Working memory and relative clause attachment preferences in Turkish: An eye-tracking study*

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1. Introduction

Readers have to understand the grammatical structure of a sentence while they read in order to accomplish this task. Therefore, they have to analyze the grammatical structure of sentences and place the constituents in their nodes in the hierarchical structure of language. Readers have greater difficulty in the parsing of ambiguous sentences and literature of sentence parsing has focused on the way participants react to these ambiguous sentences.

Researchers agree on the fact that during sentence processing the processor uses syntactic, lexical, semantic, pragmatic information and general world knowledge. Frazier (1987) indicates that the debate is about when all these kinds of information are included into the sentence processing. This conflict resulted in the emergence of different sentence processing models.

Papadopoulou (2006) categorizes sentence processing models using several criteria each one referring to one major question about parsing: The first can be the type of processing, which can be either parallel or serial. The type of processing refers to what processor does when it encounters an ambiguous structure, which is open to more than one interpretation. Parallel processing refers to the simultaneous parsing of two or more possible structures; whereas, in serial processing the processor handles the possibilities one by one. If the first interpretation is not plausible it reanalyzes the input. The second criterion for the categorization of parsing models is the type of information used in the processes, which can be either modular or interactive. Modular models (the first and most eminent model is Garden-Path Model by Frazier 1987) suggest that only one type of information (e.g. syntax) can be used at once. For instance, a modular model may argue that the first parsing of the sentences uses only syntactic information and there is no role of semantics. It can only determine the way the second analysis will be conducted. Interactive models hold that more than one type of information can be used at once during the processing (Van Gompel & Pickering 2009). For example, semantic knowledge may interfere with the syntactic analysis (Pickering & Traxler 1998). The third is about whether parsing mechanisms are universal or not. Some models like Garden-Path advocate the universality of parsing mechanism while some others accept that there are cross-

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linguistic differences in sentence processing (Eysenck & Keane 2005). The latter indicates that parsing strategies are parameterized in languages. Another type of models presume that parsing strategies depend on personal experience and the parsing system learns to adopt the ways in which parsing had been carried out successfully before (the Tuning Hypothesis; Mitchell, Cuetos, Corley & Brysbaert 1995; Cuetos, Mitchell & Corley 1996).

Relative clauses (henceforth RC) which attach to a genitive construction as in (1a) create a global ambiguity; that is, the RC can attach either to the local or the non-local NP.

(1a) *The journalist interviewed* [$_{\text{local}}$ *the daughter*] *of* [$_{\text{non-local}}$ *the colonel*] *who had the accident.*

Contrary to the consistent findings of the studies in RC studies in English, which supported Garden-Path Model, Cuetos and Mitchell (1988) showed that RC attachment preference is for the non-local (higher in the tree) noun in Spanish. (1b) is the Spanish translation of (1a) which was shown to have local attachment preference.

(1b) *El periodista entrevistó a* [$_{\text{local}}$ *la hija*] *del* [$_{\text{non-local}}$ *coronel*] *que tuvo el accidente.*

Cuetos, Mitchell and Corley (1996) tried to explain this phenomenon but it failed to find enough support in the following literature (Papadopoulou 2006). However the findings of Cuetos and Mitchell started a number of studies in other languages. English, Norwegian, Romanian, Brazilian Portuguese, Arabic and Swedish have been shown to be low-attachment languages and French, Dutch, Russian, German, Spanish and Japanese were high-attachment languages (For references see Dinçtopal 2007: 30; Papadopoulou 2006: 13, Van Gompel & Pickering 2009)

The Unrestricted Race Model was proposed by Van Gompel, Pickering and Traxler (2000) reviewing several eye-tracking studies. The researchers combined the powerful aspects of modular and interactive models. According to the model, all kinds of information are available to the parser throughout the parsing as advocated by interactive models. However, contrary to interactive models, it proposes that processing is serial and only one syntactic structure is held in the memory until it is confirmed or disconfirmed in the disambiguated region. If the first analysis is disconfirmed than the re-analysis must be carried out. In order to test the predictions of the model, Van Gompel, Pickering and Traxler (2001) presented the participants with three kinds of sentences:

(2a) Globally Ambiguous: *The burglar stabbed only the guy with the dagger during the night.*

(2b) Non-local (VP) Attachment: *The burglar stabbed only the dog with the dagger during the night.*

