

## **Toward a unified account of the length effects in sentence production and comprehension\***

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Nam, Yunju, Upyong Hong, and Hongoak Yun. 2016. Toward a unified account of the length effects in sentence production and comprehension. *Linguistic Research* 33(1), 135-175. Our research investigated how the *long-before-short (LbS) preference* affects sentence production and sentence comprehension, including the interconnectedness between the behavior of speakers and comprehenders by manipulating the relative length of the direct or indirect objects in ditransitive sentences in Korean. As a result, significant LbS preferences were observed not only in the production study where participants were asked to arrange the pre-given sentence fragments orally, but also in the comprehension study where the eye-movements of the participants were measured for reading the complete sentences. Moreover, our linear mixed-effect model revealed that the behavior of the speakers and comprehenders were closely related in a way that the structures speakers were more likely to produce were easier for comprehenders to understand. Our results are attributable to a language universal processing strategy to pack the heads of arguments and the predicate as closely as possible, for the facilitation of argument integration. (Konkuk University\*\* · Gachon University\*\*\*)

**Keywords** argument integration, long-before-short preference, word order; canonicity, head-final language, accessibility

### **1. Introduction**

Understanding the core meaning of a message, such as the argument information (i.e., WHO-did-WHAT-to-WHOM information), is crucial to comprehenders (or listeners) as well as speakers (writers) to achieve efficient information exchange in dynamic language communication. This is well documented by numerous

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psycholinguistic studies which found that the efficiency of language processing depends largely on whether or not language processors actively use the argument information of messages at hand during sentence production (Brown-Schmidt and Konopka, 2008, Lee and Thompson 2011, Meyer 1996, Wasow and Arnold 2003), sentence comprehension (Altman and Kamide 1999, 2004, Boland 2005; Boland, Tanenhaus, Garnsey, and Carlson 1995; Koenig, Mauner, and Bienvenue 2003), and discourse understanding (Altmann 1999; Hughes and Allen 2013; Mauner, Tanenhaus, and Carlson 1995; Sussman and Sedivy 2003). However, in studying the efficient integration of arguments into sentences, the issue of how (or in which order) arguments should be arranged has been relatively less highlighted compared to the issue of whether the argument information is significant or not. Even though many studies in English have reported that the argument information of a verb plays an important role in determining how the remaining structures are shaped (Boland and Tanenhaus 1991; Bresnan, Cueni, Nikitina, and Baayen 2007; Ford, Bresnan, and Kaplan 1982; Trueswell, Tanenhaus, and Garnsey 1994; Wilson and Garnsey 2009), none of the reports pinned down the issue of word order as a primary concern. In this study, we aimed to explore the issue of how arguments should be ordered to enable efficient information processing (transmit) in both production and comprehension.

In particular, we focused on gaining understanding to how the relative length of arguments can affect the efficiency of processing. Previously, many studies on head-initial languages (Arnold, Wasow, Losongco, and Ginstrom 2000; Bock and Levelt 1994; Ferreria 1996; Stallings, MacDonald, and O'Seaghdha 1998) have shown that short words/phrases are more accessible than long words/phrases, leading to the so called *short-before-long preference* (SbL preference, henceforth), and have claimed that accessibility is deeply related to incremental processing in production (Bock 1982; Kempen and Hoenkamp 1987; Levelt 1989). However, the accessibility-based approach has been faced with serious challenges/limits in accounting for the opposite preference, the *long-before-short preference* (LbS preference, henceforth) observed in head-final languages (Yamashita and Chang 2001). We argue that the accessibility account does not provide legitimate explanation for the cross-linguistic difference mentioned above. Instead, we adopt the distance-based approach for efficient argument integration (see Hawkins (1997; 2004) for a similar view), and attempt to provide a unified account of the SbL/LbS preference in production as well as comprehension.

### 1.1 Pros and cons of the accessibility-based account for the length effect

According to the accessibility-based accounts for the length effect, more accessible words/phrases simply tend to be processed easier and hence earlier than less accessible ones (Bock and Levelt 1994).<sup>1</sup> The accessibility of words/phrases, between the longer or shorter ones, varies, depending on the headedness of the language in question. In head-initial languages like English, the shorter constituent is arguably easier to access than the longer one, leading to the SbL preference (Arnold et al. 2000; Bresnan et al. 2007; Stallings et al. 1998). For example, sentences like (1a), in which a short recipient, *Mary*, appears before a long patient phrase, *the antique that was valuable*, are easier to produce and comprehend than sentences like (1b), in which a short recipient is located after a long patient. Notice that the only difference between (1a) and (1b) is the order between the dative and the accusative argument.

- (1) a. I gave [Mary] [the antique that was valuable].  
       b. I gave [the antique that was valuable] [to Mary].

The accessibility-based account is in accordance with the widely accepted assumption of existing processing models that claim language processing is highly incremental (Bock 1982; Kempen and Hoenkamp 1987; Levelt 1989) and even anticipatory (Lee, Brown-Schmidt, and Watson 2013). In these processing models, speakers do not wait until all relevant information for production of an entire utterance is completely retrieved, but they use any minimal information that they can immediately access. In other words, accessibility and incremental processing are

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<sup>1</sup> There are also a group of semantic and discourse-related properties of words that affects the word order preference. For example, animate words or phrases tend to be fronted before inanimate words or phrases (Dennison 2008; Prat-Sala and Branigan 2000); the degree of imageability and concreteness also affects the order of words in production (Bock and Warren 1985); the definite and salient phrases are better to appear prior to indefinite and less salient phrases (Grieve and Wales 1973; Osgood and Bock 1977). It is also well known that the information structure like topic-comment information plays a role as a crucial constraint in word order (Ferreira and Yishita 2003). We basically assume that word orders determined by these properties are well accounted for by the accessibility approach, although a critical discussion about this issue lies beyond the domain of the present paper.

mutually supportive in that the underlying mechanism associated with accessibility can make sense under the assumption that speakers process information incrementally, and might work in an opposite direction; that is, processors' motivation to be sensitive to any accessible information leads to conduct incremental processing and the fundamental ground for incremental processing relies on the assumption that processors are able to access available information immediately.

In contrast to the SbL preference found in head-initial languages, the adoption of exactly the opposite preference is observed in head-final languages like Japanese, i.e. a longer word/phrase is preferred to appear before a shorter one. Using ditransitive sentences (Experiment 2), Yamashita and Chang (2001) demonstrated that Japanese speakers were more likely to produce sentences like (2a), in which a long patient is located before a short recipient, than sentences like (2b), in which a short recipient is located before a long patient.

- (2) a. Masako-wa [sinmun-de syookai-sarete-ita okasi-o] [otoko-ni]  
 Masako-TOP [newspaper-in introduced cake-ACC] [man-DAT]  
 todoketa.  
 delivered  
 'Masako delivered [the cake [which was] introduced in the newspaper] [to the man].'
- b. Masako-wa [otoko-ni] [sinmun-de syookai-sarete-ita okasi-o]  
 Masako-TOP [man-DAT] [newspaper-in introduced cake-ACC]  
 todoketa.  
 delivered  
 'Masako delivered [the man] [the cake [which was] introduced in the newspaper].'

In order to explain the typological differences between head-final languages like Japanese and head-initial languages like English, Yamashita and Chang (2001) proposed to elaborate the notion of accessibility with the saliency of forms and concepts as a function of headedness. They posited that languages like Japanese would belong to the language group that puts more emphasis on concepts rather than forms, whereas languages like English belongs to the language group that focuses on forms rather than concepts. Long words or phrases are likely to be conceptually

salient, thus conceptually salient words tend to be easier to access in Japanese. Consequently, more accessible longer words/phrases are processed earlier than less accessible shorter ones, contributing to the LbS preference.

However, Yamashita and Chang's (2001) proposal on conceptual saliency has not been favored much for several reasons. Using Japanese transitive sentences, Tanaka, Branigan, and Pickering (2011) demonstrated that conceptual accessibility, such as animacy, influenced the choice of grammatical function (e.g., active sentences rather than passive sentences when subjects were animate) and word order (e.g., SOV sentences rather than OSV sentences when subjects were animate). Since their findings in Japanese replicated the findings observed in head-initial languages such as English (Branigan and Feleki 1999), Tanaka et al. (2011), they concluded that conceptual representation affected grammatical encoding in head-final languages in the same way as in head-initial languages (Bock & Warren 1985; McDonald, Bock, and Kelly 1993). In their study, there was no difference in the degree of conceptual saliency in head-initial vs. head-final languages, which stands contrary to the proposal by Yamashita and Chang (2001).

In addition to Tanaka et al. (2011), Hwang and Kaiser (2014) also provided inconsistent evidence against the accessibility theory. In this study, Hwang and Kaiser (2014) tested the effect of syntactic flexibility in production. Unlike the English data in which speakers were facilitated in production when they had a syntactic choice (Ferreira 1996), Korean speakers were not facilitated in producing sentences of syntactic flexibility in which they temporally had a syntactic choice in selecting a particular construction out of possible constructions. Hwang and Kaiser's results indicated that Korean speakers do not conduct immediate and incremental processing but wait until the moment they are sure of what to say (see similar results in Myachykov, Scheepers, Garrod, Thompson, and Fedorova 2013).

To be brief, the accessibility theory seems to provide a valid explanation for the SbL preference in head-initial languages, yet has explanatory limitations when applied to the LbS preference in head-final languages. According to the accessibility approach, it is not clear how to understand how longer words/phrases can be more accessible than shorter ones. Moreover, it is not clear whether incremental production can actually occur in head-final languages. Consequently, the accessibility-based approach does not provide a legitimate account for the typological difference in the relationship between the constituent length and processing efficiency.

