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Scope and Prosody in Multiple *Wh*-Questions

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Abstract: The prosodic marking of the *wh*-scope has been a good testing ground to shed light on syntax-prosody mapping. Many accounts have been proposed based on various theoretical models, including the E-feature agreement system, the Multiple Spell-Out Model, Contiguity Theory, and the Wrap-XP Model. However, most previous studies focused on the constructions with a single *wh*-phrase, and few studies paid attention to multiple *wh*-questions. This paper presents novel data from production experiments to show the prosodic patterns of multiple *wh*-questions in Korean, for which none of the previous accounts makes correct predictions. This study proposes a new alignment constraint considering the scope relations between *wh*-words. The necessity of such a constraint suggests that the prosodic structures for *wh*-scope interpretations are not the direct outcome of syntax and phonology but the aggregation of syntax, phonology, and semantics.

Keywords: multiple *wh*-question; *wh*-scope; *wh*-intonation; Korean

1. Introduction

This paper investigates the relationship between semantic scope and prosody, putting special attention on the *wh*-scope of multiple *wh*-questions. In *wh*-in situ languages such as Korean and Japanese, *wh*-scope is decided by the association with a question marker such as *-nunci*(Q) or *-ni*(Q) in the Korean example in (1).

(1) *Minho-nun* *[Yumi-ka* *nwukwu-lul* *mannass-nunci]* *kwungkumhayha-ni?*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-Q
a. 'Does Minho wonder who Yumi met?'
b. 'For which x, x a person, does Minho wonder whether Yumi met x'

Since the question marker *-ni*(Q) in (1) is scope-neutral, the *wh*-phrase *nwukwu* can be associated with either *-nunci*(Q) or *-ni*(Q). Consequently, the sentence is scopally ambiguous. When the *wh*-phrase *nwukwu* 'who' is associated with the embedded complementizer *-nunci*, it has embedded scope, as shown in (1a). Alternatively, if the *wh*-phrase is associated with the matrix complementizer *-ni*, it is interpreted with a matrix scope, as demonstrated in (1b). This ambiguity between the indirect question interpretation (i.e., embedded scope) and the direct question interpretation (i.e., matrix scope) can be resolved by prosody. For example, in South Kyeongsang Korean (henceforth SKK), the domain of *wh*-scope is found to correlate with the span of so-called *wh*-intonation (i.e., F0 compression or high plateau) (Hwang 2011a, 2011b, 2015). The examples (2) illustrate embedded and matrix scope *wh*-questions in SKK, which are also morphologically marked by the yes-no question ending *-na* and the *wh*-question ending *-no*, respectively. As shown in the diagrams in (2), the semantic scope of *wh*-phrases can be realized phonetically with the span of the high flat F0 contour, which starts from the *wh*-phrase and continues to its associated complementizer (Q). It ends at the embedded Q in the case of embedded-scope *wh*-phrases (2a) in Figure 1, whereas it ends at the matrix Q in the case of the matrix-scope *wh*-phrases (2b) in Figure 2. The domain of this high plateau is called *wh*-intonation. The same *wh*-intonation pattern is observed even when the scope-neutral question marker is used, in which case prosody is the only clue to disambiguation.

Citation: Lee, So-Young. 2024. Scope and Prosody in Multiple *Wh*-Questions. *Languages* 9: 226. https://doi.org/10.3390/languages9070226

Academic Editor: Jieun Kiaer

Received: 28 September 2023
Revised: 12 March 2024
Accepted: 8 April 2024
Published: 21 June 2024

(2) *Minho-nun* *[Yumi-ka* *nwukwu-lul* *mannass-nunci]* *kwungkumhayha-na/-no?*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-YNQ/- WHQ
a. 'Does Minho wonder who Yumi met?'
b. 'For which x, x a person, Minho wonders whether Yumi met x?'

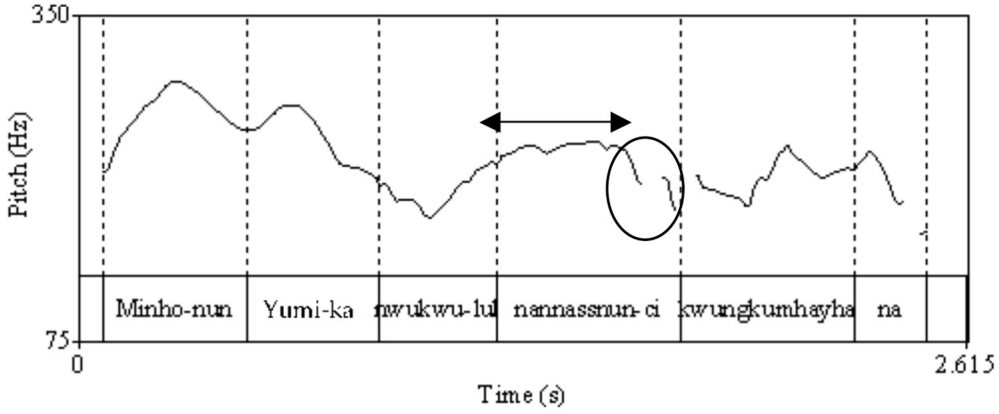


Figure 1. F0 pitch contour for the embedded scope (indirect *wh*-question) in Hwang (2011b).

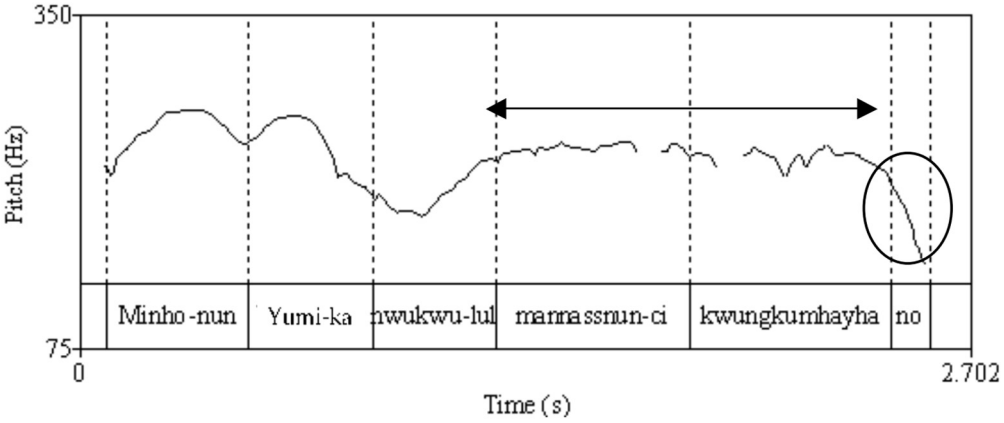


Figure 2. F0 pitch contour for the matrix scope (direct *wh*-question) in Hwang (2011b).

In order to explain the *wh*-intonation pattern, many accounts have been proposed based on various theoretical models, including the E-feature agreement system (Deguchi and Kitagawa 2002; Kitagawa 2005), the Multiple Spell-Out Model (Ishihara 2007), Contiguity Theory (Richards 2010), and the Wrap-XP Model (Smith 2011). However, most previous studies focus on the constructions with a single *wh*-phrase, and very few studies have paid attention to multiple *wh*-questions. Therefore, this paper aims to identify the major prosodic phenomena that are generally observed in multiple *wh*-questions and to illustrate how the semantic scope relationship of *wh*-phrases can influence the formation of *wh*-intonation. The study of the prosodic scope marking, including a wider range of data, helps us reveal the essential nature of *wh*-intonation, which has implications for the interfaces of phonology, syntax, and semantics.

The rest of this paper is structured as follows. In the following sections, I examine the prosodic pattern of multiple *wh*-phrases in production. Section 2 offers a background on the syntactic characteristics relevant to *wh*-questions as well as an overview of the prosodic properties of South Kyeongsang Korean. Section 3 reviews the previous studies on the correlation between prosody and semantic scope of *wh*-phrases, and makes a prediction about the prosodic formations of multiple *wh*-phrases based on the previous studies. Then, in the following sections, I provide empirical data on the phonetic implementation of *wh*-intonation in multiple *wh*-questions in SKK based on a production test. I propose new constraints to account for the surface realization of *wh*-intonation of multiple *wh*-questions, based on the observations. Finally, I conclude the paper in Section 7.

2. Background

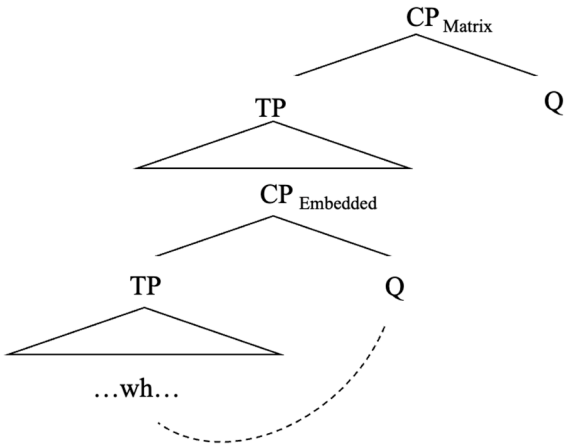
2.1. Syntactic Properties of wh-Questions

2.1.1. Syntactic Structure and Complementizers

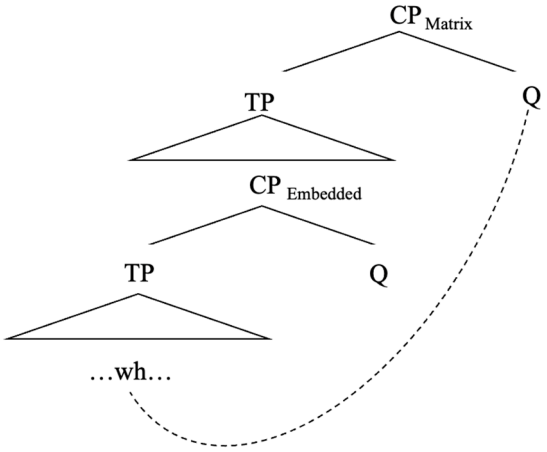
The schematic syntactic structure of (1) and its scope interpretations are illustrated in (3).