(2c) Local (NP) Attachment: *The burglar stabbed only the dog with the collar during the night.*

(2a) has a global ambiguity because (a) the burglar may have stabbed a guy who had a dagger or (b) the burglar may have stabbed the guy and may have used a dagger for stabbing. (2b) and (2c) are open to only one interpretation; that is, they are not globally

ambiguous. In (2b), since the owner of the dagger cannot be the dog but the burglar, with the dagger can be attached to the verb (i.e. stabbed). In (2c) the owner of the collar cannot be the burglar or may not be related to the action. Therefore, with the collar is attached to the NP, i.e., the dog. Modular models predicts that the reaction times (henceforth RT) of (2b) must be slower than (2c) because non-local attachment is more costly than local attachment and RTs of (2b) must not differ from non-local attachment because there is already a plausible analysis in the first trial. According to the Constraint-Based model, (2b) and (2c) will not differ in their RTs because both result in a plausible analysis in the first reading because semantic information is also included as a guiding factor and (2a) will cause a high processing difficulty and slower RTs compared to (2b) and (2c) because the parser is left with two possible syntactic structures and has to reanalyze the sentence in order to choose one (MacDonald, Pearlmutter & Seidenberg 1994). The results of the study did not confirm either hypothesis. The RTs of the ambiguous sentences were faster than local and non-local attachment sentences and the RTs of local and non-local attachment sentences did not differ from each other significantly. Van Gompel et al. (2001) argue that in ambiguous sentences readers make use of readily available semantic and syntactic information but re-analysis sometimes required in local and non-local sentences. Traxler, Pickering and Clifton showed the same pattern using ambiguous and non-ambiguous RCs (1998, as cited in Van Gompel, Pickering & Traxler 2000).

Dinçtopal (2007) tested the reading comprehension performance with mono- and bilinguals of Turkish and English. Basically, Dinçtopal (2007) created six types of NPs to test the restricted and unrestricted frameworks with Turkish (first experiment). In first two cases (3a, 3b, 4a and 4b) of both animacy and inanimacy conditions meaning is only temporarily ambiguous, because the verb requires either an inanimate or animate subject, and depending on the type of verb, RC can be bound to either the first or the second NP.

(3) Animacy-Forced Condition

a. [RC *Geçtiğimiz ay öldür-ül-en*] / [NP_{local} *kitab-ın*] / [$NP_{non\text{-}local}$ *yazar-ı*] / *ünlü-ydü.*
last month kill-PASS-PART book-GEN author-3SGPOSS famous-PASTCOP
'The author of the book that was killed last month was famous.'
(NP non-local attachment forced)

b. [RC *Geçtiğimiz ay öldür-ül-en*] / [NP_{local} *yazar-ın*] / [$NP_{non\text{-}local}$ *kitab-ı*] / *ünlü-ydü.*
last month kill-PASS-PART author-GEN book-3SGPOSS famous-PASTCOP
'The book of the author that was killed last month was famous.'
(NP local attachment forced)

c. [RC *Geçtiğimiz ay öldür-ül-en*] / [NP_{local} *yazar-ın*] / [$NP_{non\text{-}local}$ *baba-sı*] / *ünlü-ydü.*
last month kill-PASS-PART author-GEN father-3SGPOSS famous-PASTCOP
'The father of the author that was killed last month was famous.'
(Globally ambiguous)

(4) Inanimacy Forced Condition

a. [RC *Maviye boyanan*] / [NP$_{local}$ *kaptanın*] / [NP$_{non\text{-}local}$ *gemisi*] / *muhteşem görünüyor.*
Blue paint-PART captain-GEN ship-3SGPOSS impressive see-PASS-IMPF
'The ship of the captain that was painted blue seems/looks impressive.'
(NP non-local attachment forced)

b. [RC *Maviye boyanan*] / [NP$_{local}$ *geminin*] / [NP$_{non\text{-}local}$ *kaptanı*] / *muhteşem görünüyor.*
Blue paint-PART ship-GEN captain-3SGPOSS impressive see-PASS-IMPF
'The captain of the ship that was painted blue seems/looks impressive.'
(NP local attachment forced)

c. [RC *Maviye boyanan*] / [NP$_{local}$ *geminin*] / [NP$_{non\text{-}local}$ *direği*] / *muhteşem görünüyor.*
Blue paint-PART ship-GEN pole-3SGPOSS impressive see-PASS-IMPF
'The pole of the ship that was painted blue seems/looks impressive.'
(Globally ambiguous)

