Parallel Function Hypothesis revisited in the processing of Turkish relative clauses in adults*

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1. Introduction

The Parallel Function Hypothesis (PFH) Sheldon (1974) suggests that children use a strategy that assigns the same role to the co-referential NPs as their matrix clauses. That is, a complex NP that appears in an embedded clause is processed more easily when it has the same grammatical role both in the matrix and embedded clause compared to when it has different roles.

As far as relative clauses (RCs) are concerned, it predicts better performance in structures where the relativized head has the same grammatical role in the embedded clause and in the matrix clause. That is, a subject RC with the subject role (SS) or an object RC with the object role (OO) in the matrix clause should yield shorter reaction times (RTs) in processing than a subject RC with the object role (OS) and an object RC with the subject role (SO), respectively.

Sheldon (1974) suggests the same pattern should be observed in all languages regardless of their typological characteristics. In other words, it is predicted to be a universal heuristic for the parsing of complex structures that involve embedded clauses.

The PFH has been shown to work well for English (e.g., Sheldon, 1974; Grober, Beardsley, & Caramazza, 1978) but it has also received criticism (e.g., Hamburger & Crain, 1982; and Correa, 1982). Similarly, its cross-linguistic plausibility has been questioned (Hakuta, 1981 for Japanese; MacWhinney, 1989 for Hungarian; and Özcan, 1997 for Turkish). One common feature of the data from cross-linguistic studies is that they come from morphologically rich languages with variable word order. All of these studies focus on the offline end-sentence interpretation of these structures. They surely provide important insights into the general tendencies in those languages. Yet, it is hardly possible to single out the cause for the underlying pattern in those complex structures since a particular pattern could be due to a reason other than non-parallel roles in both clauses. Therefore, this hypothesis is revisited here with an on-line study with Turkish-speaking adults. We will focus on the participants' RTs during the critical phrase to see how the matrix role of the relativized head could influence processing complex sentences in Turkish and revisit Özcan (1997)'s comprehension data from Turkish children to see whether the pattern observed in adults could account for the child data.

Özcan (1997) investigated the effect of RC-Type in combination with the

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grammatical role of the relativized noun in the matrix clause. This study also compared the comprehension patterns of RCs in younger children (mean age = 3.5 and 5.5) with older children (mean age = 7.6). The results showed a significant effect of age on comprehension; the children's performance increased with age, but there was no significant effect of RC-Type or RC-Role. Although the hierarchy followed by older children was completely different from younger children (for more discussion see Özge, Marinis, and Zeyrek, 2009), the overall hierarchy was SS >[1] SO > OS > OO. That is, children seemed to perform better in an RC when it appeared as the subject of the matrix clause. This was true regardless of the type of the extraction.

Although Özcan (1997) showed that the PFH did not capture the pattern displayed by Turkish children, it omitted a discussion on possible reasons for the observed pattern. The present study aims to bridge this gap with online data from adult processing. We hypothesize that the finding reported in Özcan (1997) is largely due to the fact that all test items presented the RC as the first NP in the matrix sentence. This is a canonical position for subjects in Turkish so it might be the case that children assigned the sentence-initial complex NP the subject role ignoring the case marking cues on the relativized head NP. This reasoning seems to be warranted considering the Japanese data from Hakuta (1981), which showed that children performed better when the RC had the subject matrix role and it appeared sentence-initially while performing better when the RC had the object matrix role and it appeared as the second NP (i.e., a canonical position for the object) (henceforth: sentence-medial RCs). Below we address this issue with two experiments that vary the RC-Type (subject RC vs. object RC) and RC-Role (subject vs. object) within each experiment and the position of the RC (sentence-initial vs. sentence-medial) between experiments. Our first aim is to investigate whether or not the PFH makes correct predictions for Turkish adults. If Sheldon's predictions are right, RCs with the same roles between the RC and the matrix clause should be processed faster at the relativized head position compared to the RCs with different roles. The total listening times should also be consistent with this pattern. Our second aim is to see whether or not Hakuta's observations for Japanese children hold true for Turkish adults. If Hakuta's predictions are right, all sentence-initial RCs (regardless of the extraction type) with the subject matrix role should be processed faster at the relativized head position compared to the ones with the object matrix role, whereas all sentence-medial RCs with the object role should be processed faster than the ones with the subject role.