(3) [Matrix …[Embedded … *wh* … Q] … Q]

a. Embedded Scope



b. Matrix Scope



The diagram in (3a) shows how the embedded *wh*-phrase associates with the embedded complementizer (Q), yielding a yes/no question format. Korean speakers allow the *wh*-phrase to relate to the matrix interrogative ending (Q), as shown in (3b). Given that Korean is a *wh*-in situ language, it does not require *wh*-movement to determine scope.

Instead, sentence types and associated *wh*-scopes can be morphologically indicated through morphological markers at the end of the sentence. Generally, the choice of sentence endings (matrix clause complementizers) varies according to the sentence type, tense specification, and utterance style. The details of interrogative complementizers in two Korean varieties, Seoul Korean and South Kyeongsang Korean, are given below in Table 1. The formal endings are shown to be question-specific yet scope-neutral, as indicated by [±] on the *wh* column. In contrast, the informal endings in South Kyeongsang Korean (SKK) exclusively indicate *wh*-scope (*-na:* embedded scope (an indirect *wh*-question interpretation) vs. *-no*: matrix scope (a direct *wh*-question interpretation)).[1]

Table 1. Interrogative sentence-final particles.

Style			Property		Seoul K	SKK
Formality	**Politeness**	**Q**	***wh***	**Verb Tenses**		
formal	high	+	±	past/present/future	*-pnikka*	*-pnikka*
informal	high	±	±	past/present/future	*-eyo*	*-eyo*
informal	low	±	±	past/present/future	*-e*	
informal	low	+	±	past/present/future	*-ni, -nya*	
informal	low	+	−	past/present/future		*-na*
informal	low	+	−	present (be)/future		*-ka*
informal	low	+	+	past/present/future		*-no*
informal	low	+	+	present (be)/future		*-ko*

The embedded complementizer *-nunci* in SKK, analogous to 'whether' in English, is crucial for forming both yes/no and *wh*-questions, as demonstrated in (4).

(4) a. *Minho-nun* *[Yumi-ka* *Suci-lul* *mannass-tako]* *malhayss-ta*
Minho-TOP Yumi-NOM Suci-ACC met-DEC wonder-DEC
'Minho said that Yumi met Suci'.

b. *Minho-nun* *[Yumi-ka* *Suci-lul* *mannass-nunci]* *kwungkumhayss-ta*
Minho-TOP Yumi-NOM Suci-ACC met-Q wonder-DEC
'Minho wondered whether Yumi met Suci'.

c. *Minho-nun* *[Yumi-ka* *nwukwu-lul* *mannass-nunci]* *kwungkumhayss-ta*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-DEC
'Minho wondered who Yumi met'.

This complementizer is not optional for interrogative embedded constructions and plays a role in forming what is known as a *wh*-island, thereby potentially restricting the embedded *wh*-phrase from taking a matrix scope.

2.1.2. *Wh*-Island Effect

As in (3), Korean does not require overt *wh*-movement, in contrast to English (5), where dislocating a *wh*-phrase from its original position to its scope position is obligatory.

(5) a. [Does Minho know [**whom** Yumi met ___]]?

b. [**Whom** does Minho know [Yumi met ___]]?

Syntactically, overt *wh*-movements are subject to the *wh*-island constraint (Chomsky 1973). In other words, the *wh*-island constraint prohibits the embedded *wh*-phrase 'whom' from extending its scope beyond the boundaries of an island, formed by an interrogative element such as 'whether'. Hence, the matrix scope of 'whom' in (6) is unavailable due to a violation of *wh*-island constraint.

(6) a. [Does Minho ask [**whom** Yumi met ___]]?
b. * [**Whom** does Minho ask **whether** Yumi met ___]]?

As for a *wh*-in situ language such as Korean, it is traditionally understood, following Huang (1982), that an in situ *wh*-phrase undergoes covert movement at LF even though there is no overt movement. However, it is controversial whether the covert *wh*-movements are also susceptible to the *wh*-island constraints. On the one hand, it is argued that (1) cannot yield a matrix scope interpretation for a *wh*-phrase, positing such embedded clauses as islands (Hong 2004). This perspective implies that covert movements are restricted by the *wh*-island constraint. On the other hand, it is claimed that the matrix scope interpretation is feasible (Suh 1987; Ishihara 2002; Y.-S. Choi 2006; Hwang 2011a, 2011b, 2015), thereby questioning the application of *wh*-island constraints to covert movements and challenging the classification of these clauses as islands. Specifically, many studies, including Hwang (2011a, 2011b, 2015), highlighted the significance of *wh*-intonation. They suggest

that when appropriate prosody indicating matrix scope is provided, the *wh*-island effect is nullified. Further discussion about *wh*-intonation can be found in Section 2.2.2.

This becomes even more complicated when multiple *wh*-phrases appear in a single sentence, as shown in (7).

(7) *Minho-nun [nwu-ka nwukwu-lul mannass-nunci] kwungkumhayha-ni?*
Minho-TOP who-NOM who-ACC met-Q wonder-Q
a. 'Does Minho wonder who met whom?'
b. 'For which x, x a person, does Minho wonder who met x'.
c. 'For which y, y a person, does Minho wonder whom y met'.
d. 'For which x, y, x a person, y a person, does Minho wonder x met y'.

The sentence in (7) has multiple interpretations. However, judgments on those scope interpretations vary across previous studies. Shimoyama (2001) reported strong *wh*-island effects, indicating that only example (7a) is valid. Nishigauchi (1986, 1990); Saito (1994); and Richards (1997) argued that acceptable interpretations are those where both *wh*-phrases are assigned the same scope, making (7a) and (7d) acceptable, but not (7b) and (7c). Kurata (1991) further differentiated between (7b) and (7c), finding (7c) acceptable but not (7b). Conversely, Ishihara (2003) suggested that all scope interpretations can be considered viable given an appropriate context.

Adopting Ishihara's perspective that all potential scope combinations are plausible, this study aims to explore the correlation between each scope interpretation and its prosodic realization in SKK.

2.2. Prosodic Properties

In this section, we turn our attention to the prosodic properties of SKK.

2.2.1. Prosodic Phrasing

The prosodic categories of a commonly posited prosodic hierarchy are shown in Figure 3.

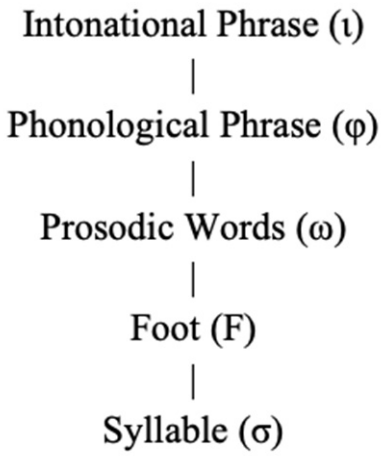


Figure 3. Prosodic hierarchy.

In some studies on prosodic categories, including from Pierrehumbert and Beckman (1988), a Phonological Phrase is further divided into two sub-levels: Major Phrase/ Intermediate Phrase (a higher level) and Minor Phrase (a lower level).

According to Jun (1993), the Korean prosodic structure is hierarchically organized, as shown in Figure 4. An Intonational Phrase can contain more than one Accentual Phrase, which corresponds to the Phonological Phrase in Figure 3, and an Accentual Phrase contains one or more phonological words.

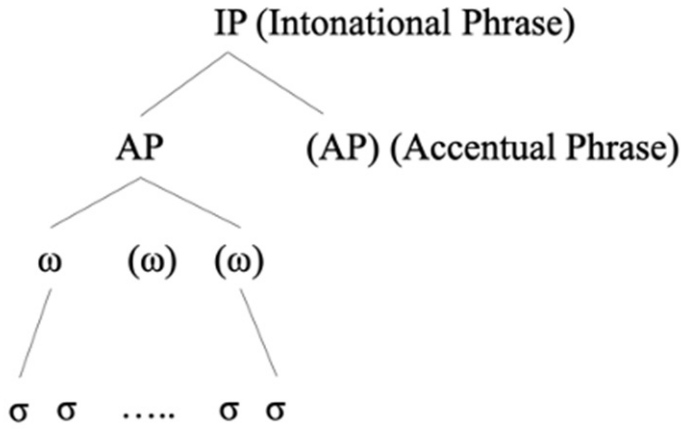


Figure 4. Prosodic hierarchy.

With regard to South Kyeongsang Korean, there is little research investigating its prosodic constituents. To the best of my knowledge, there is only one study for South Kyeongsang Korean (SKK) (Kim and Jun 2009). Kim and Jun (2009) separated a Phonological Phrase into two levels by additionally positing an Intermediate Phrase above an Accentual Phrase, following the hierarchical structure proposed by Pierrehumbert and Beckman (1988).[2] However, recent studies on this matter, i.e., Ito and Mester (2007, 2009) and Selkirk (2009), have also argued that just one category of phonological phrase should be posited because the further distinction of the Phonological Phrases (Intermediate Phrase/Major Phrase and Minor Phrase) is a syntagmatic notion; the distinction of Minor and Major phrases are not categorical but relational such as minimal and maximal projections in tree structures. Following this, this paper assumes that only one Phonological Phrase is posited in South Kyeongsang Korean.

Phonetics and phonology studies on Korean *wh*-questions, including Cho (1990) and Jun and Oh (1996), have reported that *wh*-phrases introduce changes in phonological phrasing in the sentence. For example, a *wh*-phrase creates a single prosodic unit with the following unaccented words. The prosodic unit relevant to *wh*-scope in SKK is the Phonological Phrase, which corresponds to Minor Phrase in Richards (2000, 2010, 2016) and Major Phrase in Hwang (2011b).