The results indicated that the RTs were slower when the ambiguity was disambiguated towards animate NPs rather than inanimate NPs. RTs for non-local NPs attachment were greater. Dinçtopal (2007) argues that the pattern fits into the Unrestricted-Race Model. The processor takes into account all possible information in the initial analysis. If it proves to be incompatible, then reanalyzes the sentence. However, the observed difference between the RTs of local and non-local sentences does not fit into the predictions of the Unrestricted-Race Model. Dinçtopal argues that local attachment preference (shown with a questionnaire) facilitated local attachment.

Individuals differ in their levels of verbal working memory (henceforth WM). Due to their different levels of verbal WM, they may employ qualitatively of quantitatively different parsing strategies (Daneman & Carpenter 1980). The debate is not whether WM has an effect on sentence parsing strategies but whether and how WM and sentence parsing interacts. Just and Carpenter (1992) showed the effect of animacy in sentence parsing depends on verbal WM. Readers with high reading span used the cues of animacy during the first parsing while the participants with low reading span did not. The results of Just and Carpenter also indicated that people with high levels of verbal WM had faster RTs with ambiguous sentences, because they processed the information in a parallel fashion using the advantage of high capacity while participants with low verbal WM employed serial parsing strategy.

Traxler (2007) used sentences which are very similar to Dinçtopal (2007) in an eye-tracking study. However, he did not control the animacy feature but WM. In sum, the study differed in only two aspects: (1) He tested English speakers with English sentences (as opposed to Turkish), (2) He did not control for effects of semantics. The results indicated that readers with greater WM capacity had weaker preferences for the local attachment site, which is compatible with capacity-constrained accounts of parsing preferences and high-, low- and medium-span readers all took about the same amount of time to integrate the RC with the preceding context. However, when semantic information

dictated that the RC attached to the second noun, the high-span readers showed greater difficulty integrating the RC with the preceding context, whereas the medium- and low-span readers showed no such difficulty. Again, this is consistent with a capacity constrained preference on the part of the low- and medium-span readers. Preference to attach the RC to the first noun increased with increases in WM capacity. The results were also compatible with Unrestricted-Race Model.

We aimed to test Dinçtopal's findings (2007) with a different methodology and also control for individual WM differences. This study will make use of the sentence sets tested by Dinçtopal and will try to replicate the findings of Dinçtopal's experiment which showed that animacy-forcing conditions required less time. Hence, our first hypothesis is replicating the same pattern with eye movements. Dinçtopal also showed that high attachment was very costly for Turkish speakers while ambiguous sentences resulted in faster RTs. The second hypothesis is that high attachment condition must require longer fixation durations compared to other conditions. A drawback in Dinçtopal's methodology is that it fails to show how the first analysis is carried out. Eye-tracking studies can test if the parser can immediately use semantic information. In other words, if the parser can make use of semantic information, we should observe a difference between animate and inanimate attachment forcing conditions in the first reading. Since Dinçtopal showed inanimate condition to be more costly for the human parser, the third hypothesis was that this condition must result in slower RT even in the first reading.

Dinçtopal (2007) acknowledged as a limitation that she did not control for the individual WM differences. In the light of findings of Traxler (2007), the fourth hypothesis was that higher level of WM must be associated with higher number of regressions in ambiguous sentences and higher percentages of non-local attachment preferences compared to participants with lower levels of WM.

2. Method

2.1. Participants

Forty-six participants who were registered in Introduction to Psychology or Social Psychology (28 females and 18 males) courses and who were between 19 and 22 years (M_{age} = 21.28) participated in the study. They were given one or two credits in exchange for their participation according to the number of sessions they took part. Forty of them also participated the second session one week later. All participants were obliged not to wear eye make-up for the validity of the eye-tracking data and not to be wearing contact lenses or glasses in their daily life. Three participants were excluded from eye-tracking analyses due to loss of calibration.

2.2. Materials

2.2.1. WM Measurement

In their psychometric review, Waters and Caplan (2003) suggested to employ methodological plurality in WM measurement. All measures started at span two, consisted of five trials in each span and continued up to span size eight. A trial was accepted to be correct when all items were pronounced in the correct order. The criterion for moving to the next level was completing at least three out of five trials. When participants could not pass the span, the test was discontinued. In line with the suggestions of Waters and Caplan, the number of correct trials were used in all analyses.

