, 27*, 245-260.

Mayol, L., & Clark, R. (2010). Pronouns in Catalan: Games of partial information and the use of linguistic resource. *Journal of Pragmatics, 42*(3), 781-799.

Mojtaba Zadeh, M. (2006). Study of the relationship between active memory, degree of anxiety and academic achievement among third year students of high school students in Zanjan city (Unpublished *Master's Thesis).* Allameh Tabatabaei University: Tehran. (Persian).

Montalbetti, M. (1984). *After binding: On the interpretation of pronouns* (Unpublished doctoral dissertation). MIT, Massachusetts.

Nieuwland, Mante S., and Jos JA Van Berkum. "Individual differences and contextual bias in pronoun resolution: Evidence from ERPs." *Brain Research* 1118.1 (2006): 155-167.

Oberauer, K., Süß, H. M., Schulze, R., Wilhelm, O., & Wittmann, W. W. (2000). Working memory capacity—facets of a cognitive ability construct. *Personality and individual differences*, *29*(6), 1017-1045.

Ovalle, A. L., Fernandes-Solera, S., Frazier, L., & Clifton, C. (2002). Null vs. overt pronouns and the topic-focus articulation in Spanish. *Rivista di Linguistica, 14*(2), 151-169.

Papadopoulou, D., Peristeri, E., Plemenou, E., Marinis, T., & Tsimpli, I. (2015). Pronoun ambiguity resolution in Greek: Evidence from monolingual adults and children. *Lingua 2239*, 1-23.

Peirce, J. W. (2007). PsychoPy—psychophysics software in Python. *Journal of neuroscience methods*, *162*(1-2), 8-13.

Qiu, L., Swaab, T. Y., Chen, H. C., & Wang, S. (2012). The role of gender information in pronoun resolution: Evidence from Chinese. *PLoS One*, *7*(5), e36156.

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org/.

Sorace, A., & Filliaci, F. (2006). Anaphora resolution in near-native speakers of Italian. *Second Language Research, 22*(3), 339-368.

Stevenson, R., Nelson, A. W. R., & Stenning, K. (1995). The role of parallelism in strategies of pronoun comprehension. *Language and Speech, 38,* 393–418.

Streb, J., Hennighausen, E., & Rösler, F. (2004). Different anaphoric expressions are investigated by event-related brain potentials. *Journal of Psycholinguistic Research*, *33*(3), 175-201.

Van Berkum, J. J. (2004). Sentence comprehension in a wider discourse: Can we use ERPs to keep track of things. *The on-line study of sentence comprehension: Eyetracking, ERPs and beyond*, 229-270.

Vasishth, S., & Lewis, R. L. (2006). Argument-head distance and processing complexity: Explaining both locality and antilocality effects. *Language*, 767-794.

Walker, M., Joshi, A., & Prince, E. (1998). Centering in naturally occurring discourse: An overview. In M. Walker, A. Joshi, & E. Prince (Eds.), *Centering theory in discourse.* (pp. 128). New York: Oxford University Press.

Yang C. L., Gordon, P. C., Hendrick R., & Wu, J. T. (1999). Comprehension of referring expressions in Chinese. *Language and Cognitive Processes, 14*, 715–743.

Appendix A

List of Experimental Items in Phase 1 (Acceptability Judgement Test)

1)	
coach at-EZ football player-INF REL was water DUR-ate shout hit	coach-INF REL was water DUR-ate at-EZ football player shout hit
'The coach shouted at the football player who was drinking water.'	'The coach who was drinking water shouted at the football player.'
2)	
instructor-INF REL was palm DUR-hit to child smile hit	instructor to child-INF REL was palm DUR-hit smile hit
'The instructor who was clapping smiled at the child.'	'The instructor smiled at the child who was clapping.'
3)	
old woman from girl-INF REL was step DUR-hit goodbye did	old woman-INF REL was step DUR-hit from girl goodbye did
'The old woman said goodbye to the girl who was strolling.'	'The old woman who was strolling said goodbye to the girl.'
4)	
old man-INF REL was film DUR-saw to boy baby point did	old man to boy baby-INF REL was film DUR-saw point did
'The old man who was watching a movie pointed at the baby boy.'	'The old man pointed at the baby boy who was watching a movie.'
5)	
girl to woman-EZ blind-INF REL was load DUR-carry help did	girl-INF REL was load DUR-carry to woman-EZ blind help did
'The girl helped the blind woman who was carrying a load.'	'The girl who was carrying a load helped the blind woman.'

6)	
doctor-INF REL was enter DUR-became to patient hello did	doctor to patient-INF REL was enter DUR-became hello did
‘The doctor who was entering said hello to the patient.’	‘The doctor said hello to the patient who was entering.’
7)	
Santa with child-INF REL was DUR-laughed play did	Santa-INF REL was DUR-laughed with child play did
‘Santa played with a child who was laughing.’	‘The Santa who was laughing played with the child.’
8)	
stylist-INF REL was phone DUR-hit to customer lean gave	stylist to customer-INF REL was phone DUR-hit lean gave
‘The stylist who was talking on the phone leaned at the customer.’	‘The stylist leaned at the customer who was talking on the phone.’
9)	
doorman to newcomer-INF REL was smile DUR-hit bow did	doorman-INF REL was smile DUR-hit to newcomer bow did
‘The doorman bowed at the newcomer who was smiling.’	‘The doorman who was smiling bowed at the customer.’
10)	
motorist-INFREL was puncture DUR-took to cyclist look threw	motorist to cyclist-INF REL was puncture DUR-took look threw
‘The motorist who was changing the flat tire looked at the cyclist.’	‘The motorist looked at the cyclist who was changing the flat tire.’

11)	
passenger from flight attendant-INF REL was way DUR-went question asked 'The passenger asked a question from the flight attendant who was walking.'	passenger-INF REL was way DUR-went from flight attendant question asked 'The passenger who was walking asked the flight attendant a question.'
12)	
passenger-INF REL was form fill DUR-did to inspector-EZ Customs answer gave 'The passenger who was filling in the form answered the Customs inspector.'	passenger to inspector-EZ Customs-INF REL was form fill DUR-did answer gave 'The passenger answered the Customs inspector who was filling in a form.'
13)	
officer to robber-INF was driving DUR-did shot did 'The officer shot the robber who was driving.'	officer-INF REL was driving DUR-did to robber shot did 'The officer who was driving shot the robber.'
14)	
girl-INF REL was make-up DUR-did to woman stare hit 'The girl who was doing make-up stared at the woman.'	girl to woman-INF REL was make-up DUR-did stare hit 'The girl stared at the woman who was doing make-up.'