2. Experiment 1

2.1 Method

2.1.1 Auditory moving-window (self-paced listening) paradigm

We designed the experiments in the auditory moving-window paradigm devised by Ferreira, Anes, and Horine (1996). In this paradigm, participants press a button to unfold a pre-recorded spoken utterance over headphones segment by segment (in words or phrases) on their own pace.

The idea behind this paradigm is that the listening times between the onset of the segment and the next button press for each segment reflects the processing time attached

[1] '>' is used to indicate a better performance in the former than the latter.

to it, providing information about the processing load needed to combine each incoming speech segment into the previous structure.

2.1.2 Participants

Thirty-five undergraduate students from the Middle East Technical University, Ankara participated in the experiment. All were native speakers of Turkish.

2.1.3 Materials and design

We fully crossed the RC-Type (subject RC vs. object RC) with the RC-Role in a 2 X 2 factorial design. The stimuli consisted of 32 sentence-initial RCs divided equally among four sentence types (subject RCs with the subject role in the matrix clause -SS-, subject RCs with the object role in the matrix clause -OS-, object RCs with the object role in the matrix clause -OO-, and object RCs with the subject role in the matrix clause -SO-), as exemplified in (1) and (2).

(1)

a. SS: Subject RC with the subject matrix role

Segment 1	Segment 2	Segment 3	Segment 4
Haylaz goril-i	hızlıca it-en	güçlü aslan	yavaş fil-i
naughty gorilla-Acc	hard push-SRel	strong lion-Nom	slowelephant-Acc

Segment 5
öptü.
kissed
'The strong lion that pushed the naughty gorilla kissed the slow elephant.'

b. OS: Subject RC with the object matrix role

Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Haylaz goril-i	hızlıca it-en	güçlü aslan-ı	yavaş fil	öp-tü.
naughty gorilla-Acc	hard push-SRel	strong lion-Acc	slow elephant	kiss-Past

'The slow elephant kissed the strong lion that pushed the naughty gorilla.'

(2)

a. SO: Object RC with the subject matrix role

Segment 1	Segment 2	Segment 3
Haylaz goril-in	hızlıca it-tiğ-i	güçlü aslan
naughty gorilla-Gen	hard push-ORel-Poss3sg	strong lion-Nom

Segment 4	Segment 5
yavaş fil-i	öp-tü.
slow elephant-Acc	kiss-Past

'The strong lion that the naughty gorilla pushed kissed the slow elephant.'

b. OO: Object RC with the object matrix role

Segment 1	Segment 2	Segment 3
Haylaz goril-in	hızlıca it-tiğ-i	güçlü aslan-ı
naughty gorilla-Gen	hard push-ORel-Poss3sg	strong lion-Acc

Segment 4	Segment 5
yavaş fil	öp-tü.
slow elephant-Nom	kiss-Past

'The slow elephant kissed the strong lion that the naughty gorilla pushed.'

The test items were pseudo-randomized with 64 filler items and the task was divided into two sessions. We employed a between-group design: each adult participant completed only one of the two sessions.

All NPs in the stimuli were selected among animal names and all verbs were selected among agentive actions. To make sure each segment is long enough to provide enough processing time for the participants, each NP was preceded by an adjective and each verb was preceded by an adverb in all of the items.

The sentences were matched for number of words (11 for the test items and 8 for the control items), and all lexical items were controlled for the number of syllables: the mean number of syllables for the NPs was 1.94, 2.19 for the adjectives, 2.13 for the verbs and 3 for the adverbs.

A female native speaker read the stimuli in a soundproof speech booth. The sentences were recorded as a whole with normal prosody, segmented into phrases at their natural prosodic boundaries (e.g., [adjective + noun], [adverb + verb], etc.), and each segment was saved as a waveform file. A tone was added at the end of the last segment in each sentence to mark the end of the sentence. The stimuli were presented and controlled by an HP-Laptop. We used a button-box to gather the responses and the e-prime software (Schneider, Eschman, and Zuccolotto, 2002) to measure and record the RTs (i.e., the time between the onset of the phrase and the button-press).

2.1.4 Procedure

Each participant was tested individually in a quiet room. They were asked to press a button to listen to the segments on their own pace until they have completed each sentence. They were also required to answer a comprehension question upon the completion of each sentence in order to prevent strategy formation, conscious processing, or mechanical pressing of the push-button. This also ensured that they were listening to the sentences for meaning.

2.2 Results

We used a program,[2] which was written in Python to handle the data trimming without any unseen errors the alternative manual analysis might have caused (for the details of this process see Özge, 2010).

