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Processing of Relative Clause Structural Ambiguity by Iranians' Japanese Learners - From the Perspective of the Effect of L1 and the Animacy of the Head Nouns on L2 Sentence Processing -

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Abstract

This study investigates the processing of structurally ambiguous relative clause (RC) constructions in Japanese by Persian-Japanese learners, examining the influence of their native language (L1) on second language (L2) processing. It challenges the universality of parsing strategies through a self-paced reading (SPR) task. The results indicate a preference for High Attachment (HA) and a stronger tendency towards NP-high when it's an animate noun, in both Persian and Japanese. Descriptive analyses further revealed a shift from Low Attachment (LA) to HA among native Japanese speakers, suggesting unforced revision. However, there was an absence of a clear animacy effect on their preference. These findings suggest parallel interactive mechanisms in sentence processing and the transfer of syntax and semantic information from L1 to L2. Moreover, the study underscores language-specific differences in sentence processing, emphasizing the impact of language dominance in cross-linguistic transfer and contributing to our understanding of bilingual sentence processing.

Keywords: relative clause attachment preference, L2 sentence processing, animacy, psycholinguistics

Introduction

Reading a sentence, both the semantic and syntactical structure of a sentence and its arguments contribute to the reader's final comprehension. When two possible readings are involved in sentence interpretation, these sentences are ambiguous. In cases of structural ambiguity, the language's grammar allows for assigning two distinct structures to the same sequence of words, however, each word is not ambiguous. The relative clause (RC) attachment ambiguity, as exemplified in (1) in English (Cuetos & Mitchell, 1988), is a type of structural ambiguity that has been a dominant topic in first-language (L1) and second-language (L2) language processing studies.

1) Someone shot the servant of the actress who was on the balcony.

This ambiguity arises when deciding whether the RC modifies the first noun phrase (NP-high) or the second noun phrase (NP-low). Both NPs “the servant” and “the actress” are semantically and structurally potential to be the person on the balcony. High Attachment (HA) occurs when the RC attaches to NP-high, while Low Attachment (LA) involves attaching it to NP-low. This study aims to explore RC attachment ambiguity resolution in L1, Persian, and L2, Japanese.

Literature Review

Humans use parsing strategies to resolve structural ambiguities by choosing which syntactical structure is preferred. An ongoing question in the field of psycholinguistics is whether the parser uses a universal parsing strategy that is common among all natural languages or if different parsing models are being used in each language specifically. There are two contrasting types of parsing models: serial modular models and parallel interactive models. The former suggests that humans analyze sentences step by step, sequentially. However, the latter suggests that language analysis happens in a parallel and interactive manner, which means that different kinds of information interact with each other simultaneously to process a sentence.

Serial modular models have long been the dominant viewpoint, supporting the idea that all natural languages are processed universally in the same way by sticking to a single analysis based on syntactic principles such as late closure [1](Frazier 1979). The common ground among these principles is being economically efficient by reducing cognitive effort, “a principle of economy” (Kırkıcı 2004). This involves giving preference to existing, simpler, or initial syntactic structure until there’s evidence to the contrary.

Crosslinguistic differences in attachment preferences were identified in various studies, with Cuetos and Mitchell (1988) pioneering this exploration. In the offline questionnaire study, they discovered that English native speakers tend to attach

[1] Late closure assumes that comprehenders attach incoming new content to the phrase or clause currently being processed when it is feasible (Frazier, 1979).

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the RC to the NP-low, the currently parsed NP, typically exhibiting a late closure principle. Conversely, Spanish native speakers favored HA by attaching RC to the NP-high. This necessitated proposing parsing strategies that could account for these crosslinguistic differences.

Gibson, Pearlmutter, Canseco-Gonzalez, and Hickok (1996) proposed late closure and predicate proximity as parsing principles that are related to each other and lead to LA and HA preferences respectively. According to the predicate proximity, attachments, including RCs, tend to be positioned as close as possible to the main predicate in a sentence. It suggests that the distance between a verb and its arguments influences the strength of predicate proximity. In languages with larger average distances between verbs and arguments, like VOS, VSO, SOV, and OSV languages, predicate proximity is more strongly activated, overshadowing the late closure principle's impact. Moreover, the predicate proximity is activated in non-configurational [2]languages (e.g., Turkish, Persian, Spanish) with non-rigid word order.

More studies investigating RC attachment preferences in several other languages revealed a HA preference in Korean (Miyao & Omaki, 2006), Greek (Papadopoulou & Clahsen, 2003), Arabic (Bidaoui, 2016), Persian (Marefat & Meraji, 2005; Arabmofrad & Marefat, 2008) and so on. On the other hand, LA preference was found in, Norwegian, Swedish, and Romanian (Ehrlich, Fernandez, Fodor, Stenshoel & Vinereanu, 1999), Turkish (Kırkıcı, 2004), Chinese (Kwon, Ong, Chen & Zhang, 2019) and so on. These findings provide even stronger evidence that "at least some parsing strategies are language-specific rather than universal" (Papadopoulou & Clahsen, 2003).

