Chapter 16
Cognitive Mechanisms in Korean Sentence Processing

Katsuo Tamaoka and Hyunjung Lim

Abstract This chapter investigates Korean sentence processing, focusing on case markers, scrambling effects, pre-head anticipatory processing, the animacy effect, head-driven processing, topicalization, and insights from eye-tracking research. Case markers are crucial in identifying grammatical functions, thereby facilitating efficient sentence processing. The scrambling effect in Korean shows that canonical word orders are processed more accurately and quickly than scrambled ones, highlighting the increased cognitive load imposed by non-canonical structures. Both pre-head anticipatory processing and head-driven processing play essential roles in sentence comprehension, particularly in complex or scrambled structures. Additionally, the animacy effect significantly influences sentence processing, with the absence of animacy contrast complicating syntactic interpretation. Eye-tracking studies provide further insight by capturing real-time cognitive processes during reading, revealing longer fixations and regressions in scrambled sentences, which signal increased processing difficulty. Contrary to prior expectations regarding topicalization, Tamaoka et al. (2024) found that subject topicalized orders were processed similarly to canonical orders, and no significant difference was observed between object topicalized and scrambled orders. This result may be attributed to overlapping effects of word order in topicalization and scrambling. This chapter highlights the interplay of syntactic and cognitive mechanisms in Korean sentence processing, offering insights into both universal and language-specific aspects of sentence comprehension.

Keywords Case marker · Scrambling effect · Pre-head anticipatory processing · Head-driven processing · Animacy effect · Topicalization · Eye-tracking study

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16.1 Introduction

Korean is a language that stands out for its distinct syntactic structures and the rich use of particles in noun phrases (NPs). Unlike the subject-verb-object (SVO) order found in languages like English, Korean typically follows a subject-object-verb (SOV) word order, being a verb-final language. This fundamental difference shapes many aspects of Korean sentence processing and linguistic expression. One of the key features of Korean syntax is the use of case markers, which are particles attached to NPs to indicate their grammatical roles, relationships between words, contextual cues, and nuances within a sentence (see Chap. 2 in this volume). The presence of these markers allows for a high degree of flexibility in word order, as they clarify the syntactic and semantic roles of the NPs they modify. This chapter aims to explore the intricate relationship between syntactic structures and semantic interpretation in Korean sentences. By examining how case markers and word order contribute to sentence meaning, this chapter delves into the specific cognitive processing mechanisms involved in Korean sentence comprehension.

16.2 Case Markers and Word Orders

Case markers (or particles) play a crucial role in constructing sentences across various languages (e.g., Chomsky, 1981, 1986; Fukui & Nishigauchi, 1992; Kim, 1996; Kuroda, 1978, 1987; Shibatani, 1990; Tamaoka et al., 2005). In Korean, three important case markers construct a sentence: nominative, accusative, and dative case markers. A case refers to the grammatical marking of nouns, pronouns, and adjectives to indicate their syntactic and semantic roles within a sentence. The nominative case, typically representing the subject, marks the entity performing the action, relatively independent of the verb. The accusative case, for the direct object, is defined by the verb and marks the entity directly associated with the verb's action. Verbs play a major role in determining the accusative case. The dative case, for the indirect object, indicates the recipient or beneficiary of an action and is more flexible. Some ditransitive verbs strongly influence the choice of the dative case, while others allow more flexibility. For example, in the English sentence 'My mother sent flowers to her grandmother,' the ditransitive verb 'send' strongly influences the recipient 'her grandmother' (dative case). While English does not have a robust case system, it exhibits fragments of case distinctions in pronouns, such as the nominative form 'he' and the accusative form 'him.'

Korean has a case marking (조사 *josa*) system (e.g., Chung & Lee, 2017; Kim & Kwon, 2004; Kwon & Zribi-Hertz, 2008; Lee, 2006). NPs in Korean are typically marked by one of three case markers (or particles), although there are other types: the nominative case marking the subject 이/가 *i/ga* (NP_{NOM}), the accusative case presenting the direct object 을/를 *eul/leul* (NP_{ACC}), and the dative case defining the indirect object 에게 *ege* (NP_{DAT}). A transitive verb assigns a direct object while the

subject is relatively independent of the verb. For example, the transitive verb 'see' involves both a subject marked by the nominative case 이/가 and a direct object marked by the accusative case 을/를. The case markers clearly indicate who (the subject) saw what (the direct object).

The frequency of case particles does not necessarily mean that the nominative case representing the subject is used most frequently. Based on 257,973 news articles from 10 major daily newspapers in South Korea reported in Ratsgo's Blog (Lee, 2017), Pae (2024) reported the usage of Korean grammatical particles. The most frequently used particle was the auxiliary particle 은/는 *eun/neun*, which counted 6,689,232 times or 22.31% of the total 29,983,952 instances. This auxiliary particle functions as presenting a subject as well as topicalization. These two major functions would make the auxiliary particle 은/는 very frequent. The runner-up particle was the object or accusative case marker 을/를, counting 5,837,313 times or 19.47%. Next was the subject or nominative case marker 이/가, which counted 4,841,467 times or 16.15%. Since subjects are often omitted in the flow of news articles, the accusative case may appear more frequently than the nominative case, even though objects are more likely to occur with case drop than subjects (Kim & Kwon, 2004).

The order of the subject and direct object (hereafter, simply 'object') in Korean is relatively flexible due to the presence of case markers on NPs, which clarify syntactic and semantic roles within a sentence. For example:

(1) SOV: Canonical order

Eonni	*-ga*	*chaeg*	*-eul*	*ilkeot-da.*
NP(sister)	NOM	NP(book)	ACC	V(read)-PST

언니가 책을 읽었다.

'(My) sister read (a) book.'

(2) OSV: Scrambled order

Chaeg	*-eul*	*eonni*	*-ga*	*ilgeot-da.*
NP(book)	ACC	NP(sister)	NOM	V(read)-PST

책을 언니가 읽었다.