15)	
director to actor-INF REL was tea DUR-drank point did	director-INF REL was tea DUR-drank to actor point did
‘The director pointed at the actor who was drinking tea.’	‘the director pointed at the actor who was drinking tea.’
16)	
soldier-INF REL was exit DUR-became to commander report gave	soldier to commander-INF REL was exit DUR-became report gave
‘The soldier who was leaving gave a report to the commander.’	‘The soldier gave a report to the commander who was leaving.’
17)	
receptionist to guest-INF REL was key-DOM deliver DUR-took welcome said	receptionist-INF REL was key-DOM deliver DUR-took to guest welcome said
‘The receptionist welcomed the guest who was delivering the key.’	‘The receptionist who was delivering the key welcomed the guest.’
18)	
girl-EZ florist-INF REL was get-off DUR-became to passenger beg did	girl-EZ florist to passenger-INF REL was get-off DUR-became beg did
‘The florist girl who was getting off begged the passenger.’	‘The florist girl begged the passenger who was getting off the bus.’
19)	
boy-EZ young to beggar-INF REL was from street cross DUR-became help did	boy-EZ young-INF REL was from street cross DUR-became to beggar help did

‘The young boy helped the beggar who was crossing the street.’	‘The young boy who was crossing the street helped the beggar.’
20)	
defendant-INF REL was speak DUR-did to plaintiff look threw	defendant to plaintiff-INF REL was speak DUR-did look threw
‘The defendant who was speaking looked at the plaintiff.’	‘The defendant looked at the plaintiff who was speaking.’
21)	
girl child with instructor-INF REL was DUR-laughed play did	girl child-INF REL was DUR-laughed with instructor play did
‘The child girl played with the instructor who was laughing.’	‘The child girl who was laughing played with the instructor.’
22)	
laborer-INF REL was cross DUR-became to supervisor hello did	laborer to supervisor-INF REL was cross DUR-became hello did
‘The laborer who was crossing said hello to the supervisor.’	‘The laborer said hello to the supervisor who was crossing.’
23)	
patient to doctor-INF REL was enter DUR-became frown did	patient-INF REL was enter DUR-became to doctor frown did
‘The patient frowned at the doctor who was entering.’	‘The patient who was entering frowned at the doctor.’
24)	
photographer-INF REL was up DUR-went from minister photo took	photographer from minister-INF REL was up DUR-went photo took
‘The photographer who was coming up took the photo of the minister.’	‘The photographer took the photo of the minister who was coming up.’

25)	
kidnapper to officer-INF REL was DUR-ran shot did	kidnapper-INFREL was DUR-ran to officer shot did
'The kidnapper shot the officer who was running.'	'The kidnapper who was running shot the officer.'
26)	
landlord-INF REL was shout DUR-drew with tenant argue did	landlord with tenant-INF REL was shout DUR-drew argue did
'The landlord who was shouting argued with the tenant.'	'The landlord argued with the tenant who was shouting.'
27)	
injured from pedestrian-INF REL was way DUR-went help wanted	injured-INF REL was way DUR-went from pedestrian help wanted
'The injured person asked for the pedestrian's help who was walking.'	'The injured person who was walking asked for the pedestrian's help.'
28)	
shopkeeper-INFREL was money DUR-counted to customer look did	shopkeeper to customer-INF REL was money DUR-counted look did
'The shopkeeper who was counting money looked at the customer.'	'The shopkeeper looked at the customer who was counting money.'
29)	
teacher to student-INF REL was cigarette DUR-drew insult did	teacher-INF REL was cigarette DUR-drew to student insult did
'The teacher insulted the student who was smoking.'	'The teacher who was smoking insulted the student.'

30)	
driver -INF REL was gum DUR-chewed to passenger critic hit	driver to passenger-INF REL was gum DUR-chewed critic hit
'The driver who was chewing the gum criticized the passenger.'	'The driver criticized the passenger who was chewing the gum.'
31)	
man to old man-INF REL was ride-EZ elevator DUR-became body hit	man-INF REL was ride-EZ elevator DUR-became to old man body hit
'The man jostled the old man who was getting into the elevator.'	'The man who was getting into the elevator jostled the old man.'
32)	
mechanic-INF REL was car-DOM fix DUR-did from assistant admire did	mechanic from assistant-INF REL was car-DOM fix DUR-did admire did
'The mechanic who was fixing the car admired the assistant.'	'The mechanic admired the assistant who was fixing the car.'
33)	
clerk from manager-INF REL was with phone speak DUR-did goodbye did	clerk-INF REL was with phone speak did from manager goodbye did
'The clerk said goodbye to the manager who was talking on the phone.'	'The clerk who was talking on the phone said goodbye to the manager.'

34)	
client-INF REL was DUR-returned from stylist thank did	client from stylist-INF REL was DUR-returned thank did
‘The client who was turning around thanked the stylist.’	‘The client thanked the stylist who was turning around.’
35)	
customer to waiter-INF REL was below eyes-INF look DUR-did order gave	customer-INF REL was below eyes-INF look DUR-did to waiter-INF order gave
‘The customer ordered the food to waiter who was peeking.’	‘The customer who was peeking ordered the food to the waiter.’
36)	
girl-INF REL was flower-PL-DOM water DUR-gave to old woman hello did	girl to old woman-INF REL was flower-PL-DOM water DUR-gave hello did
‘The girl who was watering the flowers said hello to the old woman.’	‘The girl said hello to the old woman who was watering the flowers.’
37)	
lady to girl-EZ young-INF REL was cooking DUR-did bell hit	lady-INF REL was cooking DUR-did to girl-EZ young bell hit
‘The lady called the young girl who was cooking.’	‘The lady who was cooking called the young girl.’

Appendix B

List of Filler Items in Phase 1 (Acceptability Judgment Test)

Negative Polarity Items (Predicted Categorical Responses)	
1)	
Ali to anyone told REL Sohrāb cake NEG-ate	Ali to anyone NEG-told REL Sohrāb cake ate
'Ali told anyone that Sohrab didn't eat the cake.'	'Ali didn't tell anyone that Sohrab ate the cake.'
2)	
Rezā to anyone inform NEG-gave REL Māziyār with car accident did	Rezā to anyone inform gave REL Māziyār with car accident NEG-did
'Reza didn't inform anyone that Maziar crashed the car.'	'Reza informed anyone that Maziar didn't crash the car.'
3)	
Zeinab to anyone told REL Bitā letter NEG-wrote	Zeinab to anyone NEG-told REL Bitā letter wrote
'Zeinab told anyone that Bita didn't write the letter.'	'Zeinab didn't tell anyone that Bita wrote the letter.'
4)	
Fereshte to anyone inform NEG-gave REL Parisā food ate	Fereshte to anyone inform gave REL Parisā food NEG-ate
'Fereshteh didn't inform anyone that Parisa ate the food.'	'Fereshteh informed anyone that Parisa didn't eat the food.'
5)	
Rostam to anyone inform gave REL Goli test-DOM NEG-failed	Rostam to anyone inform NEG-gave REL Goli test-DOM failed
'Rostam informed anyone that Goli didn't fail the exam.'	'Rostam didn't inform anyone that Goli failed the exam.'
6)	
Leilā to anyone NEG-told REL Parviz shokolāt took	Leilā to anyone told REL Parviz shokolāt NEG-took
'Leila didn't tell anyone that Parviz took a candy.'	'Leila told anyone that Parviz didn't take a candy.'