Differences in processing behaviors exist not only between languages but also within a single language and among individuals. Gilboy, Sopena, Clifton, and Frazier (1995) further explored this by focusing on English and Spanish, suggesting that parsing principles like late closure may not universally apply across all types of phrases within a language. Spanish showed a stronger preference for attaching RCs to NP-high than English. However, the differences were not as significant as in Cuetos and Mitchell's study. Gilboy et al. (1995) argued that late closure and similar parsing principles are specific to certain classes of phrases within a language. Within-language differences in attachment preferences were notable, influenced by factors such as the presence or absence of a determiner inside the complex NP. If a determiner is absent for an NP, there is a reduced tendency to attach an RC to that NP.

It should be noted that the experimental method, meaning whether it is an online experiment conducted over the Internet that occurs in real-time or an offline experiment conducted in a laboratory setting without the use of the Internet, influences attachment preferences in globally ambiguous sentences within a language as well. For instance, participants in Kamide and Mitchell (1997) preferred HA in the offline questionnaire study, and on the contrary, preferred LA in the online SPR study within the same language (Japanese).

Furthermore, semantical factors like the animacy of the NPs also play a role. It was confirmed that the order of the animacy of the NPs affects the RC attachment preferences in Chinese (Kwon et al., 2019) and Persian (Zare, 2021). In that sense, they tend to attach the RC to the animate NP, highlighting ranked-parallel interactive models that indicate the interactive nature of language processing.

Furthermore, individual differences impact how comprehenders resolve attachment ambiguities in both L1 and L2 processing. Factors like age, language proficiency, and working memory capacity (WMC) play crucial roles. Some studies suggest a preference for LA due to recency and late closure principles, reducing cognitive load. However, recent research challenges this, indicating that individuals with low WMC tend to prefer HA (Swets, Desmet, Hambrick, & Ferreira, 2007; Cotter & Ferreira, 2023). Additionally, high reading span individuals show longer processing times, maintaining multiple interpretations at the same time (Pearlmutter & MacDonald,1995).

Research on the relationship between L1 and L2 in processing RC attachment preferences has produced two types of results. Fernandez (2002) distinguishes between language-independent behavior, where attachment preferences remain consistent across languages, and language-dependent behavior, where processing behaviors vary depending on the language being used. Language-independent behavior may result from the transfer from L1 to L2, causing native-like preferences (Bai, 2019; Fernandez, 2002), or the attrition of L1 due to high proficiency in L2 (Marefat & Farzizadeh, 2018). Conversely, language-dependent behavior involves different attachment preferences in different languages. In this case, L2 performance is independent of that in L1, and they either show no attachment preference in L2, consistent with the shallow structure hypothesis (SSH) [3] (Papadopoulou & Clahsen, 2003; Miyao & Omaki, 2006) or show a preference that was entirely different from that in their native language and more similar to the target language (L2), resulting in a target-like preference (Bidaoui, 2016).

Sentence Processing in Persian and Japanese

Persian language Properties Persian sentences are written from right to left. In both affirmative sentences and relative clauses, Persian has an SOV (subject + object + verb) word order, similar to Japanese, where the verb is located at the end of the sentence. However, this word order is not rigid, and

[2] Kırkıcı (2004) further classified languages into "non-configurational languages", in which word order is relatively free, and "configurational languages", marked by rigid word order, to explain when predicate proximity strongly influences attachment preferences.

[3] Clahsen and Felser (2006) in order to account for the lack of a native-like process in L2 provide a hypothesis called the shallow structure hypothesis (SSH). SSH suggests that "the syntactic representations adult L2 learners compute for comprehension are shallower and less detailed than those of native speakers".

Persian grammar allows the word order of SVO, VOS, VSO, OSV, and so on as well.

In Persian, the word order within NPs follows the pattern of modifiers preceding head nouns which is different from the Japanese noun order. When a word is modified by the following modifier, a linking element called "ezāfe" (EZ) = -(y)e[4] is inserted between them. In essence, ezāfe is an unstressed /e/ at the end of a noun, personal pronoun, or adjective when they serve as modifiers for another noun" (Takehara & Jahedzadeh, 2020). It is a short vowel and it is not explicitly written in characters. However, it can be indicated by the diacritical mark "kasra" (ِ).

Regarding the word order in Persian, Jun (2003) indicates that Persian is a head-final language as the verb comes at the end of a sentence, similar to Japanese, but with the head noun preceding the RC, similar to head-initial languages like English. It features prenominal RCs, similar to English, in which they follow the pattern of head noun preceding the RC. That is, they appear after the noun they modify. Persian RC structure lacks relative pronouns like "who," "which," and "whom" in English. RCs in Persian are introduced by a relative complementizer "ke." The usage of "ke" is mandatory before an RC and it does not agree with any elements of a sentence in terms of animacy, number, or gender.

Additionally, in Persian, when additional modifiers or clauses are attached to a noun, limiting its meaning, an unstressed enclitic marker "-i" is affixed to the antecedent noun.