2.2.1.1. Alphabet Span: The words with medium frequency (20–100/1000000) and two syllables were randomly selected from the work of Tekcan and Göz (2005). They were located in the trials and a trial did not consist of words beginning with the same sound. Participants were asked to listen to the words the experimenter says and put them in the alphabetical order. The Pearson correlation between first and second sessions showed a satisfactory reliability (r = 0,672, n = 40, p < 0,001; Anastasi & Urbina 1997).

2.2.1.2. Subtract Two: Numbers between two and nine were randomly assigned to trials. An number was placed only once within a trial. Participants were asked to subtract two from all the numbers the experimenter says and repeat them in the same order after the experimenter finishes. The Pearson correlation between first and second sessions showed a relation which approaches to high reliability (r = 0,768, n = 39, p < 0,001; Anastasi & Urbina 1997).

2.2.2. Eye-tracking

Eye-tracking materials were the same with Dinçtopal (2007) in order to be able test the replicability of her findings. All sentences were placed in one line in the middle (horizontally) of the screen, aligned to the left with a margin of 50 px and presented with Times New Roman 30 pts. With the purpose of checking whether participants read for the meaning, a question was asked after each sentence and the questions also measured the online attachment preferences in ambiguous sentences.

Forty-eight experimental and 60 filler sentences were used. One sentence was removed from analyses due to a spelling error. As shown in (3) a, b, and c, all experimental sentences had three versions (local attachment, non-local attachment and ambiguous) and a version is randomly assigned to one of three groups. In other words, every participant saw only one version of a sentence. Half of the experimental sentences required animacy like in (3) while the other half required inanimacy as in (4). Sentences were ordered randomly such that no more than two sentences of the same kind were repeated.

Gazes with a duration of longer than 40ms were accepted to be fixations and included into analyses. All sentences were divided into four regions: relative clause (RC), local NP, non-local NP and posterior region. The corresponding sentence and region were calculated for each fixation. These variables were calculated to be used in the analyses (Liversedge, Paterson & Pickering 1998):

- *First-Pass Reading Time (Gaze Duration):* The sum of all the fixations made in a region until the point of fixation leaves the region either to the left or to the right.
- *Total Fixation Time:* The sum of all the fixations made in the region, including those fixations made when re-reading the region.
- *Total Regression Ratio:* The percentage of trials in which the subject made a backward regression from a region during the whole trial.

We obtained a value for by calculating the median of data points in each sentence type and in each region. Sentences were disambiguated using the semantic information that was in the NPs of the genitive clause; i.e., second and third regions. If the participant has an attachment preference for the local noun, longer RTs are expected in the second region in non-local attachment type. Therefore, the second region was the critical region for non-local attachment type while the third region was the critical region for local and ambiguous conditions (Dinçtopal 2007).

2.2.3. Offline attachment preferences questionnaire

In order to be able to compare and replicate findings of Dinçtopal (2007) the same questionnaire was given to the participants. The questionnaire consisted of 26 sentences which had the same kind of structural ambiguity with eye-tracking sentences. Half of the sentences had genitive clauses of which both nouns were animate as in (5) and the other half inanimate as in (6). The questionnaire also contained 31 filler sentences. The items in the questionnaire were randomized such that sentences of the same type would not be repeated more than three times. As you can see in (5) and (6), questions with two choices were presented after the sentences.

(5) *Kafe-de otur-an kız-ın arkadaş-ı konuşkan birisi.*
Cafe-LOC sit-PART girl-GEN friend-3SGPOSS talkative person
'The friend of the girl who sits at a cafe is a talkative person.'

Kafede oturan kimdir?
'Who sits at the cafe?'

a) *kız* b) *arkadaşı*
a) girl b) girl's friend (the friend of the girl)

(6) *Ahşap-tan yapılan ev-in kapı-sı yan-ıyor.*
Wood-ABL make-PASS-PART house-GEN door-3SGPOSS burn-IMPF
'The door of the house that is made of wood is on fire.'