2.2.2. *Wh*-Intonation: Pitch Compression and High Plateau

According to Hwang (2011a), *wh*-intonation is phonetically realized as either F0 pitch compression or high plateau in SKK. It is argued that this phonetic variation comes from the alternating accent patterns of the *wh*-phrases.

(8) *Minho-nun* *[Yumi-ka* *nwukwu-lul* *mannass-nunci]* *kwungkumhayha-no?*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-WHQ
'For which x, x a person, does Minho wonder whether Yumi met x?'

The *wh*-phrase *nwuku-lul* in (8) bears alternating accent patterns LH(H) ~ HH(L). On the one hand, when the *wh*-phrase is produced with a rising tone (LHH), a high plateau is formed, as shown in Figure 5. On the other hand, when the *wh*-phrase is produced with a falling tone (HHL), a pitch compression is formed, as shown in Figure 6. In addition, Hwang shows that both patterns can be used even in the same situation by a single speaker. Considering that either a pitch compression or a high plateau truly relies on the alternative accent patterns of a *wh*-phrase, this study focuses on the spans of a high plateau or a pitch compression in multiple *wh*-phrases, not the specific accent patterns (either a high plateau or a pitch compression).

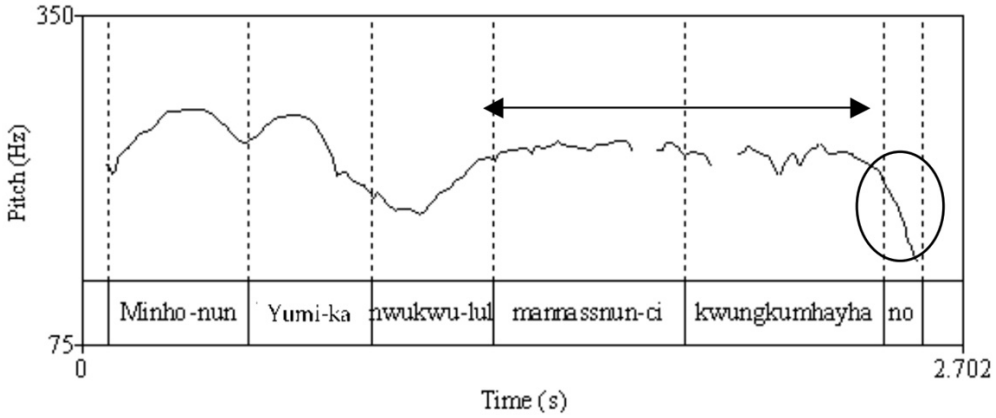


Figure 5. *Wh*-intonation: high plateau (Hwang 2011a).

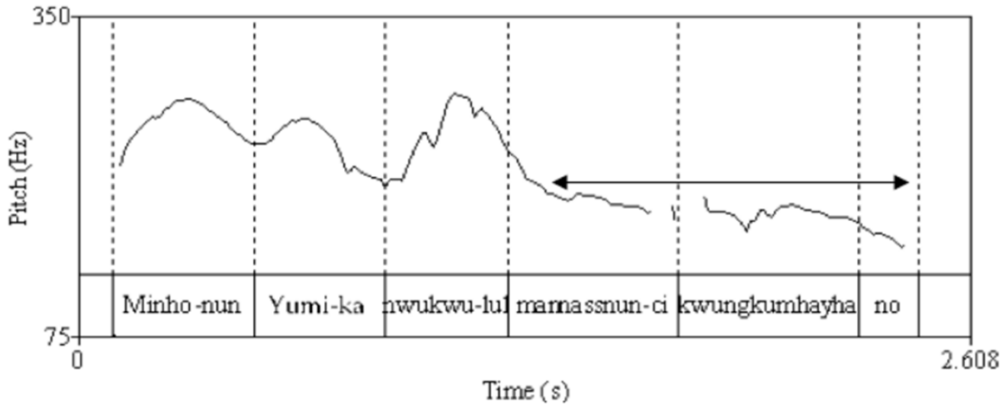


Figure 6. *Wh*-intonation: pitch compression (Hwang 2011a).

3. Models and Their Predictions

The syntax/semantics and prosody interface phenomenon on *wh*-scope has been analyzed by many different models, including the E-feature agreement system (Deguchi and Kitagawa 2002; Kitagawa 2005), Chomsky's Multiple Spell-Out model (Ishihara 2007), Contiguity Theory (Richards 2010), and the Wrap-XP Model (Smith 2011). However, most of the models in previous studies were developed based on single *wh*-questions. Hence, this section explores the main ideas of these models and their predictions on the prosodic formation of multiple *wh*-questions.

The examination of model predictions encompasses six specified conditions that relate to the potential associations between *wh*-phrases and complementizers, as outlined in example (9).

(9) Two types of multiple *wh*-questions

Both *wh*-phrases in the embedded clause:

a. [… [WH1 WH2 …V-Q] V-Q?

Possible scope combinations:

i. Embedded embedded
ii. Embedded Matrix
iii. Matrix embedded
iv. Matrix Matrix

b. One in the matrix clause, the other in the embedded clause:

[WH1 [… WH2 …V-Q] V-Q?

Possible scope combinations:

i. Matrix embedded
ii. Matrix Matrix

Note that the models were developed based on Tokyo Japanese and Fukuoka Japanese. Depending on the language used in the model, the relevant prosodic constituents to *wh*-intonations were different with either Major phrases or Minor phrases. The further distinction of phonological phrases relevant to the *wh*-intonation in SKK has not yet been discussed. Due to the lack of research on prosodic phrasing in SKK, Hwang (2011a, 2011b) also simply followed the phrasing structures shown in North Kyeongsang Korean. Since the discussion on the details of prosodic phrasing is out of the scope of this research, I will use "Phonological phrase" in the remainder of this paper. As such, the terms Minor phrase and Major phrase in each model are replaced with Phonological phrases in the prediction and the analysis.

3.1. The E-Feature Agreement System

Deguchi and Kitagawa (2002) introduced a syntactic analysis based on the operation Agreement (Chomsky 1998; Chomsky 2001) in order to explain the correlation between *wh*-scope and prosody. They proposed the following Emphatic features and assumed that those features undergo Agreement.

(10) E(mphatic)-features
- a. Uninterpretable E-feature: optionally assigned to INFL (or to T).
- b. Interpretable E-feature: on *wh*-phrases.

According to Deguchi and Kitagawa, the uninterpretable E-feature on INFL acts as a probe, and the interpretable E-feature on a *wh*-phrase acts as a goal.[3] These two features undergo agreement, which is called "E-agreement". The example (11) illustrates how prosody and *wh*-scope correlations are established in this model. At LF, the E-feature on INFL induces covert movement of a *wh*-phrase to get the correct scope interpretation, as shown in (11a). However, at PF, as shown in (11b), a pair of E-features undergoing agreement is linearly scanned and comes to be phonetically implemented as *wh*-intonation. The emphatic accent falls on a *wh*-phrase carrying the goal, and pitch-eradication follows it and continues to an INFL containing the probe.

(11) *Minho-nun [Yumi-ka nwukwu-lul mannass-nunci] kwungkumhayha-no?*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-WHQ
'For x, x a person, Minho wonders whether Yumi met x'.

a. E-agreement

LF: [CP [IEP who-ACC (E) [IE M-TOP Y-NOM who-ACC (E) met-Q wonder-WHQ ~~(E)~~]]]

Covert Movements

b. PF: [CP [IEP who-ACC (E) [IE M-TOP Y-NOM who-ACC (E) met-Q wonder-WHQ ~~(E)~~]]]

Emphatic Domain (EPD)

They argued that even in multiple *wh*-questions, there is just one extended emphatic domain, as shown in (12). They also show that when only the second *wh*-phrase is emphasized with an accent (12b), the sentence becomes uninterpretable. According to them, this occurs because, although the emphatic domain is formed at PF through the E-feature agreement, the presence of identical *wh*-features in both *wh*-phrases leads to intervention effects (*wh*-island effect) at the LF. Specifically, the non-emphasized 'who' phrase obstructs the LF movement of the emphasized 'what' phrase. Moreover, given the constraints of the E-feature system where only a single *wh*-phrase may be marked with an emphatic feature, it becomes impossible to produce the correct prosodic forms (i.e., emphatic accents on both *wh*-phrases in (12d)). To address this issue, they have adopted the "*wh*-cluster hypothesis", as proposed by Saito (1994). According to this hypothesis, the second *wh*-phrase moves up to merge with the preceding *wh*-phrase, creating a cluster. This entire *wh*-cluster then undergoes movement at LF.

(12) a. [IEP you-TOP [**who**$_1$-NOM what$_2$-ACC bought-Q] remember-WHQ$_1$]

'For x, x a person, you remember x bought what'.

b. # [IEP you-TOP [who$_1$-NOM **what$_2$**-ACC bought-Q] remember-WHQ$_2$]

*

'For y, y a thing, you remember who bought x'.

c. [IEP you-TOP [**who$_1$**-NOM **what$_2$**-ACC bought-Q] remember-WHQ$_{12}$]

'For x, y, x a person, y a thing, you remember x bought y'.

Following this idea, we can predict the prosodic formation in Table 2. The scope relation is marked with numbers on *wh*-phrases and complementizers. Under the E-feature agreement framework, when the anticipated prosodic pattern leads to unacceptable interpretations, such instances are denoted with "#".

Table 2. Prosodic phrasing of multiple *wh*-sentences predicted by the E-agreement system.

Prosodic Phrasing	Position of *wh*		*Wh*-Scope	
	WH1	WH2	WH1	WH2
a. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{YN}$Q? ( )( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb *	Emb
b. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$? #( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb	Mat **
c. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Emb
d. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$? ( )( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Mat
e. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Emb
f. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ NP $_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$? ?( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Mat

* Emb—Embedded, ** Mat—Matrix.