Relative Clause Attachment in Persian In an RC structure with two NPs lacking an enclitic marker-i, ambiguity arises as the RC can attach to either NP. The presence of an enclitic marker-i after the second NP serves as a disambiguating element, indicating that the RC modifies that NP (LA), compelling the interpretation of the RC as a modifier of the second NP (NP-low). Therefore, the Persian translation of the globally ambiguous sentence (1) without an enclitic marker-i is exemplified in Example (2).

2) شخصی خدمتکار بازیگر که در بالکن بود را زد

Shakhsi khedmatkar-e bazigar ke dar balcon bud ra zad

Someone servant-EZ actress who LOC balcony is-PAST ACC shoot-PAST

"Someone shot the servant of the actress who was on the balcony."

Persian, with an SOV word order, structures RCs after NPs, with a complementizer preceding the RC. Similar to English, upon inputting the complementizer, both NPs are recognized, allowing the RC to attach to either. Persian exhibits a strong preference for HA, particularly when NP-high is animate (Zare, 2021). This preference aligns with the predicate proximity principle proposed by Gibson et al. (1996), emphasizing attachment to the NP directly related to the main predicate's main verb (NP-high in Persian).

Moreover, Kırkıcı (2004) suggested that the Gricean maxim of quantity[5], which recommends speakers provide an appropriate quantity of information, could explain attachment preferences in Turkish. Similarly, in Persian, a similar logic can be applied based on the existence of the enclitic marker-i. If the marker attaches to the second noun, it enforces LA. Given that Persian has an unambiguous LA structure, which could have been used but wasn't, participants might have interpreted globally ambiguous structures as indicating HA instead.

Relative Clause Attachment in Japanese Japanese, on the other hand, is a head-final language, where RCs are positioned before the NPs. In structurally ambiguous sentences with RCs in Japanese, there is no relative pronoun indicating that it is an RC. The word order inside the complex NP is as the NP-low (the actress) precedes the NP-high (the servant) which is the opposite of that in English.

In a sentence like (3), the RC "barukonii-ni iru" appears first, followed by NP-low "joyuu" and then NP-high "mesitukai". Therefore, at this point, "joyuu" is initially interpreted as the head of the RC because there are no other options and the NP-high has yet to come. Subsequently, with NP-high input, ambiguity arises, and at the end of the sentence, "the servant" is interpreted as the host of the RC (HA). In other words, the parser revises the initial preference while it is grammatically correct, i.e., it is referred to as an unforced revision[6] (Yamada, Arai & Hirose, 2017). Due to this, Yamada et.al., (2017) suggested avoiding using the term "attachment" for head-final languages like Japanese and instead offered the term "association". Because both potential sites (NP-low and NP-high) are available after NP-low is initially associated with the RC as its head noun, due to the word order.

3) 誰かがバルコニーにいる女優の召使をうった。

Dareka-ga barukonii-ni iru joyuu-no mesitukai-o utta.

Someone-NOM balcony-LOC is actress (NP-Low)-GEN servant (NP-High)-ACC shot

"Someone shot the servant of the actress who was on the balcony."

[4] Ezafe is pronounced as /e/ when it follows a consonant and /ye/ when it comes after a vowel

[5] The term "the Gricean maxim of quantity" was originally introduced by philosopher H.P. Grice in his work titled "Logic and Conversation" (Grice, 1975).

[6] Kamide and Mitchell (1997) categorized RC ambiguity resolution in head-final languages into two accounts: nondeterministic and deterministic accounts. According to their proposal, nondeterministic accounts anticipate LA initially, transitioning to a preference for HA. In contrast, deterministic parsers predict a consistent preference for LA both initially and as a final judgment.

Methodology

Research Question

The current study targets Japanese language learners, whose native language is Persian, as well as Japanese native speakers, who are considered as both a control group and a target group. It attempts to answer the following two questions in the context of L1 and L2 relations.

1. To what extent does the predicate proximity principle in Persian influence the interpretation of Japanese sentence counterparts among Persian native speakers, considering the differences in word order between Persian and Japanese?

2. How does the influence of animacy on RC attachment preferences in Persian, as identified in Zare (2021), manifest in the interpretation of Japanese RC attachment by both Japanese native speakers and Persian-Japanese learners?

Experiments

Two participant groups engaged in an online self-paced reading task. The first group, 27 Iranian native Persian speakers learning Japanese in their adulthood, participated in both languages (Persian and Japanese), enabling a comparison of language processing in L1 and L2. Reading Time (RT) data from 25 subjects ($M_{(age)}$ = 29.25, *SD* = 4.53, *Range* = 24-343) were used in this study. Data from two subjects had to be eliminated before data analysis due to outliers. Two participants appeared to read the Japanese sentences superficially, randomly pressing the space button to proceed without engaging with the content. Their reading times were notably shorter than in their native language, and their incorrect response rate exceeded 40%, indicating a lack of attention to the meaning of the Japanese sentences.