7)	
Royā to anyone told REL Bijan to direction-EZ store driving NEG-did	Royā to anyone NEG-told REL Bijan to direction-EZ store driving did
‘Roya told anyone that Bijan didn’t drive to the store.’	‘Roya didn’t tell anyone that Bijan drove to the store.’
8)	
Javād to anyone NEG-told REL Yāsaman went France	Javād to anyone told REL Yāsaman NEG-went France
‘Javad didn’t tell anyone that Yasaman went to France.’	‘Javad told anyone that Yasaman didn’t go to France.’
9)	
Mahmud to Izad told REL Vahid anything NEG-ate	Mahmud to Izad NEG-told REL Vahid anything ate
‘Mahmood told Izad that Vahid didn’t eat anything.’	‘Mahmood didn’t tell Izad that Vahid ate anything.’
10)	
Yusef to Karim inform NEG-gave REL Armin anything broke	Yusef to Karim inform gaveREL Armin anything NEG-break
‘Yousef didn’t inform Karim that Amin broke anything.’	‘Yousef informed Karim that Amin didn’t break anything.’
11)	
Lāle to Fāteme told REL Donyā anything NEG-read	Lāle to Fāteme NEG-told REL Donyā anything read
‘Laleh told Fatemeh that Donya didn’t study anything.’	‘Laleh didn’t tell Fatemeh that Donya studied anything.’
12)	
Tārā to Jilā inform NEG-gave REL Reyhān anything drank	Tārā to Jilā informed REL Reyhān anything NEG-drank
‘Tara didn’t inform Jila that Reyhan drank anything.’	‘Tara informed Jila that Reyhan didn’t drink anything.’
13)	
Hoseyn to Arshad told REL Nilufar to anyone call NEG-hit	Hoseyn to Arshad NEG-told REL Nilufar to anyone called
‘Hossein told Arshad that Niloofar didn’t call anyone.’	‘Hossein didn’t tell Arshad that Niloofar called anyone.’

14)	
Mehdi to Dāvud inform NEG-gave REL Nasrin anywhere went	Mehdi to Dāvud informed REL Nasrin anywhere NEG-went
‘Mehdi didn’t inform Davood that Nasrin went anywhere.’	‘Mehdi informed Davood that Nasrin didn’t go anywhere.’
15)	
Ermiya to Maryam told REL Sāmān anyone-DOM meeting NEG-did	Ermia to Maryam NEG-told REL Sāmān anyone-DOM meeting did
‘Ermia told Maryam that Saman didn’t meet anyone.’	‘Ermia didn’t tell Maryam that Saman met anyone.’
16)	
Tāhere to Azāde inform NEG-gave REL Atash anything lost did	Tāhere to Azāde inform gave REL Atash anything lost NEG-did
‘Taraneh didn’t inform Azadeh that Atash missed anything.’	‘Taraneh informed Azadeh that Atash didn’t miss anything.’
Raising Structures (Predicted Neutral Responses)	
17)	
Hoseyn to seem DUR-come-3SG to Azāde bell DUR-hit-3SG	to Azāde to seem DUR-come-3SG Hoseyn bell DUR-hit-3SG
‘Hossein seems to call Azadeh.’	‘Hossein seems to call Azadeh.’
18)	
Dāvud-DOM to seem DUR-come-3SG Maryam like have-3SG	Maryam to seem DUR-come-3SG Dāvud-DOM like have-3SG
‘Maryam seems to love Davood.’	‘Maryam seems to love Davood.’
19)	
child-PL to seem DUR-come-3SG book-DOM DUR-read-3PL	book-DOM to seem DUR-come-3SG child-PL DUR-read-3PL
‘Children seem to read the book.’	‘Children seem to read the book.’

20)	
meat-DOM to seem DUR-come-3SG dog-PL smell DUR-draw-3PL	dog-PL to seem DUR-come-3SG meat-DOM smell DUR-draw-3PL
'Dogs seem to smell the meat.'	'Dogs seem to smell the meat.'
21)	
Ali to seem DUR-come-3SG candy-PL-DOM DUR-eat-3SG	candy-PL-DOM to seem DUR-come-3SG Ali DUR-eat-3SG
'Ali seems to eat the candies.'	'Ali seems to eat the candies.'
22)	
Shabnam to seem DUR-come-3SG bowl-PL-DOM DUR-wash-3SG	bowl-PL-DOM to seem DUR-come-3SG Shabnam DUR-wash-3SG
'Shabnam seems to wash the bowls.'	'Shabnam seems to wash the bowls.'
23)	
music-DOM to seem DUR-come-3SG I DUR-hear-1SG	I to seem DUR-come-3SG music-DOM DUR-hear-1SG
'I seem to hear the music.'	'I seem to hear the music.'
24)	
I to seem DUR-come-3SG car-DOM DUR-drive-1SG	car-DOM to seem DUR-come-3SG I DUR-drive-1SG
'I seem to drive the car.'	'I seem to drive the car.'
25)	
me-DOM to seem DUR-come-3SG film DUR-scare-3SG	film to seem DUR-come-3SG me-DOM DUR-scare-3SG
'The film seems to scare me.'	'The film seems to scare me.'
26)	
cat to seem DUR-come-3SG from me hate become-3SG	from me to seem DUR-come-3SG cat hate become-3SG
'The cat seems to hate me.'	'The cat seems to hate me.'

Control Structures (Predicted Categorical Responses)	
27)	
Rezā DUR-want-3SG cry SUB-do-3SG	Rezā DUR-want-3SG cry SUB-do-1SG
‘Reza wants to cry.’	‘Reza wants me to cry.’
28)	
Goli DUR-want-3SG shopping SUB-do-1SG	Goli DUR-want-3SG shopping SUB-do-3SG
‘Goli wants me to shop.’	‘Goli wants to shop.’
29)	
you DUR-want-2SG sweep SUB-pull-3SG	you DUR-want-2SG sweep SUB-pull-2SG
‘You want him/her to sweep (the floor).’	‘You want to sweep (the floor).’
30)	
you DUR-want-2SG SUB-jump-2SG	you DUR-want-2SG SUB-jump-3SG
‘You want to jump.’	‘You want him/her to jump.’
31)	
Behnām promise DUR-give-3SG SUB-sleep-1SG	Behnām promise DUR-give-3SG SUB-sleep-3SG
‘Behnam promises I sleep.’	‘Behnam promises to sleep.’
32)	
Nasrin promise DUR-give-3SG SUB-write-3SG	Nasrin promise DUR-give-3SG SUB-write-1SG
‘Nasrin promises to write’	‘Nasrin promises I write.’
33)	
you promise DUR-give-2SG answer SUB-give-3SG	you promise DUR-give-2SG answer SUB-give-2SG
‘You promise he/she answers.’	‘You promise to answer.’