## 1.2 Argument Packing Principle (APP)

Obviously, the LbS preference implies that processors will wait until all of the necessary information for the production of an entire utterance becomes accessible. This further means that processors need to deal with cognitive overload as they will need to keep all the information retrieved already and add on to this memory load before they produce their utterances. Why do they do so? Given the fact that speakers often plan what they are going to say lexically (Griffin 2001, 2003; Griffin and Bock 2000) as well as structurally (Alum and Wheeldon 2007; Lee et al. 2013), they are able to avoid a way of utterances if it causes heavy processing load to them. Besides, speakers are known to be probabilistically optimal and strategic in controlling for the uncertainty degree of information on what they produce (Jaeger 2010). Nonetheless, if speakers of head-final languages hold information instead of using it immediately, there should be some processing benefit from doing so. We propose that the processing benefit is for speakers (and comprehenders) to complete the efficient integration of arguments into their utterances while attempting to fulfill their strategies in order to minimize the distance between the heads of arguments and a predicate, which could be formalized as ‘Argument Packing Principle’:

### Argument Packing Principle (APP)

Pack together the heads of arguments and the predicate as closely as possible.

The APP fundamentally constrains the surface order of arguments encoded in an event that a predicate defines. Its origin is rooted on *Behagel’s first law*: “Elements that belong together intellectually will also be placed closely” (Behagel 1932). Taking the spirit of this law, the APP notifies that arguments and a predicate that originally belong together in the argument information encoded by the predicate should be placed as closely as possible, in order to facilitate the processing of argument structure.

In practice, the locus of the APP can reveal in clarity when arguments have to be ordered by their relative lengths. If the length of an argument gets longer by attaching a modifier that does NOT necessarily belong to the verb-argument structure, the APP requires the processor to pick up the head of the argument phrase

cued by case markers<sup>2</sup> and locate it closely to the verb. By doing so, this principle does not need to refer to other additional constraints based on ‘accessibility’ or ‘conceptual saliency,’ but it correctly predicts whether arranging arguments of different lengths is mapped to the SbL preference or the LbS preference. That being said, the APP allows for processors of head-initial languages to stick to the SbL preference because pre-positioning short phrases before long phrases enables the processors to pack the heads of arguments with a predicate as closely as possible. For example, in (1a), *I gave [Mary] [the antique that was valuable]*, the distance of packing the predicate *gave* with the heads of its arguments (*Mary* and *the antique*) is minimized since the shorter phrase *[Mary]* is placed before the longer one *[the antique...]*. Yet, the APP is not fulfilled when the longer phrase is placed prior to the shorter one, as illustrated in (1b), *I gave [the antique that was valuable] [to Mary]*, because the distance of packing the predicate *gave* with the heads of its arguments (*the antiques* and *Mary*) is maximized. In head-final languages, on the contrary, it should not be the SbL order but the LbS order to satisfy the APP. For example, in (2a), *Masako-TOP [newspaper-in introduced **cake-ACC**] [**man-DAT**] delivered*, the heads of arguments (*cake* and *man*) are closely packed with the predicate *delivered* to minimize the distance. This is the preferred case that the LbS order is satisfied. In contrast, the APP is violated and a dis-preferred case occurs in sentences like (2b), *Masako-TOP [**man-DAT**] [newspaper-in introduced **cake-ACC**] delivered*, where the distance of *man-cake-deliver* is widened. If this line of argumentation is on the right track, the SbL or the LbS preference across languages could be taken as nothing more than an epiphenomenon. Instead, we would rather say that the typological phenomenon is commonly derived from processors’ natural need to process verb-argument information as efficiently as possible, as we pin down in the APP.

The basic idea underlying the APP is not novice, *per se*. For instance, Hawkins (1997, 2004) has posited that language processors’ cognitive burden is reduced when the distance between the heads of the arguments and the predicate that encodes the arguments is minimized. Another well-known processing model, the Dependency Locality Theory (DLT) (Gibson 1998, 2000), could also yield a similar prediction, especially, when words or phrases are lengthened with relative clauses being

<sup>2</sup> In the Choi and Trueswell’s (2010) study, structural cues like case markers were used for grammatical function assignments.

attached. For example, both the APP and Hawkins predict that in head-final languages, locating long phrases modified by relative clauses before short words could reduce the degree of integration cost than locating short words before long phrases. In the viewpoint of the DLT, the LbS preference in head-final languages makes sense because the number of intervening materials between the argument heads (i.e., governed elements) and a predicate (i.e., governor) is less when the distance between the heads of arguments and a predicate was short than when it was long. In short, similar to Hawkins (1997, 2004) and Gibson (1998, 2000), the APP also emphasizes that having the minimized distance between arguments and a predicate would facilitate language processors to grasp the argument information of a message and to integrate the arguments into sentences.

## 2. The current study

Given the conceptual and empirical plausibility of the APP and other similar distance-based approaches, the current study addresses the question of whether the APP underlies the behaviors from both language *production* and language *comprehension*. In other words, a crucial question arises on whether the APP belongs to the cognitive apparatus by which speakers are interconnected with comprehenders, and if so, in what manners. More specifically, the current study concentrates on the question of whether the behaviors of speakers predict those of comprehenders.

In the psycholinguistic literature, the idea that speakers' linguistic behaviors are in many respects interconnected with comprehenders' behaviors has been elaborated from various viewpoints (Chang 2009; Gric, 1975; Hawkins 2004; MacDonald 2013; Pickering and Garrod 2007, 2013). For instance, the proposal by Hawkins (2004) is fundamentally based on a comprehension mechanism to account for production patterns. Consider also the proposal by Levelt (1989) where it is stated that speakers monitor their own utterances using their own comprehension mechanism. The assumption that speakers go through comprehension procedures through a self-monitoring implies that speakers and comprehenders are closely intertwined through a common comprehension-based processing mechanism.

There are also models of production-driven comprehension. For instance, Pickering and Garrod (2007, 2013) asserted that language comprehension involves



making simultaneous predictions at different linguistic levels, and these predictions are generated by a language production system. MacDonald (2013) proposed the Production-Distribution-Comprehension (PDC) account, according to which comprehenders implicitly learn the statistical regularities based on the distribution of repeated utterances. MacDonald's (2013) suggestion is supported by Chang's (2009) computational model in which the comprehenders' behaviors emerged from their implicit learning based on overused input. Basically, we agree that there should be some cases in which comprehenders would be able to predict the choices of the speakers' utterances, yielding support for the models of production-driven comprehension. Nonetheless, we are unsure of whether comprehenders were able to predict the behaviors of the speakers in any of the cases, regardless of types of information that speakers have to deal with.

At any rate, there appears to be a growing body of theoretical as well as empirical discussions in regards to how the speakers' and comprehenders' processing mechanisms are intertwined. The goal of the current paper is to contribute to the settlement of this important issue by investigating the length-related preference in both production and comprehension within a single language, namely Korean. The foremost value of our study lies in the fact that we use the same materials within a single language to investigate the preference bias of arranging arguments with relatively different lengths by observing the speakers' behaviors in production, the comprehenders' behaviors in comprehension, and the interconnectedness between speakers and comprehenders. The evidence from our study will directly contribute to illuminating the relationship between production and comprehension at a fine-grained degree, a method that not many studies have attempted.

It is fairly desirable that the evidence from the studies like ours directly contributes to illuminate the relationship between production and comprehension at a fine-grained degree, but few studies have taken the way that we did.

Using ditransitive sentences in which the relative lengths of indirect object (IO) corresponding to recipients and direct object (DO) corresponding to themes were manipulated, we firstly examined whether Korean speakers, like Japanese speakers, prefer to locate long constituents prior to short constituents when they produce sentences (Study 1). In addition, we investigated whether Korean comprehenders, like Korean speakers, have less difficulty in comprehension of sentences in which long constituents appear prior to short constituents by using the eye-movement tracking

technique (Study 2). Given the characteristics of our experiment sentences that include recipient NPs and theme NPs, we could also examine the role of the well-known canonicality effect, the general preference for the order of ‘recipients (IO)-before-themes (DO)’, and subsequently determine the strength that can be purely attributable to the effect of length-related processing preference.<sup>3</sup> Finally, we examined the relationship between the observed behaviors of speakers and those of comprehenders statistically, by conducting a mixed-effect regression model in which the degree of speakers’ preference on the length matter would predict the degree of processing difficulty that comprehenders might have (Study 3). To preview, our studies demonstrate that the LbS preference is observed not only in sentence production but also in sentence comprehension, and that the comprehenders’ processing difficulty can be predicted by speakers’ processing preference. This indicates that the behaviors of speakers and comprehenders are commonly driven by the APP, by which speakers and comprehenders are interconnected and the argument structure processing becomes considerably facilitated.