Regarding their Japanese proficiency, all participants have taken the Japanese Language Proficiency Test (JLPT)[7] and they achieved proficiency in one of the JLPT levels (N3, N2, or N1) with a total score of 117.52 out of 180. Their Japanese reading section scores were also considered. Participants self-evaluated their reading proficiency, indicating a relatively high mean of 6.79 (*SD* = 1.66) on a scale of 1 to 10. The mean time they spent learning Japanese is 8.12 years, with a standard deviation of 3.60. The overall results indicated relatively high proficiency in Japanese.

The second group, 29 native Japanese speakers ($M_{(age)}$ = 22.26, *SD* = 3.16, *Range* = 18 - 30), served as a control, participating solely in Japanese.

A questionnaire on Google Forms gathered personal and background information covering age, gender, education, language learning experience, proficiency, and other languages spoken.

The self-paced reading task, hosted on PCIbex, measured reading time (RT). Materials were manipulated based on semantics congruency (forced HA vs. forced LA), and NP animacy (animate-first vs. inanimate-first) conditions, as shown in (4) (English translation[8]). Each sentence was presented in four conditions, with four regions for participant viewing. If either HA or LA is preferred, the RT in the critical region is expected to be shorter in the preferred condition. The critical region is considered where the disambiguation clue exists and is the moment where readers can resolve the ambiguity. Although the word order in Persian and Japanese varies, the critical region in both languages is region 2. In Japanese, region 2 presents both NPs after reading the RC in Region 1, allowing readers to see both NPs simultaneously. In Persian, however, after recognizing the NPs in Region 1, the RC appears in Region 2, where readers can identify which noun is modified by the RC (refer to Tables A1 and A2).

Each language had 48 target sentences (12 sets with 4 conditions each) and 12 fillers (unambiguous sentences with a single NP modified by an RC). Participants viewed 12 sentences, encompassing all four conditions, randomly reading three sentences per condition in each language. Participants were asked to read the sentences carefully and at their own natural pace.

4)

HA, Inanimate-Animate: The restaurant of the chef / that has become less crowded / soon / will be closed.

HA, Animate-Inanimate: The chef of the restaurant / that burnt the food / today / was angry.

LA, Inanimate-Animate: The restaurant of the chef / that burnt the food / soon / will be closed.

LA, Animate-Inanimate: The chef of the restaurant / that has become less crowded / today / was angry.

All the sentences in both the Japanese and Persian parts were followed by a yes-or-no question about the content of each sentence to check if the participants paid attention to the content of the experimental sentence.

Results

Results showed exceptionally high accuracy, indicating attentive and careful reading among all participants (L1 Persian = 99.63%, L2 Japanese = 96.92%, L1 Japanese = 99.63%).

To analyze the RC attachment preference and animacy effects in Persian, first RT data from Persian-Japanese learners was examined. Linear Mixed-Effects (LME) model, considering attachment (HA vs. LA) and animacy of NPs (animate-first vs. inanimate-first) as two fixed effects, and participants as a random effect, was conducted on reading times, using Jeffreys's Amazing Statistics Program (JASP). As no significant differences were observed in Regions 1, 3, and 4, only the results for Region 2 (critical region) were reported. Estimated coefficient (β), standard error (*SE*), *t* values, and *p* values are shown.

The result from L1 Persian revealed that in Region 2 there is a significant main effect of both predictor variables, attachment (β = 167.11, *SE* = 57.28, t = 2.91, $p < .05$) and

[7] The JLPT has five levels: N1, N2, N3, N4, and N5, ranging from the most difficult level to the easiest respectively.

[8] Refer to table A1 and A2 for original Persian and Japanese version of experimental sentences examples.

animacy (β = 144.53, SE = 57.28, t = 2.52, p < .05). However, the interaction was not significant (p =.24). In other words, significant differences in RT between HA and LA and between animate-first and inanimate-first conditions exist.

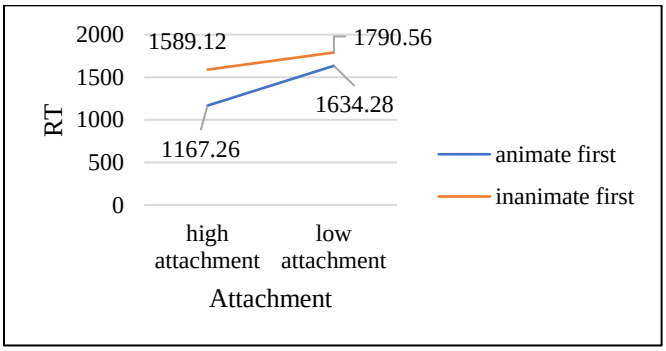

Figure 1: L1 Persian Region 2 RT in Four Conditions

As the statistical analysis and Figure 1 revealed, mean RT comparisons between four conditions showed that RT in forced HA animate-first (M = 1167.26, SD = 820.78) significantly differed (less) than forced LA animate-first (M = 1634.28, SD = 1293.23), forced HA inanimate-first (M = 1589.12, SD = 1124.61), and forced LA inanimate-first (M = 1790.56, SD = 1472.60). These findings suggest that Persian native speakers rapidly read sentences where HA is forced, especially when the first NP is animate, aligning with their interpretation predictions.