34)	
you promise DUR-give-2SG song SUB-read-2SG	you promise DUR-give-2SG song SUB-read-3SG
‘You promise to sing.’	‘You promise he/she sings.’
35)	
Rezā DUR-try-3SGcry SUB-do-1SG	Rezā DUR-try-3SGcry SUB-do-3SG
‘Reza tries me to cry.’	‘Reza tries to cry.’
36)	
Goli DUR-want-3SG shopping SUB-do-3SG	Goli DUR-want-3SG shopping SUB-do-1SG
‘Goli tries to shop.’	‘Goli tries me to shop.’
37)	
you try DUR-do-2SG sweep SUB-pull-3SG	you try DUR-do-2SG sweep SUB-pull-2SG
‘You try him/her to sweep (the floor).’	‘You try to sweep (the floor).’
38)	
you try DUR-do-2SG SUB-jump-2SG	you try DUR-do-2SG SUB-jump-3SG
‘You try to jump.’	‘You try him/her to jump.’
39)	
Behnām dare have-3SG SUB-sleep-1SG	Behnām dare have-3SG SUB-sleep-3SG
‘Behnam dares I sleep.’	‘Behnam dares to sleep.’
40)	
Nasrin dare have-3SG SUB-write-3SG	Nasrin dare have-3SG SUB-write-1SG
‘Nasrin dares to write.’	‘Nasrin dares I write.’

41)	
you dare have-2SG answer SUB-give-3SG	you dare have-2SG answer SUB-give-2SG
‘You dare he/she answers.’	‘You dare to answer.’
42)	
you dare have-2SG song SUB-read-2SG	you dare have-2SG song SUB-read-3SG
‘You dare to sing.’	‘You dare he/she sings.’
Tense in Subjunctives (Predicted Categorical Responses)	
43)	
yesterday Kimyā decision took REL tomorrow SUB-go-3SG	yesterday Kimyā decision took REL SUB-go-3SG
‘Yesterday Kimiea decided to leave tomorrow.’	‘Yesterday Kimiea decided to leave.’
44)	
yesterday Javād encourage did Royā SUB-dance-3SG	yesterday Javād encourage did Royā tomorrow SUB-dance-3SG
‘Yesterday Javad encouraged Roya to dance.’	‘Yesterday Javad encouraged Roya to dance tomorrow.’
45)	
yesterday Rostam DUR-wanted tomorrow to direction-EZ school driving SUB-do-3SG	yesterday Rostam DUR-wanted to direction-EZ school driving SUB-do-3SG
‘Yesterday Rostam wanted to drive to school tomorrow.’	‘Yesterday Rostam wanted to drive to school.’
46)	
yesterday Parisā try did fish-DOM bury SUB-do-3SG	yesterday Parisā try did fish-DOM tomorrow bury SUB-do-3SG
‘Yesterday Parisa tried to bury her fish.’	‘Yesterday Parisa tried to bury her fish tomorrow.’

Matching the Raising Verb and the Subject (Predicted Categorical Responses)	
47)	
I to seem DUR-come-3SG tired become-1SG	I to seem DUR-come-1SG tired SUB-become-1SG
'I seem to be tired.'	'I seem to be tired.'
48)	
I to seem DUR-come-1SG SUB-go-1SG	I to seem DUR-come-3SG SUB-go-1SG
'I seem to leave.'	'I seem to leave.'
49)	
They to seem DUR-come-3SG hungry SUB-become-3PL	They to seem DUR-come-3PL hungry SUB-become-3PL
'They seem to be hungry.'	'They seem to be hungry.'
50)	
They to seem DUR-come-3PL SUB-laugh-3PL	They to seem DUR-come-3SG SUB-laugh-3PL
'They seem to laugh.'	'They seem to laugh.'
Persian Critical Marker (-esh) (Predicted Categorical Responses)	
51)	
man with wife-3SG CL to trip will-3SG went	man with wife-3SG CL to trip will-3SG went-**esh**
'The man will go to travel with his wife.'	'The man will go to travel with his wife.'
52)	
teacher from student in class question will-3SG asked-**esh**	teacher from student in class question will-3SG asked
'The teacher will ask the student in the classroom.'	'The teacher will ask the student in the classroom.'

53)	
Ali with Rezā to restaurant will-3SG went	Ali with Rezā to restaurant will-3SG went-**esh**
‘Ali will eat with Reza in the restaurant.’	‘Ali will eat with Reza in the restaurant.’
54)	
Maryam with Zahrā to party will-3SG went-**esh**	Maryam with Zahrā to party will-3SG went
‘Maryam will go to the party with Zahra.’	‘Maryam will go to the party with Zahra.’
55)	
man to son-EZ self in way-EZ school money will-3SG gave	man to son-EZ self in way-EZ school money will-3SG gave-**esh**
‘The man will give money to his son on his way to school.’	‘The man will give money to his son on his way to school.’
56)	
hunter in jungle with gun-3SG CL hunt will-3SG did-**esh**	hunter in jungle with gun-3SG CL hunt will-3SG did
‘The hunter will hunt in the jungle with his gun.’	‘The hunter will hunt in the jungle with his gun.’
57)	
Amir with Majid from museum seeing will-3SG did	Amir with Majid from museum seeing will-3SG did-**esh**
‘Amir will visit the museum with Majid.’	‘Amir will visit the museum with Majid.’
58)	
zan with husband-3SG CL to office-EZ doctor will-3SG went-**esh**	zan with husband-3SG CL to office-EZ doctor will-3SG went
‘The woman will go to the doctor’s office with her husband.’	‘The woman will go to the doctor’s office with her husband.’
59)	
Fereshteh with Sahar in bus talk will-3SG did	Fereshteh with Sahar in bus talk will-3SG did-**esh**
‘Fereshteh will talk to Sahar on the bus.’	‘Fereshteh will talk to Sahar on the bus.’

60)	
teacher from student-PL thank will-3SG did-**esh**	teacher from student-PL thank will-3SG did
‘The teacher will thank the students in the ceremony.’	‘The teacher will thank the students in the ceremony.’
61)	
customer from waiter in restaurant thank will-3SG did	customer from waiter in restaurant thank will-3SG did-**esh**
‘The customer will thank the waiter at the restaurant.’	‘The customer will thank the waiter at the restaurant.’
62)	
mother to baby in kitchen food will-3SG gave-**esh**	mother to baby in kitchen food will-3SG gave
‘The mother will feed the baby in the kitchen.’	‘The mother will feed the baby in the kitchen.’
63)	
announcer-EZ news about-EZ earthquake in news talk will-3SG did	announcer-EZ news about-EZ earthquake in news talk will-3SG did-**esh**
‘The news announcer will talk about the earthquake in the news.’	‘The news announcer will talk about the earthquake in the news.’
64)	
weather in north from Tuesday cold will-3SG became-**esh**	weather in north from Tuesday cold will-3SG became
‘The weather will become cold in north from Tuesday.’	‘The weather will become cold in north from Tuesday.’
65)	
Hossein from watching-EZ film in cinema enjoy will-3SG took	Hossein from watching-EZ film in cinema enjoy will-3SG took-esh
‘Hossein will enjoy watching the film at the cinema.’	‘Hossein will enjoy watching the film at the cinema.’