Except for the conditions (a), (b), and (d) in Table 1, it is expected that a Phonological Phrase starts at the first *wh*-phrase and continues to the associated complementizer. The second *wh*-phrase is encompassed in the Phonological Phrase initiated by the first *wh*-phase, so its pitch will be deleted. Particularly, in (f), since two *wh*-phrases are not adjacent, even if both *wh*-phrases initially receive the emphatic accents, the following focus reduction process will delete the pitch of the second *wh*-phrase. Regarding (b) in Table 1, as shown in (6b), the first *wh*-phrase lacks an emphatic accent and does not constitute a single Phonological Phrase by itself.

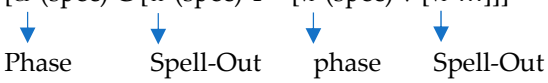
3.2. The Multiple Spell-Out Model

Ishihara (2003, 2004, 2005, 2007) applied Chomsky's (2001) and Fox and Pesetsky's (2005) Multiple Spell-Out Model to a cyclic derivation of prosody for proper *wh*-scope marking. The details regarding phase and multiple spell-out systems are as follows.

(13) Phase and Multiple Spell-Out (Chomsky 2001)

a. Phases: CPs and vPs.

b. Spell-Out domain: TP/VP.
When a syntactic derivation reaches a phase (CP/vP) in the syntax, the complement of the phase head (TP/VP) is transferred to the interface levels. The phonological part of the transfer is called Spell-Out.



(14) Phase and Multiple Spell-Out (Fox and Pesetsky 2005)

a. Phases: CPs and vPs.

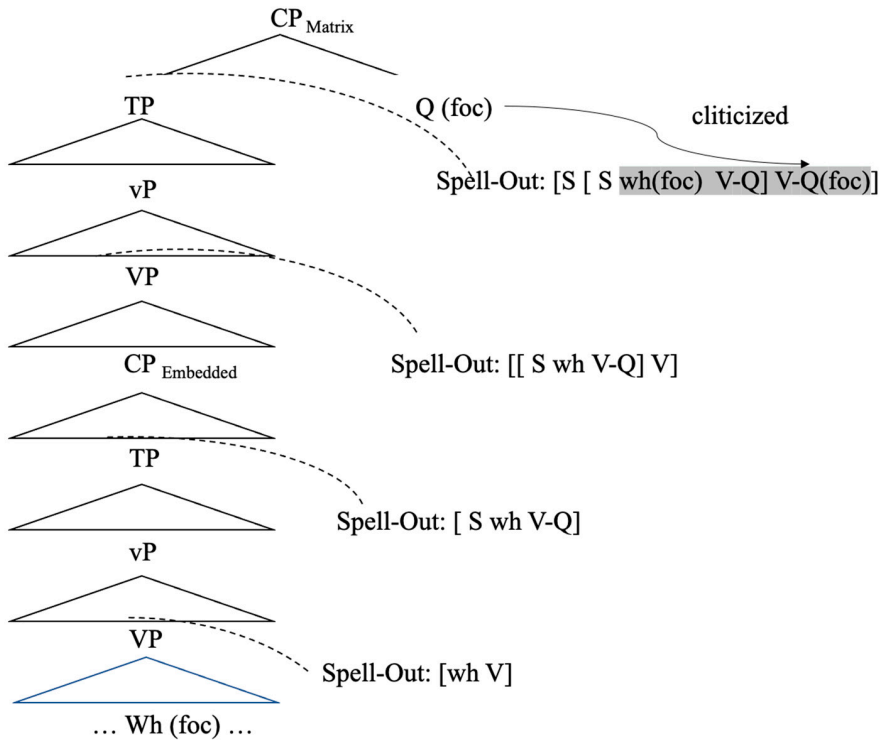
b. Spell-Out domain: CPs and vPs.
When a syntactic derivation reaches a phase (CP/vP) in the syntax, the complement of the phase head (TP/VP) is transferred to the interface levels. The phonological part of the transfer is called Spell-Out.

As seen in (13) and (14), Chomsky (2001) and Fox and Pesetsky (2005) identified the Spell-Out domain differently. While Ishihara (2007) follows the basic concepts of Fox and Pesetsky (2005), he additionally assumed that phrases that are adjoined to a phase, such as adjuncts and A'-moved material, are excluded from the spell-out domain.

Ishihara also assumed that focus features participate in an agreement process; however, this agreement involves items containing focus features, specifically one associated with a *wh*-phrase and another with a question particle (Q). According to Ishihara (2007), after the agreement between two focus features takes place, the complement of the phase head (TP) is transferred to the interface level. Then, at PF, it creates a prosodic domain; a focus feature on a *wh*-phrase initiates the generation of *wh*-intonation from a *wh*-phrase to the right edge of a spell-out domain. Since a C head is not included in the Spell-Out domain (TP), he suggests that the C head is phonologically cliticized to the preceding phrase in order to contain C in the *wh*-intonation domain.

According to Ishihara, when a prosodic domain is created, all phonological materials at the interface level are included, even for the materials that were transferred at earlier spell-out cycles. This means that the prosodic domain incrementally gets bigger and bigger as spell-out takes place cyclically, as illustrated in (15).

(15)



At each spell-out domain, *wh*-intonation is created by the phonological rules in (16).

(16) a. P-focalization rule:
If α_{FOC} bears FOCUS, add x's to α_{FOC} at a metrical line until a new line is formed.
b. Post-FOCUS Reduction (PFR) Rule:
If α_{FOC} bears FOCUS and precedes β, and α_{FOC}'s peak (after P-focalization) is at Line n, then delete an x of β on Line n-1.

(Ishihara 2003)

Unlike the E-agreement system, the Multiple Spell-Out Model assumes that phonological *wh*-scope marking is an outcome of a phase-by-phase syntactic derivation, not a result of the direct phonology-syntax/semantics interaction.

In Ishihara's Multiple Spell-Out system, *wh*-intonation is created within the Spell-Out domain containing both a *wh*-phrase and an associated complementizer. When a prosodic domain is created, all phonological materials at the interface level are included, even the materials that are transferred at earlier spell-out cycles. For multiple *wh*-questions, if the first *wh*-phrase has a wider scope than the second *wh*-phrase as shown in (c) and (e) in Table 3, both *wh*-phrases will be phased together in one single prosodic domain. After the agreement between the second *wh*-phrase and the embedded complementizer happens first, the *wh*-intonation between them will be created at the embedded CP spell-out domain. Then, after the agreement between the first *wh*-phrase and the matrix complementizer takes place, the *wh*-intonation from the first *wh*-phrase to the matrix complementizer will be created, as boosting the focalized *wh*-phrase first and then reducing all the elements up until the end of the matrix complementizer. As a consequence, the pitch accent on the second *wh*-phrase will be deleted. In South Kyeongsang Korean, the pitch accent deletion will result in either a high plateau or a pitch compression.

Table 3. Prosodic phrasing of multiple *wh*-sentences predicted by the Multiple Spell-Out system.

Prosodic Phrasing	Position of *wh*		*Wh*-Scope	
	WH1	WH2	WH1	WH2
a. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{YN}$Q? i.( )( ) ii.( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb *	Emb
b. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$? ( )( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb	Mat **
c. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Emb
d. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$? i.( )( ) ii.( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Mat
e. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Emb
f. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ NP $_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$? i.( )( ) ii.( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Mat

* Emb—Embedded, ** Mat—Matrix.

For the cases where both *wh*-phrases have the same scope as shown in (a), (d), and (f) in Table 3, after the agreements between two *wh*-phrases and their associated complementizer happen, both *wh*-phrases go to the same spell-out domain. In the spell-out domain, both *wh*-phrases are boosted at first, and then the pitch accents of all the following elements are reduced up until the end of the complementizer. As long as there is no additional rule that forces preservation of the boosted pitch accents of *wh*-phrases, the pitch accent of the second *wh*-phrase should be reduced as shown in (ii) in (a), (d), and (f) because it falls into the pitch accent reduction domain. However, Ishihara's (2003) experimental data shows the prosodic phrasing in (i), and he assumed that the pitch reduction happened only after the second *wh*-phrase. As for (b) in Table 3 where the first *wh*-phrase has narrower scope than the second *wh*-phrase, the first *wh*-phrase will be phased by itself because the first *wh*-phrase is outside of the domain for the *wh*-intonation of the second *wh*-phrase, so the boosted pitch on the first *wh*-phrase will be preserved. Even though he mentioned that the interpretation (b) is available in a certain context, as shown in (17), he did not include this scope relation in his experiments by simply following the claims that (b) is an illegitimate reading (Kurata 1991, Saito 1994, Shimoyama 2001).

(17) a. Naoya: [*dáre-ga* *bíiru-o* *nónda ka*] *obóeteru?*
who-NOM beer-ACC drank Q remember
'Do you remember who drank beer?'

b: Mari: [*dáre-ga* *BÍIRU-o* *nónda ka*] -wa *obóete-nai.*
who-NOM beer-ACC drank Q—TOP remember-NEG
'I don't remember who drank BEER'.

c. Naoya: [*dáre-ga* *NÁNI-o* *nónda ka*]-wa *obóeteru* ***no****?*
who-NOM what-ACC drank Q- TOP remember
'What$_i$ do you remember who drank t$_i$?'

d: Mari: [*dáre-ga* *WÁIN-o* *nónda ka*] -wa *obóeteru yo.*
who-NOM wine-ACC drank Q—TOP remember
'I remember who drank WINE.'

To ascertain the prosodic patterns for the scope relationship, where WH1 is embedded within WH2 in the matrix, an experimental investigation is necessitated.