## 2.1 Study 1

The purpose of Study 1 is to investigate whether Korean speakers, like Japanese speakers (Yamashita and Chang 2001), would prefer the LbS order in sentence production. The APP predicts that we should replicate the results of Yamashita and Chang (2001). Ditransitive sentences in Korea were used for this study because it was necessary to use sentences with at least two internal arguments such as an IO corresponding to a recipient role and a DO corresponding to a theme/patient role. In this way, we were able to force participants to produce the two internal arguments in their production and simultaneously observe in which order participants would arrange the target arguments. Since the argument status of object nouns becomes clearly visible through discriminative case markers in Korean (*-ekey* for recipient/dative IO; *-ul/-rul* for theme/accusative DO), it is methodologically easier to

<sup>3</sup> There are empirical evidence indicating that the canonical order of internal arguments in ditransitive sentences of Korean is that IOs (recipients) appear prior to DOs (themes/patients) (Choi 2007; Hong, Nam, and Kim 2012; Yun and Hong 2014). Given this, ‘short IOs-before-long DOs preference’ cannot be automatically taken to support the SbL preference, since it might simply due to the canonicality effect. In the same vein, ‘long IOs-before-short-DOs preference’ would not necessarily imply the LbS preference.

induce Korean speakers to produce ditransitive sentences.

In spite of the aforementioned advantages in using ditransitive sentences for our investigation, there is also an apparent drawback that should not be dismissed. That is, as for Korean ditransitive sentences, the order of ‘recipient (IO) before theme (DO)’ is known as being unmarked and canonical (Choi 2007; Hong et al. 2012; Yun and Hong 2014). This means that with other things being equally controlled, Korean speakers would dominantly prefer locating recipients (IOs) before themes (DOs). Therefore, having the condition that recipients and themes are equally short, the experiment paradigm allows us to approximate the effect of canonicity as a baseline and leads to determine the pure length-related effect (see also footnote 3). In addition, it is crucial to make one of the arguments longer than the other to observe the effect of the LbS preference. In short, we had three conditions: 1) both recipients and themes were equally short, 2) recipients were longer than themes, and 3) themes were longer than recipients.

We predicted that the results of Study 1 would basically replicate those of Yamashita and Chang (2001), demonstrating that Korean speakers produce ditransitive sentences in accordance with the LbS preference. However, unlike Yamashita and Chang (2001), we attempted to account for the observed processing preference in terms of not the accessibility but the APP. Moreover, we discussed in what manner the canonicity effect, if any, seemed to interact with the effect of the LbS preference.

### 2.1.1 Method

**Participants.** Thirty undergraduate students at Konkuk University participated in this experiment. Each participant was paid 5,000 Korean won (approximately equivalent to US \$5).

**Materials and procedures.** Thirty sets of experimental materials were constructed with a subject NP attached with a topic marker (i.e., *-nun*), an indirect object NP associated with a recipient, a direct object NP associated with a theme, and a ditransitive verb, as shown in sentences like (3a-c). Experimental materials differed by the length of internal arguments (i.e., recipient and theme). The length of the two arguments was equally short in the reference condition (3a), without any pre-nominal modifier. A prenominal relative clause was added in order to lengthen the recipient

object in the long recipient condition (3b) and the theme in the long theme condition (3c). The relative clause was controlled to insure that it was equally suitable to each argument. We used personal names for subjects and animate common nouns for recipients but inanimate common nouns for themes. The lengths and frequencies of lexical items corresponding to the target arguments were equated across the conditions. All target materials were distributed to 3 experimental lists by Latin-square design and each list included additional 60 filler materials with various syntactic structures. All filler materials had two internal arguments or adjuncts like experimental materials. Appendix A displays a full set of experimental materials.

(3) a. **Short Recipient, Short Theme:**

Minsu-nun [chinkwu-eykey] [meymo-lul] namky-ess-ta  
 Minsu<sub>TOP</sub> [friend<sub>DAT</sub>] [memo<sub>ACC</sub>] leave<sub>PAST-DECL</sub>

b. **Long Recipient, Short Theme:**

Minsu-nun [cokyo-ka pwull-ess-ten chinkwu-eykey] [meymo-lul]  
 Minsu<sub>TOP</sub> [assistant<sub>NOM</sub> call<sub>PAST-REL</sub> friend<sub>DAT</sub>] [memo<sub>ACC</sub>]  
 namky-ess-ta  
 left<sub>PAST-DECL</sub>

c. **Short Recipient, Long Theme:**

Minsu-nun [chinkwu-eykey] [cokyo-ka caksengha-n meymo-lul]  
 Minsu<sub>TOP</sub> [friend<sub>DAT</sub>] [assistant<sub>NOM</sub> write<sub>REL</sub> memo<sub>ACC</sub>]  
 namky-ess-ta  
 leave<sub>PAST-DECL</sub>

In order to elicit production data in a systematic way, we adopted the paradigm of Yamashita and Chang (2001) (see Figure 1). Participants first fixated their attention on ‘+’ presented at the center of the computer screen (Step 1), then they gazed at a screen presenting two target arguments and a verb located in each corner of a square (Step 2). They were asked to take enough time or as much as they needed. The location of arguments was counterbalanced from upper to low and from right to left across trials. Next, a blank page stayed for 1500 ms (Step 3), followed by a simple math question (Step 4). Finally, a screen with a subject at the upper left corner and a verb at the lower right corner occurred as a prompt cue (Step 5). Then, participants were asked to produce a sentence by using the subject and the verb and

by retrieving two other target arguments that were presented before. The production data were recorded with a built-in voice recorder of a computer.

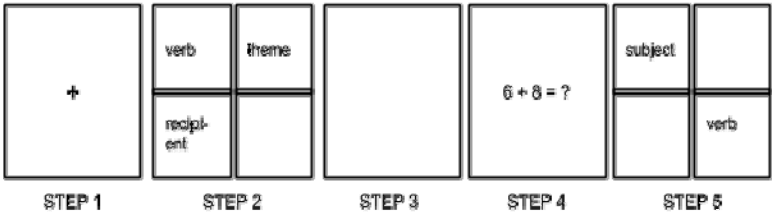


Figure 1. An example of the procedure in Study 1

### 2.1.2 Results and discussion

We analyzed the recorded sentences only when they contained the two target arguments. Only 33 numbers of 99 total outcomes were not included, and this affected only 4% of data removal. We counted the proportions of how many times participants produced the sentences that contained recipients and themes in a canonical recipient-theme order (see Table 1).

In the reference condition in which the two target arguments were of same length (equally short), the proportions of the canonically ordered sentences were extremely high (85%). This result undoubtedly replicated the previous studies that demonstrated the canonicity effect in Korean (Choi 2007; Hong et al. 2012; Yun and Hong 2014), and can be taken as the baseline for quantifying the length-related effect in sentence production. As for the long recipient condition, in which recipient NPs were longer than theme NPs, the canonicity effect for locating the former prior to the latter increased significantly, i.e. from 85% to 93%. In other words, the effect of LbS preference was added to the canonicity effect, hence indicating the existence of LbS preference in Korean sentence production. Interestingly, we observed the inversed results that the canonicity effect diminished remarkably in the long theme condition, i.e. from 85% to 33%. When themes were longer than recipients, the proportions of canonical order dropped drastically, apparently because the LbS preference for locating long themes before short recipients contradicted to the preference for locating recipients prior to themes in a canonical way. Taken together, our descriptive data, as in Table 1, strongly supported that Korean sentence

production was significantly affected by the LbS preference in interaction with the canonicity strategy.

Table 1. Mean (standard deviation) proportions of canonically-ordered sentences

| All shorts | Long recipients | Long themes |
|------------|-----------------|-------------|
| .85 (.12)  | .93 (.07)       | .33 (.17)   |

Note. ‘All shorts’ refers to the condition of short recipient and short theme; ‘Long recipients’ refers to the condition of long recipient and short theme; ‘Long themes’ refers to the condition of long theme and short recipient.

For a statistical scrutiny of the relationship between the canonicity effect and the LbS preference, we conducted a linear-mixed logistic regression in which a binary code was assigned to target sentences: 1 corresponding to canonically ordered sentences and 0 corresponding to non-canonically ordered sentences. The length condition was entered as a predictor taking the condition of ‘all shorts’ as a reference condition. Both participants and items were considered as random variables and the length type of arguments was a fixed variable. Analyses were conducted with mixed-effect logit models (Baayen 2008; Jager 2008), using lme4 (Bates, Maechler, Bolker, and Walker 2013) and languageR libraries (Baayen 2014) for the R statistics program (R Development Core Team 2014). For the structure of random effects, fully crossed and specified random effects were reduced step by step until the model converged. Only the effects which contributed to the significant improvement for the model were included in the final model. Table 2 displays the results from the final logistic model that included the interactions between random variables and fixed variables.

Table 2. The results of the linear mixed effect logistic regression from Study 1

|                            | Estimates | S.E. | z-score | p-value |
|----------------------------|-----------|------|---------|---------|
| Intercept                  | 2.19      | .29  | 7.60    | <.01 *  |
| Long Theme - All short     | -3.21     | .43  | -7.51   | <.01 *  |
| Long Recipient - All short | 1.77      | .40  | 4.46    | <.01 *  |

Note. All short condition was taken as a reference condition.

Table 2 clearly shows that the preference for positioning recipients prior to themes was significantly stronger in the long recipient condition than in the all-short condition, since the canonicity effect and the LbS preference converged when recipients were longer than themes. In contrast, the preference to put recipients before themes became significantly weaker in the long theme condition than in the all-short condition, indicating that the canonicity effect has decreased through the interference of the LbS preference. In conclusion, the overall results of Study 1 reconfirmed the well-known canonicity effect. More importantly, we were able to demonstrate the role of the LbS preference derived from the APP that operated either in concert with or in contradiction to the canonicity effect.