In Sentence (1), '(My) sister read (a) book,' follows the SOV order with '(my) sister' marked by the nominative case marker 가 NP_{NOM}), '(a) book' marked by the accusative case marker 을 (NP_{ACC}), and the past tense verb (V-PST) 읽었다 *ilgeot-da* 'read' at the end. In Sentence (2), the positions of NP_{NOM} and NP_{ACC} are scrambled, as is the characteristic of the OSV order. The OSV order is formed by moving the object to the beginning of the sentence. This word order was termed *scrambling* by Ross (1967), who primarily discussed this phenomenon in relation to Germanic languages (Broekhuis, 2008; Neeleman, 1994). Consequently, while the verb consistently appears at the end of the sentence, the positions of the subject and object can vary. This flexibility in word order plays a crucial role in the cognitive processing of Korean sentences.

16.3 Scrambling Effect

Korean is a verb-final language with the SOV canonical order (Lee & Ramsey, 2000; Pae, 2024). Previous psycholinguistic studies (e.g., Imamura et al., 2016; Koizumi & Tamaoka, 2004, 2010; Mazuka et al., 2002; Miyamoto, 2006; Miyamoto & Takahashi, 2004; Tamaoka & Mansbridge, 2019; Tamaoka et al., 2005, 2014; Ueno & Kluender, 2003; Witzel & Witzel, 2016) conducted in the verb-final language of Japanese, which shares similar syntactic features with Korean, have consistently found that the canonical SOV order is processed faster than the scrambled OSV order. Likewise, the Korean language also displays the same tendency. In a study by Tamaoka et al. (2024), native Korean speakers were tasked with evaluating the correctness of each sentence, considering both its semantic coherence and grammatical accuracy. This approach is referred to as a sentence correctness decision task (see Fig. 16.1).

Utilizing this task, Tamaoka et al. (2024) measured the processing time for both canonical SOV and scrambled OSV sentence orders in Korean, employing sentences analogous to Sentences (1) and (2). They found that Korean canonical SOV sentences were processed both more rapidly and accurately compared to their scrambled OSV counterparts. The task for sentences in the OSV scrambled order was performed without any preceding context. If the OSV order was created within a certain discourse, the processing time should be faster with context. Without context, it should be slower. The difference in accuracy between SOV (M = 97.40%, SD = 15.95%) and OSV (M = 93.75%, SD = 24.24%) was 3.65% on average. The difference in processing speed between SOV (M = 1270 ms SD = 526 ms) and OSV (M = 1551 ms, SD = 698 ms) was substantial, with an average difference of 281 ms. The processing inefficiency observed in both accuracy and speed for scrambled sentences is commonly referred to as the *scrambling effect*. The study clearly indicated a significant scrambling effect in Korean, showing that the OSV scrambled order was processed more slowly than the SOV canonical order.

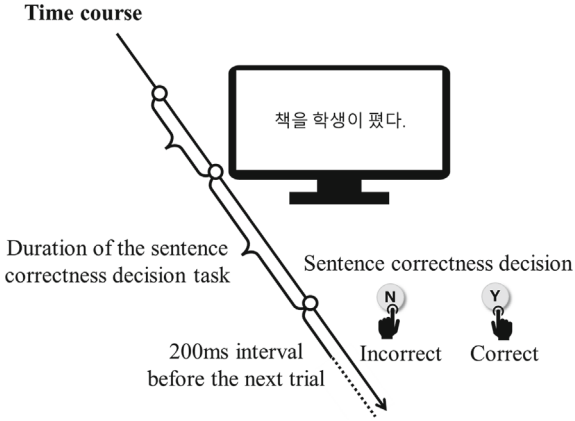


Fig. 16.1 A single trail of the Korean sentence correctness decision task

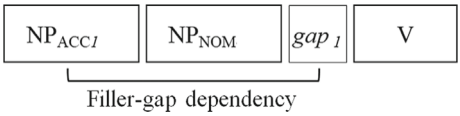


Fig. 16.2 The filler-gap dependency in a transitive sentence (O_1S t_1 V)

One potential explanation for the delay in processing the scrambled OSV order comes from the *gap-filling parsing model* (Frazier & Clifton, 1989; Frazier & Flores d'Arcais, 1989; Frazier & Rayner, 1982; Stowe, 1986). According to this model, as shown in Fig. 16.2, native Korean speakers likely identify the initial NP marked by the accusative maker 을/를 (NP$_{ACC1}$) of a Korean scrambled sentence as a filler, and subsequently search for its original position in the specifier of the gap (gap_1) to establish the filler-gap dependency. This scrambling can be explained as a syntactic operation of phrasal movement from the original locus (t_1 as trace) of the object (NP$_{ACC1}$) in the canonical position to the sentence-initial position as in [$_{CP}$ NP$_{ACC1}$ [$_{IP}$ NP$_{NOM}$ [$_{VP}$ t_1 V]]], where IP refers to inflectional phrase and CP to complementizer phrase (or simply O_1S t_1 V). The t_1 (gap_1) indicates the original position in the canonical order from which the NP$_{ACC}$ is moved to the sentence's initial position. To accomplish the processing of a scrambled sentence, native Korean speakers must recognize the initial NP$_{ACC1}$ as a filler, and then find its original position in VP (gap_1) in order to establish the filler-gap dependency. Since an OSV scrambled order (O_1S t_1 V) is syntactically more complex than an SOV canonical order, a sentence in the SOV canonical order is expected to be processed more quickly than its OSV scrambled counterpart.

Given that Korean is a *null-subject* (or *pro-drop*) language, the subject of a sentence can be omitted. In the case of a null subject, native Korean speakers initially interpret the sentence as having an omitted subject. However, in a scrambled sentence where the subject follows the object, native Korean speakers will search for the gap_1, representing the position where the object would occur in the SOV canonical order. They establish the filler-gap dependency between the object and the gap as O_1 S gap_1 before encountering the verb to fully comprehend the scrambled sentence. This additional processing demand may prolong the processing time and potentially lead to comprehension errors.