3.3. The Contiguity Theory

Regarding the correlation between prosody and *wh*-scope, Richards (2006, 2010) has an opposite view of the E-agreement system and the Multiple Spell-Out Model. Contrary to the E-agreement system and the Multiple Spell-Out Model, which propose that a certain syntactic operation on relevant features may affect its phonological realization, Richards suggested that syntactic operations such as *wh*-movement or *wh*-in situ happen when prosody requires them.[4] He proposed a universal condition on *wh*-prosody that accounts for the motivation for *wh*-movement: when a *wh*-phrase in situ cannot form a proper prosodic domain for *wh*-scope in the following fashion (18) and (19), *wh*-movement takes place in order to create the proper prosodic domain.

(18) Universal condition on *wh*-prosody (Richards 2006, 2010):
Given a *wh* phrase α and a complementizer C where α takes scope, α and C must be separated by as few minor phrase boundaries as possible for some level of minor phrasing.

(19) Algorithm for *wh*-domains:
a. For one end of the larger Minor Phrase, use a Minor Phrase boundary that was introduced by a *wh*-phrase.
b. For the other end of the larger Minor Phrase, use any existing Minor Phrase boundary.

Two important factors for constructing the prosodic domain are the position of the complementizer and the placement of Minor Phrase boundaries (i.e., the prominence of either the Left or Right boundary). In Korean, a left edge is more prominent (Jun 1998), and a complementizer appears at the sentential-final position. According to the Contiguity Theory regarding a *wh*-question, the procedure to form the prosodic domain for matrix *wh*-scope in (20), hence, is like (21).

(20)

Yengwu-nun	[*Mila nwuna-ka*	*mwusun kok-ul*	*yencwuhayss-nunci*]	*mwuless-no?*
Yengwu-TOP	Mila sister-NOM	which song-ACC	played-Q	asked-WHQ

'For which x, x a song, Yengwu asked whether Mila played x'

(21)

	NP	[$_{\text{Embedded}}$NP	wh	Verb-C(Q)]	Verb-C(WHQ)
a.	( )	( )	( )		( )
b.	( )	( )	(		)

Following the algorithm in (19), a larger Minor Phrase containing the *wh*-phrase and the associated complementizer (a matrix Q) is created by keeping the Minor Phrase boundary associated with the Left edge (prominent edge) of the *wh*-phrase, skipping the immediately following one, and using the Minor Phrase boundary associated with the right edge of the complementizer (a matrix Q) as shown in (21b). Likewise, since the proper prosodic domain for *wh*-scope can be created successfully, Koreans can leave *wh*-phrases in situ. In other words, in Richards' view, the *wh*-intonation in Korean is the result of a universal condition on *wh*-prosody, not because of the effect of the syntactic operation.

Hence, under the algorithm of Richards' Contiguity Theory, the left edge of each *wh*-phrase and the right edge of its associated complementizer is used for creating a large Phonological phrase. This large Phonological phrase is referring to the domain of a high plateau or a pitch compression. When a large Phonological phrase, including a *wh*-phrase and its associated complementizer, cannot be formed, such as in English, *wh*-movement takes place in order to create the proper prosodic domain. As a result, in multiple *wh*-questions the first *wh*-phrase will not be in the same prosodic domain with its associated complementizer because the second *wh*-phrase in the stimuli always appears before complementizers and the new prosodic domain starts at the second *wh*-phrase as shown in Table 4. In the Contiguity Theory, it is illicit for a *wh*-phrase and its associated complementizer to be phased separately.

Table 4. Prosodic phrasing of multiple *wh*-sentences predicted by the Contiguity Theory.

Prosodic Phrasing	Position of *wh*		*Wh*-Scope	
	WH1	WH2	WH1	WH2
a. NP_{-NOM} [$_{Emb}$ WH_{1-NOM} WH_{2-ACC} V-Q_{12}] V-$_{YN}$Q? *( )( )	S_{-Emb}	O_{-Emb}	Emb *	Emb
b. NP_{-NOM} [$_{Emb}$ WH_{1-NOM} WH_{2-ACC} V-Q_1] V-$_{WH}Q_2$? *( )( )	S_{-Emb}	O_{-Emb}	Emb	Mat **
c. NP_{-NOM} [$_{Emb}$ WH_{1-NOM} WH_{2-ACC} V-Q_2] V-$_{WH}Q_1$? *( )( )	S_{-Emb}	O_{-Emb}	Mat	Emb
d. NP_{-NOM} [$_{Emb}$ WH_{1-NOM} WH_{2-ACC} V-Q] V-$_{WH}Q_{12}$? *( )( )	S_{-Emb}	O_{-Emb}	Mat	Mat
e. WH_{1-NOM} [$_{Emb}$ NP_{-NOM} WH_{2-ACC} V-Q_2] V-$_{WH}Q_1$? *( )( )	S_{-Mat}	O_{-Emb}	Mat	Emb
f. WH_{1-NOM} [$_{Emb}$ NP_{-NOM} WH_{2-ACC} V-Q_{12}] V-$_{WH}Q_{12}$? *( )( )	S_{-Mat}	O_{-Emb}	Mat	Mat

* Emb—Embedded, ** Mat—Matrix.

In order to resolve this problem, the first *wh*-phrase is supposed to move next to its associated complementizer to make them be in one prosodic domain together as a last resort. This syntactic movement, however, does not happen in Korean. In other words, Richards' Contiguity Theory cannot be applied to the prosodic domain formation for multiple *wh*-questions in Korean.

3.4. The Wrap-XP Model

Smith (2011) proposed an alternative model based on Optimality Theory (Prince and Smolensky 2002). To account for the *wh*-intonation, Smith introduced three constraints related to the phonological phrasing for *wh*-scope. They are shown in (22).

(22) Constraints on the *wh*-intonation:

a.	Wrap-C	Every $C_{[+wh]}$ must be in the same phrase as some associated *wh* element.
b.	Wrap-WH	Every *wh* element must be in the same phrase as some associated $C_{[+wh]}$.
c.	Align-L(wh, MiP)	The left edge of every *wh* element is aligned with the left edge of some MiP.

(23) The ranking of constraints:
Wrap-C >> Align-L (wh, MiP) >> Wrap-WH

The ranking in (23) is derived from multiple *wh*-questions as well as single *wh*-questions. First, let us take a look at the example of a single *wh*-question (2), repeated in (24).

(24) *Minho-nun* *[Yumi-ka* *nwukwu-lul* *mannass-nunci]* *kwungkumhayha-no?*
Minho-TOP Yumi-NOM who-ACC met-Q wonder-WHQ
'For which x, x a person, does Minho wonder whether Yumi met x'

(25)

Input: … [… **WH1** … C(Q)] …**C(Q1)**	Wrap-C	Align-L (wh, MiP)	Wrap-WH
a. ( ) ( )	*!		*
☞ b. ( )			

The ranking (Wrap-C >> Align-L (wh, MiP) >> Wrap-WH) rules out the candidate (25a), which cannot create a single prosodic domain including a *wh*-phrase (WH1) and an associated complementizer (Q1).

When this ranking is applied to the sentence including multiple *wh*-phrases, as shown in (26), the prosodic domain, which starts from the first *wh*-phrase and ends at the end of the sentence, is predicted to be the winner.

(26) *enu nwuna-ka* [*Mila nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*] *mwuless-no?*
which sister-NOM Mila-NOM **which song**-ACC played-Q asked-WHQ
'For which sister, x a sister, x asked which song Mila played.'

(27)

Input: **WH1**…[…**WH2**…**C(Q2)**]…**C(Q1)**	Wrap-C	Align-L (wh, MiP)	Wrap-WH
a. ( )( )( )	*!		*
b. ( )( )	*!	*	*
c. ( )( )	*!		*
☞ d. ( )		*	

The constraint ranking *Wrap-C* >> *Align-L (wh, MiP (henceforth, PoP))* >> *Wrap-WH* from Smith's (2011) Wrap-XP Model predicts the following.

As seen in Table 5, since *Wrap-C* is the highest ranked, when both *wh*-phrases have different semantic scopes, the prosodic domain is predicted to start at the first *wh*-phrase and end at the matrix complementizer. When both *wh*-phrases have the same semantic scope, as the associated complementizer is phased with the second *wh*-phrase, the *Wrap-C* constraint is not violated. Thus, the separate phrasing of the first *wh*-phrase is predicted as an outcome because one single Phonological phrase from the first *wh*-phrase to the associated complementizer violates the second-ranked constraint *Align-L (wh, PoP).*

Table 5. Prosodic phrasing of multiple *wh*-sentences predicted by the Wrap-XP Model.

Prosodic Phrasing	Position of *wh* WH1	Position of *wh* WH2	*Wh*-Scope WH1	*Wh*-Scope WH2
a. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{YN}$Q? ( )( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb *	Emb
b. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$? ( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb	Mat **
c. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Emb
d. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$? ( )( )	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Mat
e. $WH_{1\text{-NOM}}$ [$_{Emb}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$? ( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Emb
f. $WH_{1\text{-NOM}}$ [$_{Emb}$ NP $_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{WH}Q_{12}$? ( )( )	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Mat

* Emb—Embedded, ** Mat—Matrix.

In sum, the models' predictions on the prosodic domain of multiple *wh*-questions differ according to two key factors: the treatment of each *wh*-phrase's prominence, leading to its segmentation into a distinct prosodic domain, and the onset and offset of the pitch reduction process, which is associated with the size of the pitch reduction domain. The application of these factors is influenced by each model's theoretical perspectives, such as whether syntax precedes phonology, phonology precedes syntax, or both are considered simultaneously. Consequently, these factors lead to two potential prosodic structures for each scope relation among multiple *wh*-phrases, as detailed in Table 6. The predictions from each theory or model are summarized in Table 6 (✓: prediction success, ✗: prediction failure). As shown in Table 6, the predictions of each theory or model vary. This calls for an experiment to investigate what is the phonetic realization of multiple *wh*-scope relationships.

