

Examining Cross-linguistic Influence of Japanese Word Order: An Eye-Tracking Study on L2 English Learners' Text Comprehension

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Abstract

Cross-linguistic influence is a systematic and unavoidable feature of language learning. This study aimed to investigate whether prepositive word order in Japanese noun clauses can serve as a cross-linguistic influence element in the acquisition of relative clauses (a form of a postpositive modifier) in English. To test this hypothesis, this study conducted an eye-tracking experiment with native Japanese speakers and showed the following results statistically. First, Japanese participants generally paid more attention to modifier clauses than the noun phrases they modified when reading English sentences with relative clauses. Second, when interpreting accusative relative clauses, longer fixations were observed both in the modifier clauses and in the antecedents, likely due to their complexity for Japanese L2 learners of English, as evidenced by the lowest accuracy rate. Finally, and most notably, the findings revealed that the participants who had not fully acquired the relative clause construction focused more on the left side of the relative pronoun than those who had. This tendency was most prominent when interpreting subjective relative clauses, a result that supports the hypothesis that prepositive L1 modifiers could be a CLI element in the acquisition of English postpositive modifiers.

Keywords: cross-linguistic influence, eye movements, L2 reading, postpositive modifier, relative clauses

1. Introduction

Cross-linguistic influence (CLI) is the phenomenon in which the knowledge and usage of one language (usually the first language) can affect that of a second or third language during the acquisition process. However, providing a simple definition of CLI or language transfer in traditional terms is challenging because it varies over time. In the 1950s, when behaviorism was mainstream, language learning was perceived as habit formation or a process of overcoming established L1 habits. In this behaviorist framework, language transfer was regarded as the physical carryover of L1 surface forms into an L2 context (Gass, 1988). All errors were considered a result of failing to imitate the L2 surface structure and thus were thought to be predictable by identifying the differences between L1 and L2.

However, in the early 1970s, with the decline of behaviorism and the rise of mentalism, researchers moved toward a psychological approach that focused on learners' internal cognitive capacities. Corder (1967) proposed that unconsciously repeated errors are proof that learners form hypotheses about the target language and continue to test them. For example, French-speaking L2 learners of English are inclined to make errors such as "We enjoyed to ski" because French has no grammatical category equivalent to a gerund in English. Such errors are attributable to the difference between L1 and L2 and thus can be interpreted as a type of language transfer. On the other hand, English beginners often make mistakes such as "He comed yesterday" regardless of their L1. This phenomenon cannot be explained within the framework of language transfer because it does not arise from the difference between L1 and L2; instead, it is an example of overgeneralization: learners creatively build a hypothesis on how to form a verb in the past tense and try adding "ed" to any verb.

This cognitive approach to L2 acquisition assumes that L2 learning is similar to L1 in that learners have an innate mental apparatus for language learning, as with the Language Acquisition Device posited by Chomsky (1986). In the behaviorist framework mentioned above, L2 acquisition was regarded as a process of replacing L1 habits with L2 habits; hence, the process of L2 learning was thought to be divergent depending on the L1. By contrast, as Corder (1981, p83) suggested, "if a universal core grammar is the starting point of the interlanguage continuum, then initial stages tend to be similar across different language backgrounds." This hypothesis was

supported by Duray and Burt's (1974) English morpheme studies, which revealed that Spanish and Chinese children showed similar acquisition orders regardless of their L1. From this perspective, L2 errors may be developmental and not the result of language transfer.

These two extreme positions on L2 acquisition were unified into one theory by Schachter (1983, 1992): language transfer is not a process but a constraint on the acquisition process. Schachter stated that L2 learning is an integrated process in which learners formulate hypotheses about the target language, test them, and revise them, where learners' existing knowledge, including their L1, can function as constraints. This study employs this definition of CLI.

Empirical research has observed CLI cases across linguistic domains, including orthography, phonetics, phonology, morphology, syntax, semantics, and pragmatics (Lado, 1957; Selinker, 1972; Schachter, 1974; Kellerman, 1978; Dulay et al., 1982; Huebner, 1983). Moreover, positive language transfer has been found to sometimes facilitate L2 learning: learners use L1 knowledge as a resource for formulating hypotheses about the forms, structures, functions, meanings, rules, and patterns of their target language (Ellis, 1994; Jarvis & Pavlenko, 2008). CLI is thus a systematic and unavoidable feature of language learning.