66)	
photographer from scene-EZ crash in street photo will-3SG took-**esh**	photographer from scene-EZ crash in street photo will-3SG took
'The photographer will take a photo of the crash scene on the street.'	'The photographer will take a photo of the crash scene on the street.'
67)	
Mohammad with Dāvood with cellphone talk will-3SG did	Mohammad with Dāvood with cellphone talk will-3SG did-**esh**
'Mohammad will call Davood on his cellphone.'	'Mohammad will call Davood on his cellphone.'
68)	
Nikā with friend-3SG CL in kindergarten play will-3SG did-**esh**	Nikā with friend-3SG CL in kindergarten play will-3SG did
'Nika will play with her friend in kindergarten.'	'Nika will play with her friend in kindergarten.'
69)	
child to babysitter-3SG CL in absence-EZ mother-3SG CL habit will-3SG did	child to babysitter-3SG CL in absence-EZ mother-3SG CL habit will-3SG did-**esh**
'The kid will get used to her babysitter in her mother's absence.'	'The kid will get used to her babysitter in her mother's absence.'
70)	
landlord against-EZ tenant-3SG CL in court complaint will-3SG did-**esh**	landlord against-EZ tenant-3SG CL in court complaint will-3SG did
'The landlord will complain against his tenant in the court.'	'The landlord will complain against his tenant in the court.'
71)	
police to driver-EZ careless in highway warning will-3SG gave	police to driver-EZ careless in highway warning will-3SG gave-**esh**
'Police will warn the careless driver on the highway.'	'Police will warn the careless driver on the highway.'

72)	
police rate-EZ crime-DOM in news report will-3SG gave-**esh**	police rate-EZ crime-DOM in news report will-3SG gave
'Police will report the crime rate in the news.'	'Police will report the crime rate in the news.'
73)	
patient from lack-EZ medications in hospital will-3SG died	patient from lack-EZ medications in hospital will-3SG died-**esh**
'The patient will die from the lack of medications in the hospital.'	'The patient will die from the lack of medications in the hospital.'
74)	
Sārā with Nikā while-EZ play argue will-3SG did-**esh**	Sārā with Nikā while-EZ play argue will-3SG did
'Sarah will argue with Nike while playing.'	'Sarah will argue with Nike while playing.'
75)	
government from decision-EZ self in parliament regret will-3SG became	government from decision-EZ self in parliament regret will-3SG became-**esh**
'The government will regret its decision in the parliament.'	'The government will regret its decision in the parliament.'
76)	
woman from victory-EZ self in court happy will-3SG became-**esh**	woman from victory-EZ self in court happy will-3SG became
'The woman will be happy for her victory in the court.'	'The woman will be happy for her victory in the court.'

Appendix C

Items in Working Memory Test

Audio Stimuli

Two-Sentence Section

1)

māhi va xorus be shart-e zendegi dar āb zende mi-mān-and

fish and rooster to condition-EZ life in water alive DUR-stay-3PL

'Fish and roosters will die out of water.'

2)

joqd parande-i-st ke mānand-e sāyer-e parande-gān dar ruz be parvāz mi-āyad

owl bird-INF-is REL like-EZ other-EZ bird-PL in day to flight DUR-come.3SG

'An owl is a bird which will fly during daylight like other birds.'

Three-Sentence Section

1)

te'dād-e setāre-gān-e āsemān barābar ast bā te'dād-e angosht-ān-e dast

number-EZ star-PL-EZ sky equal is with number-EZ finger-PL-EZ hand

'The number of stars in the sky equals to the number of fingers in hands.'

2)

tolu-e xorshid az samt-e qarb manzare-i zibā sāxte bud

rise-EZ sun from west-EZ west view-INF nice made was

'Sunrise from the west had made a spectacular view.'

3)

har gerd-i dāyere hast o har chāhārzel-i morabba

every round-INF circle is and every quadrilateral-INF square

‘Every round object is a circle and every quadrilateral is a square.’

Four-Sentence Section

1)

zemestān sardtarin va pāiz tulānitarin fasl-hā-ye sāl hast-and

winter coldest and fall longest season-PL-EZ year is-3PL

‘Winter is the coldest and fall is the longest season of the year.’

2)

bāqbān mive-hā-ye nareside-ra zudtar az mive-hā-ye reside mi-chin-ad

gardener fruit-PL-EZ raw-DOM earlier from fruit-PL-EZ ripe DUR-pick-3SG

‘Gardeners usually pick the raw fruits sooner than ripe ones.’

3)

xorshid az sharq tolu va az qarb qorub mi-kon-ad

sun from east rise and from west set DUR-do-3SG

‘The sun will rise in the east and set in the west.’

4)

agar pariruz panjshanbe bash-ad, fardā mi-sha-vad yekshanbe

if two-days-ago Thursday be.SUB-3SG, tomorrow DUR-become-3SG Sunday

‘If two days ago is Thursday, tomorrow will be Sunday.’

Five-Sentence Section

1)

xāb o xāmushi-ye xorshid yani farāresidan-e tāriki o shab

sleep and turning off-EZ sun means arriving-EZ darkness and night

‘Sun’s sleep and darkness means the night.’

2)

dāneshmand-ān motaqed-and ke mansha-e zelzele harekat-e gosal-hā-ye zamin ast

schientist-PL believer-are REL source-EZ earthquake movement-EZ fault-PL-EZ earth is

‘Scientists believe that earthquakes are due to the movement of earth’s faults.’

3)

ān-che ziyād-ash kam ast dust ast o ān-che kam-ash ziyād doshman

that-thing many-3SG CL few is friend is and that-thing few-3SG CL many enemy

‘What is very rare is friend and what is frequent is enemy.’

4)

pedar-e pedar-e pedar-am mi-sha-vad pedarbozorg-e pedar-am

father-EZ father-EZ father-1SG CL DUR-become-3SG grandfather-EZ father-1SG CL

‘My father father’s father is my father’s grandfather.’

5)

varzesh vasile-i-st barā-ye salāmati va farār az piri

sport tool-INF-is for-EZ health and escape from ageing

‘Sports are tools for making you healthy and avoiding aging.’

Six-Sentence Section

1)

zaminlarze-i mahib asemān-ra larzānd

earthquake-INF grand sky-DOM shook

'A big earthquake struck the sky.'

2)

vijegi-ye āhan in ast ke dar sarmā monqabez va dar garmā monbaset mi-sha-vad

feature-EZ iron this is REL in coldness contract and in heat expand DUR-become-3SG

'The iron's feature is that it contracts in cold weather and expands in hot weather.'

3)

setāre-hā dar ruz bishtar az shab mi-deraxsh-and

star-PL in day more from night DUR-glow-3PL

'Stars will glow more in daylight than in dark nights.'

4)

hamvāre vaqāye-e mohemm-I dar tool-e tārix-e bashar be voqu peyvaste-and

always events-EZ important-INF in length-EZ history-EZ human to happen occur-3PL

'Important events have occurred in history.'

5)

hame bāzi-ra dust dār-and, vali kudak-ān bishtar

all play-DOM love have-3PL, but child-PL more

'Everybody loves playing games, but kids love more.'

6)

rābete-ye beyn-e mādar o farzand mānand-e rābete-ye bāqbān ast o bāq

relation-EZ between-EZ mother and child like-EZ relation-EZ gardener is and garden

‘The relation between mothers and children is similar to the relation between gardeners and gardens.’

