研究論文

Using Prosodic Cues in Syntactic Processing: From the Perspective of the English Proficiency and Working Memory Capacity of Japanese EFL Learners

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1. Introduction

Many first language (L1) studies have demonstrated that prosody facilitates the comprehension of spoken languages. For example, Speer et al. (1996) tested temporally ambiguous sentences, such as "Whenever the guard checks the door it's locked." They concluded that syntactic processing is facilitated when the prosodic boundary (indicated by "%") matches the syntactic structure (e.g., "Whenever the guard checks the door % it's locked"). However, syntactic processing interferes when prosodic boundaries are placed at misleading points in the syntactic structure (e.g., "Whenever the guard checks % the door it's locked"). This is different from the baseline prosody condition with an acoustically subtle boundary. Speer et al. (1996) suggested that prosodic information is used not only for final interpretation but also to guide initial syntactic processing. Furthermore, in their visual world eye-tracking study, Snedeker and Trueswell (2003) showed that such prosodic cues are used to predict the upcoming syntactic structure. They did this by using sentences with globally ambiguous structures, such as "Tap the frog with the flower."

For studies of second language (L2) learners, Nakamura et al. (2015) suggested that Japanese English as a foreign language (EFL) learners do not use prosodic information for their syntactic analysis, which contradicts the findings for native English speakers. These researchers found no difference between Japanese EFL learners' reaction times in comprehending the reduced relative clause under prosodic boundary conditions (e.g., "The boy % insulted in the classroom % ran away from his friend"), the reduced relative clause when there were no prosodic boundary conditions (e.g., "The boy, insulted in the classroom, ran away from his friend"), and an unambiguous relative clause condition (e.g., "The boy, who was insulted in the classroom, ran away from his friend"). Native English speakers, by contrast, could understand the sentence faster in the prosodic boundary condition than in other conditions. Furthermore, Nakanishi (2021) revealed that the degree of using prosodic cues significantly differs according to a person's English proficiency. In his experiment

using the listening span test, participants were required to listen to object relative clause sentences and remember the sentence's final words. The recall score was reflected as the efficiency of their working memory. The sentences were displayed under three prosody conditions. The first was an appropriate prosody condition, where the prosodic boundary was placed on the syntactic boundary (e.g., "The man that married the woman % became her husband"). The second was the baseline condition, where subtle prosodic information was given (e.g., "The boy that the volunteers support is a young man"). The third was an inappropriate prosody condition, where the prosodic boundary was located on an erroneous parse (e.g., "The parents that help % the boy are older than he is"). The main results were that learners with high proficiency had better scores under the appropriate prosodic condition than learners with low proficiency did. However, the recall scores in the listening span tests were not different according to the user's proficiency, regardless of the prosodic condition. This suggests that even high-proficiency learners exhaust their working memory resources to process objective relative sentences even in the appropriate prosody condition, and this makes retaining the final words of the sentence difficult.

Taken together, previous L2 studies showed that L2 learners, especially low-proficiency learners, have difficulty using prosodic cues in syntactic processing. However, there is a remaining issue: The sentences in L2 studies were difficult for learners to process. For example, the object relative clause sentences used in Nakanishi (2021) were cognitively demanding (Gibson, 1998; Grodner & Gibson, 2005; Hashimoto, 2011, 2012; Sakakibara & Yokokawa, 2015; Yokokawa et al., 2014). Therefore, less proficient learners would exhaust their working memory in processing object relative clause sentences, and they could not allocate their resources to direct their attention to informative prosody. Therefore, this study uses a simpler syntactic structure consisting of a subjective noun phrase and prepositional phrase as a subject clause (e.g., "The suspect in the accident will be arrested") with a view to exploring the prosodic influence on syntactic processing for Japanese EFL learners in terms of their proficiency and the efficiency of their working memory.

2. Research Questions

This study explores how Japanese EFL learners use prosodic cues to facilitate syntactic processing in terms of their English proficiency and working memory capacity. To this end, two research questions (RQs) are addressed:

RQ1: When prosodic boundaries match syntactic boundaries, is sentence comprehension made easier, and thus, is working memory used more efficiently compared with when prosodic boundaries are placed at misleading points in syntactically structured sentences?

RQ2: Does the degree of the result for RQ1 differ according to individual English ability?