This study focused on the effects of CLI on syntax: word order. One case of syntactic CLI that has received considerable empirical attention is adverbial placement. For example, Alonso (2002) conducted a series of experiments with Spanish-speaking learners of English and showed that Spanish adverbial placement was frequently observed in L2 English constructions (e.g., I speak at home Spanish). Alonso further pointed out that lower-level learners were more likely to exhibit these CLI effects on adverbial placement than higher-level learners.

Another case of syntactic transfer concerns null subjects (e.g., ____ didn't come yesterday). English does not allow null subjects, whereas Japanese, Korean, and Chinese are languages in which subjects can (or must) be omitted depending on the context. This syntactic difference has been found to be a cause for CLI in L2 production. Notably, Xiao (2004) conducted experiments on L2 Chinese learners with different L1 backgrounds and found that English-speaking Chinese learners overused subject nouns in their L2 production far more frequently than Japanese- and Korean-speaking learners.

The effects of CLI on syntax were also examined using a physiological experimental design. For example, Jackson et al. (2012) employed an eye-tracking device and observed how L2 learners of German (English L1) process temporarily ambiguous L2 sentences. Jackson et al. (2012) asked 25 English-speaking German learners to read ambiguous German interrogative sentences and found that they spent more time reading subject-first interrogative sentences than object-first interrogative sentences, unlike the control group of German native speakers.

Eye-tracking technologies have been used in a variety of language studies (Bernhardt, 1991; Keating, 2009; Miwa et al., 2014; Arunachalam, 2016; Prichard & Atkins, 2016; Hessel et al., 2020; Arai, 2022; Imamura, 2022), but these technologies are expected to be particularly effective for investigating how learners read and process L2 sentences physiologically online (Yamashita, 2013). This study used a Tobii eye tracker to investigate whether syntactic differences between Japanese and English can serve as CLI elements in L2 acquisition. In the following sections, the Japanese syntactic features related to this study are detailed, and an eye-tracking experiment conducted on Japanese native speakers is discussed.

1.1 Word Order

This section examines the syntactic difference between English and Japanese to address in this research: word order in noun clauses. In English, the modifier clause is placed immediately after the noun it modifies (postpositive), as illustrated in (1). Here, the relevant noun phrase is indicated in bold, and the modifier clause in italics.

(1)

a. This is the **PC_{NP}** *which_{COMP} I bought last year*_S.

b. We were surprised at the **news_{NP}** *that_{COMP} she won first prize*_S.

The modifier clause is introduced by the relative pronoun "which" in (1a) and the conjunction "that" in (1b).

By contrast, modifier clauses in Japanese always precede the nouns they modify (prepositive). The following are the Japanese translations of the aforementioned English examples (1a-1b). Again, in each example, the relevant noun phrase and the modifier clause are denoted in bold and italics, respectively.

(2)

a. これは、私が去年買った_Sパソコン_{NP}だ。b. 彼女が一等賞を取った_Sという_{COMP}ニュース_{NP}に私たちは驚いた。

The exact opposite order is observed in the Japanese examples. In (2a), the modifier clause, 私が去年買った (I bought last year), immediately precedes the noun phrase that it modifies, パソコン (the PC), without any complementizer such as a relative pronoun, as in (1a). In the second example (2b), the modifier clause, 彼女が一等賞を取った (she won first prize), is followed by a complementizer, という (that), and is placed before the noun phrase that it modifies, ニュース (the news).

In summary, Japanese has a head-final structure in its noun clauses in which the noun (the head element of the noun clause) always appears at the end of the clause. This head-final structure is not restricted to nouns. Indeed, this feature is pervasively observed across linguistic categories in Japanese, including clauses, sentences, and discourses. This is illustrated below, where the verb follows its object (3a), tense and mood affixes are expressed as verbal suffixes (3b), complementizers appear to the right of the complement clauses (3c), and language is postpositional (3d).