16.4 Pre-head Anticipatory Processing

In verb-final languages such as Korean and Japanese, where the verb comes last in a sentence, information about the verb is encountered only after most of the sentence has been read. For instance, 검은색 긴 머리를 한 소녀가 라벤더가 피어 있는 공원을 천천히 걷고 있었다. *Geomeunsaek gin meorireul han sonyeo-ga rabendeo-ga pieo inneun gongwon-eul cheoncheonhi geotgo-isseot-da.* 'A girl with long black hair was walking slowly through a park where lavender blooms.' In this long Korean sentence, the verb cannot be seen for reading comprehension or for listening comprehension

until the end. If native Korean speakers cannot completely understand this sentence without seeing or hearing the verb or predicate 걷고 있었다 *geotgo-isseot-da* 'was walking,' they may have to return to the already-read or already-heard long context. This would require a great deal of effort in terms of efficiency for sentence processing. Kimball (1975) suggested that native speakers are regularly able to guess what comes next in a sentence. If so, it is expected that native Korean speakers would deduce the last verb with some degree of anticipation, even without seeing or hearing the ending verb.

The cognitive processing of predictive reading or listening may be a common practice in efficient real-time sentence comprehension. In studies on the verb-final language of Japanese, Kamide and Mitchell (1999) and Kamide et al. (2003) investigated pre-head (before seeing a verb) processing using the 'visual-world' eye-tracking paradigm. In this paradigm, multiple pictorial items are presented on a single screen, some of which are related to a sentence that is auditorily presented. Participants look at this screen for approximately one second. A sentence is then auditorily presented, and the sequential duration of eye fixation times is recorded by the eye-tracker. Kamide and her colleagues (1999, 2003) found that participants were likely to focus on pictorial items on the screen that had not yet been auditorily presented. This suggests that native Japanese speakers engage in advanced planning for comprehending sentences incrementally before the final verb is seen. Similarly, native Korean speakers can also anticipate the formation of a sentence based on the argument information provided by the case markers and NPs meanings. This anticipatory processing allows for more efficient real-time comprehension, as it enables speakers to predict upcoming components of a sentence even before encountering the final verb.

Based on the findings of Kamide and her colleagues (1999, 2003), in a Korean SOV sentence such as 누나가 사과를 먹었다 (*Nuna-ga sagwa-reul meogeot-da*, '(My) sister ate (an) apple'), it can be expected that native Korean speakers first see or hear the agent 누나가 '(my) sister-NOM' in the processing sequence. They identify the subject by referring to the nominative case marker 가. At this stage, native Korean speakers already know that '(my) sister' is the actor. Next, the theme 사과를 '(an) apple' with the accusative case marker 를 following. By relying on these nominative and accusative case markers, native Korean speakers can begin to form a sentence containing two NPs, as in $[_{IP}$ NP(sister)$_{NOM}$ $[_{VP}$ NP(apple)$_{ACC}$…]]. They then simply wait for the ending verb 먹었다 'ate' to comprehend the sentence. Thus, a Korean sentence is mostly formed before seeing or hearing the ending verb. This process is known as *pre-head anticipatory processing* (Kamide & Mitchell, 1999; Kamide et al., 2003; see also Kamide, 2008; Altmann & Kamide, 1999 for a general discussion).

Using an eye-tracking method using the visual-world paradigm used by Kamide and her colleagues (1999, 2003), Lee (2019) also demonstrated the importance of case markers in the pre-head anticipatory processing of Korean sentences. Native Korean speakers showed significantly more anticipatory eye movements toward the potential referent of a theme object when hearing a sequence with a nominative-marked NP followed by a dative-marked NP, compared to when the following NP was marked

with an accusative case. This suggests that Korean sentences can be interpreted incrementally and predictively at each moment of processing. Lee (2019) explained these results to mean that when NPs marked by case markers are available earlier in the input, native Korean speakers can predict forthcoming NP arguments, leading to the partial construction of the syntactic structure of NPs. Lee (2019) referred to this anticipatory tendency as the *case effect* on anticipatory processing.

16.5 Head-Driven Processing

While the classification of Korean and Japanese within the Altaic language family is still controversial, it is widely accepted that these languages share many linguistic features (Lee & Ramsey, 2000; Pae, 2024). As head-final languages, Korean and Japanese are often assumed to rely less on head (verb)-driven processing strategies. Lee (2019) argues that a sentence in Korean can be easily understood without the ending verb due to the clarity provided by case markers. The concept of pre-head anticipatory processing (Kamide & Mitchell, 1999; Kamide et al., 2003 for Japanese; Lee, 2019 for Korean) emphasizes the role of noun meanings, including animacy, in conjunction with case marker information. As Kimball (1975) pointed out, even in head-final languages, native speakers can predict the next phrase in a sentence, suggesting that this predictive mechanism is common in both reading and listening comprehension.

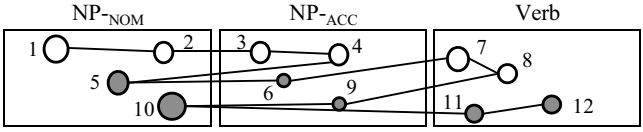
Then, in the absence of an animacy contrast, such as in a sentence containing two proper nouns, 동급생 진수가 영자를 초대했다. *Donggeupsaeng Jinsu-ga Yeongja-reul chodaehaet-da.* 'A classmate Jinsu invited Yeongja,' two animate proper nouns can lead to several possibilities for an ending verb, such as 'invite,' 'praise,' 'comfort,' or even 'hit,' 'kill,' etc. In this case, although the nominative 가 and accusative 를 case markers allow for the construction of a syntactic structure depicting a relationship between 진수 and 영자, the sentence still requires the final verb 초대했다 *chodaehaet-da* 'invited' to complete the relationship between the two people, as both 진수 and 영자 can be either the subject or the object. Furthermore, when this sentence is scrambled into the OSV order as 영자를 동급생 진수가 초대했다, it may be more difficult to comprehend than the canonical SOV order. This difficulty arises due to the semantic ambiguity caused by the lack of animacy contrast between the subject and object NPs, making it challenging to construct the syntactic structure of the NPs. This raises the question of how pre-head anticipatory processing occurs and how the sentence-final verb functions as the head of the sentence.

The animacy contrast in NPs plays a crucial role in sentence processing, particularly in languages with flexible word order, such as Korean and Japanese. Typically, animate nouns are more likely to be interpreted as subjects, while inanimate nouns tend to be seen as objects. In these head-final (verb-final) languages, native speakers may rely on the sentence-final verb as a key indicator to determine the subject and object. When encountering an OSV scrambled sentence with NPs that lack animacy contrast, the cognitive load becomes even greater compared to processing an SOV

canonical order. Tamaoka and Mansbridge (2019) explored this increased cognitive load by examining the processing of scrambled sentences using an eye-tracking technique. Their study involved phrase-by-phrase reading of simple Japanese transitive sentences with shorter-distance scrambling and no animacy contrast.