Here, we only focus on the critical segment (i.e., Segment 3) that reveals the effect of the RC-Role on processing.[3] We conducted a repeated-measures ANOVA with RC-Type (Subject, Object) and RC-Role (Subject, Object) as a within-subjects factors.

For Segment 3, the ANOVA did not reveal an effect of RC-Type $F(1, 34) = 2.19$, $p >$

[2] We thank Umut Özge for writing this program.

[3] Due to space limitations, we omit segment-by-segment analysis that provides information about how each segment was processed incrementally from the first segment onwards. See Özge (2010) for the full analysis and discussion of the data.

.1; but the effect of RC-Role was significant $F(1, 34) = 3.62$, $p < .05$. Pairwise comparisons with Bonferroni correction indicated that the participants showed shorter RTs when the relativized NP had the subject role (i.e., when the NP had a bare nominative case) in the matrix clause compared to when it had the object role (i.e., when the NP was marked with the accusative case). There was also no interaction between the RC-Type and RC-Role $F(1.34) = .01$, $p > .1$, which indicated that the effect we found in RC-Role was true for both RC-Types.

2.3 Discussion

We tested SS, OS, SO, and OO structures to evaluate the PFH, which predicted the following processing pattern SS < SO and OO < OS (i.e., shorter RTs or better performance in SS compared to SO and in OO compared to OS in Segment 3).

The participants showed the following pattern: SO < OO and SS < OS in the critical segment. This indicates that the PFH cannot capture the present data. The present results support the child data from Özcan (1997) and Hakuta (1981) regarding the finding that parallel roles did not facilitate comprehension in languages typologically different from English. The adults in this experiment performed just like children in Özcan (1997). This seems to be in line with our hypothesis considering the fact that all RCs appeared at the sentence-initial position in both studies. In an independent eye-tracking study with adults, Demiral, Kaya, Mungan, and Tekman (submitted) found very similar results to the ones we are reporting here, which ensures the fact that the auditory-moving window paradigm revealed comparable results to the eye-tracking paradigm.

However, unlike our present study, the study by Demiral et al. (submitted) is interested in whether the sentence-initial RCs would be assigned the subject role due to a universal strategy that assigns the first NP the subject role. Hence, they did not vary the position of the RC in the sentence. Given the data from Japanese children, our predictions are different from this study in that we predict that while the sentence-initial RCs will be assigned the subject role, sentence-medial RCs will be assigned the object role. Thus, according to our prediction, the tendency to assign the first NP the agent role is not necessarily due to a universal agent-first strategy but it may be due to the canonical word order of Turkish. It is hardly possible to answer this question with the design that does not vary the position of the RC within the matrix clause. Experiment 2 tests the structures locating RCs in the object position to test our predictions that derive from Hakuta's offline findings.

3. Experiment 2

3.1 Method

3.1.1 Participants

The same participants reported in Experiment 1 participated in this experiment.

3.1.2 Materials and design

Similarly to the previous experiment, we crossed the RC-Type (Subject vs. Object) and RC-Role in the matrix clause (Subject vs. Object) using the same auditory moving-window paradigm. In the previous experiment, all RCs appeared sentence-initially whereas in the present one they appeared as the second NP, as exemplified in (3) and (4).

(3)

a. SS: Subject RC with the subject matrix role

Segment 1	Segment 2	Segment 3	Segment 4
Yavaş fil-i	haylaz goril-i	hızlıca it-en	güçlü aslan
slow elephant-Acc	naughty gorilla-Acc	hard push-SRel	strong lion-Nom

Segment 5
öp-tü.
kiss-Past
'The strong lion that pushed the naughty gorilla kissed the slow elephant.'

b. OS: Subject RC with the object matrix role

Segment 1	Segment 2	Segment 3	Segment 4
Yavaş fil	haylaz goril-i	hızlıca it-en	güçlü aslan-ı
slow elephant-Nom	naughty gorilla-Acc	hard push-(y)An	strong lion-Acc

Segment 5
öp-tü.
kiss-Past
'The slow elephant kissed the strong lion that pushed the naughty gorilla.'