Analyzing data from L2 Japanese showed a notable main effect of animacy in Region 2 (β = 394.32, SE = 203.95, t = 1.93, p < .05). There were no significant effects of the attachment nor an interaction.

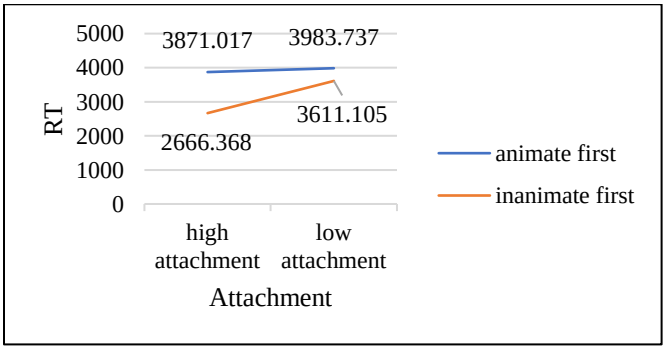

Figure 2: L2 Japanese Region 2 RT in Four Conditions

The overall results suggest a preference toward high association in Region 2 when the NP-high is animate (M = 2666.368, SD = 1697.053). Even when the attachment site is animate, participants find it challenging to process sentences in the low association condition (M = 3983.73, SD = 4033.96).

Persian-Japanese L2 learners exhibited a final preference for HA and showed animacy effects in both L1 Persian and L2 Japanese. Therefore, the real-time parsing analysis indicated the transfer of the predicate proximity principle and animacy effects from L1 Persian to L2 Japanese (these results are in line with Bai, 2019 and Fernandez, 2002).

Furthermore, for the random effect, participant, the standard deviation is 687.84, and the variance estimate is 473130.10. This suggests a considerable variability among participants, implying diverse behaviors within the participant group. To explore the relationship between RC attachment tendencies in L1 Persian and L2 Japanese at the individual level, a Pearson correlation coefficient was calculated. This analysis aims to determine whether individuals who prefer LA in Persian also exhibit similar behavior in Japanese, considering the different word order. The correlation assessed the linear relationship between Persian (PHA, PHI, PLA, PLI) and Japanese (JHA, JHI, JLA, JLI) conditions based on their Region 2 RT. In summary, a significant, moderate, and positive correlation was observed between PLA vs. JLI (r = .50, p < .05), PLI vs. JLI (r = .53, p < .05), and PLI vs. JHI (r = .47, p < .05). This suggests that irrespective of NP animacy, native Persian speakers displaying a preference for LA in their L1 tend to exhibit a similar tendency in associating the RC with NP-low in their L2 Japanese. Additionally, the common feature of preferring animate NP, regardless of attachment preference, is shared only between PLI and JHI. This indicates that the tendency to interpret the RC modifying the animate NP is consistent among Persian Japanese learners in both L1 and L2. This underscores the transfer of L1 to L2, encompassing both syntactic and semantic aspects.

The results from Japanese native speakers were only significant in Region 3 (spillover). According to a LME model, there were significant effects for both attachment (β = -104.09, SE = 49.95, t = -2.08, p < .05) and animacy (β = 102.58, SE = 49.95, t = 2.05, p < .05) but not for the interaction.

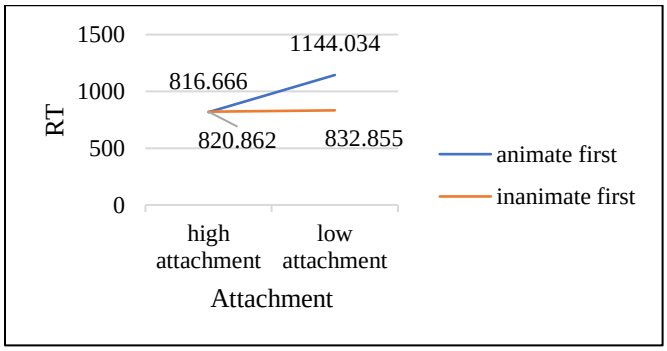

Figure 3: L1 Japanese Region 3 RT in Four Conditions

The significantly high RT in the animate first low association condition (M = 1144.03, SD = 1501.41) in Region 3 indicates that Japanese native speakers had difficulties processing conditions where RC modifies the animate NP-low. Since this behavior was observed later in the spillover region and not in the critical region, it can explain their final preference. Therefore, they typically don't tend to associate the RC low to the animate noun as their final preference.

However, the low RT in HA conditions shows a final preference toward HA.

Regarding the initial association preference of native Japanese speakers, no statistically significant difference was observed in the critical region where both potential NPs appear. Descriptive analysis showed shorter RT in low attachment / inanimate first condition (M = 2164.20, SD = 2297.62) than the other conditions in Region 2. Although the statistical analysis was not significant, it still might suggest an initial preference for associating the RC low with the first NP, independent of animacy. Subsequently, upon entering the second NP, a revision toward NP-high preference was observed in the next region (Region 3) (aligned with the results from Kamide & Mitchell, 1997 and Yamada et.al., 2017).