3. Method

3.1 Participants

A total of 58 Japanese EFL undergraduate and graduate students (9 male and 49 female) participated in the study. Their proficiencies were measured using the Oxford Online Placement Test (OOPT). Their scores ranged from 15 to 94 out of 120 possible marks (M = 49.27, S.D.= 17.44). When their scores were converted to the Common European Framework of Reference for Languages (CEFR), the 58 participants comprised 5 Beginner (A1), 17 Pre-Intermediate (A2), 28 Intermediate (B1), 6 Upper-Intermediate (B2), and 2 Advanced (C1) students.

3.2 Procedure

All participants completed three types of listening span tests under three different prosodic conditions (see Section 3.3.1). They also completed the OOPT as noted in Section 3.1. The listening span tests were administered by three groups, and OOPTs were held individually.

3.3 Materials

3.3.1 Listening Span Test

On the listening span test, there were three types of tasks, each including 42 sentences (see Appendix). Type A was referred to as the "cooperating condition," in which the prosodic boundary matched the syntactic structure. Type B was the "baseline condition," where a subtle prosodic boundary was placed. Type C was referred to as the "conflicting condition," in which the prosodic boundary was placed where it conflicted with the syntactic structure. Examples of sentences defined as Types A, B, and C are as follows (% indicates a prosodic boundary, / indicates a syntactic boundary):

(A) Cooperating condition: The suspect in the accident %/ will be arrested.
(B) Baseline condition: The guide for the tour knows the popular spot well.
(C) Conflicting condition: The husband of % the wife / is a very beautiful woman.

Semantic judgment was incorporated into this task, so half the sentences were semantically correct (e.g., "The suspect in the accident will be arrested"). Half were incorrect (e.g., "The husband of the wife is a very beautiful woman"). The model sounds were recorded by a female American native speaker of English at a speaking rate of

approximately 152 words per minute. She was asked to record sentences under the three conditions described above.

The length of pauses was manipulated by Praat (0.4 seconds) so that the length of the pause between A and C was not different. The wave form and pitch track of the sentences are shown in Figures 1, 2, and 3.

The sentences were presented to listeners over a speaker. There were 3.5 second pauses between the sentences. The participants were required to listen to the sentence, write ○ on the answer sheet if the sentence was semantically plausible or × if it was implausible, and remember the last word as quickly as possible. For all the listening span tasks, these procedures were repeated until the end of the session was indicated with a beep. The participants would then write down the final words of the sentences on the answer sheet.

As an example, under the three-sentence condition, the participants listened to three sentences and memorized the final word of each sentence. At the end of the session, they had to write the three final words on the answer sheet. Sentences were presented to the participants in groups of two, three, four, and five sentences. Each group had three sets. Therefore, they had to listen to 42 sentences in total. The participants were asked to listen to increasingly longer sets of sentences until they had listened to three sets of five sentences.

Following the procedure of Ushiro and Sakuma (2000), the time to recall the final word in each sentence was increased by 5 seconds while increasing a set by one sentence. For example, 20 seconds was given to recall the final words of four-sentences, and 25 seconds was given in the case of five sentences.

3.3.2 English Proficiency Test

The OOPT was implemented and conducted on the internet. It was used to measure the participants' English fluency in reading and listening. Each question was accompanied by three or four possible answers, only one of which was correct. There was a time limit of 90 minutes.

Figure 1

Condition A: The suspect in the accident will be arrested.

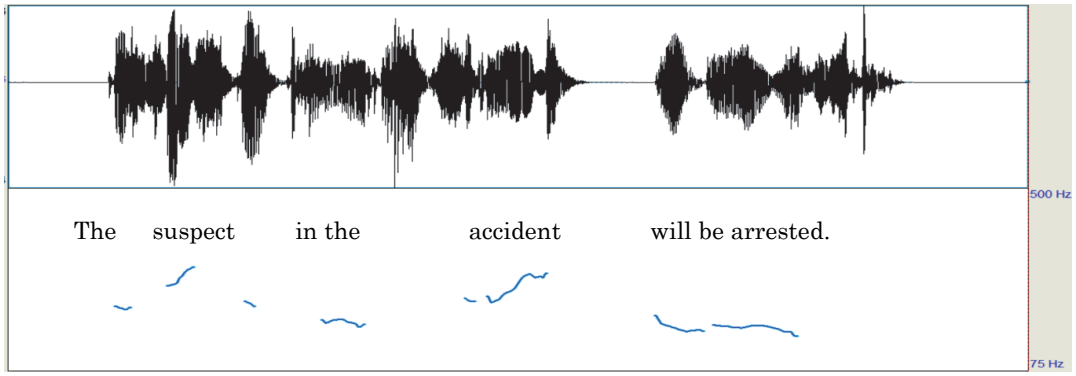


Figure 2

Condition B: The guide for the tour knows the popular spot well.