(3)

a. エマが窓を割った。

Emma-ga [vp mado-o wattav].

Emma-nom window-acc break-past

“Emma broke the window.”

b. エマは窓を割るべきではなかった。

[tp Emma-wa [[[vp mado-o waruv] bekide-wa_T] na_{-neg}] katta_T].

Emma-top window-acc break should-top not-past

“Emma should not have broken the window.”

c. エマは窓を割ってないと言った。

Emma-wa [[mado-o watte_V nai_S] to_{COMP} cp] i-tta_V.

Emma-top window-acc broke not comp say-past

“Emma said that she had not broken the window.”

d. エマは宮殿の広間で踊った。

Emma-wa [[[[kyuden_{NP}] no_P pp] hiroma_{NP}] de_P pp] odo-tta_V.

Emma-top palace of room in dance-past

“Emma danced around the room in the palace.”

This study assumes that this head-final disposition could be one of the reasons why Japanese learners of English often have difficulty acquiring English relative clauses. Japanese speakers habitually plan and interpret sentences by placing modifiers before head elements, consciously or unconsciously, due to the Japanese prepositional structure. This linguistic feature could pose challenges for Japanese speakers to master postpositive relative clauses.

1.2 Hypothesis

CLI, especially the negative type of language transfer, is thought to occur when there are few or no similarities between L1 and L2, often resulting in errors or avoidance (Bussmann 1996). In light of this observation, this study assumes that prepositional word order in Japanese noun clauses can serve as a CLI element in acquiring English postpositive modifiers: relative clauses. It is then hypothesized that Japanese L2 English learners who have not fully acquired relative pronouns are more likely to focus on the antecedent (left side) of a relative clause while interpreting sentences, owing to their prepositional L1 word order. This study empirically tests this hypothesis by conducting an eye-tracking experiment on native Japanese speakers.

2. Materials and Methods

2.1 Participants

Data were collected from 18 native Japanese speakers learning English as a second language (14 males, four females). Only undergraduate students (18–22 years old) at the Sanyo-Onoda City University, Japan, were recruited to control for the participants' educational backgrounds. Their English proficiency level was pre-intermediate, equivalent to scores of approximately 300–600 on the TOEIC Listening and Reading Test. This is categorized as the A1 level in the Common European Framework of Reference for Languages (CEFR).

All the participants began learning English in junior high school in Japan at 12 years of age. Relative clauses are usually taught between the ages of 14 and 15 years in English lessons and practiced explicitly or implicitly thereafter. Relative clauses appear to be one of the most challenging grammatical aspects for Japanese students, whose L1 has nominal clauses in the opposite word order.

2.2 Materials

A Tobii Pro Nano, a non-contact eye movement measurement device using infrared rays, was attached to a PC running Tobii Pro Lab, a software program for eye-tracking data collection and analysis. The size of the PC monitor was 323 mm × 517 mm, with a sampling rate of 60 Hz.

The stimuli shown on the monitor were two pages of instructions and 24 pages of text. Each page included a single fill-in-the-blank question designed to test the student's knowledge and understanding of English relative clauses. The questions, 24 in total, comprised six sentences in which a relative pronoun in the subjective case was to be inserted into the blank space (4a), six sentences in which a relative pronoun in the accusative case was to be inserted (4b), six sentences in which a relative pronoun in the possessive case was to be chosen (4c), and six sentences in which an accusative relative pronoun was abbreviated (4d). The questions were shown individually on the monitor, and the participants proceeded to the next page by pressing the designated keyboard key.

(4)

a. I have a friend () helps me when I am in trouble.

① who ② whose ③ whom

b. He is a soccer player () everyone knows.

① whose ② whom ③ which

c. I have a friend () father is a policeman.

① whom ② who ③ whose

d. This is the book () bought yesterday.

① who ② I ③ which

Note. The correct answers are ① 4a, ② 4b, ③ 4c, and ② 4d.

2.3 Procedure

The experiments were conducted individually in a quiet room on the Sanyo-Onoda City University campus. After reading the instructions and signing the consent form, each participant was asked to sit in front of the monitor with the eye-tracking device, with a consistent distance of 70 cm between the participant's eyes and the screen.