## 2.2 Study 2

In Study 2, we aimed to investigate whether as the APP predicts, comprehenders would also prefer the sentences in which the heads of argument and a predicate are packed as closely as possible. We used an eye-tracking reading paradigm for our aim. If the APP is supported, we predict that comprehenders would feel easier to process the constructions in which long arguments occur prior to short arguments than the constructions in which short arguments occur prior to long arguments.

Recall that speakers in Study 1 showed a tendency to favor canonicity. Without any manipulation of the relative length on arguments, the default preference for an argument order was matched to the canonical order (i.e., recipients before themes). Even when direct objects were lengthened, 33% production out of the total output still observed the canonicity preference while violating the LbS preference. The patterns from the production study indicated that the effect of the relative length might not be completely independent from the effect of canonicity. In this regard, we also investigated whether the LbS preference would be independently or interactively effective from the canonicity preference in comprehension.

We discuss two possibilities. First, the APP predicts that when one argument is longer than the other, comprehenders, like speakers, would show the LbS preference such that they would read fast when long arguments are located before short arguments. However, the APP, by its definition, does not have a particular prediction on processing difficulty with respect to canonicity preference. Thus, the APP predicts to observe the main effect of the LbS preference, but it does not necessarily

predict that the length effect has to be interacted with the effect of canonicity.

Second, there is alternative view that we call the frequency-based probabilistic view (Bresnan et al. 2007; Chang 2009; Hale 2001; Levy 2008; MacDoland 2013). Its prediction is not that simple. First, this view predicts that there will be processing benefit of reading argument phrases that are arranged in a canonical order, under the scenario that comprehenders could be cognitively ready to encounter what is coming next (i.e., themes or patients) based on the existing information (e.g., recipients). Second, also recall that Choi (2007)'s corpus study in Korean showed that the long-before-short occurrences were more frequent than the short-before-long occurrences (also in Japanese, Kondo and Yamashita 2011). Chang (2009) demonstrated that the LbS preferences were successfully learnable through the increase of exposures. These studies suggest that the frequency-based view should predict some processing benefit for the LbS preference. If this is so, it is likely that there might be processing differences between when canonicity preference is observed but the LbS preference is violated and when neither canonicity nor LbS preference is violated, or between when the LbS preference is observed but the canonicity preference is violated and when neither canonicity nor LbS preference is violated. Taken together, the frequency-based view would predict the main effect of canonicity and length. More crucially, the view predicts to observe a significant interaction between the canonicity preference and the LbS preference.

### 2.2.1 Method

**Participants.** Thirty students at Konkuk University attended in the experiment. Each were paid at Korean 5,000 won (approximately equivalent to US \$5) for their participation.

**Materials.** We used 30 sets of experimental materials used in Study 1 and converted them into the sentence form. The experimental stimuli differed in two ways. First, the order of internal arguments (i.e., recipients and themes in bolds) was manipulated into whether the arguments were arranged in a canonical order, as in the sentences in (4a), (4c), and (4e) or whether they were arranged in a non-canonical order, as in the sentences like (4b), (4d), and (4f). Second, the length of arguments was differentiated. In Examples (4a-b), both recipient NPs and theme NPs were equally short. In Examples (4c-d), the length of the first internal arguments was longer than that of the second internal argument NPs. The arguments were in



canonically order in (4c) and non-canonically in (4d). On the other hand, short arguments occurred before long arguments in canonical order, as in (4e), and in non-canonical order, as in (4f). The experimental sentences were counterbalanced across 6 presentation lists. Each list included additional 46 filler sentences that had various syntactic structures. All sentences were presented in a randomized order. In order to keep participants' attention on reading, we inserted comprehension questions every 2 or 3 trials. Appendix A displays a full set of experimental materials.

(4) a. *Short Recipient-Short Theme* (Canonical, Short Short)

Minsu-nun [**chinkwu-eykey**] [**meymo-lul**] namky-ess-ta  
 Minsu -TOP [friend-DAT] [memo-ACC] leave-PAST-DECL

b. *Short Theme-Short Recipient* (Non-canonical, Short Short)

Minsu-nun [**meymo-lul**] [**chinkwu-eykey**] namky-ess-ta  
 Minsu -TOP [memo-ACC] [friend-DAT] leave-PAST-DECL

c. *Long Recipient-Short Theme* (Canonical, Long Short)

Minsu-nun [cokyo-ka pwullesste-n **chinkwu-eykey**] [**meymo-lul**]  
 Minsu-TOP [assistant-NOM called-REL friend-DAT] [memo-ACC]  
 namky-ess-ta  
 leave-PAST-DECL

d. *Long Theme-Short Recipient* (Non-canonical, Long Short)

Minsu-nun [cokyo-ka caksengha-n **meymo-lul**] [**chinkwu-eykey**]  
 Minsu -TOP [assistant-NOM write-REL memo-ACC] [friend-DAT]  
 namky-ess-ta  
 leave-PAST-DECL

e. *Short Recipient-Long Theme* (Canonical, Short Long)

Minsu-nun [**chinkwu-eykey**] [cokyo-ka caksengha-n **meymo-lul**]  
 Minsu -TOP [friend-DAT] [assistant-NOM write-REL memo-ACC]  
 namky-ess-ta  
 leave-PAST-DECL

f. *Short Theme-Long Recipient* (Non-canonical, Short Long)

Minsu-nun [**meymo-lul**] [cokyo-ka pwullesste-n **chinkwu-eykey**]  
 Minsu -TOP [memo-ACC] [assistant-NOM call-REL friend-DAT]  
 namky-ess-ta  
 leave-PAST-DECL

**Procedure.** The eye-tracking experiment was implemented using the Experiment Center provided by the SMI. Participants were seated in front of a 19" display and the distance between the participant's eyes and the monitor display was 70cm (27.5 5"). They were instructed to minimize their head movements as little as possible during the experiment. Eye movements of the participants were recorded by using a SMI RED 500 that had a remote system. The sampling rate was 500Hz from the left eye (viewing was binocular). All sentences started from the left upper corner and were displayed on a single line. A fixation marker (+) at a starting point was presented between trials. Participants were required to read the instruction presented on the screen and move on to the next trial by fixating their eyes for two seconds on an indicator of 'next' depicted on the bottom of the screen. For the comprehension judgment task, yes-no questions were presented in every two or three trials. There were five practice trials before the main experimental session started.

### 2.2.2 Results and discussion

We measured first-pass RTs that were the sum of first pass fixations on the word before leaving it for the first time. The first-pass RTs were often referred to as the early processing measures to detect an initial processing difficulty (Straub and Rayner 2007). We also computed second pass RTs and the rates of regression, which represented the late processing measures that examined the difficulty associated with re-analysis or semantic integration (HyÖna, Lorch, and Rinck 2003; Rayner, Sereno, Morris, Schmauder, and Clifton 1989). The total gaze duration, which was the sum of all fixations in the first pass and second pass reading, was also computed.

We first computed eye-movement measurements (i.e., first pass reading times, second pass reading times, total gaze duration, and regression rates) for target phrases that consisted of recipients and patients, by summing up the measurements corresponding to the two constituents. For example, if a reader spent 200 ms in reading a recipient and 300ms in reading a patient, the total reading times of the target phrase, for this particular reader, was 500ms. Each of the computed measurements was submitted to a linear mixed-effect regression model for analysis, respectively. As in Experiments, analyses were conducted with mixed-effect regression, using the lme4 (version 0.999375-33, Bates and Maechler 2014) and languageR libraries (version 1.0, Baayen 2013) for the R statistics program (R

Development Core Team 2014).

The measurements corresponding to the phrases associated with target arguments were submitted as dependent variables. A lengthening variable, a canonicity variable, and their interaction were included as a set of fixed variables. These fixed variables were dummy coded. As for the lengthening variable, the long-short condition was coded as 0, while the short-long condition was coded as 1. As for the canonicity variable, the canonical condition (recipient-theme) was coded as 0, whereas the non-condition (theme-recipient) was coded as 1. All fixed factors were centered. The factor regarding the length of target phrases was added to control for the effect associated with comprehenders' perceptual effort regarding length (Juhasz and Rayner 2003). We included participants and items as random variables and the interaction between random variables and fixed variables in all models. We performed an initial fit for our models, and then removed all data points with residuals greater than 2.5 standard deviations from the mean of residuals (Baayen 2008). This procedure removed about 3% data points of overall data as outliers. As in the final model reported in Experiment 1, fully crossed and specified random effects were reduced until the model converged. The means and standard deviations of target constituents across conditions are displayed in Table 3, and the results from the mixed-effect regression models are displayed in Table 4.

Table 3. Means and standard deviations of target constituents across conditions

|                   |               | First-pass RTs      | Second-pass RTs      | Total gaze duration  | Regression rates |
|-------------------|---------------|---------------------|----------------------|----------------------|------------------|
| Equally short     | Canonical     | 538.13<br>(294.05)  | 488.36<br>(493.11)   | 1026.50<br>(560.22)  | 1.74<br>(1.38)   |
|                   | Non-canonical | 555.13<br>(262.53)  | 536.86<br>(601.56)   | 1091.99<br>(608.54)  | 2.13<br>(1.98)   |
| Long-before short | Canonical     | 1040.79<br>(375.36) | 959.31<br>(908.22)   | 2000.10<br>(977.51)  | 3.68<br>(3.08)   |
|                   | Non-canonical | 1095.51<br>(388.61) | 866.55<br>(773.30)   | 1962.06<br>(848.79)  | 3.38<br>(2.80)   |
| Short-before-long | Canonical     | 1008.48<br>(352.06) | 1277.28<br>(1107.45) | 2285.75<br>(1112.94) | 4.20<br>(3.15)   |
|                   | Non-canonical | 1061.72<br>(372.50) | 1221.54<br>(988.10)  | 2283.26<br>(1011.28) | 4.44<br>(3.16)   |

Note. C refers to canonical condition, NC refers to non-canonical condition

First, because we could not test the effect of lengthening for the condition in which the length of the two arguments was equally short, we only tested the effect of canonicity for those sentences. The results revealed that the canonicity effect emerged on regression rates (Estimate = .22, S.E. = .08,  $t$ -value = 2.77), suggesting that comprehenders' regressive looks occurred more frequently when themes appeared before recipients than when recipients occurred prior to themes, that is, when the canonical order of arguments was violated. The canonicity effect in production in Experiment 1 was replicated in comprehension. The effect of canonicity that we observed replicated previous comprehension studies (Choi 2007; Hong et al. 2012; Hyönä et al. 1997; Yun and Hong 2014).