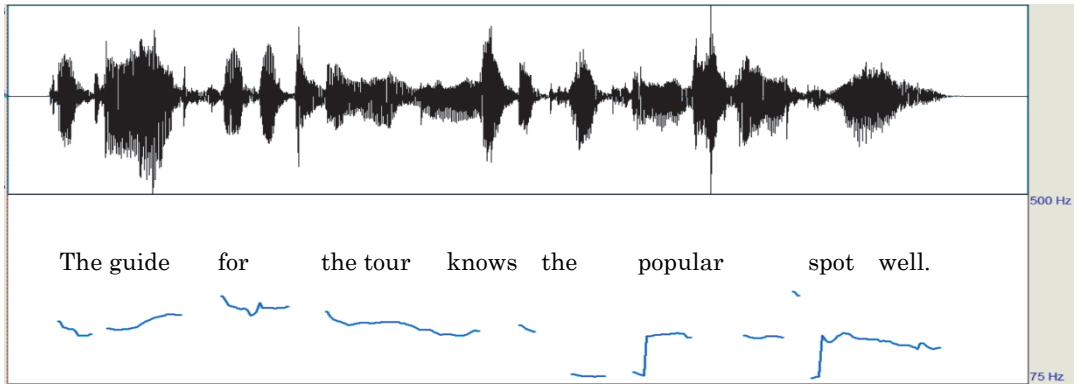
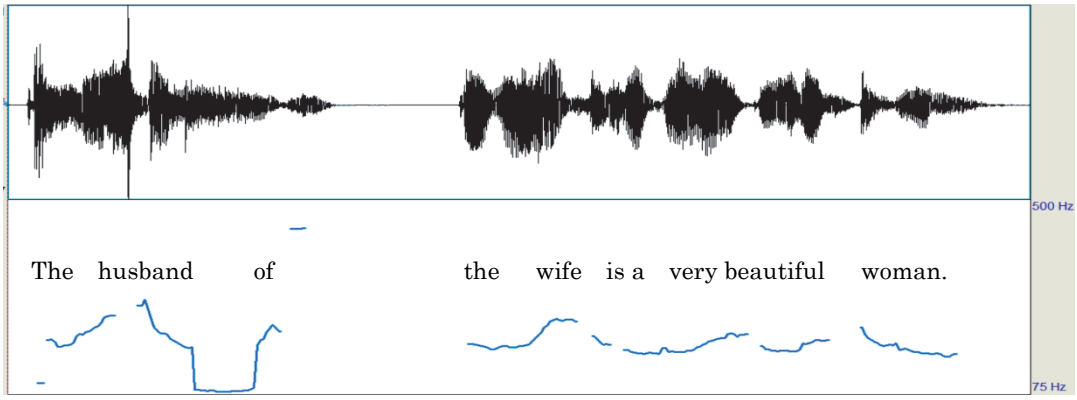


Figure 3

Condition C: The husband of the wife is a very beautiful woman.



4. Method and Discussion

4.1. OOPT Listening Score by English Proficiency

The participants were divided into three groups according to their OOPT listening scores (see Table 1). One-way analysis of variance (ANOVA; F (2,171) = 385.45, p < .01, η_p^2 = .818) and post hoc Bonferroni multiple comparisons confirmed that average listening scores were significantly different among the groups (p < 01). The high-proficiency group was made up of 11 Intermediate (B1), 6 Upper-Intermediate (B2), and 2 Advanced (C1) students. The middle-proficiency group consisted of 2 Pre-Intermediate (A2) and 17 Intermediate (B1) students. The low-proficiency group was made up of 5 Beginner (A1) and 15 Pre-Intermediate (A2) students.