(4)

a. SO: Object RC with the subject matrix role

Segment 1	Segment 2	Segment 3
Yavaş fil-i	haylaz goril-in	hızlıca it-tiğ-i
Slow elephant-Acc	naughty gorilla-Gen	hard push-ORel-Poss3sg

Segment 4	Segment 5
güçlü aslan	öp-tü.
strong lion-Nom	kiss-Past

'The strong lion that the naughty gorilla pushed kissed the slow elephant.'

b. OO: Object RC with the object matrix role

Segment 1	Segment 2	Segment 3
Yavaş fil	haylaz goril-in	hızlıca it-tiğ-i
Slow elephant-Nom	naughty gorilla-Gen	hard push-ORel-Poss3sg

Segment 4	Segment 5
güçlü aslan-ı	öp-tü.
strong lion-Acc	kiss-Past

'The slow elephant kissed the strong lion that the naughty gorilla pushed.'

The test stimuli consisted of 32 RCs: they appeared as the second NP in the matrix clause and they were divided equally among four sentence types (i.e., SS, OS, OO, and SO).

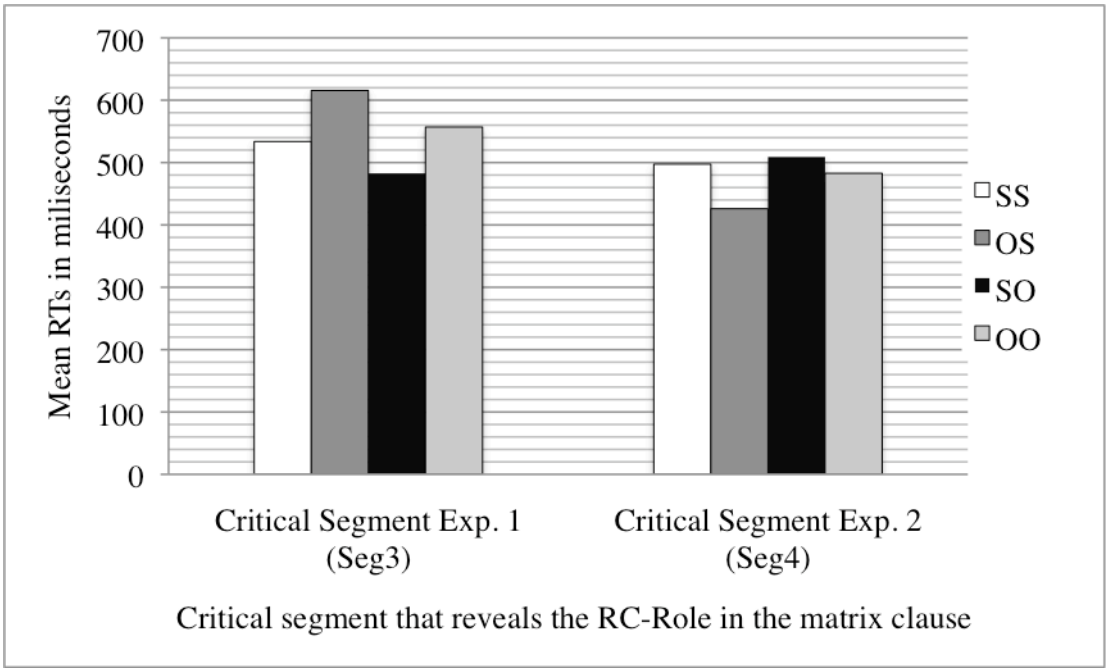
3.1.3 Procedure

The procedure was the same as described in Experiment 1.

3.2 Results

The relativized head in Segment 4 was the critical segment in this experiment. The case marking cues on the head noun revealed the role of the RC in the matrix clause. Figure 1 displays the mean RTs for the critical segment in Experiment 1 and Experiment 2.

Figure 1: Mean RTs for the critical segment in Experiment 1 and Experiment 2



We conducted a repeated-measures ANOVA, with the RC-Type (Subject, Object) and RC-Role (Subject, Object) as within-subject factors for this segment. This revealed a significant effect of RC-role $F(1,35) = 4.91$, $p < .05$. Pairwise comparisons indicated that participants showed shorter RTs when the RC was marked in the accusative case compared to the nominative case, which demonstrates that Turkish speakers expect the sentence-medial RC to be in the object role since the RC appears as the second NP in the matrix clause. Recall that the same adult participants showed shorter RTs if the RC was marked in the nominative case compared to the accusative case when it appeared sentence-initially (i.e., they expected the sentence initial RC to be in the subject role). Thus, the pattern presented in the experiment reported in Experiment 1 was SS < OS and SO < OO whereas it was OS < SS and OO < SO in the present experiment. The statistics did not reveal a significant effect of RC-Type or an interaction between the RC-Type and the RC-Role.