Second, using the remaining data in which one argument was longer than the other argument, we tested the effect of canonicity, lengthening, and their interactions, while controlling for the potential effect by the physical length associated with comprehenders' perceptual effort (see Table 4). The effect of canonicity was observed only on first pass RTs such that the first pass RTs for target phrases were longer when themes appeared before recipients than when recipients occurred before themes, regardless of the length matter, suggesting that comprehenders preferred encountering arguments in a canonical order. Except the first pass RTs, no other measurements yielded the differences by canonicity. Interestingly, note that the lengthening effect (i.e., LbS preference) did not appear on the early-processing measurements but emerged only on the late-processing measurements. That is, the LbS preference emerged on second pass RTs, total gaze durations, and regression rates. The second pass RTs for target phrases were longer when short arguments appeared before long arguments than when long arguments occurred before short arguments, regardless of canonicity orders. The result on the total gaze duration and regression rates for target phrases showed exactly the same patterns. However, interactions between length order and canonical order did not appear in any of the eye movement measurements.

Table 4. The results from linear mixed-effect regression models on eye-tracking measurements obtained from Study 2

|                         | Estimates | S.E.   | t-value |
|-------------------------|-----------|--------|---------|
| First-pass RTs          |           |        |         |
| Intercept               | 1018.15   | 38.42  | 26.50   |
| Length                  | 23.06     | 35.65  | 0.65    |
| Canonical-order type    | 74.28     | 23.55  | 3.15*   |
| Lengthening-order type  | -9.81     | 23.45  | -0.42   |
| Order type *Length type | -55.58    | 48.32  | -1.15   |
| Second-pass RTs         |           |        |         |
| Intercept               | 1003.96   | 118.46 | 8.48    |
| Length                  | 105.76    | 96.97  | 1.09    |
| Canonicity              | -51.86    | 50.28  | -1.03   |
| Lengthening             | 296.44    | 50.28  | 5.90*   |
| Canonicity*Lengthening  | -3.19     | 105.44 | -0.03   |
| Total gaze duration     |           |        |         |
| Intercept               | 2051.44   | 116.65 | 17.59   |
| Length                  | 221.42    | 107.00 | 2.07*   |
| Canonicity              | 24.32     | 56.68  | 0.43    |
| Lengthening             | 284.66    | 56.36  | 5.05*   |
| Canonicity*Lengthening  | -117.40   | 118.21 | -0.99   |
| Regression rates        |           |        |         |
| Intercept               | 3.71      | 0.34   | 11.01   |
| Length                  | -0.29     | 0.38   | -0.77   |
| Canonicity              | 0.01      | 0.19   | 0.04    |
| Lengthening             | 0.70      | 0.19   | 3.67*   |
| Canonicity*Lengthening  | 0.62      | 0.40   | 1.56    |

Note. If the absolute t-value of a fixed factor was over 2, the effect of the factor was considered to be significant at  $\alpha < .05$  (Gelman and Hill 2007).

To sum up our results, as we found in Study 1, the canonicity effect was elicited on regression rates when target arguments were equally short. Comprehenders made less regression rates when they encountered recipients before themes than when they did themes before recipients, suggesting that they had less difficulty in the integration of canonically ordered argument phrases than non-canonically ordered argument phrases. Of interest, when one of the target arguments was lengthened, the canonicity effect emerged only on the first-pass RTs but it did not appear on the measurements such as second-pass RTs, total gaze durations, and regression rates. Instead, on those measurements, we observed the independent main effect of the relative length preference, meaning that comprehenders had difficulty in the

integration of arguments when the LbS preference was not satisfied, regardless of whether the arguments were canonically ordered or not. In our knowledge, our results provided the first evidence supporting the LbS preference in comprehension by using the exact same materials from production. In short, our results were in support of the APP in that comprehenders, like speakers, also preferred the phrases that the heads of arguments and a predicate were packed as closely as possible.

Most interestingly, the results of Study 2 suggest that processing difficulty associated with the canonicity preference and the length preference appeared at different stages of processing, respectively. First, the effect of canonicity emerged on the measurement corresponding to the early processing difficulty could be viewed as a token referring to the predictability effect (Altarriba, Kroll, Sholl, and Rayner 1996; Ashby, Clifton, and Rayner 2005; Binder, Pollatsek, and Rayner 1999; Rayner, Ashby, Pollatsek, and Reichle 2004). Namely, canonically ordered phrases were easier to read than non-canonically ordered phrases, in part, because comprehenders could predict what speakers might say next as a function of their sensitive use of statistical regularities on those constructions. This result supports the frequency-based approach (Bresnan et al. 2007; Chang 2009; Hale 2001; Levy 2008; MacDoland 2013) and the production-driven models (MacDoland 2013; Pickering and Garrod 2007, 2013). However, when lengthened arguments appeared later than short arguments (i.e., when the LbS preference was violated), comprehenders' difficulty continued for further processing. During this late processing, comprehenders felt easier to integrate arguments into sentences when lengthened arguments were fronted prior to short arguments rather than when short arguments were fronted prior to lengthened arguments. The late effect represents the processors' effort in the semantic integration of arguments, or presumably, processors' difficulty in reanalyzing the given structures (Hyönä 2003; Rayner et al. 1989). Importantly, this result supports our view that processing associated with the length preference might not belong to the immediate and incremental processing (c.f., Tanaka et al. 2011). To be brief, the canonicity effect appeared on the measurements corresponding to the early processing difficulty, but the effect of the LbS preferences emerged on the measurements corresponding to the late processing difficulty. The two types of ordering principles were not processed at the same stage of processing.

### 2.3 Study 3: Production-comprehension model

The results from Study 1 and 2 support the prediction of the APP that speakers and comprehenders share the same internal mechanism such that they prefer the way to pack the heads of arguments and a predicate as closely as possible. In this scenario, we think that the degree to which speakers prefer locating long arguments prior to short arguments should be proportional to the degree of comprehension difficulty to which comprehenders might have in the integration of arguments into sentences. Subsequently, we were able to present supporting evidence that speakers and comprehenders are closely interconnected in a way that what speakers prefer to produce is easier for comprehenders to process.

In order to run statistical models to test the relationship between production and comprehension, we conducted four linear mixed-effect regression models in which we submitted four eye-tracking measurements obtained from Study 2 as dependent variables to represent the degree of comprehension difficulty and the proportions of the long-before-short occurrences obtained from Study 1 as independent variables to represent the degree of speakers' favor for the LbS preference. The proportions of the long-before-short occurrences were computed by dividing the counts of how many times speakers produced the phrases that long arguments were located before short arguments with the total counts in each item across all speakers. The actual length of target phrases was added to control for its potential effect, as we did in Study 2. We predict that the degree of comprehension difficulty would be reduced as the degree of speakers' favor on the LbS preference increased. The methods in the model were the same that we did in Study 1 and 2.

The results from the model are displayed in Table 5. Second-pass RTs, total gaze duration, and regression rates significantly decreased in the proportion that the rates of speakers' favor on the LbS preferences increased, indicating that the structures that speakers were more likely to say were easier for comprehenders to understand. However, first-pass RTs were not significantly predicted by the rates of speakers' LbS preferences, indicating that speakers' LbS preferences did not predict the degree of the early processing difficulty. In short, the results of the production-comprehension model demonstrated that speakers and comprehenders are closely interconnected. We argue that both speakers and comprehenders intended to have an easier integration of arguments into sentences, by minimizing the

distance between the heads of arguments and verbs (c.f., Hawkins 1997, 2004).

Table 5. The results of linear mixed-effect regressions to model the relationship between production preferences and comprehension difficulties

|                            | Estimates | S.E.  | t-value |
|----------------------------|-----------|-------|---------|
| <b>First - pass RTs</b>    |           |       |         |
| Intercept                  | 843.37    | 29.88 | 28.23   |
| Preference rates           | -29.95    | 26.01 | -1.15   |
| Length                     | 79.83     | 3.12  | 25.63*  |
| <b>Second-pass RTs</b>     |           |       |         |
| Intercept                  | 806.52    | 86.96 | 9.28    |
| Preference rates           | -232.64   | 62.27 | -3.74*  |
| Length                     | 80.70     | 6.66  | 12.12*  |
| <b>Total gaze duration</b> |           |       |         |
| Intercept                  | 1682.95   | 86.96 | 19.35   |
| Preference rates           | -232.48   | 60.37 | -3.85*  |
| Length                     | 170.45    | 7.47  | 22.82*  |
| <b>Regression rates</b>    |           |       |         |
| Intercept                  | 3.04      | .26   | 11.72   |
| Preference rates           | -.69      | .26   | -2.66*  |
| Length                     | .30       | .02   | 12.55*  |

Note. \* refers to the significant role of the factor at  $\alpha < .05$ .