Table 1

Average listening score by English proficiency

	High (n = 19)	Middle (n = 19)	Low (n = 20)
Ave.	62.37	45.16	26.95
S.D.	9.20	4.26	6.75

4.2. Listening Span Test score

4.2.1. Semantic Judgment Task Score by Prosody Condition

Table 2 illustrates the mean scores from the semantic judgment tasks by prosody condition. One-way ANOVA revealed a significant main effect (F(2,171) = 6.23, p < .01, η_p^2 = .068). The analysis of the main effect revealed that the scores of condition A were significantly higher than those of condition C (p < .01). In addition, condition A tended to produce significantly better scores than condition B did (p = .069).

Table 2

Semantic judgment task score by prosody condition

	A (Cooperating)	B (Baseline)	C (Conflicting)
Ave.	24.26	22.67	21.86
S.D.	4.20	3.73	3.83

4.2.2. Recall Score by Prosody Condition

Table 3 reveals the mean recall scores by prosody condition. One-way ANOVA revealed a significant main effect (F(2,171) = 7.144, p < .01, η_p^2 =.077). The analysis

of multiple comparison revealed that recall scores of condition A was significantly better than those of condition C ($p < .01$) and condition B ($p < .05$).

Table 3

Recall score by prosody condition

	A (Cooperating)	B (Baseline)	C (Conflicting)
Ave.	24.24	22.86	20.09
S.D.	5.89	5.96	6.23

4.3. Listening Span Scores by Proficiency

4.3.1. Semantic Judgment Task Score by Proficiency and Prosody Condition

Table 4 shows the mean scores of the semantic judgment task by proficiency and prosody condition. A 3 (proficiency) × 2 (prosody) ANOVA revealed significant main effects of proficiency ($F(2,165) = 6.420$, $p < .01$, $\eta_p^2 = .072$) and prosody ($F(2,165) = 6.610$, $p < .01$, $\eta_p^2 = .074$). The analysis of multiple comparisons on proficiency revealed that the high-proficiency group scored significantly better than the low-proficiency group ($p < .01$) did, and the middle proficiency group tended to produce better scores than the low proficiency group did ($p = .069$). The analysis of multiple comparisons on prosodic condition revealed that condition A produced significantly higher scores compared with condition C ($p < .01$) and tended to produce higher scores than condition B did ($p = .060$). However, there were no significant interactions between proficiency and prosody ($F(4,165) = 4.242$, n.s., $\eta_p^2 = .008$, n.s.).

Table 4

Semantic judgment task scores by proficiency and prosody condition

	A (Cooperating)			B (Baseline)			C (Conflicting)		
	High	Mid	Low	High	Mid	Low	High	Mid	Low
Ave.	25.84	24.58	22.45	23.58	23.00	21.50	22.63	22.00	21.00
S.D.	5.00	3.86	3.02	3.70	4.15	3.19	3.17	2.81	3.37

4.3.2. Recall Scores by Proficiency and Prosody Condition

Table 5 illustrates the mean recall scores by proficiency and prosody condition. A 3 (proficiency) × 2 (prosody) ANOVA revealed significant main effects of proficiency ($F(2,165) = 8.38$, $p < .01$, $\eta_p^2 = .092$) and prosody ($F(2,165) = 7.643$, $p < .01$, $\eta_p^2 = .085$). The analysis of multiple comparisons revealed that the recall scores of the high-proficiency group were significantly better than those of the low-proficiency group

($p < .01$), whereas the recall scores of the middle-proficiency group were significantly better than those of the low-proficiency group ($p < .01$). However, there were no significant interactions between proficiency and prosody (F (4,165)= .146, ns., η_p^2 =.004).

Table 5

Recall score by proficiency and prosody condition

	A (Cooperating)			B (Baseline)			C (Conflicting)		
	High	Mid	Low	High	Mid	Low	High	Mid	Low
Ave.	25.42	25.58	21.85	24.32	24.58	19.85	21.58	20.79	18.00
S.D.	7.15	4.82	4.93	6.47	5.16	5.21	6.91	5.16	6.23

5. Discussion

The main purpose of this study is to explore whether Japanese EFL learners use prosodic cues for sentence processing and whether they use working memory resources efficiently, as well as the degree to which this differs according to individual English proficiency. With this aim, listening span tests were implemented under three types of prosodic conditions (Cooperating, Baseline, and Conflicting conditions).