Ahşaptan yapılan hangisidir?
'Which one is made of wood?'

a) *kapı* b) *ev*
a) door b) house

2.3. Procedure and apparatus

All participants signed an informed consent form and filled a questionnaire about their demographic information. In the first session they participated in eye-tracking task, alphabet span and subtract two tests. In the second session they first took alphabet span and subtract two tests and later Dinçtopal's (2007) offline attachment preferences questionnaire. The participants who will not be able participate in the second session took the questionnaire in their first session.

Eye movements were recorded using a Tobii 1750 eye tracker (binocular sampling at 50Hz, with an accuracy 0.5 degrees, using a 17" TFT monitor with a resolution of 1280x1024 pixels). The data was processed by the ClearView 2.0 software and exported from the device. In the later analyses variables were calculated with Visual Basic for Applications which ran on Microsoft Office Excel 2007.

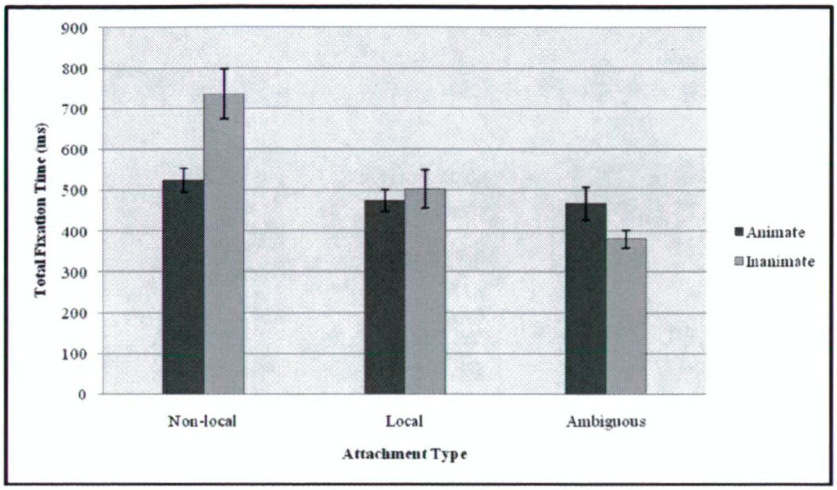
In the eyetracking task, the participants were seated around 60 cm away from the screen and fastened their heads on a chinrest. In order to calibrate the eye-tracking device for the eye of the participant, they were asked to follow a dot in the middle of a circle which moves on the screen. After obtaining an acceptable calibration, the instructions were presented orally and participants took a practice session with a design which matches that of the experimental session. A cross sign (+) appeared on the 50 px left margin for 500 ms and participants were instructed to fixate on it. This assured that all participants started to read to each sentences on the same region. After participants finished reading the sentence, they pressed the space key. Later they took a question about the meaning of the sentence. They answered the questions either by pressing the yes ("d") or no ("k") keys.

3. Results

The closest variable to Dinçtopal's (2007) RT measure is total fixation time in eye-tracking. In order to test the replicability of the findings, a 2 × 3 repeated measures ANOVA (Animacy [animate, inanimate] × Attachment Type [non-local, local, ambiguous]) was conducted. As you can see on Figure 1, there was a main effect for animacy ($F(1, 42) = 5.844$, $p = .02$, $MS_e = 28965.95$, $\eta^2_p = .122$). This main effect showed that total fixation time was shorter for animacy condition ($M_{animacy} = 488.236$, $SD_{animacy} = 213.59$) compared to inanimacy condition ($M_{inanimacy} = 539.465$, $SD_{inanimacy} = 300.766$, $F(2, 84) = 29.746$, $p < .001$, $MS_e = 32335.05$, $\eta^2_p = .415$). There was also a interaction effect between attachment type and animacy ($F(2, 84) = 11.769$, $p < .001$, $MS_e = 491583.373$, $\eta^2_p = .219$). All post-hoc pairwise comparisons yielded significant results. The longest total fixation time was observed in non-local attachment ($M_{non\text{-}local} = 630.221$, $SD_{non\text{-}local} = 332.073$) and local attachment followed it ($M_{local} = 487.721$, $SD_{local} = 167.844$). Ambiguous attachment had the shortest total fixation time ($M_{ambiguous} = 423.611$, $SD_{ambiguous} = 214.097$).