Before presenting the findings of this eye-tracking research by Tamaoka and Mansbridge (2019), it is important to first introduce the real-time eye-tracking measurement indices used in their study. During reading, eye movements consist of two basic components: *fixations* and *saccades* (Rayner, 2009). Fixations occur when the eyes stop moving to gather information, while saccades refer to the rapid movement of the eyes from one point to another. Eye-tracking has been widely used in experiments involving the processing of complex phrasal structures, including ambiguous sentences (e.g., Binder et al., 2001; Clifton et al., 2007; Frazier & Rayner, 1982; Rayner & Frazier, 1987, 1989; Rayner et al., 1983). Eye-tracking allows for the collection of reading time measures for each phrase in a sentence. As illustrated in Fig. 16.3, the early stages of sentence processing are captured by two key measurements: *first-fixation time* and *first-pass time*. First-fixation time refers to the duration of the very first fixation within a region of interest upon initial visual entry. First-pass time includes the total duration of all fixations within the region from the moment the eyes first enter it from the left, until they exit—regardless of direction. These early processing indices are crucial for understanding initial sentence processing stages, such as lexical access and the early integration of information.

Late-stage sentence processing is reflected in measurements such as *go-past time* and *total reading time*. These indices are associated with later processing activities,



Measurement	Region 1	Region 2	Region 3
Early measurements			
(1) First-fixation time	1	3	7
(2) First-pass time	1+2	3+4	7+8
Late measurements			
(3) Go-past time	Not applicable	3+4+5+6	7+8+9+10+11+12
(4) Re-reading time	5+10	6+9	11+12
(5) Regression-out	Not applicable	Yes (4 to 5 / 9 to 10)	Yes (8 to 9)
(6) Regression-in	Yes (4 to 5 / 9 to 10)	Yes (8 to 9)	Not applicable
Total measurements			
(7) Dwell time	1+2+5+10	3+4+6+9	7+8+11+12

Fig. 16.3 Real-time eye-tracking measurement indices. *Note* The circles (○) represent fixations, with the numbers indicating the sequence of the participant's fixations. Each fixation is labeled with its corresponding number, such as 'Fixation 6.' The size of each circle reflects the duration of the fixation

including structural re-analysis, recovery from processing difficulties, and discourse integration (Rayner, 2009). Go-past time measures the total duration spent on a region before the eye exits it to the right for the first time. Additionally, regression measurements—*regression-in* and *regression-out*—are important indicators of processing difficulty. Regression-in indicates whether the reader returns to a previous region, while regression-out refers to an eye movement out of a region into a preceding region during the first pass through the text.

For example, in a transitive three-phrase sentence with SOV or OSV order (where S or O is in Region 1 and/or Region 2, and V is in Region 3 in Fig. 16.3), even though there is no region to the right of the verb in Region 3, the go-past time at the end of the sentence (the verb in Japanese) serves as a useful index for understanding the total reading time, including the time spent within and moving out of that region (i.e., the sentence wrap-up effect). Thus, a difference in go-past time with no difference in first-pass time in Region 2 (Fixation 3 plus Fixation 4 in Fig. 16.3) could be a key measurement for evaluating pre-head anticipatory processing, particularly in the context of scrambled OSV-ordered sentences.

Re-reading time, which is the sum of all fixations after the first pass through an interest region, is especially important for identifying post-head processing, particularly in Region 2 (Fixation 6 plus Fixation 9 in Fig. 16.3) after the participants encounter the verb. The total measurement in each region is referred to as dwell time, encompassing both early and late fixation measurements. Regressions, or backward saccades, are also crucial indices for analyzing the processing of scrambled sentences. The regression-out index indicates the backward eye movement from the verb in Region 3 to the NP-$_{ACC}$ in Region 2 (e.g., an eye movement from Fixation 8 to Fixation 9), including any regressive readings out of the region to the left before moving right. In contrast, the regression-in index reflects the forward eye movement from the NP-$_{ACC}$ in Region 2 back to the verb in Region 3 (e.g., an eye movement from Fixation 9 to Fixation 8).

Tamaoka and Mansbridge (2019) recorded durations of eye fixations and frequencies of regressions-in/-out by native Japanese speakers in each target region. The results of processing transitive sentences are shown in Fig. 16.4 in milliseconds (ms), with delta (Δ) indicating differences in fixation times between OSV (O_1 S t_1 V) and SOV transitive sentences. Processing times for canonical ordered sentences (SOV) were subtracted from processing times for scrambled ordered sentences (OSV), resulting in the Δ values (OSV minus SOV). The involvement of pre-head anticipatory processing (e.g., Aoshima et al., 2004, 2009; Kamide & Mitchell, 1999; Kamide, 2008; Kamide et al., 2003; Lee, 2019; Mazuka et al., 2002; Miyamoto, 2006; Witzel & Witzel, 2016) in Japanese short-distance scrambling sentences indicated a significantly longer go-past time of Δ129 ms in Region 2 before seeing the verb. The ending verb in Region 3 also received a significantly longer go-past time of Δ140 ms. Additionally, evidence of heavy head-driven processing (Ikuta et al., 2009; Wolff et al., 2008) was seen in the re-reading time of Δ147 ms in Region 2. Since the gap_1 (or t_1) in OSV (O_1 S t_1 V) scrambled sentences is found between $NP_{NOM\text{-}ga}$ (subject) in Region 2 and the head verb (V) in Region 3, the significantly longer re-reading time suggested that native Japanese speakers read back to the crucial

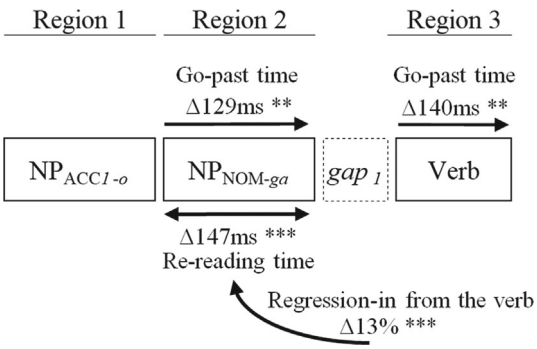


Fig. 16.4 Processing of scrambled transitive sentences observed by eye-tracking. *Note* ** $p <$ 0.01. *** $p < 0.001$. Δ (ms) is a difference in fixation time (O_1 S t_1 V—SOV)

$NP_{NOM\text{-}ga}$ in Region 2 to check the argument structure of $NP_{NOM\text{-}ga}$ and $NP_{ACC\text{-}o}$ after seeing the head verb. This trend was further supported by the occurrence of a significantly higher regression-in frequency of Δ13% for O_1 S t_1 V scrambled sentences in Region 2 from the ending verb.