Participants were asked to answer each question presented on the monitor, choosing the most appropriate answer from the three choices (Figure 1). They were instructed to use as much time as they needed to answer each question and then proceed to the next question by pressing the designated key on the keyboard.



Figure 1. Stimuli Sample

3. Results

Correct answers were calculated for each of the four relative pronoun types. The section on relative pronouns in the subjective case had the highest accuracy rate (78.7%), followed by the possessive case (69.4%) and the abbreviated accusative case (64.8%). Relative pronouns in the accusative case were the most challenging for participants, with an accuracy rate of 54.6%. An analysis of variance revealed a reliable main effect of relative pronouns, $F(3,71) = 2.73$, $p = .05$, with post-hoc comparisons (Tukey's HSD) showing significant differences between the accuracy rate of the subjective case and that of the accusative case, $p < .05$.

Next, the participants' eye movements were measured according to the Total Fixation Duration or the total time they fixated on the designated area. For this purpose, each stimulus had the Antecedent Area and the Modifier Clause Area designated in advance by using Tobii Pro Lab, which allowed us to measure the Total Fixation Duration for each area (Figure 2).

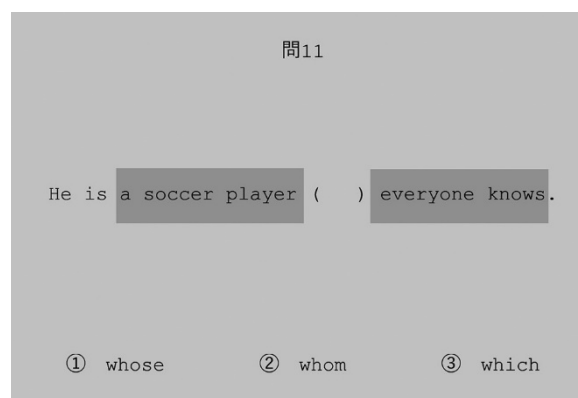


Figure 2. Areas of Interest for Eye-Tracking Data Analysis

Note. The left enclosure is the Antecedent Area; the right enclosure is the Modifier Clause Area.

Statistical data analysis revealed that Japanese participants focused more on a postpositive clause modifier than on its antecedent when interpreting English sentences with a relative clause. Figure 3 shows a sample heat map displaying attention patterns, where darker areas indicate longer fixations. The mean value of the Total Fixation Duration on the Modifier Clause Area was significantly longer ($M = 4094.28$ msec., $SD = 3758.26$) than on the Antecedent Area ($M = 1687.30$ msec., $SD = 1414.48$), $p < .01$ (t -test). This tendency was consistent across all four relative pronoun categories (Note 1).



Figure 3. Sample Heat Map Displaying Fixations

Subsequently, the values of the Total Fixation Duration in the Antecedent Area were compared among the four relative pronoun categories—subjective, accusative, possessive, and abbreviated accusative. Fixations were found to increase in the Antecedent Area when participants interpreted sentences with accusative relative pronouns (Figure 4). The mean value of the Total Fixation Duration on the Antecedent Area in the accusative case was significantly longer ($M = 1992.35$ msec., $SD = 1664.63$) than that in the possessive case ($M = 1364.11$ msec., $SD = 1042.08$). An analysis of variance revealed a reliable main effect of relative pronouns, $F(3,431) = 3.7740$, $p < .05$, with post-hoc comparisons (Tukey's HSD) showing significant differences between the accusative and possessive cases ($p < .01$).