### 3. General discussion

The goal of the study was to provide a unified account on the LbS preference observed in head-final languages in production as well as comprehension with an approach for the efficient argument integration. For our goal, we proposed the APP, stating that processors would prefer packing the heads of arguments and a predicate as closely as possible to increase the efficiency of argument integration during their sentence utterances or comprehension. Using Korean ditransitive sentences, we observed the APP to be supported; 1) Korean speakers preferred to locate long arguments before short arguments (Study 1) and 2) Korean comprehenders had an easy integration of constructions into sentences when long arguments were placed before short arguments (Study 2). Furthermore, the results from our production-comprehension model in Study 3 revealed that comprehenders' difficulty was reduced to the degree that speakers



preferred to locate long arguments before short arguments. Altogether, as the APP proposes, our results strongly indicate that the preference of speakers and comprehenders are driven by a common cognitive demand to have the heads of arguments and predicates as closely as possible (c.f., Gibson 1998, 2000; Hawkins 1997, 2004).

Our findings raised significant discussions in several aspects. First, we replicated the empirical finding observed by Yamashita and Chang (2001) in Japanese by testing another head final language, Korean. Like Japanese speakers, Korean speakers had strong bias to shift heavy NPs before short NPs. This empirical replication is powerful given other consistent findings observed from the corpus studies in Japanese (Kondo and Yamashita 2011) and Korean (Choi 2007), respectively. Taken together, our data from the current study confirmed that the LbS preference is a typical phenomenon in the processing of head-final languages.

In contrary to the accessibility-based view that had difficulty in accounting for why long phrases should be more accessible than short words or phrases in head-final languages, we instead proposed an argument-integration approach through the APP (similar to distance-based approach by Hawkins). The APP fundamentally hints that speakers are more concerned about how to arrange arguments structurally in a sentence rather than care for which lexical items is more or less accessible. Our data and Yamashita and Chang's (2001) data fit well to the idea of the APP with no troubles. In fact, we are not alone to argue that speakers' behaviors would be better explained in terms of their understanding on structural relations (e.g., who-did-what-to-whom argument information) rather than lexical items, *per se*. The similar conclusion was driven by Hwang and Kaiser's (2014) observation that Korean speakers were better facilitated in production with case markers being attached on lexical items than without case markers being attached on lexical items, suggesting that lexical items themselves did not affect production facilitation but case markers, as a token for grammatical function, facilitated production. In any way, we were able to show that the APP is the principle that well explained the LbS preference in head-final languages with the view that speakers' production is based on their understanding of structural relationship such as argument information.

Second, as far as we understand, we provided the first evidence supporting the LbS preference in comprehension. Comprehenders in our Study 2 showed more difficulty in reading when they encountered phrases that violated the APP than when they encountered phrases that satisfied the APP. Recall that Yamashita and Chang (2001)

conducted productions studies only, leaving questions remaining on comprehension for this matter. Also, Hawkins (1997, 2004) proposed a comprehension-based mechanism to explain the crosslinguistic asymmetry about the relative length in production, but there was no actual comprehension data that could support the presence of comprehension difficulty in the violation of the long-before-short constraint. Our data filled this shortage and showed that the LbS preference is effectively present in comprehension of head-final language.

Notice that the APP allows for comprehenders to exploit the comprehension-based processing manner as well in the same way that speakers could achieve the efficient integration of arguments into sentences. We would like to emphasize that the beauty of the APP lies on its flexible application such that it offers a unified account to explain the behaviors of speakers as well as those of comprehenders. Without presenting any additional principle, the APP adequately offers a unified way to explain the behaviors of both speakers and comprehenders.

Third, we presented the interconnected model between speakers and comprehenders based on our empirical evidence, given the assumption that speakers and comprehenders shared the same mechanism (c.f., Hawkins 1997, 2004), in particular, with respect to the matter of how to arrange arguments that had different lengths.

As for the results, it is of interest to notice that speakers' behaviors on their favor for the LbS preference predicted comprehenders' behaviors on the measurement corresponding to the late processing difficulty (i.e., second pass RTs, total gaze duration and regression rates), but not the measurement corresponding to the early processing difficulty (i.e., first pass RTs). These patterns hint that comprehenders did not seem to predict speakers' choices on how to arrange arguments of different lengths. If then, these patterns are not precisely supportive to other production-comprehension models claiming that production drives comprehension through comprehenders' prediction to speakers (e.g., Pickering and Garrod 2007, 2013; MacDoland 2013). However, we would also point out that our data on the canonicity preference well support these models in other senses. Comprehenders in Study 2 had less difficulty (i.e., faster first RTs) in encountering canonically ordered phrases than non-canonically ordered phrases, regardless of the length differences. Considering the widely-accepted assumption that first pass RTs (or first fixation) could refer to the aspects of predictability (Altarriba et al. 1996; Ashby et al. 2005; Binder et al. 1999; Rayner et al. 2004), we could say

that those production-driven comprehension models succeeded in predicting comprehenders' behaviors on first pass RTs.

Taken together, the information such as canonicity that comprehenders could predict what speakers would like to say next could be well captured by those production-based comprehension models (Chang 2009; MacDonald 2013; Pickering and Garrod 2007, 2013). However, if comprehenders do not have crucial cues that enable them to predict speakers' behaviors, comprehension-based production models might play a better role (c.f., Hawkins 1997, 2004). Presumably, whether or not production drives comprehension, or *vice-versa*, could be the matter of what kinds of the information they have to deal with during information exchange, depending on the easiness to predict the behaviors of communication counterparts.

Finally, our claim based on the APP could provide a language-general solution about the issue of relative length preferences across languages (c.f., Tanaka et al. 2011). Under the APP view, the asymmetry on the preferences on the relative length of phrases across languages might be just an epiphenomenon. We posit that the cognitive demand of language processors for the matter of relative length in word order might not fundamentally differ across languages, but their preferences are realized in reverse as a function of the head position in each language.

In fact, there have been several attempts to show that language processors, in general, do not use different mechanism fundamentally across languages, but crosslinguistic phenomena are just outputs due to language-specific grammar functions. For example, Gibson, Piantadosi, Brink, Bergen, Lim, and Saxe (2013) attempted to account for the prevalence of SOV and SVO orders in terms of noise channel hypothesis. In this hypothesis, speakers choose SVO or SOV word order because they desire to maximize meaning recoverability by avoiding possible noise as much as they can. Languages like Korean employ case markers, and thus, the recoverability of who-did-what information is less affected by possible noises even the reversible events in which objects occur next to subjects. In contrast, languages like English that word order takes over the function of case markers will be faced with potential ambiguity on who-did-what-to-whom information in reversible events where objects appear in parallel to subject. With no case markers, languages like English should take SVO order over SOV order for the reduction of potential noises. That being said, the crucial point of the noise channel hypothesis is that the fundamental cognitive mechanism working in the minds of speakers does not differ

across languages, but how it is realized is the matter of each individual language. Similarly, we argue that the APP plays a role as a parsimonious constraint in determining the order of arguments by relative length language-generally.

So far we have discussed the positive points that our study could contribute to the field. However, we are also aware of the fact that there are several remaining controversial issues for future studies. First, it is not clear yet how the APP would define the interactions between the constraint regarding relative length and other constraints that affect ordering arguments. Canonicity is one of them. As we found in our study, speakers were less likely to locate long NPs before short NPs when the relocation violated the canonical order. However, for the current version, the APP does not have any specific prediction about how and in which way the length constraint will be interactive to canonicity constraint. Indeed, it has been known for a while that there is a hierarchy of arranging arguments. For example, in languages like English, thematic roles are often realized syntactically in an order like agent > beneficiary > patient > location > instrument (Givón 1984). In languages like Korean, there was recent empirical finding showing that arguments such as recipient, location, or instrument often appear before patients (Kwon, Choi, Hong, and Hong 2010). Our remaining question is on how persistent the length constraint will be observed depending on the hierarchy of arguments, and how the APP will define those interactions in its revised version.

Our second issue is related to testing the role of argumenthood that is defined in the APP. According to the current version of the APP, it predicts that it will have more significant effects on the orders of arguments rather than those of adjuncts. This raises questions regarding the argument-adjunct distinction in processing. For example, when there is a short theme NP and a long location NP, do processors still prefer to move the long location NP phrases before the short theme NP as much as they prefer doing it when they have a long recipient NP and a short theme, or do processors feel less likely to do so? It is our question to clarify whether the APP is applicable in the processing of the argument information yet not that of the adjunct information.

Finally, we questioned the methodology to lengthen arguments. In our study, we used object-extracted relative clauses as post-nominal modifiers to lengthen argument NPs (also, Yamashita and Chang 2001). Thus, our relative clause phrases consisted of subjects, extracted objects, their traces, and relativized verbs that needed to be

integrated into sentences. This hierarchical structure could be a potential problem because processors had to complete argument integration in addition to the integration of arguments in the main clauses and/or because they might have to be involved in reanalysis associated with the center-embedded relative clauses. Here, we had a question; what if we just use much simpler modifiers like simple adjective phrases that no constituents were extracted from? If the LbS preference is persistent to the lengthening type, we speculate to observe a solid effect of the preference. However, further studies will confirm our speculation.