Table 6. The summary of predictions by each model.

The Conditions for Multiple *wh*-Sentences	EA: E-Agreement MS: Multiple Spell-Out Model CT: Contiguity Theory WM: Wrap-XP Model			
	EA	**MS**	**CT**	**WM**
a. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{YN}$Q?				
i.( )( )	✓	✗	✗	✓
ii.( )	✗	✓	✗	✗
b. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$?				
i.( )( )	✗	✓	✗	✗
ii.( )	✗	✗	✗	✓
c. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?				
i.( )( )	✗	✗	✗	✗
ii.( )	✓	✓	✗	✓
d. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$?				
i.( )( )	✓	✗	✗	✓
ii.( )	✗	✓	✗	✗
e. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?				
i.( )( )	✗	✗	✗	✗
ii.( )	✓	✓	✗	✓
f. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$?				
i.( )( )	✗	✗	✗	✓
ii.( )	?	✓	✗	✗

✓: The model's prediction.

Most empirical data regarding prosody and *wh*-scope in Korean are restricted to less complex sentences that include only one *wh*-question, as shown in (2). As a result, it remains unknown what the phonological realization of the semantic scope of multiple *wh*-phrases is and whether the correlation between *wh*-intonation and *wh*-scope is maintained in the constructions of multiple *wh*-questions. Moreover, it is difficult to examine whether the suggested models succeed in accounting for the relationship of *wh*-scope and *wh*-intonation in Korean multiple *wh*-questions. In the later sections of this paper, I will describe an empirical investigation of *wh*-intonation in multiple *wh*-question constructions in Korean, which shows that none of the suggested models in the previous literature explains the data.

4. Experiment

4.1. Materials and Methods

In order to examine the domain of *wh*-intonation when a sentence includes multiple *wh*-phrases, the stimuli in this experiment consisted of three different types of sentences: baseline sentences without *wh*-items, single *wh*-sentences, and multiple *wh*-sentences.

In the stimuli of single *wh*-sentences, two different positions of *wh*-phrases in an embedded clause were included, as shown in (28).

(28)	The conditions for **single *wh*-**sentences	position of *wh*	*wh*-scope
	a. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ *WH*-$_{\text{NOM}}$ $NP_{\text{-ACC}}$ V-Q] V-$_{YN}$Q?	S	Emb
	b. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ *WH*-$_{\text{NOM}}$ $NP_{\text{-ACC}}$ V-Q] V-$_{WH}$Q?	S	Mat
	c. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ *WH*-$_{\text{ACC}}$ V-Q] V-$_{YN}$Q?	O	Emb
	d. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ *WH*-$_{\text{ACC}}$ V-Q] V-$_{WH}$Q?	O	Mat

In (28a) and (28b), *wh*-phrases are in the subject position in the embedded clause, and the *wh*-phrase in (22a) has embedded scope, but the one in (28b) has matrix scope. In (28c) and (28d), *wh*-phrases are in the object position in the embedded clause, and their semantic scope is embedded clause in (22c) but the matrix clause in (22d). In order to lead to the

intended *wh*-scope interpretation, the distinct question complementizers *-na* (YNQ) or *-no* (WHQ) were used; *-na* (YNQ) indicates the embedded scope of *wh*-phrases and *-no* (WHQ) indicates the matrix scope of *wh*-phrases.[5] Sixteen sentences (= 4 sets x 4 conditions) were created. They are in Appendix A.

To investigate the prosodic domain of multiple *wh*-questions, sentences were constructed with two *wh*-phrases, adhering to the two different types of multiple *wh*-questions outlined in (29). For instance, *wh*-phrases were located either in the same clause (both in the embedded clause) or in the different clauses (one in the matrix clause and the other in the embedded clause). The specific conditions for multiple *wh*-questions are as follows.

(29) The conditions for **multiple *wh*-sentences**

	Position of *wh*		*wh*-scope	
	WH1	WH2	WH1	WH2
a. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-$Q_{1,2}$] V-$_{YN}Q$?	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb	Emb
b. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$?	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Emb	Mat
c. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Emb
d. $NP_{\text{-NOM}}$ [$_{\text{Emb}}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{1,2}$?	$S_{\text{-Emb}}$	$O_{\text{-Emb}}$	Mat	Mat
e. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Emb
f. $WH_{1\text{-NOM}}$ [$_{\text{Emb}}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{1,2}$?	$S_{\text{-Mat}}$	$O_{\text{-Emb}}$	Mat	Mat

Similar to single *wh*-questions, the positions of *wh*-phrases and the scope of *wh*-phrases were controlled in the stimuli of multiple *wh*-questions. In (23a–d), both *wh*-phrases are located in the same clause. Each *wh*-phrase can have either embedded or matrix scope, so the four different scope relations between the two *wh*-phrases (2 × 2) were tested. In (23e–f), two *wh*-phrases are in the different clauses. The first *wh*-phrase is in the subject position in the matrix clause, and the second *wh*-phrase is in the object position in an embedded clause. In Korean, *wh*-phrases cannot be associated with a lower-level clause complementizer, so the first *wh*-phrase can have matrix scope only. On the other hand, the second *wh*-phrase can take either an embedded or matrix scope. Consequently, the study tested the two distinct scope relations (1×2) between the *wh*-phrases. Although this creates unequal stimulus conditions across two types of *wh*-phrases, including both variations in the positions of *wh*-phrases allows us to investigate the presence of consistent prosodic patterns across them. All the associations between *wh*-phrases and complementizers (Q) are marked with numbers in (29). Four different sets were tested, varying the embedded verbs: *yencwuhata* 'play', *mekta* 'eat', *mantulta* 'make', and *masita* 'drink'. These embedded verbs were selected in consideration of segmental context; they start with sonorant consonants.

One set of stimuli where both *wh*-phrases are embedded is listed in (30). The remainders are in Appendix B.

(30) *Yengwu-nun* [*enu nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Yengwu-TOP **which sister**-NOM **which song**-ACC played-Q
mwuless-no? (*-na* for (a))
asked-WHQ (-YNQ)

a. *which sister* (embedded scope) = *which song* (embedded scope)
'Did Yengwu ask which sister played which song?'

b. *which sister* (embedded scope) < *which song* (matrix scope)
'For which y, y a song, Yengwu asked which sister played y?'

c. *which sister* (matrix scope) > *which song* (embedded scope)
'For which x, x a sister, Yengwu asked which song x played?'

d. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, Yengwu asked whether x played y?'

Enu nwuna-ka [*Mila nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Which sister-NOM Mila (sister)-NOM **which song**-ACC played-Q
yencwuhayss-nunci] *mwuless-no?*
played-Q asked-WHQ

e. *which sister* (matrix scope) > *which song* (embedded scope)
'Which sister asked which song Mila played?'

f. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, x asked whether Mila played y?'

In the stimuli, D-linked *wh*-phrases such as *enu nwuna* 'which sister' were used in order to reduce the lexical ambiguity between *wh*-indefinite and *wh*-interrogative. For each target interrogative sentence, the short context and the proper answer were provided to lead the specific scope interpretation. One example set of contexts is shown in Appendix C.

4.2. Participants and Procedure

Eight native speakers of South Kyeongsang Korean (five females and three males) participated in the recording. All participants were born and grew up in South Kyeongsang province (3: Ulsan, 2: Busan, 1: Changwon, and 2: Grew up in Ulsan and moved to Busan to attend colleges) and had no history of speech or hearing impairment. Participants were recruited on Korean social network websites (facebook.com, accessed on 12 March 2024) and through word of mouth.

The experiments were separated into three sessions: (i) non-*wh*, (ii) single-*wh*, and (iii) multiple *wh*s. For each session, I briefly explained the procedure for the recording to the speakers. Since the target sentences were provided with the contexts and answers in the written scripts, the participants were asked to read them silently first in order to get the intended scope interpretations. Participants were instructed to give natural renditions at a comfortable speed. For example, they were asked to read the sentences naturally as if they were talking to their family members or friends. Practice time was given in order to induce natural-sounding speech. While the recording was being made, when the participants misread the sentences or produced unnatural long pauses, they were asked to repeat the sentences.[6] When participants themselves wanted to re-record the sentences, those sentences were re-recorded. Note that it was a difficult task for participants because multiple *wh*-questions are not very frequently used in daily conversation. In order to alleviate the difficulty, particularly for multiple *wh*-questions, I provided additional information to make it clear what the intended interpretation was. For example, I verbally mentioned the expected answers. They were told that they were going to ask a question to get those answers. In order to encourage the participants to produce natural speech, I produced the answer parts to the target question sentences that the participants produced, as shown in (31).

(31) a. ***which sister* (embedded scope) = *which song* (embedded scope)**
nye.
'yes'

b. ***which sister* (embedded scope) < *which song* (matrix scope)**
Moccaluthu-yo.
Mozart-DEC.
'It was Mozart'

c. ***which sister* (matrix scope) > *which song* (embedded scope)**
'For which x, x a sister, Yengwu asked which song x played?'
Mila nwuna-ka-yo.
Mila sister-NOM-DEC
'It was Mila'.

d. ***which sister* (matrix scope) = *which song* (matrix scope)**
'For which x, y, x a sister, y a song, Yengwu asked whether x played y?'
Mila nwuna-ka Moccaluthu-lul yencwuhayss-nunci mwuless-eyo.[7]
Mila sister-NOM Mozart-ACC played-C asked- DEC.
'(He) asked whether Mila (sister) played Mozart'.

e. ***which sister* (matrix scope) > *which song* (embedded scope)**
'Which sister asked which song Mila played?'
Mila nwuna-ka-yo.
Mila sister-NOM-DEC
'It was Mila'.

f. ***which sister* (matrix scope)** = ***which song* (matrix scope)**
'For which x, y, x a sister, y a song, x asked whether Mila played y?'
Cia nwuna-ka Mila nwuna-ka Moccaluthu-lul yencwuhayss-nunci mwuless-eyo.[8]
Cia nwuna-ka Mila sister-NOM Mozart-ACC played-Q asked- DEC.
'Cia (sister) asked whether Mila (sister) played Mozart'.