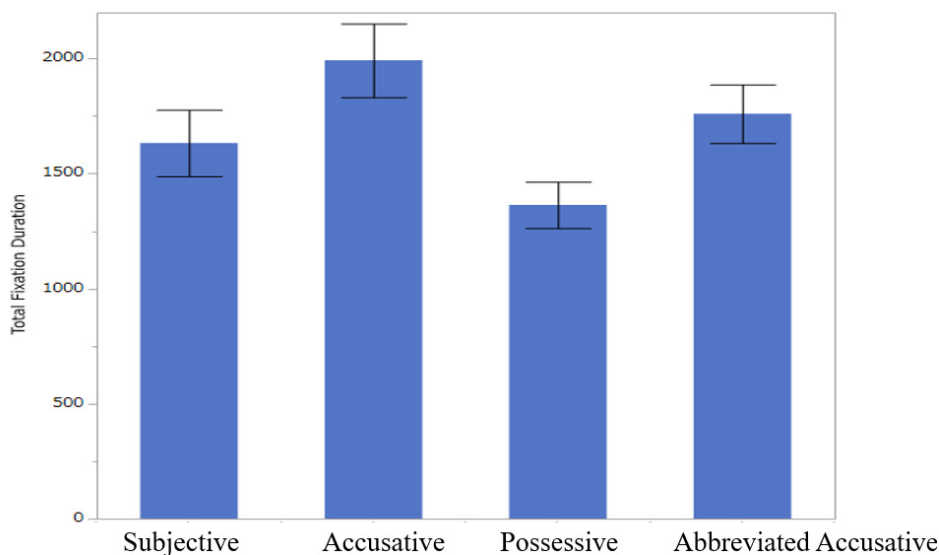


Figure 4. Total Fixation Durations in the Antecedent Area

The results for the Total Fixation Duration in the Modifier Clause Area were similar: participants paid more attention to postpositive modifier clauses when interpreting accusative relative clauses (Figure 5). The mean value of the Total Fixation Duration on the Modifier Clause Area in the accusative case was significantly longer ($M = 5277.36$ msec., $SD = 4704.52$) than in the subjective ($M = 3477.93$ msec., $SD = 3144.96$) and possessive ($M = 3415.25$ msec., $SD = 2794.22$) cases. An analysis of variance revealed a reliable main effect of relative pronouns, $F(3,431) = 5.9405$, $p < .01$, with post-hoc comparisons (Tukey's HSD) showing significant differences between the accusative case and the subjective case and between the accusative case and the possessive case, both at the level of $p < .01$.

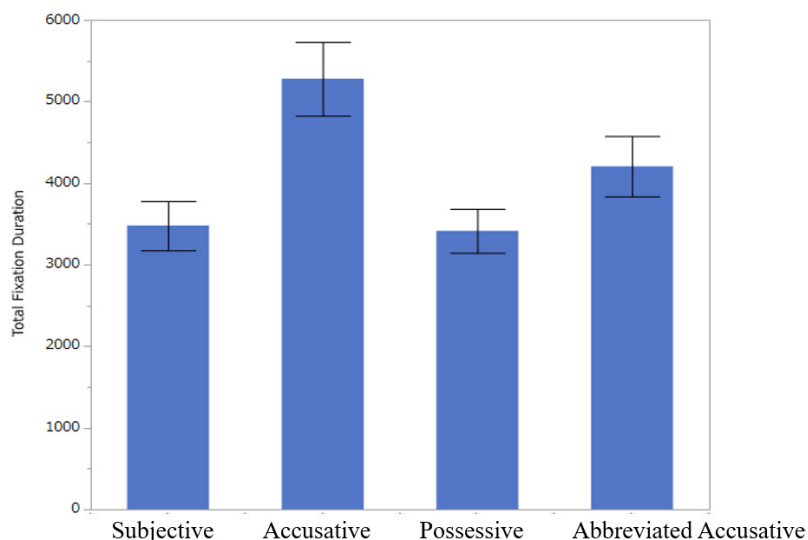


Figure 5. Total Fixation Durations in the Modifier Clause Area

This study aims to investigate whether prepositional word order in Japanese noun clauses could be a CLI element in English relative clauses. The hypothesis is that Japanese L2 English learners still acquiring relative clauses are more likely to focus on the antecedent (or left side) of a modifier clause because of their prepositional L1 word order. In testing this hypothesis, data were analyzed for the participants who provided correct answers and incorrect answers. The results indicated that the participants who provided incorrect answers focused more on the Antecedent Area when interpreting subjective relative clauses ($M = 2297.43$ msec., $SD = 1906.95$) than those who provided correct answers ($M = 1452.86$ msec., $SD = 1328.11$) at the $p < .01$ level (t -test). Additionally, no divergence was found between the participants who provided correct and incorrect answers regarding their focus on the modifier clause areas when interpreting subjective relative clauses.