Discussion

The results revealed that Persian native speakers demonstrated preferences for RC attachment patterns in Japanese that align with their L1 tendencies, particularly influenced by the predicate proximity principle. Additionally, animacy played a significant role, with participants showing a stronger attachment preference based on the animacy of the NPs. These contribute to our understanding of cross-linguistic influences and the interplay of syntactic and semantic factors in RC attachment preferences in bilinguals. However, these findings contradict the target-like preference, L1 attrition, and the SSH hypothesis.

In the case of the native Japanese control group, no statistically significant differences were observed in the critical region, but the descriptive analysis could show an initial LA and a revision towards NP-high attachment occurred during subsequent processing of NPs aligned with the non-deterministic account (Kamide & Mitchell, 1997) and unforced revision (Yamada et.al., 2017). Timing and reasons for reanalysis in Japanese remain subjects of debate, consistent with prior studies.

The study's findings contribute to examining the idea that parsing strategies are the same across all languages, rejecting the belief in a universal view of RC attachment preference. Moreover, it supports the notion put forth by Papadopoulou and Clahsen (2003) that “at least some parsing strategies are language-specific rather than universal.” The findings align with models emphasizing ranked-parallel interactive processing (similar to what was observed in Yamada et.al., 2017). This model suggests that various sources of information contribute to sentence interpretation. Specifically, in Persian, both semantic and syntactic information influenced ambiguity resolution, indicating that Persian parsing goes beyond relying solely on syntax, inconsistent with Arabmofrad and Marefat's (2008) findings.

In Japanese sentence processing, although the easiest interpretation might favor LA, comprehenders consider multiple factors and opt for HA through unforced revision. This contradicts the principle of economy proposed by Kırkıcı (2004).

Bai (2019) proposed that the stronger the similarity in processing features between L1 and L2, the greater the influence. However, the current study did not align with this suggestion. Despite the shared final RC attachment preference (HA) in Persian and Japanese, the entire processing behavior leading to this preference is markedly different. Additionally, both languages feature unique linguistic properties. Despite these differences, the influence of Persian L1 on Japanese L2 was significant.

Rah (2010) proposed that language dominance serves as a reliable indicator of patterns in cross-linguistic transfer than the length of exposure to a foreign language, and this notion holds in the present study. This is because all participants in this study exhibit high Japanese proficiency and relatively long exposure to their Japanese L2 (M = 8.12 years), yet their dominant language, L1 Persian, demonstrated a stronger tendency to have effects and was transferred.

In conclusion, the notably longer reaction times observed in Japanese sentence processing by Persian native speakers compared to their Japanese counterparts, in addition to other findings of this study, align with Clahsen and Felser's (2006) identification of four ways in which language learners process their L2 differently from their L1. These differences include difficulties in real-time processing, slower processing speed in L2, the potential influence of L1 on L2 processing, and the inability of L2 learners to fully attain the language processing behavior of native speakers.

Lastly, it should be noted that the statistical LME analysis in all the experiments did not reveal a significant interaction between variables. However, upon visual inspection of the graphs, it appears that if we were to extend the lines, they would intersect, suggesting a potential interaction with a larger sample size. This limitation could be addressed in future studies by having more participants.

Conclusion

This study explored how Persian speakers learning Japanese process RC attachment ambiguity. Findings revealed their preferences mirrored Persian patterns, influenced by proximity and animacy, particularly favoring HA with animate nouns. They utilized both syntactic and semantic cues interactively, indicating parallel mechanisms across languages rather than a strictly sequential approach. Native Persian influence shaped their Japanese comprehension, suggesting cross-linguistic transfer.

Native Japanese speakers exhibited unforced revision from initial LA to final HA. The findings challenge universal parsing strategies, highlighting language-specific factors in sentence processing. Language dominance played a crucial role in cross-linguistic transfer, surpassing exposure duration.

This study contributes to understanding language processing complexities and adds to the broader discussion on cross-linguistic differences. This was the first time that actual data from both Persian and Japanese had been investigated, and it not only added new information to sentence processing research but also opened up interesting possibilities for future studies.

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References

Arabmofrad, A., & Marefat, H. (2008). RC attachment ambiguity resolution in Persian. *Iranian Journal of Applied Linguistics*, 29-49.

Bever, T.G. (1970). The cognitive basis for linguistic structures. In J. R. Hayes (Ed.), *Cognition and the development of language* (pp. 279-362). New York: Wiley.

Bidaoui, A., Foote, R., & Abunasser, M. (2016). Relative Clause Attachment in Native and L2 Arabic. *The International Journal of Arabic Linguistics (IJAL)*, *2*(2), 75-95.

Clahsen, H., & Felser, C. (2006). Grammatical processing in language learners. *Applied Psycholinguistics*, *27*, 3-42. DOI: 10.1017/S0142716406060024.