Seven-Sentence Section

1)

tup vasile-i-st baraye bazi-ye fardi va goruhi

ball tool-INF-is for play-EZ individual and team

‘The ball is a tool for individual and team plays.’

2)

dar asar-e yek xoshksali āb-e rudxāne-hā xoshk va mazāre az biābi sukht-and

in result-EZ one drought water-EZ river-PL dried and farms from drought burnt-3PL

‘The rivers dried up due to a drought and farms were burnt out.’

3)

do bealāve-ye do menhā-ye chāhār mi-sha-vad sefr

two plus-EZ two minus-EZ four DUR-become-3SG zero

‘2 plus 2 minus 4 multiply by 4 equals to zero.’

4)

xorshid dar shab hamejā-rā roshan karde bud

sun in night everywhere-DOM bright done was

‘The sun had lightened everywhere at night.’

5)

vaqt baad az raftan-ash bāzgasht-i nist

time after from going-3SG CL return-INF isn't

'Time never comes back after leaving.'

6)

xorshid ruz-hā mi-deraxsh-ad va shab-hā dar āsemān be esterāhat mi-pardāz-ad

sun day-PL DUR-glow-3SG and night-PL in sky to relaxation DUR-do-3SG

'The sun glows during the day and rests during the night in the sky.'

7)

chāhār adad-e zoj beyn-e yek tā noh vojud dār-ad

four number-EZ even between-EZ one to nine exist have-3SG

'There are 4 even numbers between 1 and 9.'

Written Stimuli

Two-Sentence Section

1)

dar markaz-e Iran bārān ziyād mi-bār-ad

in centre-EZ Iran rain many DUR-rain-3SG

'It rains a lot in centre of Iran.'

2)

Rostam yek-i az qahramān-ān-e Shāhnāme ast

Rostam one-INF from hero-PL-EZ Shahname is

'Rostam is one of the heroes in Shahname.'

Three-Sentence Section

1)

gorbe heyvān-i-st vahshi va malus

cat animal-INF-is wild and cute

'Cat is a wild and cute animal.'

2)

bānk-e Melli-e Iran bank-i-st xosusi

bank-EZ Melli-EZ Iran bank-INF-is private

'Iranian National Bank is a private bank.'

3)

ensān barxalāf-e digar chāhār pā-yān mojud-i-st do pā

human unlike-EZ other four leg-PL creature-INF-is two leg

‘Human-beings have two legs unlike four-legged creatures.’

Four-Sentence Section

1)

kudak-an-e ziyād-i sar-e chāhār rāh-hā be kār mashqul-and

child-PL-EZ many-INF at-EZ four way-PL to work busy-are

‘A lot of children work on the street.’

2)

aqlab-e mardom dar tatilāt-e Noruz be mosāferat mi-ra-vand

most-EZ people in holiday-EZ Noruz to trip DUR-go-3PL

‘Most people take a trip on Noruz holidays,’

3)

Ingilis jazire-i-st dar qarb-e āfriqā va shomāl-e orupa

England island-INF-is in west-EZ Africa and north-EZ Europe

‘England is an island in west of Africa and north of Europe.’

4)

hes-e buyāi-ye sag-hā qavitar ast az hes-e buyāi-ye ensān-hā

feel-EZ smell-EZ dog-PL stronger is from feel-EZ smell-EZ human-PL

‘Dogs have a sharper sense of smell compared to human beings.’

Five-Sentence Section

1)

mādar mojud-i-st sarshār az mehr o ātefe

mother creature-INF-is full from kindness and compassion

‘Mother is a creature full of kindness and compassion.’

2)

moādel-e fārsi-ye kāmpiyuter barābar ast bā yārāne

equivalent-EZ Farsi-EZ computer equal is with Yarane

‘The Persian equivalent for the word ‘computer’ is ‘Yaraneh.’

3)

keshāvarzi shāmel-e se marhale ast: kāsht dāsht bardāsht

agriculture include-EZ three stage is: growing maintenance picking up

‘The agriculture process has three stages: Planting, Maintenance and Picking up.’

4)

Damāvand qolle-i-st vāqe dar jonub-e Iran va hamvāre pushide az barf

Damavand summit-INF-is located in south-EZ Iran and always covered from snow

‘Damavand is a mount located in south of Iran and always covered with snow.’

5)

qorān ketāb-e moqaddas-e mosalmān-ān ast o torāt ketāb-e moqaddas-e masihi-yān

quran book-EZ holy-EZ muslim-PL is and Torah book-EZ holy-EZ christian-PL

‘Quran is the holy book of Muslims and Torah is the holy book of Christians.’

Six-Sentence Section

1)

har gerd-i dayere ast o har sezel-i mosallas

every round-INF circle is and every threesided-INF triangle

‘Every round object is a circle and every three-sided a triangle.’

2)

arus dar shab-e arusi lebās-e sefid mi-push-ad

bride in night-EZ wedding dress-EZ white DUR-wear-3SG

‘The bride wears white dress in her wedding ceremony.’

3)

mahsulāt-e laban-i ebārat-and az: shir, māst o toxm-e morq

products-EZ dairy-INF equal-are from: milk, yogurt and egg-EZ hen

‘The dairy products are: milk, yogurt and eggs.’

4)

se zarbdar chāhār bealāve-ye do menhā-ye se mi-sha-vad davāzdah

three multiply four plus-EZ two minus-EZ three DUR-become-3SG twelve

‘Three by four plus two minus three is twelve.’

5)

tamām-e pesar-ān o doxtar-ān-e irani molzam be raftan be sarbāzi hast-and

all-EZ boy-PL and girl_PL-EZ Iranian required to going to military-service is-3PL

‘All Iranian boys and girls are required to go to military service.’

6)

shab-e Yaldā tulanitarin shab-e sāl ast ke dar āxarin shab-e pāiz bargozār

night-EZ Yalda longest night-EZ year is REL in last night-EZ fall hold

mi-sha-vad

DUR-become-3SG

‘Yalda is the longest night which is held the last day of fall.’

Seven-Sentence Section

1)

edde-ye ziyad-i dar asar-e tasādofāt-e jādde-i dar ayyām-e Noruz mi-mir-and

number-EZ many-INF in result-EZ accidents-EZ road-INF in days-EZ Noruz DUR-die-3PL

‘Many people die on Noruz holidays due to road accidents.’

2)

shir mādde-i-st hāvi-ye kalsiyom va charbi-hā-ye moredeniyāz-e badan

milk substance-INF-is including-EZ calcium and fat-PL-EZ required-EZ body

‘Milk is a substance containing calcium and fats required for the body.’

3)

namāz xāndan yek-i az farāyez-e mosalmān-ān ast barāye ebādat-e xodāvand

Salāt reading one-INF from duties-EZ Muslim-PL is for worshipping-EZ God

‘Salat is one of the Muslims’ duties for worshipping God.’

4)

nesbat-e shab o ruz be yekdigar moshābeh ast bā nesbat-e bahār o tābestān

relation-EZ night and day to each other similar is with relation-EZ spring and summer

‘The relationship between days and nights is similar to the relationship between spring and summer.’