A scrambled order of NP-$_{ACC}$ and NP-$_{NOM}$ in a transitive Japanese sentence may trigger pre-head anticipatory processing, as suggested by Kamide and her colleagues (e.g., Kamide, 2008; Kamide & Mitchell, 1999; Kamide et al., 2003). However, when two NPs consist of commonly-used individuals' first names, they do not provide sufficient information to utterly establish the filler-gap dependency before encountering the sentence-ending verb. In the absence of animacy contrast, the OSV (O_1 S t_1 V) sentence is often read up to the verb, with readers then going back to the crucial NP-$_{NOM}$-*ga*. The backward reading from the ending verb to Region 2, along with re-reading times in Region 2 observed by Tamaoka and Mansbridge (2019), indicates that native Japanese speakers rely on the verb-and-NP argument information provided by the verb to resolve the filler-gap dependency as well as to complete the whole syntactic structure in scrambled sentences, even in simple transitive constructions.

As seen in this eye-tracking study by Tamaoka and Mansbridge (2019), the sentence-final verb plays a pivotal role in comprehending sentences, even in the verb-final structure of Japanese, particularly when there is no animacy contrast between the subject and object. Similarly, in Korean, another verb-final language, sentence comprehension likely relies heavily on verb-and-NP argument information, particularly when there is no animacy contrast between the NPs. While not yet empirically confirmed for Korean, as demonstrated by Tamaoka and Mansbridge (2019) in Japanese, it is anticipated that backward reading from the sentence-final verb may occur when processing Korean scrambled sentences with no animacy contrast between NPs. This hypothesis opens the door for future research, specifically eye-tracking studies, to explore this phenomenon in Korean.

16.6 Integration of Pre-head Anticipatory and Head-Driven Processing

In head-final languages like Japanese and Korean, the cognitive mechanisms of pre-head anticipatory processing and verb-driven processing may seem contradictory. Pre-head anticipatory processing occurs before encountering the verb, while verb-driven processing primarily takes place after the verb is encountered. However, when there is no animacy contrast between the subject and object NPs, there is insufficient information to construct the NP structure without relying on the sentence-final verb. In such cases, the verb becomes crucial for identifying the arguments of the verb and NPs, allowing for the construction of the entire sentence structure.

Animacy, which refers to the degree of life or sentience attributed to a noun, plays a significant role in structuring and encoding arguments within a language. In many languages, animate nouns such as humans and animals are more likely to serve as subjects, while inanimate nouns, like objects or substances, are typically used as objects. This animacy effect often influences word order, with animate nouns tending to appear earlier in a sentence. The interaction between grammatical structures and the animacy of noun phrase (NP) referents is captured in various animacy scales (e.g., de Swart et al., 2008; Nelson & Vihman, 2018; Vihman & Nelson, 2019). The contrast in animacy between NPs is a powerful cue in sentence processing, as demonstrated by studies on languages like Mandarin Chinese (e.g., Hsiao & Gibson, 2003; Kwon et al., 2019; Pu, 2007) and Dutch (e.g., Mak et al., 2002).

Japanese and Korean share several syntactic similarities due to their classification as head-final, agglutinative languages. In both languages, the verb typically appears at the end of the sentence, with subject and object modifiers preceding it. They use agglutinative morphology, wherein words are formed by stringing together morphemes that convey specific meanings such as tense, mood, and politeness. Both languages employ postpositional particles as case markers to indicate the grammatical functions of NPs within a sentence, such as subject, object, and topic. Flexible word order is permitted in both languages due to case marking, with the canonical SOV order being common. Scrambling is frequently used to emphasize focus. Despite differences in the use and function of particles, the integration of honorifics, the distinction between topic and subject, and the extent of ellipsis and noun modification strategies, Japanese and Korean both exhibit fundamental syntactic features of head-final structure, agglutinative morphology, postpositional particles, and flexible word order. These shared characteristics would mainly influence the cognitive mechanisms underlying sentence processing in both languages.

Objects with high animacy are conceptually more accessible, making them easier to retrieve from memory (Branigan et al., 2008). Positioning animate nouns earlier in a sentence helps clarify their roles, thereby making the sentence easier to understand. In English, for instance, animate subjects typically precede inanimate objects, as seen in *The dog* (animate) *chased the ball* (inanimate). This word order aligns with cognitive expectations, making it feel natural. In contrast, reversing the animacy contrast, as in *The ball chased the dog,* introduces a processing delay because it

disrupts the usual animacy hierarchy. Similarly, in Korean, animacy influences word order. For example, the sentence 개가 공을 쫓았다 (*Gae-ga gong-eul jjoch-at-da,* 'The dog chased the ball') feels more natural and is processed faster than 공이 개를 쫓았다 (*Gong-i gae-reul jjoch-at-da,* 'The ball chased the dog'). Although the latter is grammatically correct, native Korean speakers may find it less natural due to the reversed animacy order. Japanese, like English and Korean, also shows a similar pattern where animacy affects sentence processing.

As evidenced by the prolonged eye fixations observed during the processing of OSV scrambled sentences without animacy contrast (Tamaoka & Mansbridge, 2019), animacy aids in the rapid assignment of syntactic roles, reduces cognitive load, and facilitates anticipatory processing, especially in languages with flexible word order. When an animacy contrast is present, it triggers anticipatory processing, guiding the reader or listener to expect a particular syntactic structure. This anticipation streamlines sentence processing, as the mind prepares for the most probable continuation of the sentence. In languages with case markers, such as Korean and Japanese, animacy works in conjunction with these markers to reinforce the syntactic roles of noun phrases, further enhancing processing efficiency.