Figure 6 demonstrates the difference in attention to the Antecedent Area between the correct and incorrect answer groups when interpreting subjective relative clauses. Participants who provided incorrect answers focused more on the antecedent, *many people* (right heat map), than those who provided correct answers (left heat map).

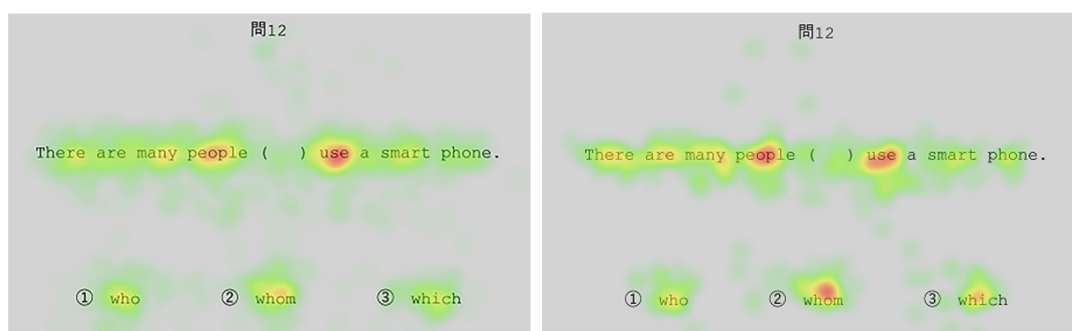


Figure 6. Heat Maps Displaying Fixations on Subjective Relative Clauses

Note. The left shows fixations from correct answers group; the right shows fixations from incorrect answers group.

4. Discussion

This study focused on prepositional word order in Japanese noun clauses and empirically investigated whether this linguistic feature functions as an element of CLI in the acquisition of English postpositive relative clauses. The hypothesis was that Japanese L2 learners of English who have not fully acquired relative clauses are more likely to focus on antecedents owing to their prepositional L1 word order. An eye-tracking experiment was conducted to test this hypothesis, and the results are as follows:

First, when reading sentences with relative clauses, Japanese participants generally paid more attention to modifier clauses than the noun phrases they modified. An interpretation of this finding is that Japanese L2 learners of English, even at the pre-intermediate level, appear to understand the postpositive structure of English

relative clauses and focus on the segment to the right of the relative pronoun. This tendency was consistent across the four categories of relative clauses. Regardless of the relative pronoun type—subjective, possessive, accusative, or abbreviated—the Total Fixation Duration in the Modifier Clause Area was significantly longer than that in the Antecedent Area, all at the $p < .01$ level.

However, there was cross-categorical divergence in the duration of attention. Statistical analysis revealed that Japanese participants were more likely to focus on antecedents when interpreting accusative relative clauses than possessive relative clauses ($p < .01$). This tendency was also observed in the focus on the modifier clauses. When interpreting accusative relative clauses, Japanese participants were more likely to gaze at modifier clauses than subjective and possessive relative clauses (both $ps < .01$). The prolonged attention to both antecedents and modifier clauses of accusative relative pronouns likely stemmed from their complexity, particularly for Japanese L2 learners of English, evidenced by the lowest accuracy rate.

Finally, and most notably, the findings revealed significant differences between the participants who fully acquired relative clauses and those who did not. As predicted, the participants who provided incorrect answers were more likely to focus on the left side of the relative pronouns than the participants who provided correct answers. This tendency was most prominent when interpreting subjective relative clauses ($p < .01$), a result that supports the hypothesis that prepositive L1 modifiers could be a CLI element in the acquisition of English postpositive modifiers.

The findings illustrated in Figure 6 offer significant insights into the cognitive processes involved in the interpretation of subjective relative clauses among Japanese L2 learners of English. Specifically, they highlight a clear divergence in attention allocation between participants who provided correct versus incorrect answers. Participants who provided incorrect responses tended to focus more on the antecedent, as evidenced by the heatmap on the right side. By contrast, those who provided correct answers demonstrated a different pattern, with less emphasis on the antecedent, as depicted in the heatmap on the left side. This discrepancy suggests that attentional focus on the antecedent may impede accurate comprehension of subjective relative clauses, implicating the role of L1 word order in L2 acquisition. These observations underscore the importance of considering learners' native language structures and cognitive processing mechanisms in designing effective language instruction and intervention strategies.