#### **4. Conclusion**

The present study aimed to examine whether the preference of locating long phrases before short phrases in head-final languages would continue to exist in a consistent manner in production and comprehension. We also attempted to show the proximity of the interconnectedness between speakers and comprehenders. Using Korean ditransitive sentences, we demonstrated that Korean comprehenders as well as Korean speakers have the LbS preference during their information processing. As expected, our production-comprehension model revealed that speakers and comprehenders do go through a similar cognitive demand in trying to locate the heads of arguments and a predicate as closely as possible. Our data is significant in that we provide a unified account for the behaviors of speakers and those of comprehenders with the view of achieving the efficient argument-integration. We claim that our proposal can be extended as a parsimonious constraint to explain the crosslinguistic asymmetry about the length preference, LbS preference vs. SbL preference.

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## Appendix A

A full set of experimental materials that we used for Study 1 (production) and Study 2 (comprehension). Materials are presented in an individual constituent for Study 1 but they were displayed in a sentence format for Study 2. In each number, the condition ‘a’ refers to the condition that the length of recipient NP and that of theme NP is equally short, the condition ‘b’ refers to the condition that recipient NP is longer than theme NP is equally short, and the condition ‘c’ refers to the condition that theme NP is longer than recipient NP. Each condition has its counterpart in a non-canonical format. For the sentences of the non-canonical condition, we switch the order of the target arguments (i.e., from ‘recipient + them’ to ‘theme + recipient’).

- (1) a. Chelswu-nun [chinkwu-eykey] [meymo-lul] cuksi namky-ess-ta.  
(Chelswu immediately left a memo to a friend.)  
b. Chelswu-nun [cokyo-ka pwull-ess-ten chinkwu-eykey] cuksi [meymo-lul] namky-ess-ta.  
(Chelswu immediately left a memo to a friend who a teaching assistant called.)  
c. Chelswu-nun [chinkwu-eykey] [cokyo-ka caksengha-n meymo-lul] cuksi namky-ess-ta.  
(Chelswu immediately left a memo that a teaching assistant left to a friend.)
- (2) a. Minswu-nun [haksayng-eykey] [khatu-lul] iltan cwu-ess-ta.  
(Minswu first gave a card to a student.)  
b. Minswu-nun [senpay-ka mit-ess-ten haksayng-eykey] iltan [khatu-lul] cwu-ess-ta.  
(Minswu first gave a card to a student who a senior believed.)  
c. Minswu-nun [haksayng-eykey] [senpay-ka sayongha-n khatu-lul] iltan cwu-ess-ta.  
(Minswu first gave a card which a senior used to a student.)
- (3) a. Yengho-nun [samchon-eykey] [phyenci-lul] imi ponay-ss-ta.  
(Yengho already sent a letter to his uncle.)  
b. Yengho-nun [hwupay-ka conkyengha-n samchon-eykey] imi [phyenci-lul] ponay-ss-ta.  
(Yengho already sent a letter to his uncle who a junior respected.)  
c. Yengho-nun [samchon-eykey] [hwupay-ka salphyepo-n phyenci-lul] imi ponay-ss-ta.  
(Yengho already sent a letter which a junior examined to an uncle.)
- (4) a. Minho-nun [kokayk-eykey] [myengham-ul] palo kenney-ss-ta.  
(Minho directly handed a business card to a client.)  
b. Minho-nun [tongsayng-i senthaykha-n kokayk-eykey] palo [myengham-ul] kenney-ss-ta.  
(Minho directly handed a business card to a client who a younger brother selected.)  
c. Minho-nun [kokayk-eykey] [tongsayng-i ceycakha-n myengham-ul] palo kenney-ss-ta.  
(Minho directly handed a business card which a younger brother made to a client.)
- (5) a. Hyeymin-un [senpay-eykey] [taychwu-lul] kwuti kwenha-yss-ta.

- (Hyeymin obstinately recommended a loan to a senior.)
- b. Hyeymin-un [enni-ka cohaha-n senpay-eykey] kwuti [taychwu-lul] kwenha-yss-ta.  
(Hyeymin obstinately recommended a loan to a senior who her older sister liked.)
- c. Hyeymin-un [senpay-eykey] [enni-ka pantayha-n taychwu-lul] kwuti kwenha-yss-ta.  
(Hyeymin obstinately recommended a loan which her older sister opposed to a senior.)
- (6) a. Yenglan-un [enni-eykey] [ai-lul] kyeysok mathky-ess-ta.  
(Yenglan continuously entrusted a child to an older sister.)
- b. Yenglan-un [emma-ka chingchanha-n enni-eykey] kyeysok [ai-lul] mathky-ess-ta.  
(Yenglan continuously entrusted a child to an older sister who a mother praised.)
- c. Yenglan-un [enni-eykey] [emma-ka chingchanha-n ai-lul] kyeysok mathky-ess-ta.  
(Yenglan continuously entrusted a child who a mother praised to an older sister.)
- (7) a. Ciho-nun [ai-eykey] [sathang-ul] cikcep cwu-ess-ta.  
(Ciho directly gave a candy to a child.)
- b. Ciho-nun [atul-i teylyeo-n ai-eykey] cikcep [sathang-ul] cwu-ess-ta.  
(Ciho directly gave a candy to a child who a son brought.)
- c. Ciho-nun [ai-eykey] [atul-i kwuipha-n sathang-ul] cikcep cwu-ess-ta.  
(Ciho directly gave a candy which a son purchased to a child.)
- (8) a. Minswu-nun [appa-eykey] [sikyey-lul] mollay tuly-ess-ta.  
(Minswu secretly gave a watch to a father.)
- b. Minswu-nun [komo-ka mwusiha-n appa-eykey] mollay [sikyey-lul] tuly-ess-ta.  
(Minswu secretly gave a watch to a father who his aunt ignored.)
- c. Minswu-nun [appa-eykey] [komo-ka cohaha-n sikyey-lul] mollay tuly-ess-ta.  
(Minswu secretly gave a watch that his aunt liked to a father.)
- (9) a. Cihyey-nun [swukmo-eykey] [yongton-ul] sulccek kenney-ss-ta.  
(Cihyey furtively handed pocket money to an aunt.)
- b. Cihyey-nun [namphyen-i miweha-n swukmo-eykey] sulccek [yongton-ul] kenney-ss-ta.  
(Cihyey furtively handed pocket money to an aunt who a husband hated.)
- c. Cihyey-nun [swukmo-eykey] [namphyen-i mou-n yongton-ul] sulccek kenney-ss-ta.  
(Cihyey furtively handed pocket money which a husband gathered to an aunt.)
- (10) a. Yenghuy-nun [kica-eykey] [calyo-lul] pelsse nemky-ess-ta.  
(Yenghuy already handed data to a reporter.)
- b. Yenghuy-nun [kyengchal-i kwusokha-n kica-eykey] pelsse [calyo-lul] nemky-ess-ta.  
(Yenghuy already handed data to a reporter who the police arrested.)
- c. Yenghuy-nun [kica-eykey] [kyengchal-i chacanay-n calyo-lul] pelsse nemky-ess-ta.  
(Yenghuy already handed data which the police found out to a reporter.)
- (11) a. Hyencwu-nun [haksayng-eykey] [kongmwun-ul] kanhok mathky-ess-ta.  
(Hyencwu sometimes entrusted an official document to a student.)
- b. Hyencwu-nun [kyoswu-ka cicengha-n haksayng-eykey] kanhok [kongmwun-ul]

mathky- ess-ta.

(Hyencwu sometimes entrusted an official document to a student who a professor designated.)

- c. Hyencwu-nun [haksayng-eykey] [kyoswu-ka cicengha-n kongmwun-ul] kanhok mathky- ess-ta.

(Hyencwu sometimes entrusted an official document which a professor designated to a student.)

- (12) a. Ciswu-nun [chinkwu-eykey] [sosik-ul] kuphi cenha-yss-ta.

(Ciswu hastily delivered news to a friend.)

- b. Ciswu-nun [atul-i kekcengha-n chinkwu-eykey] kuphi [sosik-ul] cenha-yss-ta.

(Ciswu hastily delivered news to a friend who a son worried.)

- c. Ciswu-nun [chinkwu-eykey] [atul-i molu-nun sosik-ul] kuphi cenha-yss-ta.

(Ciswu hastily delivered news which a son doesn't know to a friend.)

- (13) a. Senghuy-nun [cikwen-eykey] [swulpyeng-ul] kamhi tency-ess-ta.

(Senghuy boldly threw a liquor bottle to a staff.)

- b. Senghuy-nun [hoycang-i kamssa-nun cikwen-eykey] kamhi [swulpyeng-ul] tency-ess-ta.

(Senghuy boldly threw a liquor bottle to a staff who a president protected.)

- c. Senghuy-nun [cikwen-eykey] [hoycang-i akki-nun swulpyeng-ul] kamhi tency-ess-ta.

(Senghuy boldly threw a liquor bottle which a president cherished to a staff.)

- (14) a. Cwunho-nun [namca-eykey] [senmwu-lul] cacwu ponay-ss-ta.

(Cwunho frequently sent a gift to a man.)

- b. Cwunho-nun [nwuna-ka sakwi-nun namca-eykey] cacwu [senmwu-lul] ponay-ss-ta.

(Cwunho frequently sent a gift to a man who an older sister met.)

- c. Cwunho-nun [namca-eykey] [nwuna-ka ceycakra-n senmwu-lul] cacwu ponay-ss-ta.

(Cwunho frequently sent a gift which an older sister made to a man.)