Let's consider how the Korean and Japanese scrambled sentence processing mechanisms function when there is no animacy contrast between the subject NP and the object NP. Since studies on Korean scrambled sentence processing in eye-tracking are lacking, it is reasonable to assume that Korean and Japanese might exhibit similar processing mechanisms. The steps of sentence processing depicted in Fig. 16.5 are thus a plausible hypothesis, based on findings from the processing of scrambled sentences in the similar verb-final language of Japanese (Tamaoka & Mansbridge, 2019). As described in pre-head anticipatory processing (Kamide, 2008; Kamide & Mitchell, 1999; Kamide et al., 2003), native Korean speakers may be able to partially construct a structure for a simple transitive scrambled sentence involving subject and object NPs as [$_{CP}$ NP-$_{ACC}$ [$_{TP}$ NP-$_{NOM}$ [$_{VP}$ gap_1 …]]] (Step 1 in Fig. 16.5), even in the absence of an animacy contrast. However, because there is no animacy contrast to assist in constructing the syntactic structure for NPs, verb information becomes crucial at this stage.

When extracting verb-and-NP argument information from the sentence-final verb, processing takes longer for sentences with scrambled word order. The prolonged eye fixations observed in OSV-ordered scrambled sentences compared to SOV-ordered canonical sentences suggest that scrambling affects how verb information is acquired (Step 2 in Fig. 16.5). This suggests that constructing the syntactic structure of a scrambled sentence may be more challenging than for SOV-ordered canonical sentences, especially after the final verb is processed and a structure like [$_{CP}$ NP-$_{ACC}$ [$_{TP}$ NP-$_{NOM}$ [$_{VP}$ gap_1 V]]] is formed. Moreover, as seen in the processing of Japanese scrambled sentences, it is anticipated that head-driven processing, particularly 'backward' verb-and-NP argument checking (Tamaoka & Mansbridge, 2019), will occur. This likely results in extensive re-reading of the NP-$_{NOM}$ and gap_1 area (Step 3 in Fig. 16.5) compared to canonical sentences. Therefore, both pre-head anticipatory processing and head-driven processing are essential for understanding the cognitive mechanisms

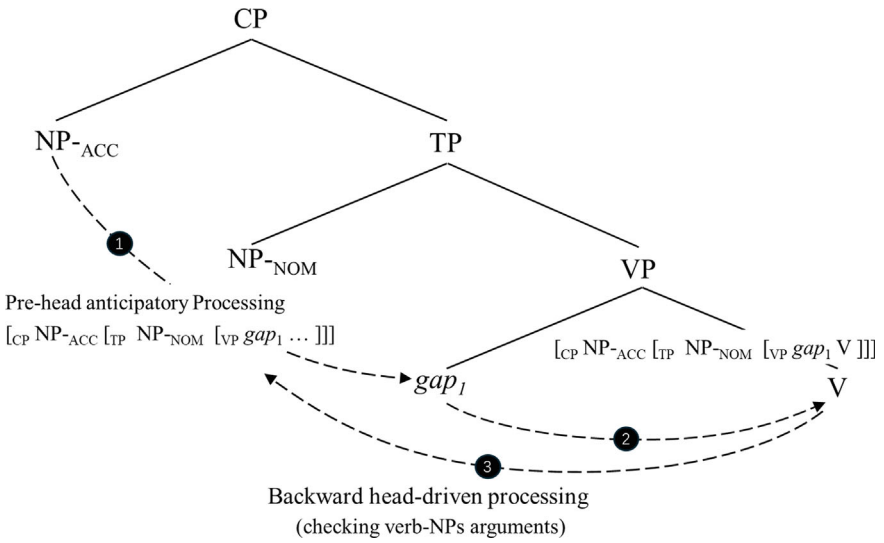


Fig. 16.5 Three steps in processing scrambled sentences with no animacy contrast. *Note* The numbers indicate the processing sequence by participants

underlying the comprehension of scrambled sentences in these languages. Consequently, pre-head anticipatory processing (Kamide, 2008; Kamide & Mitchell, 1999; Kamide et al., 2003) and head-driven processing (Pritchett, 1988, 1991, 1992) play crucial roles in processing OSV scrambled order sentences without animacy contrast.

16.7 Topicalization

Korean is often referred to as a language with a topic-comment structure (Li & Thompson, 1976). The topic (주제, *juje*) indicates what the sentence is about and can be the subject or any other element that the speaker wants to highlight. In Korean, topicalization is commonly achieved through the use of the auxiliary particle or topic marker 은/는. This particle, being the most frequently used (Pae, 2024), can denote either a topic or a subject. The comment (서술, *seosul*) provides information about the topic, describing the action or conveying additional details. Due to this syntactic structure, Korean is often referred to as a topic-prominent language.

Topicalization is a crucial aspect of sentence structure in Korean, reflecting how information is organized and presented in discourse. In Korean, the topic is most frequently positioned at the beginning of the sentence. For example:

(3) SOV: Canonical order
여동생이 점심을 샀다.

Yeodongsaeng-i	*jeomsim*	*-eul*	*sat*	*-da.*
NP(sister)	NOM NP(lunch)	ACC	V(buy)	-PST

'(My) sister bought the lunch.'

(4) OSV: Scrambled order
점심을 여동생이 샀다.

Jeomsim	*-eul*	*yeodongsaeng-i*	*sat*	*-da.*
NP(lunch)	ACC	NP(sister)	NOM	V(buy)-PST

(5) SOV: Subject topicalized order
여동생은 점심을 샀다.

Yeodongsaeng	*-eun*	*jeomsim*	*-eul*	*sat*	*-da.*
NP(sister)	TOP	NP(lunch)	ACC	V(buy)	-PST

(6) OSV: Object topicalized order
점심은 여동생이 샀다.