5)

shahriye-ye madāres-e xosusi besyār gerāntar ast az shahriye-ye madāres-e

tuition-EZ schools-EZ private many more expensive is from tuition-EZ schools-EZ

dolati

public

‘The tuition fees in private schools is much more expensive than tuition fees in public schools.’

6)

havās-e panjgāne-ye ensān ebārat-and az: bināi, shenavāi, cheshāi, buyāi va lāmese

feelings-EZ five-EZ human include-are from: vision, hearing, tasting, smelling and touch

‘Five senses in humans are: vision, hearing, tasting, smelling and touching.’

7)

har shabāneruz shāmel-e 24 sāat ast o har sāat shāmel-e 60 daqiqe va

each day include-EZ 24 hour is and each hour include-EZ 60 minute and

har daqiqe shāmel-e 60 sāniye

each minute include-EZ 60 seconds

‘Each day includes 24 hours and each hour includes 60 minutes and each minute includes 60 seconds.’

Appendix D

List of Experimental Items in Phase 2 (Self-paced Reading Task)

		Region 1	Region 2	Region 3	Region 4
1	Subject	instructor cordially (in-EZ class)	to girl-PL	while (pro/she) was palm DUR-hit	smile hit
		'The instructor cordially smiled at the girls (in the class) while she was clapping.'			
	Object	Instructor-PL cordially (in-EZ class)	to girl	while (pro/she) was palm DUR-hit	smile hit-3PL
		'The instructor cordially smiled at the girls (in the class) while she was clapping.'			
2	Subject	old woman slowly (in-EZ park)	from girl-PL young	while (pro/she) was stroll DUR-hit	goodbye did
		'The old woman slowly said goodbye to the young girls (in the park) while she was strolling in the park.'			
	Object	old woman-PL slowly (in-EZ park)	from girl young	while (pro/she) was stroll DUR-hit	goodbye did-3PL
		'The old women slowly said goodbye to the young girl (in the park) while she was strolling in the park.'			
3	Subject	old man shakily (in-EZ room)	to boy-PL	while (pro/he) was film DUR-saw	point did
		'The old man shakily pointed at the boys (in the room) while he was watching a movie.'			
	Object	old man-PL shakily (in-EZ room)	to boy	while (pro/he) was film DUR-saw	point did-3PL
		'The old men shakily pointed at the boy (in the room) while he was watching a movie.'			
4	Subject	doctor again (in-EZ office)	to patient-PL	while (pro/he) was in DUR-became	hello did
		'The doctor again said hello to the patients (in the office) while he was entering the office.'			
	Object	doctor-PL again (in-EZ office)	to patient	while (pro/he) was in DUR-became	hello did-3PL

		‘The doctors again said hello to the patient (in the office) while he was entering the office.’			
5	Subject	Santa finally (in party)	with child-PL	while (pro/he) was laugh DUR-hit	play did
		‘Santa finally played with children (in the party) while he was laughing.’			
	Object	Santa-PL finally (in party)	with child	while (pro/he) was laugh DUR-hit	play did-3PL
		‘Santas finally played with child (in the party) while he was laughing.’			
6	Subject	stylist inadvertently (in salon)	to client-PL	while (pro/she) was with phone talk DUR-hit	lean gave
		‘The hairstylist inadvertently leaned on the clients (in the salon) while she was talking on the phone.’			
	Object	stylist-PL inadvertently (in salon)	to client	while (pro/she) was with phone talk DUR-hit	lean gave-3PL
		‘The hairstylists inadvertently leaned on the client (in the salon) while she was talking on the phone.’			
7	Subject	doorman again (in hotel)	to newcomer-PL	while (pro/he) was smile DUR-hit	bow did
		‘The doorman again bowed at the newcomers (in hotel) while he was smiling.’			
	Object	doorman-PL again (in hotel)	to newcomer	while (pro/he) was smile DUR-hit	bow did-3PL
		‘The doormen again bowed at the newcomer (in hotel) while he was smiling.’			
8	Subject	motorist accidentally (in sidewalk)	to cyclist-PL	while (pro/he) was puncture DUR-took	look threw
		‘The motorist accidentally looked at the cyclists (on the sidewalk) while he was changing the flat tire.’			
	Object	motorist-PL accidentally (in sidewalk)	to cyclist	while (pro/he) was puncture DUR-took	look threw-3PL
		‘The motorists accidentally looked at the cyclist (on the sidewalk) while he was changing the flat tire.’			

9	Subject	passenger hurriedly (in airplane)	from flight attendant-PL	while (pro/she)was way DUR-went	question asked
		‘The passenger hurriedly asked the flight attendants a question (on the plane) while she was walking.’			
	Object	passenger-PL hurriedly (in airplane)	from flight attendant	while (pro/she)was way DUR-went	question asked-3PL
		‘The passengers hurriedly asked the flight attendant a question (on the plane) while she was walking.’			
10	Subject	passenger finally (in airport)	to inspector-PL Customs	while (pro/he) was form fill DUR-did	answer gave
		‘The passenger finally answered the Customs inspectors (at the airport) while he was filling in the form.’			
	Object	passenger-PL finally (in airport)	to inspector Customs	while (pro/he) was form fill DUR-did	answer gave-3PL
		‘The passengers finally answered the Customs inspector (at the airport) while he was filling in the form.’			
11	Subject	officer unwillingly (in car)	to robber-PL	while (pro/he) was driving DUR-did	shot did
		‘The officer unwillingly shot the robbers (in the car) while he was driving.’			
	Object	officer-PL unwillingly (in car)	to robber	while (pro/he) was driving DUR-did	shot did-3PL
		‘The officers unwillingly shot the robber (in the car) while he was driving.’			
12	Subject	girl accidentally (in salon)	to woman-PL	while (pro/she) was make-up DUR-did	stare hit
		‘The girl accidentally stared at women (in the salon) while she was doing make-up.’			
	Object	girl-PL accidentally (in salon)	to woman	while (pro/she) was make-up DUR-did	stare hit-3PL
		‘The girl accidentally stared at women (in the salon) while she was doing make-up.’			

13	Subject	director suddenly (on stage)	to actor-PL	while (pro/he) was tea DUR-drank	point did
		‘The director suddenly pointed at the actors (on stage) while he was drinking tea.’			
	Object	director-PL suddenly (on stage)	to actor	while (pro/he) was tea DUR-drank	point did-3PL
		‘The directors suddenly pointed at the actor (on stage) while he was drinking tea.’			
14	Subject	soldier unwillingly (in garrison)	to commander-PL	while (pro/he) was exit DUR-became	report gave
		‘The soldier unwillingly gave a report to the commanders (in the garrison) while he was leaving.’			
	Object	soldier-PL unwillingly (in garrison)	to commander	while (pro/he) was exit DUR-became	report gave-3PL
		‘The soldiers unwillingly gave a report to the commander (in the garrison) while he was leaving.’			
15	Subject	boy-EZ young secretly (in street)	to beggar-PL	while (pro/he) was from street pass DUR-became	help did
		‘The young boy secretly helped the beggars (on the street) while he was crossing the street.’			
	Object	boy-PL-EZ young secretly (in street)	to beggar	while (pro/he) was from street pass DUR-became	help did-3PL
		‘The young boys secretly helped the beggar (on the street) while he was crossing the street.’			
16	Subject	defendant helplessly (in court)	to plaintiff-PL	while (pro/he) was speak DUR-did	look threw
		‘The defendant helplessly looked at the plaintiffs (in the court) while he was speaking.’			
	Object	defendant-PL helplessly (in court)	to plaintiff	while (pro/he) was speak DUR-did	look threw-3PL
		‘The defendants helplessly looked at the plaintiff (in the court) while he was speaking.’			