RQ1 deals with whether sentences with cooperating prosody promote comprehension and efficient functioning of working memory. The answer for RQ1 is yes. The results of this study reveal that when prosodic and syntactic boundaries coincide, the comprehension rates (Table 2) and working memory scores (Table 3) are better when the prosodic boundary is located at an inappropriate syntactic boundary. The result is consistent with many previous L1 studies, which reveal the presence of a prosodic boundary at an appropriate position that can facilitate syntactic processing (Speer et al., 1996). This study also reveals that Japanese EFL learners utilize informative prosody for syntactic processing. Syntactic processing places a heavier cognitive load on working memory resources compared with semantic and pragmatic processing for Japanese EFL learners (Nakanishi & Yokokawa, 2011). Therefore, the use of prosodic cues allows cognitive resources for syntactic processing, reserving the resources for retention of previously processed information.

RQ2 focuses on whether the degree of prosodic cue use in syntactic processing and working memory efficiency relate to individual English proficiency. The answer for the RQ2 is no. Table 4, which lists the listening comprehension scores, reveals that there is no interaction between the variables of proficiency and prosody. However, this result is inconsistent with the Nakanishi (2021)'s study, which included higher, middle, and lower proficiency groups. In this author's results, the higher proficiency group

achieved significantly better scores than the lower proficiency group did under the cooperating and conflicting prosodic conditions, whereas the middle proficiency group obtained better scores than the lower proficiency group did under the conflicting prosody condition.

There are two main differences between Nakanishi (2021)'s research and this study. The first difference is that the proficiency of the participants in this study is much lower than in Nakanishi (2021)'s study, as shown in Table 6. The second difference is the complexity of the sentence structures used in the listening span test. As noted in the introduction section, the sentences used in Nakanishi (2021)—which included the object relative clause as subject (e.g., "The man that married the woman became her husband")—were more cognitively demanding than the sentences in this experiment were; the latter included an initial noun phrase followed by a prepositional phrase as subject (e.g., "The suspect in the accident will be arrested").

Table 6

Average listening score by English proficiency in Nakanishi (2021)

	Nakanishi (2021)			This study		
	High	Middle	Low	High	Middle	Low
Number	24	24	22	19	19	20
Ave.	75.46	53.50	40.77	62.37	45.16	26.95
S.D.	14.17	10.11	8.61	9.20	4.26	6.75

Under the cooperating condition (e.g., "The girl that the helpers support %/ is a young woman"), the high-proficiency participants in Nakanishi (2021)—whose proficiencies were higher compared with the proficiencies of participants in this study—performed better than the low-proficiency participants did. This means that the informative prosodic cues facilitated the syntactic processing more for the high-proficiency group than it did for the low-proficiency group. In contrast, in this study—which used a simpler structure—the comprehension performances under the cooperating condition (e.g., "The suspect in the accident %/ will be arrested") for high proficiency group were not different from those for the low-proficiency group (see Table 4). This means that even the high-proficiency group could not fully utilize the informative prosodic cues for sentence comprehension to the same degree as the low-proficiency group could. It is difficult to conclude whether the proficiency difference, complexity of the structure, or both brought about the different result compared with the previous study. However, it is possible that the easier syntactic structure in this study, which needs less cognitive resources for processing, enabled all

proficiency groups to utilize informative prosodic information for sentence comprehension.

Under the conflicting prosody condition (e.g., “The runner that respects % the swimmers / can run fast”), the high- and middle-proficiency groups in Nakanishi (2021) performed better than the low-proficiency group did. In contrast, under the conflicting prosody condition in this study (i.e., “The husband of % the wife / is a very beautiful woman”), the comprehension scores are not different according to the proficiency. Even the high- and middle-proficiency groups in this study could not reach appropriate interpretation. To correctly understand the sentence in the mismatch condition between prosodic and syntactic structure, listeners are required to reanalyze the early decision, which is guided by misleading prosody (Pauker et al., 2011). It can be said that the syntactic processing ability for high and middle proficiency groups in this study is not fully developed, so they tend to easily adopt the incorrect syntactic analysis led by misplaced the prosodic boundary.

Regarding working memory efficiency, Table 5 reveals that there was no different according to proficiency. In addition, Table 4 shows that comprehension performance is not significantly different among prosodic conditions depending on proficiency. This means that even the high proficiency group exhausted many working memory resources for comprehension to the same extent as low proficiency group, leaving insufficient resources for the storage of target words.