Jeomsim	*-eun*	*yeodongsaeng*	*-i*	*sat*	*-da.*
NP(lunch)	TOP	NP(sister)	NOM	V(buy)	-PST

Sentence (3) is the most frequently-used common expression of SOV order, expressing '(My) sister bought the lunch' while Sentence (4) is its scrambled OSV order. This difference and background cognitive processing mechanism is explained in Sects. 16.2, 16.3 and 16.6 of this chapter. Topicalization allows speakers to emphasize different elements of the sentence, thereby guiding the listener's attention to what is deemed important or relevant in the discourse. In the subject topicalized order as shown in Sentence (5), 여동생은 '(my) sister' is highlighted as the topic, whereas in the object topicalized order as shown in Sentence (6), 점심은 'the lunch' is emphasized. While the topicalization due to the difference in focus has an emphasis effect, the meaning of Sentences (3) to (4) remains unchanged (Suh, 1996). Topicalization in Korean is not only a syntactic phenomenon but also a pragmatic tool that reflects the speaker's intent and the discourse context. The flexibility in topicalization demonstrates the nuanced ways in which Korean speakers can manipulate sentence structure to achieve specific communicative goals. By choosing to topicalize certain elements, speakers can convey subtle nuances and ensure that the listener's focus aligns with the intended message.

In the study by Tamaoka et al. (2024), native Korean speakers were presented with sentences of four different word orders, as shown in Sentences (1) to (4), and were asked to make correctness judgments. The sentence correctness decision task is

illustrated in Fig. 16.1. The factor of sentence types significantly impacted accuracy rates. Multiple comparisons of the word orders, with results displayed in Fig. 16.6, indicated that $S_{NOM}O_{ACC}V$ ($M = 97.40\%$) and $S_{TOP}O_{ACC}V$ ($M = 97.92\%$) were processed with similar levels of accuracy. Both $S_{NOM}O_{ACC}V$ and $S_{TOP}O_{ACC}V$ orders were processed more accurately than $O_{ACC}S_{NOM}V$ ($M = 93.75\%$) and O_{TOP} $S_{NOM}V$ ($M = 91.67\%$) orders. The accuracy for $O_{ACC}S_{NOM}V$ and $O_{TOP}S_{NOM}V$ orders was equivalent.

Furthermore, the time taken to determine sentence correctness was also measured. Processing time is considered a more sensitive indicator of sentence processing than the correct response rate, which is the result of judgment. The results of multiple comparisons are shown in Fig. 16.7. The findings indicated that $S_{NOM}O_{ACC}V$ ($M = 1{,}270$ ms) and $ST_{OP}O_{ACC}V$ ($M = 1{,}267$ ms) orders were processed at the same speed. Both $S_{NOM}O_{ACC}V$ and $S_{TOP}O_{ACC}V$ orders were processed faster than O_{ACC} $S_{NOM}V$ ($M = 1{,}551$ ms) and O_{TOP} $S_{NOM}V$ ($M = 1{,}571$ ms) orders. The O_{ACC} $S_{NOM}V$ and O_{TOP} $S_{NOM}V$ orders were processed at roughly the same speed.

Various syntactic similarities are found between Korean and Japanese. In both languages, a scrambled order is created by moving the object in front of the subject. As shown in Figs. 16.6 and 16.7, sentences in canonical order ($S_{NOM}O_{ACC}V$) were processed more accurately and quickly than their scrambled counterparts ($O_{ACC}S_{NOM}V$). This result confirms the existence of the scrambling effect, as also observed in previous studies on Japanese sentence processing (e.g., Imamura et al., 2016; Koizumi & Tamaoka, 2004, 2010; Mazuka et al., 2002; Miyamoto & Takahashi, 2004; Tamaoka & Mansbridge, 2019; Tamaoka et al., 2005, 2014; Ueno & Kluender, 2003; Witzel & Witzel, 2016). The processing delay for the syntactic structure of the scrambled order in both Japanese and Korean can be explained by the gap-filling

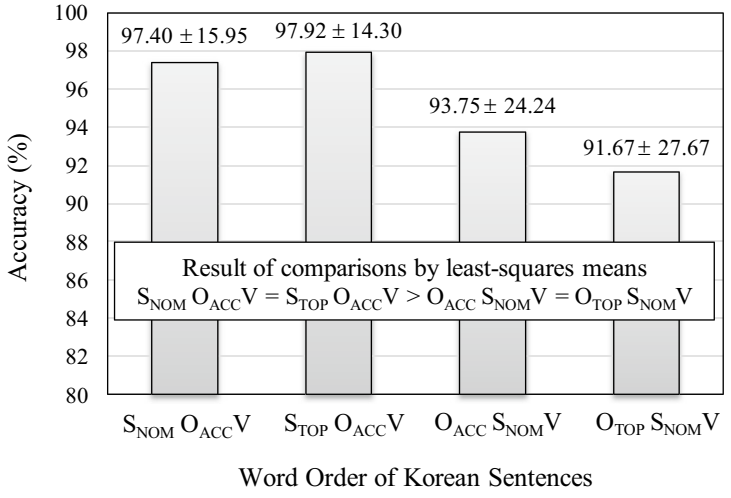


Fig. 16.6 Accuracies of the four orders of Korean sentences. *Note* The values after ± refer to standard errors. This figure is taken from Tamaoka et al. (2024, Fig. 2

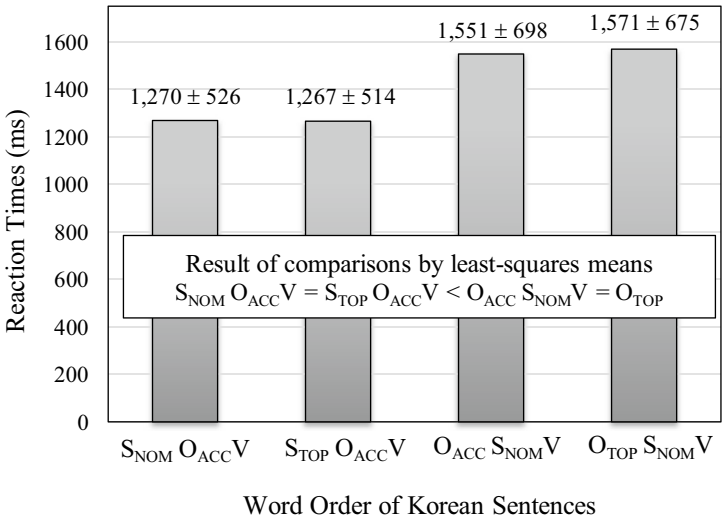


Fig. 16.7 Reaction times of the four orders of Korean sentences. *Note* The values after ± refer to standard errors. This figure is taken from Tamaoka et al. (2024, Fig. 3)

parsing model (Frazier, 1987; Frazier & Clifton, 1989; Frazier & Flores d'Arcais, 1989; Frazier & Rayner, 1982; Stowe, 1986) which was presented in Sect. 16.3 of this chapter.