17	Subject	girl cordially (in yard)	with instructor-PL	while (pro/she) was DUR-smiled	play did
		'The girl cordially played with instructors (in the yard) while she was smiling.'			
	Object	girl-PL cordially (in yard)	with instructor	while (pro/she) was DUR-smiled	play did-3PL
		'The girls cordially played with the instructors (in the yard) while she was smiling.'			
18	Subject	laborer compulsorily (beside building)	to supervisor-PL	while (pro/he) was cross DUR-became	hello did
		'The laborer compulsorily said hello to the supervisors (next to the building) while he was crossing.'			
	Object	laborer-PL compulsorily (beside building)	to supervisor	while (pro/he) was cross DUR-became	hello did-3PL
		'The laborers compulsorily said hello to the supervisor (next to the building) while he was crossing.'			
19	Subject	patient suddenly (in hospital)	to doctor-PL	while (pro/he) was enter DUR-became	frown did
		'The patient suddenly frowned at doctors (in hospital) while he was entering.'			
	Object	patient-PL suddenly (in hospital)	to doctor	while (pro/he) was enter DUR-became	frown did-3PL
		'The patients suddenly frowned at doctor (in hospital) while he was entering.'			
20	Subject	photographer quickly (in hall)	to minister-PL	while (pro/he) was up DUR-came	photo took
		'The photographer quickly took photo of the ministers (in hall) while he was climbing up the stairs.'			
	Object	photographer-PL quickly (in hall)	to minister	while (pro/he) was up DUR-came	photo took-3PL
		'The photographer quickly took photo of the ministers (in hall) while he was climbing up the stairs.'			
21	Subject	kidnapper desperately (in park)	to officer-PL	while (pro/he) was DUR-ran	shot did
		'The kidnapper desperately shot the officers (in park) while he was running.'			
	Object	kidnapper-PL desperately (in park)	to officer	while (pro/he) was DUR-ran	shot did-3PL

'The kidnappers desperately shot the officer (in park) while he was running.'

22	Subject	landlord again (behind door)	with tenant-PL	while (pro/he) was shout DUR-drew	argue did
		'The landlord again argued with the tenants (by the door) while he was shouting.'			
	Object	landlord-PL again (behind door)	with tenant	while (pro/he) was shout DUR-drew	argue did-3PL
		'The landlords again argued with the tenant (by the door) while he was shouting.'			
23	Subject	shopkeeper accidentally (in shop)	to customer-PL	while (pro/he) was money DUR-counted	look did
		'The shopkeeper accidentally looked at the customers (in the shop)n while he was counting money.'			
	Object	shopkeeper-PL accidentally (in shop)	to customer	while (pro/he) was money DUR-counted	look did-3PL
		'The shopkeepers accidentally looked at the customer (in the shop)n while he was counting money.'			
24	Subject	teacher severely (in yard)	to student-PL	while (pro/he) was cigarette DUR-drew	insult did
		'The teacher severely insulted the students (in the yard) while he was smoking.'			
	Object	teacher-PL severely (in yard)	to student	while (pro/he) was cigarette DUR-drew	insult did-3PL
		'The teachers severely insulted the student (in the yard) while he was smoking.'			
25	Subject	driver deliberately (in car)	to passenger-PL	while (pro/he) was gum DUR-chewed	critic told
		'The driver deliberately criticized the passengers (in car) while he was chewing the gum.'			
	Object	driver-PL deliberately (in car)	to passenger	while (pro/he) was gum DUR-chewed	critic told-3PL

'The drivers deliberately criticized the passenger (in car) while he was chewing the gum.'

26	Subject	man strongly (beside elevator)	to oldman-PL	while (pro/he) was ride elevator DUR-became	body hit
		'The man strongly jostled the old men (beside the elevator) while he was getting into the elevator.'			
	Object	man-PL strongly (beside elevator)	to old man	while (pro/he) was ride elevator DUR-became	body hit-3PL
		'The men strongly jostled the old man (beside the elevator) while he was getting into the elevator.'			
27	Subject	mechanic deliberately (in garage)	from assistant-PL	while (pro/he) car-DOM fix DUR-did	admire did
		'Mechanic deliberately admired the assistants (in the garage) while he was fixing the car.'			
	Object	mechanic-PL deliberately (in garage)	from assistant	while (pro/he) car-DOM fix DUR-did	admire did-3PL
		'Mechanics deliberately admired the assistant (in the garage) while he was fixing the car.'			
28	Subject	clerk compulsorily (in office)	from manager-PL	while (pro/he) was with phone DUR-talk	goodbye did
		'The clerk compulsorily said goodbye to the managers (in office) while he was talking on the phone.'			
	Object	clerk-PL compulsorily (in office)	from manager	while (pro/he) was with phone DUR-talk	goodbye did-3PL
		'The clerks compulsorily said goodbye to the manager (in office) while he was talking on the phone.'			
29	Subject	customer again (in salon)	from stylist-PL	while (pro/she) was DUR-returned	thank did
		'The customer again thanked the stylists (in the salon) while she was turning around.'			
	Object	customer-PL again (in salon)	from stylist	while (pro/she) was DUR-returned	thank did-3PL
		'The customers again thanked the stylist (in the salon) while she was turning around.'			

30	Subject	customer mischievously (in restaurant)	to waiter-PL	while (pro/he) was below eyes look DUR-did	order did
		‘The customer mischievously ordered to the waiters (in the restaurant) while he was peeking.’			
	Object	customer-PL mischievously (in restaurant)	to waiter	while (pro/he) was below eyes look DUR-did	order did-3PL
		‘The customers mischievously ordered to the waiter (in the restaurant) while he was peeking.’			
31	Subject	girl accidentally (in front of-EZ house)	to old woman-PL	while (pro/she) was flower-PL-ra water DUR-gave	hello gave
		‘The girl accidentally said hello to the old women (in front of the house) while she was watering the plants.’			
	Object	girl-PL accidentally (in front of-EZ house)	to old woman-PL	while (pro/she) was flower-PL-ra water DUR-gave	hello gave-3PL
		‘The girls accidentally said hello to the old woman (in front of the house) while she was watering the plants.’			
32	Subject	woman finally (in kitchen)	to girl-PL young	while (pro/she) was cooking DUR-did	bell hit
		‘The woman finally called the young girls (in the kitchen) while she was cooking.’			
	Object	woman-PL finally (in kitchen)	to girl young	while (pro/she) was cooking DUR-did	bell hit-3PL
		‘The women finally called the young girl (in the kitchen) while she was cooking.’			