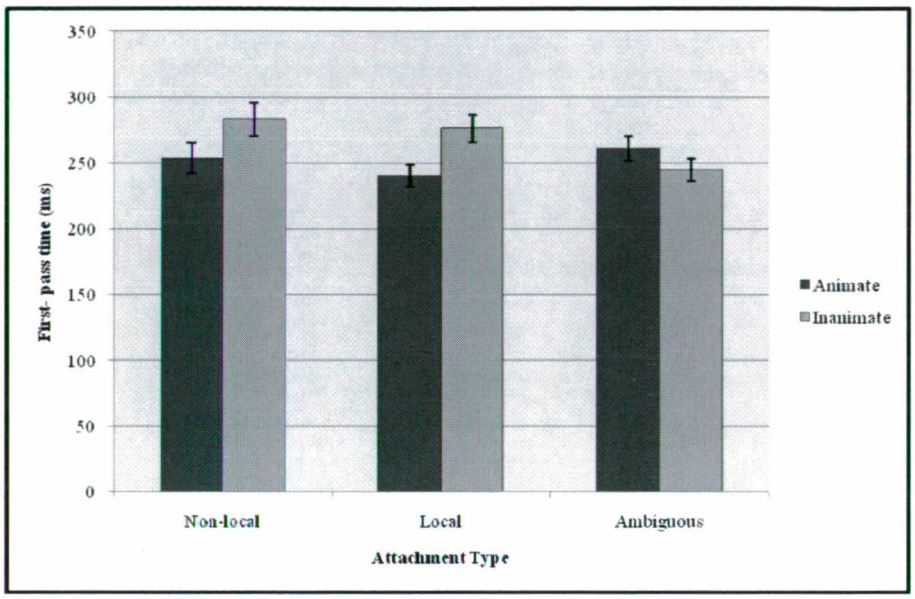
Figure 1. Total fixation time was higher in non-local and inanimate conditions.

In order to understand the nature of this interaction effect, animacy and inanimacy-



forcing conditions were contrasted with paired samples *t*-tests in each attachment type. Whilst animacy did not create a significant difference in local attachment ($t(42) = .989$, $p = .328$, $M_{animacy} = 473.767$, $SD_{animacy} = 177.103$, $M_{inanimacy} = 501.67$, $SD_{inanimacy} = 158.903$), inanimacy-forcing sentences had longer total fixation times in non-local attachment ($t(42) = 3.565$, $p = .001$, $M_{animacy} = 523.849$, $SD_{animacy} = 191.118$, $M_{inanimacy} = 736.59$, $SD_{inanimacy} = 404.321$) and shorter total fixation time in ambiguous attachment ($t(42) = 2.939$, $p = .005$, $M_{animacy} = 473.767$, $SD_{animacy} = 263.006$, $M_{inanimacy} = 380.128$, $SD_{inanimacy} = 21.417$). Two repeated measures ANOVAs with three levels (non-local, local, ambiguous) were used to investigate the interaction effect dividing by animacy conditions. Whereas there was no effect of attachment type within animacy-forcing condition ($F(2, 84) = 1.106$, $p = 0.207$, $MS_e = 25771.246$, $\eta^2_p = .037$), there was a significant effect in inanimacy-forcing condition ($F(2, 84) = 29.214$, $p < .001$, $MS_e = 48333.865$, $\eta^2_p = .41$). Post-hoc pairwise comparisons showed that the longest total fixation time was in non-local attachment condition and the shortest one was in ambiguous condition ($p < .001$ for all comparisons).

Figure 2. Animate and inanimate conditions differed in their first-pass time.