- (15) a. Cangho-nun [kkoma-eykey] [cenyek-ul] mence meky-ess-ta.

(Cangho first fed a dinner to a kid.)

- b. Cangho-nun [ayin-i akki-nun kkoma-eykey] mence [cenyek-ul] meky-ess-ta.

(Cangho first fed a dinner to a kid who a girlfriend cherished.)

- c. Cangho-nun [kkoma-eykey] [ayin-i mantu-n cenyek-ul] mence meky-ess-ta.

(Cangho first fed a dinner which a girlfriend made to a kid.)

- (16) a. Sinyeng-un [sipwumo-eykey] [yongton-ul] hangsang pwuchy-ess-ta.

(Sinyeng always remitted pocket money to the parents-in-law.)

- b. Sinyeng-un [namphyen-i posalphi-n sipwumo-eykey] hangsang [yongton-ul] pwuchy-ess- ta.

(Sinyeng always remitted pocket money to the parents-in-law who a husband supported.)

- c. Sinyeng-un [sipwumo-eykey] [namphyen-i cwunpiha-n yongton-ul] hangsang pwuchy-ess- ta.

(Sinyeng always remitted pocket money which a husband prepared to the parents-in-law.)

- (17) a. Miyen-un [iwus-eykey] [panchan-ul] mayil kenney-ss-ta.

(Miyen every day handed a side dish to a neighbor.)

- b. Miyen-un [enni-ka chingchanha-n iwus-eykey] mayil [panchan-ul] kenney-ss-ta.  
(Miyen every day handed a side dish to a neighbor who an older sister praised.)
- c. Miyen-un [iwus-eykey] [enni-ka culki-nun panchan-ul] mayil kenney-ss-ta.  
(Miyen every day handed a side dish which an older sister enjoyed to a neighbor.)
- (18) a. Sekwen-un [chinkwu-eykey] [maykcwu-lul] kanhok sacw-ess-ta.  
(Sekwen sometimes bought a beer to a friend.)
- b. Sekwen-un [senpay-ka koylophi-n chinkwu-eykey] kanhok [maykcwu-lul] sacw-ess-ta.  
(Sekwen sometimes bought a beer to a friend who a senior bothered.)
- c. Sekwen-un [chinkwu-eykey] [senpay-ka swuipha-n maykcwu-lul] kanhok sacw-ess-ta.  
(Sekwen sometimes bought a beer which a senior imported to a friend.)
- (19) a. Ciyeng-un [kamtok-eykey] [kwail-ul] kakkum ponay-ss-ta.  
(Ciyeng sometimes sent a fruit to a director.)
- b. Ciyeng-un [tongsayng-i pipanha-n kamtok-eykey] kakkum [kwail-ul] ponay-ss-ta.  
(Ciyeng sometimes sent a fruit to a director who a younger brother criticized.)
- c. Ciyeng-un [kamtok-eykey] [tongsayng-i malyenha-n kwail-ul] kakkum ponay-ss-ta.  
(Ciyeng sometimes sent a fruit which a younger brother prepared to a director.)
- (20) a. Yengsik-un [thimcang-eykey] [calyo-lul] mili cenha-yss-ta.  
(Yengsik beforehand delivered data to a chief.)
- b. Yengsik-un [tonglyo-ka twulyeweha-n thimcang-eykey] mili [calyo-lul] cenha-yss-ta.  
(Yengsik beforehand delivered data to a chief who a co-worker was afraid.)
- c. Yengsik-un [thimcang-eykey] [tonglyo-ka iyongha-n calyo-lul] mili cenha-yss-ta.  
(Yengsik beforehand delivered data which a co-worker used to a chief.)
- (21) a. Hyenho-nun [chinchek-eykey] [pohem-ul] ellun phal-ass-ta.  
(Hyenho quickly sold insurance to a relative.)
- b. Hyenho-nun [imo-ka piwus-un chinchek-eykey] ellun [pohem-ul] phal-ass-ta.  
(Hyenho quickly sold insurance to a relative who an aunt laughed.)
- c. Hyenho-nun [chinchek-eykey] [imo-ka senthaykha-n pohem-ul] ellun phal-ass-ta.  
(Hyenho quickly sold insurance which an aunt selected to a relative.)
- (22) a. Unhuy-nun [sachon-eykey] [hakpi-lul] mollay ponay-ss-ta.  
(Unhuy secretly sent a school expenses to a cousin.)
- b. Unhuy-nun [kyocang-i akki-nun sachon-eykey] mollay [hakpi-lul] ponay-ss-ta.  
(Unhuy secretly sent a school expenses to a cousin who a principal cherished.)
- c. Unhuy-nun [sachon-eykey] [kyocang-i insangha-n hakpi-lul] mollay ponay-ss-ta.  
(Unhuy secretly sent a school expenses which a principal raised to a cousin.)
- (23) a. Unyeng-un [hwupay-eykey] [meyil-ul] tasi ponay-ss-ta.  
(Unyeng again sent a mail to a junior.)
- b. Unyeng-un [chinkwu-ka ppwulichi-n hwupay-eykey] tasi [meyil-ul] ponay-ss-ta.  
(Unyeng again sent a mail to a junior who a friend rejected.)
- c. Unyeng-un [hwupay-eykey] [chinkwu-ka sakceyha-n meyil-ul] tasi ponay-ss-ta.

- (Unyeng again sent a mail which a friend deleted to a junior.)
- (24) a. Cangho-nun [cemwen-eykey] [wusan-ul] kyewu pilly-ess-ta.  
(Cangho barely borrowed an umbrella from a clerk.)  
b. Cangho-nun [sacang-i nayponay-n cemwen-eykey] kyewu [wusan-ul] pilly-ess-ta.  
(Cangho barely borrowed an umbrella from a clerk who a boss fired.)  
c. Cangho-nun [cemwen-eykey] [sacang-i kwiupha-n wusan-ul] kyewu pilly-ess-ta.  
(Cangho barely borrowed an umbrella which a boss purchased from a clerk.)
- (25) a. Kiyeng-un [noin-eykey] [tosilak-ul] congcong cwu-ess-ta.  
(Kiyeng often gave a lunch to an elderly.)  
b. Kiyeng-un [samchon-i tolpo-nun noin-eykey] congcong [tosilak-ul] cwu-ess-ta.  
(Kiyeng often gave a lunch to an elderly who an uncle supported.)  
c. Kiyeng-un [noin-eykey] [samchon-i ssao-n tosilak-ul] congcong cwu-ess-ta.  
(Kiyeng often gave a lunch which an uncle brought to an elderly.)
- (26) a. Sencwu-nun [tongchang-eykey] [saynghwalpi-lul] ketup pilly-ess-ta.  
(Sencwu repeatedly borrowed living expenses from an alumnus.)  
b. Sencwu-nun [namphyen-i molu-nun tongchang-eykey] ketup [saynghwalpi-lul] pilly-ess-ta.  
(Sencwu repeatedly borrowed living expenses from an alumnus who a husband doesn't know.)  
c. Sencwu-nun [tongchang-eykey] [namphyen-i nalli-n saynghwalpi-lul] ketup pilly-ess-ta.  
(Sencwu repeatedly borrowed living expenses which a husband spent from an alumnus.)
- (27) a. Swuci-nun [ayin-eykey] [mwunca-lul] mayil ponay-ss-ta.  
(Swuci every day sent a message to a boyfriend.)  
b. Swuci-nun [pwumo-ka pantayha-n ayin-eykey] mayil [mwunca-lul] ponay-ss-ta.  
(Swuci every day sent a message to a boyfriend who parents opposed.)  
c. Swuci-nun [ayin-eykey] [pwumo-ka hwakinha-n mwunca-lul] mayil ponay-ss-ta.  
(Swuci every day sent a message which parents checked to a boyfriend.)
- (28) a. Cinyeng-un [kangsa-eykey] [yoka-lul] cacwu payw-ess-ta.  
(Cinyeng frequently learned a yoga from an instructor.)  
b. Cinyeng-un [imo-ka incengha-n kangsa-eykey] cacwu [yoka-lul] payw-ess-ta.  
(Cinyeng frequently learned a yoga from an instructor who an aunt admitted.)  
c. Cinyeng-un [kangsa-eykey] [imo-ka kaypalha-n yoka-lul] cacwu payw-ess-ta.  
(Cinyeng frequently learned a yoga which an aunt developed from an instructor.)
- (29) a. Wucin-un [paywu-eykey] [payyek-ul] cakkwu mathky-ess-ta.  
(Wucin repeatedly cast a role to an actor.)  
b. Wucin-un [kamtok-i silheha-n paywu-eykey] cakkwu [payyek-ul] mathky-ess-ta.  
(Wucin repeatedly cast a role to an actor who a director hated.)  
c. Wucin-un [paywu-eykey] [kamtok-i silheha-n payyek-ul] cakkwu mathky-



ess-ta.

(Wucin repeatedly cast a role which a director hated to an actor.)

- (30) a. Sinci-nun [komo-eykey] [komin-ul] kwaynhi malha-yss-ta.  
(Sinci needlessly said a trouble to an aunt.)  
b. Sinci-nun [oppa-ka ttalu-nun komo-eykey] kwaynhi [komin-ul] malha-yss-ta.  
(Sinci needlessly said a trouble to an aunt who an older brother loved.)  
c. Sinci-nun [komo-eykey] [oppa-ka haykyelha-n komin-ul] kwaynhi malha-yss-ta.  
(Sinci needlessly said a trouble which an older brother solved to an aunt.)

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