Regarding topicalization in Japanese, Shibatani (1990) proposed that $NP_{SUB\text{-}TOP}$ of transitive sentences ($S_{TOP}O_{ACC}V$) are external to the inflectional phrase (IP) in the structure [$_{CP}$ $NP_{SUB\text{-}TOP1}$ [$_{IP}$ t_1 [$_{VP}$ NP_{ACC} V]]]. In this structure, $NP_{SUB\text{-}TOP}$ belongs to a complementizer phrase (CP) that is positioned structurally higher than the IP. If this is true, $S_{TOP}O_{ACC}V$ will be more complex in syntactic structure than $S_{NOM}O_{ACC}V$. It is generally assumed that increased structural complexity leads to a heavier processing load (e.g., Bates et al., 1999; Caplan et al., 1998; Ford, 1983; Gibson, 1998, 2000; Just et al., 1996; King & Just, 1991; Sekerina, 2003). If so, the difference in structural complexity predicts that $S_{TOP}O_{ACC}V$ sentence processing will take longer than $S_{NOM}O_{ACC}V$. However, the results of Korean sentence processing did not support this prediction by Shibatani (1990) for Japanese: the subject topicalized order in Korean was processed as accurately and quickly as the canonical order. This observation may be explained by the possibility that the particle 은/는 can act as a pseudo-subject. This might partially account for the lack of difference found in this study between canonical and subject topicalized orders in Korean in both accuracy and reaction time. However, since both canonical and subject topicalization have the same SOV order, it remains uncertain whether the processing speed of subject topicalization is influenced by the SOV canonical order.

In addition, Kuroda (1987) proposed that the topicalized $O_{TOP}S_{NOM}V$ order involves not only topicalization movement but also scrambling movement. Since $O_{TOP}S_{NOM}V$ involves movements of both topicalization and scrambling, the sentence

structure becomes even more complex than the scrambled $O_{ACC}S_{NOM}V$. This difference in structural complexity leads to the prediction that sentences of the topicalized $O_{TOP}S_{NOM}V$ order will require longer processing time than their scrambled $O_{ACC}S_{NOM}V$ counterparts. However, the results of Korean sentence processing indicated no discernible difference in processing time between object topicalized $O_{TOP}S_{NOM}V$ sentences and scrambled $O_{ACC}S_{NOM}V$ sentences. Once again, since the scrambled order overlaps with the object topicalized order, the null difference result may have been caused by the influence of the scrambled order and bears no relation to the object topicalization effect.

The findings on topicalization in Korean reveal the intricate interplay between syntax and processing efficiency. The Korean study (Tamaoka et al., 2024) showed that, contrary to the proposal by Shibatani (1990), subject topicalized orders ($S_{TOP}O_{ACC}V$) were processed with similar speed and accuracy as canonical orders ($S_{NOM}O_{ACC}V$). The role of topic markers in Korean appears to facilitate processing, possibly by serving as pseudo-subjects for subject topicalized orders. Additionally, in contrast to Kuroda's (1987) proposal, no significant difference in sentence processing was found between object topicalized ($O_{TOP}S_{NOM}V$) and scrambled orders ($O_{ACC}S_{NOM}V$). This study challenges the expectation that added complexity invariably leads to slower processing. Future research could elucidate these differences by exploring the cognitive mechanisms underlying topicalization and its interaction with other syntactic phenomena in various languages.

16.8 Conclusion

This chapter delves into the intricate aspects of Korean sentence processing, highlighting the roles of case markers, scrambling effect, pre-head anticipatory processing, animacy effect, head-driven processing, and topicalization. These aspects provide significant insights into the syntactic and cognitive mechanisms underlying sentence comprehension in Korean, a verb-final language with flexible word order.

Case markers play a pivotal role in Korean, serving as crucial indicators of grammatical and semantic roles within a sentence. They facilitate the identification of subjects, objects, and other syntactic functions, enabling more efficient sentence processing. The existence of the scrambling effect in Korean sentence processing mirrors findings from Japanese sentence processing. Sentences with canonical word order ($S_{NOM}O_{ACC}V$) were processed more accurately and quickly than scrambled orders ($O_{ACC}S_{NOM}V$). This scrambling effect is indicative of the additional cognitive load imposed by non-canonical word orders, where the parser must resolve syntactic ambiguities and establish proper argument structures, possibly using the gap-filling parsing model.

Pre-head anticipatory processing, where the parser makes predictions about upcoming syntactic structures before encountering the verb, plays a significant role in Korean sentence comprehension (Lee, 2019). Head-driven processing, where the

sentence-final verb provides critical information for resolving syntactic dependencies, is another key aspect of Korean sentence comprehension. Similar to sentence processing in Japanese (Tamaoka & Mansbridge, 2019), Korean speakers may rely on both anticipatory and head-driven mechanisms to process complex sentence structures, particularly for sentences of scrambled order with no animacy contrast.

Topicalization in Korean reveals the intricate interplay between syntax and processing efficiency. The Korean data showed that, contrary to Shibatani's (1990) proposal, subject topicalized orders ($S_{TOP}O_{ACC}V$) were processed with similar speed and accuracy as canonical orders ($S_{NOM}O_{ACC}V$). The role of topic markers in Korean appears to facilitate processing, possibly by serving as pseudo-subjects for subject topicalized orders. Additionally, the absence of a significant difference in processing times between object topicalized and scrambled orders challenges Kuroda's (1987) proposal. This suggests that the processing mechanisms for topicalization and scrambling may overlap, reducing the expected impact of increased structural complexity.

Future research should further investigate the cognitive mechanisms underlying topicalization and its interaction with other syntactic phenomena. Comparative studies across different languages will also enhance our understanding of universal and language-specific aspects of sentence processing. This chapter contributes to a deeper comprehension of Korean syntax and cognition, offering valuable insights for linguistic theory and cognitive sentence processing.

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