6. Conclusion

This study revealed that regardless of their individual English proficiency, Japanese EFL learners utilize prosodic cues to interpret relatively simple syntactic sentences. Combining this study’s results with those of Nakanishi (2021), we can say that more proficient learners are sensitive to mismatches between prosody and syntactic structure. When they apprehend such a mismatch, they reanalyze earlier decisions led by misleading prosodic boundary.

My future research will consider when and how prosodic cues are implemented as Japanese EFL learners process syntactically ambiguous sentences. This will contribute to further investigations of cognitive mechanism of L2 processing. In addition, as an in-depth pedagogical study, the methodology of utilizing prosodic cue-based sentences that accelerate the automatization of syntactic processing should be explored. Prosody provides the syntactic structure of utterances (Frazier et al., 2006), the repeated exposure to syntactically complex sentences with cooperative prosody greatly assists learners in the overall development of their syntactic processing abilities.

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References

Frazier, L, Carlson, K, & Clifton, C. (2006). Prosodic phrasing is central to language comprehension. *Trends in Cognitive Sciences*, *10*(6), 244–249.

Gibson, E. A. F. (1998). Linguistic complexity: Locality and syntactic dependencies. *Cognition*, *68*, 1–76.

Grodner, D., & Gibson, E. (2005). Consequences of the serial nature of linguistic input. *Cognitive Science*, *29,* 261–291.

Hashimoto, K. (2011). Syntactic processing of L2 English relative clause sentences: The Effect of proficiency. *Annual Review of English language Education in Japan*, *22*, 95–110.

Hashimoto, K. (2012, March 27). *The effect of semantic information on L2 relative clause processing as a function of proficiency* [Paper presentation]. Paper presented at American Association for Applied Linguistics 2012, Boston, MA, United States.

Nakamura, C., Arai, M., & Harada, Y. (2015). Effect of prosody on resolving reduced relative clause ambiguity in L2 sentence processing. *Proceedings of the 44th Annual Meeting of the English Language Education Society of Japan*, 60–67.

Nakanishi, H. (2021). Prosody zyoho ga listening span test no bunrikai to bunmatsutango saisei seiseki ni oyobosu eikyo nitsuite [The effects of prosody on Japanese EFL learners' listening span]. *Seinan Journal of Foreign Language Studies*, *2*(1), 1–16.

Nakanishi, H., & Yokokawa, H. (2011). Determinant processing factors of recall performance in reading span tests: An empirical study of Japanese EFL learners. *JACET Journal*, *53*, 93–108.

Pauker, E., Itzhak, I., S., B., & Steinhauer, K. (2011). Effect of cooperating and conflicting prosody in spoken English garden path sentences: ERP evidence for the boundary deletion hypothesis. *Journal of Cognitive Neuroscience*, *23*(10), 2731–2751.

Sakakibara, K., & Yokokawa, H. (2015). Repeated exposure effects on Japanese EFL learners' relative clause processing: Evidence from a self-paced reading experiment. *Journal of the Japan Society for Speech Sciences*, *16*, 36–58.

Snedeker, J., & Trueswell, J. (2003). Using prosody to avoid ambiguity: Effects of speaker awareness and referential context. *Journal of Memory and Language*, *48* (l), 103–130.

Speer, S. R., Kjelgaard, M. M., & Dobroth, K. M. (1996). The influence of prosodic structure on the resolution of temporary syntactic closure ambiguities. *Journal of Psycholinguistic Research*, *25*, 249–271.

Ushiro, Y., & Sakuma, Y. (2000). Modifying reading and listening span tests for group testing. *JLTA Journal*, *3*, 67–82.

Yokokawa, H., Sadato, N., & Yoshida, H. (Eds.). (2014). *Gaikokugo unyou nouryoku ha ikani jyukutatsuka suruka: Gengo jyouhou syori no jidouka process wo saguru* [How does foreign language proficiency develop?: Investigating the automatization process of linguistic information processing]. Shohakusha.

Appendix

Sample Sentences for Types A–C.

Sample Sentences for Type A

The suspect in the accident will be arrested.
The prince of the country will become a king.
The dog of the actor drives his car by himself.

Sample Sentences for Type B

The husband of the woman is a strong lady.
The house of the lawyer has a lot of knowledge.
The magazine about the actress is sold at book stores.

Sample Sentences for Type C

The doctor in the hospital was built for the patients.
The pet of the writer had an idea for the next book.
The table in your house is the best place for sleeping.