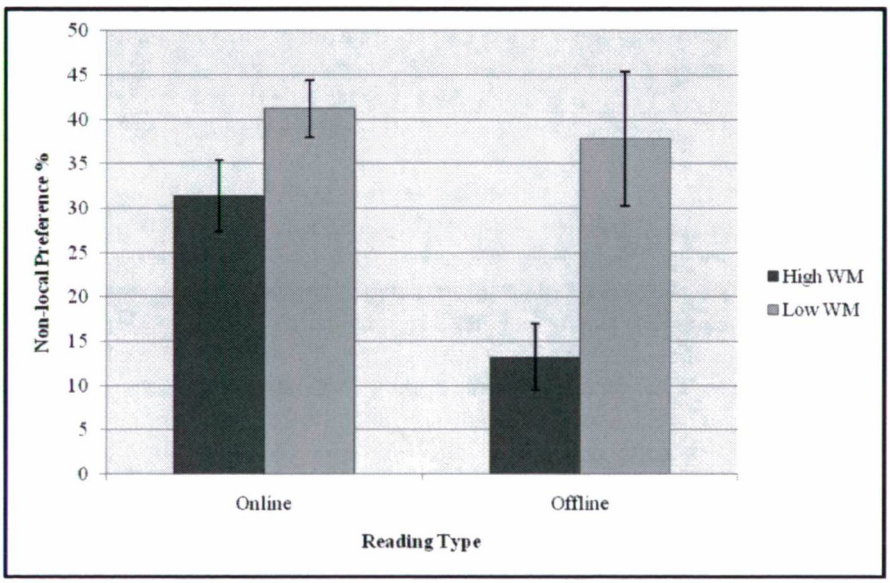
With the aim of testing whether the human parser used semantic information in its first analysis, we conducted a 2 × 3 repeated measures ANOVA (Animacy [animate, inanimate] × Attachment Type [non-local, local, ambiguous]) with the medians of first-pass reading time variable. As presented in Figure 2, there was a significant main effect of animacy ($F(1, 42) = 6.325$, $p < .016$, $MS_e = 2716.707$, $\eta_p^2 = .131$) and inanimacy-forcing condition ($M = 268.275$, $SD = 71.575$) required longer first-pass reading time than animacy-forcing condition ($M = 251.953$, $SD = 65.113$) . A significant main effect of attachment type was not detected. However, there was an interaction effect between animacy and attachment type ($F(2,84) = 4.615$, $p < .005$, $MS_e = 3102.981$, $\eta_p^2 = .118$). In order to reveal the nature of this interaction effect animacy and inanimacy-forcing conditions were contrasted within each attachment type with paired samples *t*-tests.

In local attachment type animacy-forcing condition ($M = 240.65$, $SD = 54.8$) had longer first-pass reading time compared to inanimacy-forcing condition ($M = 276.60$, $SD = 68.655$, $t(42) = 3.241$, $p = .002$). In non-local attachment type animacy-forcing condition ($M = 253.88$, $SD = 76.686$) showed shorter first-pass reading time which closes to significancy compared to inanimacy-forcing condition ($M = 283.221$, $SD = 83.004$, $t(42) = 1.985$, $p = .054$). In ambiguous attachment type, animacy-forcing condition ($M = 261.33$, $SD = 61.746$) showed higher first-pass reading time which again closes to significancy compared to inanimacy-forcing condition ($M = 245$, $SD = 56.172$, $t(42) = 1.905$, $p = .064$).

In order to test the fourth hypothesis which stated that participants with higher WM capacity would make more backward eye-movements, we conducted a Pearson correlation between WM scores and two types of ambiguous sentences. The correlations

did not reach significancy ($p > .115$). To test the same hypothesis, we also assigned participants into three groups according to their WM scores with cut-off points of 30th and 70th percentile and created groups which has the highest and the lowest WM scores. For the purpose of simplification, we summed regression ratios in animacy and inanimacy-forcing conditions. The comparison was conducted in the second ($M_{\text{high WM}}$ = .2, $SD_{\text{high WM}}$ = .3496, $M_{\text{low WM}}$ = .1364, $SD_{\text{low WM}}$ = .3233, $t(19) = .433$, $p = .67$), the third ($M_{\text{high WM}}$ = .2, $SD_{\text{high WM}}$ = .4830, $M_{\text{low WM}}$ = .2727, $SD_{\text{low WM}}$ = .7538, $t(19) = -.260$, $p = .798$) and the fourth ($M_{\text{high WM}}$ = 2.45, $SD_{\text{high WM}}$ = .7246, $M_{\text{low WM}}$ = 2.36, $SD_{\text{low WM}}$ = 1.185, $t(19) = 0.199$, $p = .840$) regions and there was no significant difference between the two groups.

Figure 3. Readers with high WM showed less non-local attachment preference.