The heat maps further revealed that the participants who provided incorrect answers focused more on the wrong choice, *whom*, than the correct choice, *who*. These results show that the participants who provided incorrect answers could not allocate sufficient attention to the right side of the relative pronoun, *use*, and create a subject-verb sentence structure by selecting the subjective relative pronoun. Instead, they seemed to search for a clue to answer the question on the left-hand side of the relative pronoun.

Yamashita (2013) stated that physiological data, such as eye movements, brain waves, and neuroimaging, can serve as useful tools for investigating and understanding the reading process of L2 learners. This information collection technique might be applied in a classroom setting, where eye movement data will enable teachers to instantly evaluate their students' cognitive processes when reading L2 sentences, provide appropriate feedback, and further improve their pedagogical approaches. This study suggests that eye movement data effectively manipulates learners' attention, enabling teachers to instruct learners to focus on the area to the right of relative pronouns to appropriately interpret relative clause constructions.

5. Conclusion

This study hypothesized that Japanese prepositive word order in noun clauses could function as a CLI element in the acquisition of English postpositive modifier clauses and then physiologically examined how Japanese-speaking English learners process English relative clauses with the use of an eye-tracking device. The findings showed that Japanese participants were more likely to focus on modifier clauses than on the noun phrases they modified when interpreting relative clauses. However, attention patterns differed depending on the type of relative pronoun used. Statistically longer fixations were observed in the modifier clauses and antecedents of accusative relative pronouns. This prolonged attention was likely because accusative relative clauses are the most challenging for Japanese L2 English learners, as evidenced by the lowest accuracy rate.

Moreover, as predicted, the participants who had not fully acquired the relative clause construction focused more on the left side of the relative pronoun when interpreting subjective relative clauses. This finding supports the hypothesis that the prepositive word order of Japanese noun clauses can function as a CLI element—it predisposes Japanese L2 learners to focus on the left side of the relative pronouns.

However, except for subjective relative clauses, there was no significant difference between the correct and incorrect answer groups regarding attention to the antecedents. Eye movement data are useful for determining where the eyes focus; however, these data cannot identify the reason for doing so. To further investigate whether Japanese prepositive modifiers could be CLI elements in the acquisition of English postpositive relative clauses, further research could design an experiment to identify why Japanese L2 learners who have not mastered relative clauses tend to focus on antecedents, especially when interpreting subjective relative clauses.

Additionally, this study employed fill-in-the-blank questions to investigate the attention patterns of Japanese L2 learners when interpreting relative clauses. Hence, the collected data are expected to differ from eye movements when reading sentences with relative clauses without restrictions. Further research is required to explore the CLI element and investigate why subjective relative clauses evoke varying attention patterns. This may necessitate experimental designs that differ from those of this study.

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Notes

Note 1. The mean value of the Total Fixation Duration on the Modifier Clause Area in the subjective case was 3477.93 msec. ($SD = 3144.96$), significantly longer than that on the Antecedent Area ($M = 1632.72$ msec., $SD = 1501.03$), $p < .01$ (t -test). This tendency was also observed in the other three categories. The mean value of the Total Fixation Duration on the Modifier Clause Area in the possessive case was 3415.25 msec. ($SD = 2794.22$), which was significantly longer than that on the Antecedent Area ($M = 1364.11$ msec., $SD = 1042.08$), $p < .01$ (t -test); the mean value of the Total Fixation Duration on the Modifier Clause Area in the accusative case was 5277.36 msec. ($SD = 4704.52$), which was longer than on the Antecedent Area ($M = 1992.35$ msec., $SD = 1664.63$), $p < .01$ (t -test); and the mean value of the Total Fixation Duration on the Modifier Clause Area in the abbreviated accusative case was 4206.56 msec. ($SD = 3845.63$), which was longer than on the Antecedent Area ($M = 1760.03$ msec., $SD = 1319.64$), $p < .01$ (t -test).

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