Cotter, B. T., & Ferreira, F. (2023). *The Relationship Between Working Memory Capacity, Bilingualism, and Ambiguous Relative Clause Attachment*. University of California: Davis. https://doi.org/10.31234/osf.io/y3gm4

Ehrlich, K., Fernández, E., Fodor, J. D., Stenshoel, E., & Vinereanu, M. (1999). *Low attachment of relative clauses: New data from Swedish, Norwegian and Romanian*. Poster presented at the 12th annual CUNY Conference on Human Sentence Processing, New York, NY, March 18–20.

Fernández, E. M. (2002). Relative clause attachment in bilinguals and monolinguals. *Advances in Psychology*, *134*, 187-215. https://doi.org/10.1016/S0166-4115(02)80011-5

Frazier, L. (1979). *On comprehending sentences: Syntactic parsing strategies* (reproduced unpublished doctoral dissertation, University of Connecticut, in 1978). Bloomington: Indiana University Linguistics Club.

Frenck-Mestre, C. (2002). An on-line look at sentence processing in the second language. In J. Altarriba and R. Herridia (Eds.), *Syntactic processing in the second language*.

Gibson, E., Pearlmutter, N., Canseco-Gonzalez, E., & Hickok, G. (1996). Recency preference in the human sentence processing mechanism. *Cognition*, *59*, 23-59.

Grice, H. P. (1975). *Logic and Conversation*. William James Lectures, delivered at Harvard University in 1967. To be published by Harvard University Press. Copyright 1975 by H. Paul Grice.

Hemforth, B., Fernandez, S., Clifton Jr., C., Frazier, L., Konieczny, L., & Walter, M. (2015). Relative Clause Attachment in German, English, Spanish, and French: Effects of Position and Length. *Lingua*. https://doi.org/10.1016/j.lingua.2015.08.010

Jun, S.-A. (2003). Prosodic Phrasing and Attachment Preferences. *Journal of Psycholinguistic Research*, *32*(2).

Kimball, J. (1973). Seven principles of surface structure parsing in natural language. *Cognition*, *2*, 15-47.

Kırkıcı, B. (2004). The processing of relative clause attachment ambiguities in Turkish. *Turkic Languages*, *8*.

Kishimoto, H. (2020). *Analyzing Japanese Syntax: A Generative Perspective* (ix, 224 p.: ill.; 22 cm). Japan. ISBN 9784894769885. NCID BC03847639.

Kwon, N., Ong, D., Chen, H., & Zhang, A. (2019), The role of Animacy and Structural Information in Relative Clause Attachment : Evidence from Chinese, *Front.Psychol*., 10'1576.

Lau, E. (2016). *Acquisition of Relative Clauses in Cantonese: A Multi-Factorial Analysis*. (Doctoral dissertation, University of Hawai 'i at Mānoa).

Li, H., & Sheng, X. (2017). A Study on the Garden Path Phenomenon from the Perspective of Generative Grammar. *Journal of Language Teaching and Research*, *8*(6), 1190-1194. doi:10.17507/jltr.0806.21

MacDonald, M. C., & Christiansen, M. H. (2002). Reassessing Working Memory: Comment on Just and Carpenter (1992) and Waters and Caplan (1996). *Psychological Review*, *109* (1), 35–54. DOI: 10.1037//0033-295X.109.1.35

Marefat, H., & Farzizadeh, B. (2018). Relative Clause Ambiguity Resolution in L1 and L2: Are Processing Strategies Transferred? *Iranian Journal of Applied Linguistics (IJAL)*, *21*(1), 125-161.

Marefat, H., & Meraji, M. (2005). Parsing preferences in structurally ambiguous relative clauses' L1 vs. L2. J. *Humanit*., *12*(1), 111-126.

McRae, K., & Matsuki, K. (2013). Constraint-Based Models of Sentence Processing. In R. Van Gompel (Ed.), *Sentence Processing* (pp. 51-77). New York, NY: Psychology Press.

Miyao, M., & Omaki, A. (2006), No ambiguity about it : Korean learners of Japanese have a clear attachment preference. In D. Bamman, T. Magnitskaia, & C. Zaller (Eds.), *Proceedings of the 30th Annual Boston University Conference on Language Development (Suppl.)*. Somerville, MA: Cascadilla Press.

Nomura, M. (2000). *The Internally-Headed Relative Clause Construction in Japanese: A Cognitive Grammar Approach* (Doctoral dissertation, University of California, San Diego).

Papadopoulou, D., & Clahsen, H. (2003). Parsing Strategies in L1 and L2 Sentence Processing: A Study of Relative Clause Attachment in Greek. *Studies in Second Language Acquisition*, *25*, 501-528. https://doi.org/10.1017/S0272263103000215

Pearlmutter, N. J., & Macdonald, M. C. (1995). Individual Differences and Probabilistic Constraints in Syntactic Ambiguity Resolution. *Journal of Memory and Language*, *34*(4), 521-542. https://doi.org/10.1006/jmla.1995.1024

Rah, A. (2009). *Sentence Processing in a Second Language: Ambiguity Resolution in German Learners of English* [Doctoral dissertation, Universität zu Köln].