Finally, to see whether the effect of the position of the RC (sentence-initial vs. sentence-medial) would be reflected in the total RTs, we conducted a separate repeated-measures ANOVA for each RC-Type from the two experiments with the RC-Role (Subject/Object) and RC-Location (Sentence-initial vs. Sentence-medial) as a within-subjects factor.

The pattern revealed for both RC-Types was exactly the same: we did not find an effect of RC-Role (subject RCs: $F(1, 33) = .002$, $p > .05$; object RCs: $F(1, 33) = 2.39$, $p > .05$) or RC-Location (subject RCs: $F(1, 33) = 3.02$, $p > .05$; object RCs: $F(1, 33) = .14$, $p > .05$) but we found a significant interaction between the two (subject RCs: $F(1, 33) = 2.27$, $p < .05$; object RCs: $F(1, 33) = 5.32$, $p < .05$). The pairwise comparisons with Bonferroni correction indicated that this interaction was due to the fact that RCs (both subject and object) with the subject role had shorter RTs when they appeared at the sentence-initial position while the RCs with the object role had shorter RTs when they appeared as the second NP (i.e., sentence-medial).

3.3 Discussion

RTs in the critical segment demonstrated that the participants tended to assign the object role to the RCs that appeared as the second NP in the matrix clause. In Experiment 1, they interpreted sentence-initial RCs as the subject of the matrix clause. This indicates that the parser takes into account the position of the RC in the matrix clause while assigning it a role. When a relativized NP appears as the first NP in the matrix clause, it is more likely to receive the subject role; when it appears as the second NP, it tends to receive the object role.

4. General Discussion and Conclusion

This study presented two experiments to test the PFH, according to which the processing of a complex structure would be easier when the syntactic role of the NP in the embedded clause is the same in the matrix clause, compared to the cases when it has different roles in each clause. Both experiments failed to support the PFH: Experiment 1 showed that the RC is assigned a subject role when it appeared as the first NP in the sentence and Experiment 2 showed that it is assigned the object role when it appeared as the second NP in the sentence.

The results from these studies also provided a reasonable account for children's performance in Özcan (1997): they most probably performed better in RCs when they had the subject matrix role because all RCs in the experiment appeared in the sentence-initial canonical subject position. The same was observed in Demiral et al.'s (submitted) study most probably due to the same reason. The present study extends the effect of word order and shows that RCs that appear in the canonical object position are assigned the object role regardless of the case marking on the head NP.

This is in line with the pattern displayed in Hakuta's (1981) off-line act-out task. It appears that word-order cues guide interpretation better than the parallel-role cues in languages with variable word order such as Turkish and Japanese.

However, Hakuta (1981) also claimed that configurational features of Japanese provide better contribution to parsing compared to morphosyntactic cues. Had these cues been as effective as word order in guiding the role assignment, the findings would have revealed no effect of RC-Role. To illustrate, having heard an NP-ACC sentence-initially, the participants should have formed an expectation for another NP that is in the subject role and they should have assigned the RC a subject role. Similarly, having heard a sentence-initial nominative NP, the participants should have predicted a second NP with the accusative case and they should have assigned the RC the object role. This was observed neither in Hakuta's nor in our experiment.

Nevertheless, we think that the conclusion that word order is a better determinant

than morphosyntax is too broad a generalization with the following reasoning. In the present experiments, the participants dealt with complex NPs composed of an RC. That is, the processor is expected to assign a role for the relativized NP that is preceded by two other NPs. It has to keep these NPs and one relativized verb in memory before assigning a role to the relativized NPs. Therefore, we suggest the participants' inability to use the case marking cues on the sentence-initial NPs might be related to the fact that the processor realised the existence of a complex NP earlier than the head NP (most probably during the relativized verb) and assigned a provisional role to this NP and failed to revise this interpretation due to the processing cost arising from the number of arguments in these structures.

The present study reported online data from Turkish-speaking adults to bring an explanation for the offline effects observed in the child language acquisition literature in head-final languages (i.e., Hakuta, 1981 and Özcan, 1997). Further studies are required to show whether the effects reported for adults would also be observed in the online processing of Turkish RCs in children, which is extensively addressed in Özge (2010).

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List of abbreviations

OO: Object RC with the object role
OS: Subject RC with the object role
RCs: Relative clauses
SDH: Structural Distance Hypothesis
RTs: Reaction times
SO: Object RC with the subject role
SS: Subject RC with the subject role