In addition, while the two specific morphological markers *-na* (YNQ) or *-no* (WHQ) were used in the stimuli, if the participants indicated that other markers such as *-nuntey* (WHQ) were the most frequently used in their daily conversation, using them was allowed as a substitute for the given morphological markers in order to help participants produce the sentences easily. Dropping case markers such as the *-ul* accusative marker was also allowed.

Recording was conducted both in a lab and over Zoom. The recording of three participants was conducted in the phonetics lab in the Department of Linguistics at Stony Brook University. A portable Zoom H6 Handy recorder and a Shure SM 10A-CN microphone were used for the recordings. The remaining five participants were done over Zoom rather than in the lab due to COVID-19 safety concerns. The procedure of conducting the experiment via Zoom paralleled that of the in-lab setup, with participants instructed to be in a quiet room. The speech was recorded using both a separate recorder and the built-in recording function on Zoom as a backup measure. While the recording did capture sound through the speaker, incidental background noise, such as that from a computer's cooling fan, was also present. However, given that the focus of this study is on the overall pitch contour rather than segment-level analysis, these noises did not compromise the quality of the data. 16 target sentences for single *wh*-questions and 24 multiple *wh*-questions were recorded with fillers. The filler sentences vary in terms of length and 1–3 adverbial phrases were included in each sentence. Of the total 180 sentences per participant, 44 sentences (non-*wh*) were recorded in session 1, 36 sentences (single *wh*) were recorded in session 2, and 90 sentences (multiple *wh*s: one scope relation per sentence) were recorded in session 3. In each session, the sentences were pseudorandomized to ensure that the sentences with identical lexical elements or those implying similar scope relationships did not appear consecutively. The recording sessions for each speaker took approximately 40 to 60 min, including practice time and the breaks. All participants were paid USD 20 for their participation at the end of the recording session.

5. Results

5.1. Measurements

The data from eight participants were digitized at a 44.1 kHz sampling rate and 16-bit quantization. Analysis was carried out in Praat, version 6.0.33. For each utterance, syntactic phrase boundaries were labeled manually, as illustrated in Figure 7. The example shown in Figure 7 is a multiple *wh*-phrase question in which two *wh*-phrases appear in the embedded clause, and their scope relationship is WH1 > WH2 (WH1: matrix scope, WH2: embedded scope). While there are some microvariations in the pitch contour, the high flat pitch pattern (or the pitch compression) is observed from the end of the first *wh*-phrase to the syllable preceding the matrix clause complementizer. In this way, the pitch patterns of each sentence were examined by focusing on the prosodic domain of *wh*-intonation.

(32) *Yengwu-nun* [*enu nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Yengwu-TOP **which sister**-NOM **which song**-ACC played-C(Q)
mwuless-no?
asked-C(WHQ)
'For which x, x a sister, Yengwu asked which song x played?'

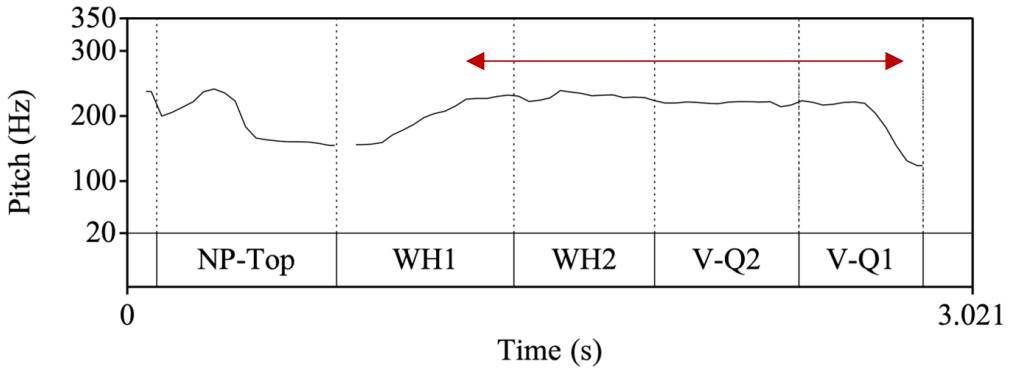


Figure 7. F0 contour of the multiple *wh*-question in (26).

Note that the prosodic patterns were largely consistent across both the sets and participants. Therefore, the pitch contours described in Section 5 illustrate the dominant patterns observed among participants based on a single set of stimuli. For details on variations in pitch patterns, please see Appendix D.

5.2. Phonetic Description of the Intonation of Non-Multiple wh-Questions

Before taking a look at the results of multiple *wh*-questions, let us briefly take a look at the results of baseline recording in non-*wh* question constructions and single *wh*-question constructions. Figure 8 shows the F0 contour of a complex sentence that has no *wh*-phrase.

(33) *Yengwu-nun* [Mila *nwuna-ka* *Moccaluthu-lul* *yencwuhayss-nunci*]
Yengwu-TOP Mila sister-NOM Mozart -ACC played-C(Q)
mwuless-na?
asked-C(YNQ)
'Did Yengwu ask whether Mila played Mozart?'

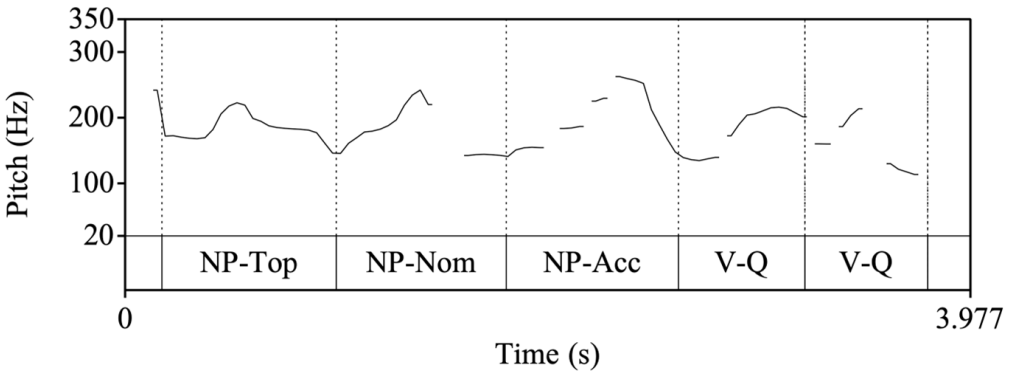


Figure 8. F0 contour of non *wh*-question in (27).

Figures 9 and 10 below present the F0 contour of the same construction as in (33), but with a *wh*-phrase in an object position within the embedded clause as in (34), corresponding to the embedded scope and the matrix scope, respectively.

(34) *Yengwu-nun* [Mila *nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Yengwu-TOP Mila sister-NOM **which song**-ACC played-C(Q)
mwuless-na?
asked-C(YNQ)/-C(WHQ)
a. 'Did Yengwu ask which song Mila played?'
b. 'For which y, y a song, Yengwu asked Mila played y?'

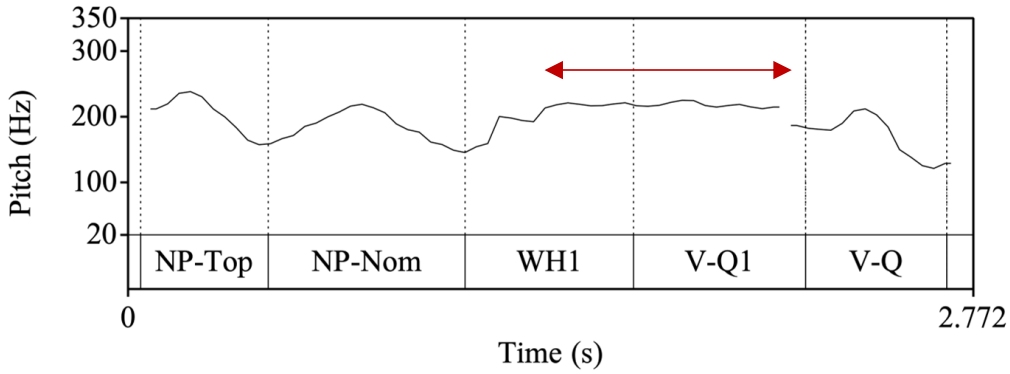


Figure 9. F0 contour of a single *wh*-question with embedded *wh* scope in (28a).

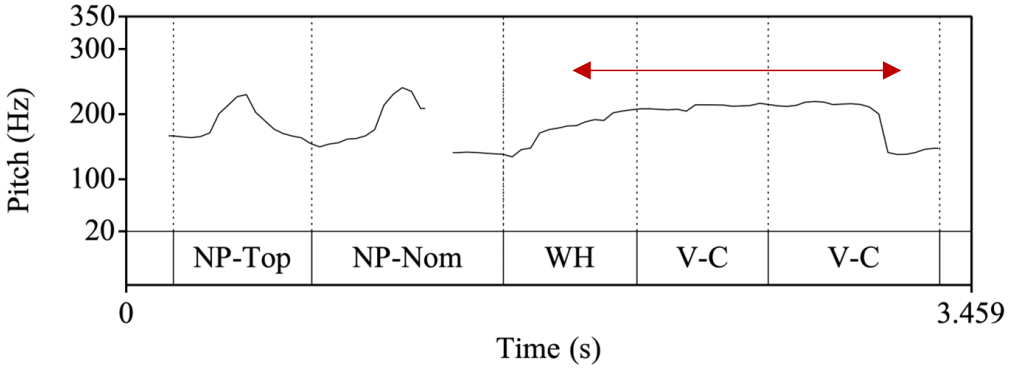


Figure 10. F0 contour of a single *wh*-question with matrix *wh*-scope in (28b).