Shabani, K. (2018). *Resolving relative clause attachment ambiguity in Persian sentences*. Allameh Mohaddes Nouri

University, Nour, Iran. TEFL from the University of Tehran, Iran. Received 28 March 2018; received in revised form 29 April 2018; accepted 13 May 2018.

Smith, J. (2023). *An analysis of XYZ phenomenon*. Unpublished manuscript, Department of Psychology, University of ABC.

Swets, B., Desmet, T., Hambrick, Z., & Ferreira, F. (2007). The Role of Working Memory in Syntactic Ambiguity Resolution: A Psychometric Approach. *Journal of Experimental Psychology General*, *136*(1), 64-81. DOI: 10.1037/0096-3445.136.1.64.

Yamada, T., Arai, M., & Hirose, Y. (2017). Unforced Revision in Processing Relative Clause Association Ambiguity in Japanese: Evidence Against Revision as Last Resort. *J Psycholinguist Res*, *46*, 661–714. doi:10.1007/s10936-016-9457-8.

Zare, F. (2021). ペルシャ語母語話者の関係節の構造的曖昧性構文における処理について一解釈選好性への主要部の有生性の影響の観点から一 *[Processing of structural ambiguity in Persian native speakers' relative clause sentences: From the perspective of the impact of animacy on interpretation preferences]*. 入試論文, 東京大学, 東京.

Zudianto, H. (2020). *Relative Clause Attachment Preference in Second Language Sentence Processing: Evidence from Indonesian Learners of English* (Master's thesis, Yogyakarta State University).

Appendix

Table A1: Japanese Experimental Sentences for SPR Task

Condition			Region 1 (RC)	Region 2 (NP-low + NP-high)	Region 3 (Adverb)	Region 4 (Main Verb)
Language	Attachment	Animacy				
Japanese	(Forced) Low- Attachment	Animate-First	ひどく酔っていた	パイロットの飛行機は	谷に	墜落しました。
			hidoi yotte ita	pairotto no hikōki wa	tani ni	tsuirakushimashita.
			very drunk is-PST	pilot-GEN airplane-TOP	valley-LOC	crash-PST
			"The airplane of the pilot that was very drunk crashed into a valley."			
		Inanimate-First	故障のあった	飛行機のパイロットは	今日	尋問されました。
			koshō no atta	hikōki-no pairotto-wa	kyō	jinmonsaremashita.
			damaged is-PST	airplane-GEN pilot-TOP	today	question-PASS-PST
			"The pilot of the airplane that was damaged was questioned today."			
	(Forced) High- Attachment	Animate- First	故障のあった	パイロットの飛行機は	谷に	墜落しました。
			koshō no atta	pairotto no hikōki wa	tani ni	tsuirakushimashita.
			damaged is-PST	pilot-GEN airplane-TOP	valley-LOC	crash-PST
			"The airplane of the pilot that was damaged crashed into a valley."			
		Inanimate- First	ひどく酔っていた	飛行機のパイロットは	今日	尋問されました。
			hidoi yotte ita	hikōki no pairotto wa	kyō	jinmonsaremashita.
			very drunk is-PST	airplane-GEN pilot-TOP	today	question-PASS-PST
			"The pilot of the airplane that was very drunk was questioned today."			

Table A2: Persian Experimental Sentences for SPR Task

Condition			Region 1 (NP-low + NP-high)	Region 2 (RC)	Region 3 (Adverb)	Region 4 (Main Verb)
Language	Attachment	Animacy				
Persian	(Forced) Low- Attachment	Animate-First	آشپز رستوران / که اخیرا خلوت شده / بسیار / عصبانی بود.			
			āshpaz-e restorān	ke akhīran khalvat shode	besyār	āsabānī būd
			chef-EZ restaurant	that recently less crowded become-PRS PRF	very	angry is-PST
			"The chef of the restaurant that has recently become less crowded was very angry."			
		Inanimate- First	رستوران آشپز / که غذا را سوزاند / به زودی / تعطیل می شود.			
			restorān-e āshpaz	ke ghazā rā sūzānd	be zūdī	ta'tīl mīshavad
			restaurant-EZ chef	that food-ACC burn-PST	soon	close is-PASS-FUT
			"The restaurant of the chef that burnt the food will be closed soon."			
	(Forced) High- Attachment	Animate- First	آشپز رستوران / که غذا را سوزاند / بسیار / عصبانی بود.			
			āshpaz-e restorān	ke ghazā rā sūzānd	besyār	āsabānī būd
			chef-EZ restaurant	that food-ACC burn-PST	very	angry is-PST
			"The chef of the restaurant that burnt the food was very angry."			
		Inanimate- First	رستوران آشپز / که اخیرا خلوت شده / به زودی / تعطیل می شود.			
			restorān-e āshpaz	ke akhīran khalvat shode	be zūdī	ta'tīl mīshavad
			restaurant-EZ chef	that recently less crowded become-PRS PRF	soon	close is-PASS-FUT
			"The restaurant of the chef that has recently become less crowded will be closed soon."			