The overall percentage of attachment preference was 40.4% in online reading. In offline reading the attachment preference for the non-local noun was 30%. In order to show the relationship between attachment preferences and WM capacity several Pearson correlations were calculated. The number of correct trials in alphabet span had a correlation of -.404 ($N = 42$, $p = 0.008$) with non-local preference percentages in online reading and correlation of -.427 ($N = 42$, $p = 0.004$) in offline reading. The number of correct trials in subtract two had a correlation of -.340 ($N = 42$, $p = .027$), with non-local preference percentages in online reading and a correlation of -.527 ($N = 42$, $p < .001$) in offline reading. As another test, WM groups were also compared. In online reading readers with the high WM ($M = .3142$, $SD = .1276$) capacity yielded t values which closed to significance ($t(19) = 1,953$, $p = .066$) in showing more local attachment preference compared to the low WM group ($M = .4121$, $SD = .1018$). In accordance with this pattern, in offline reading the high WM group ($M = .1320$, $SD = .1180$) showed less non-local

attachment preference ($t(19) = 2.939$, $p = .008$) compared to the low WM group ($M = .3782$, $SD = .2394$).

4. Discussion

In accordance with Dinçtopal's results (2007), the first hypothesis was that total fixation times in inanimacy-forcing condition must be longer than animacy-forcing condition. The second hypothesis was that total fixation duration would be higher in non-local attachment condition compared to other conditions. Both hypotheses were supported. Since an interaction effect between attachment type and animacy conditions was observed, the data was analyzed with post-hoc ANOVAs and *t*-tests. While animacy created an advantage in non-local attachment condition, it turned into a small disadvantage in ambiguous condition. Inanimacy-forcing conditions showed a significant difference from each other while this was not detected in animacy-forcing condition. Sentences which force non-local attachment and inanimacy had the highest total fixation time. Critical regions in ambiguous sentences were read faster than the ones in local attachment. In brief, Dinçtopal's results were replicated with eye-tracking.

Dinçtopal's (2007) methodology did not give any results about which types of information the human parser used in its first analysis. As interactive models suggested, the hypothesis that parser uses semantic information even in the first analysis was supported by showing that inanimacy-forcing condition resulted in longer first-pass durations.

The fourth hypothesis was that since participants with higher WM would be processing in parallel instead of serial, at the end of their first analysis they would be left with two possible interpretations and this would lead them to have make more regressions in ambiguous sentences than participants with lower WM. There was not a correlation between WM scores and regression rations. In fact, we failed to show that there was a difference between high and low WM memory groups in regression ratios.

Dinçtopal (2007) reported the percentage of non-local attachment to be 55% in online reading and 34% in offline reading. In this study, non-local attachment preference was 30%, which is quite close to the previous result. However, in online reading, we obtained 40% non-local preference, which is smaller than Dinçtopal's ratio. Dinçtopal explained the cause of the gap between online and offline reading with the possibility that participants may have felt a time pressure while reading online because they knew that computer was logging the time. Nevertheless, there was one significant difference between online and offline attachment preference data. In offline reading participants had two equal options while in online reading they had to accept or refuse the attachment pattern presented to them. To put it differently, they could choose the first interpretation in their mind in while reading offline. In online reading they may have shown a yea-saying bias because the interpretation presented to them to judge was also true. In one hand, the results of the questionnaire may have yielded better results, in the other hand because their preferences was consulted explicitly, they may have tried to be consistent in their answers.

Participants with higher WM were accepted to show higher percentages of non-local attachment preference. Contrary to the expectations, WM scores showed a negative corre-

lation with non-local attachment preference percentages and this pattern is also replicated with grouping analysis.

An important point to keep in mind about the experimental design is that in Turkish RCs can also be placed between local and non-local NPs like in (7) and in this case the only possible interpretation is the second NP, which does not leave room for any ambiguity.

(7) *Yazar-ın geçtiğimiz ay öldür-ül-en baba-sı*
Author-GEN last month kill-PASS-PART father-3SGPOSS
'Author's father who was killed last month'

Because Turkish does have this kind of an alternative structure to disambiguate the information, participants may have tended to show a preference for local attachment. Participants who had high motivation may have had higher WM scores and responded attachment preference questions with considering also alternative structures. In fact, people with higher WM may be more apt in considering these structures. This relationship may explain the association between high WM and local attachment preference.

As a second explanation to this association, one should remember that in prescriptive grammars of Turkish, non-local attachment may be considered to be a grammatically unacceptable due to ambiguity (Karahan 1997, pp. 13–22 ve Banguoğlu 1990). Considering the age range of participants, they may be more adhesive to their knowledge from highschool. Especially participants with higher motivation who are more likely to score higher on WM tests may have considered this kind of prescriptive grammar rules more seriously. In future researcher should also take the specifics and differences of Turkish into account.

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