Figures 11 and 12 below present the F0 contour of a construction with a *wh*-phrase in the subject position at the embedded clause, corresponding to the embedded scope and the matrix scope, respectively.

(35) *Yengwu-nun* [*enu nwuna-ka* *Moccaluthu-lul* *yencwuhayss-nunci*]
Yengwu-TOP **which sister**-NOM Mozart -ACC played-C(Q)
mwuless-na?
asked-C(YNQ)/-C(WHQ)
a. 'Did Yengwu ask which sister played Mozart?'
b. 'For which x, x a sister, Yengwu asked x played Mozart?'

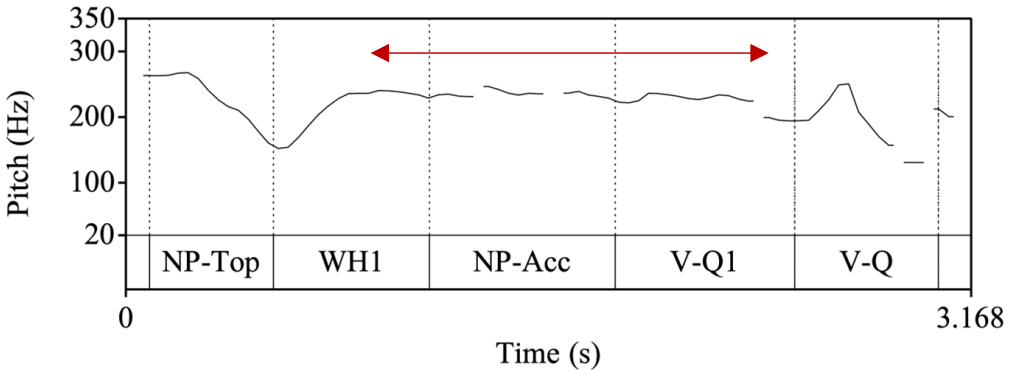


Figure 11. F0 contour of a single *wh*-question with embedded *wh*-scope in (29a).

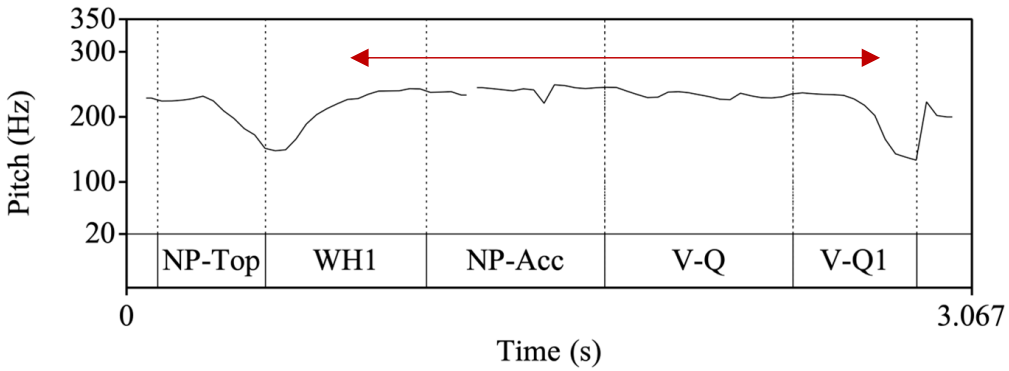


Figure 12. F0 contour of a single *wh*-question with matrix *wh* scope in (29b).

As shown in Figure 8, when there is no *wh*-phrase in a sentence (33), neither pitch compression nor high plateau are observed. As for single *wh*-questions in (34) and (35), a high plateau extends from the *wh*-phrase to the complementizer, contingent upon its scope. Regardless of the syntactic position of the *wh*-phrase—whether as a subject or an object—within the embedded clause, this acoustic feature remains consistent. For example, in the pitch contours depicted in Figures 9 and 11 for the embedded scope, a high plateau appears from the *wh*-phrase to the embedded complementizer. Conversely, in the contours for the matrix scope, as shown in Figures 10 and 12, the high plateau spans from the *wh*-phrase to the matrix complementizer. The pitch contour patterns shown in Figures 9–12 conform to Hwang's (2011b) observation of *wh*-intonation in South Kyeongsang Korean.

5.3. Phonetic Description of the Intonation of Multiple wh-Questions

In the analysis of multiple *wh*-questions, the data are categorized into two types depending on the positions of the *wh*-phrases: (i) both *wh*-phrases in the same clause (i.e., the embedded clause) or (ii) one *wh*-phrase in the matrix clause and the other in the embedded clause.

The pitch contours of the sentences, including two *wh*-phrases in the same clauses as in (30a–d), repeated in (36), are shown in Figures 13–16. Observe that the prosodic phrasing and the span of high-plateau *wh*-intonation vary depending on the scope relationship between the two *wh*-phrases.

(36) *Yengwu-nun* [*enu nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Yengwu-TOP **which sister**-NOM **which song**-ACC played-C(Q)
mwuless-no? (*-na* for (a))
asked-C(WHQ) (-C(YNQ))

a. *which sister* (embedded scope) = *which song* (embedded scope)
'Did Yengwu ask which sister played which song?'

b. *which sister* (embedded scope) < *which song* (matrix scope)
'For which y, y a song, Yengwu asked which sister played y'

c. *which sister* (matrix scope) > *which song* (embedded scope)
'For which x, x a sister, Yengwu asked which song x played'

d. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, Yengwu asked whether x played y'.

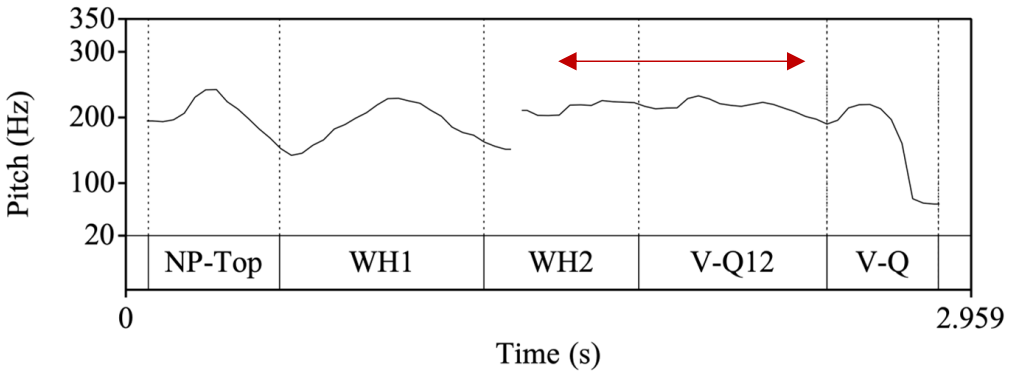


Figure 13. F0 contour of multiple *wh*-questions: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) = WH2 (embedded) in (36a)).

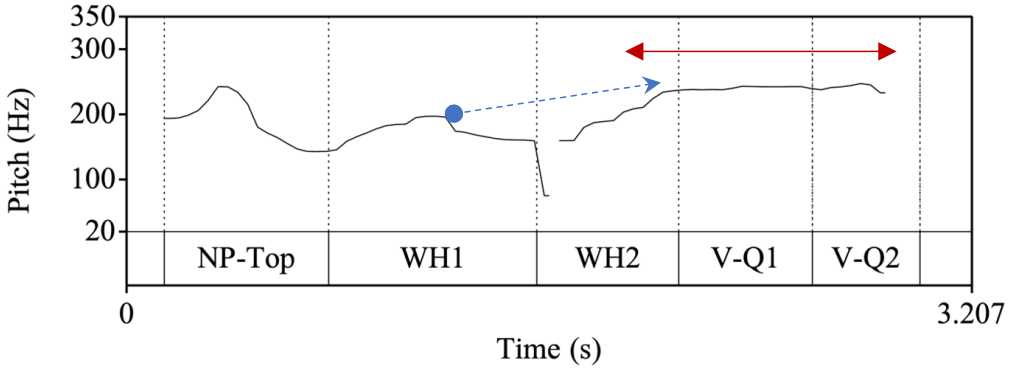


Figure 14. F0 contour of multiple *wh*-questions: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) < WH2 (matrix) in (36b)).

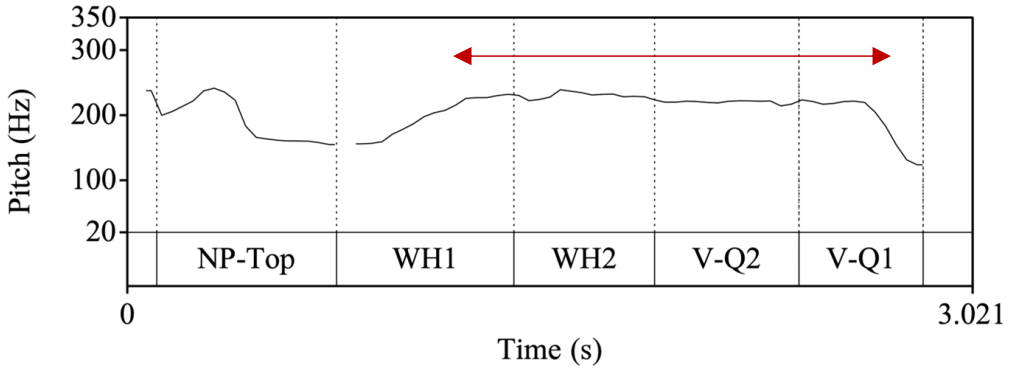


Figure 15. F0 contour of multiple *wh*-questions: two *wh*-phrases in the embedded clause (scope relationship: WH1(matrix) > WH2 (embedded) in (36c)).

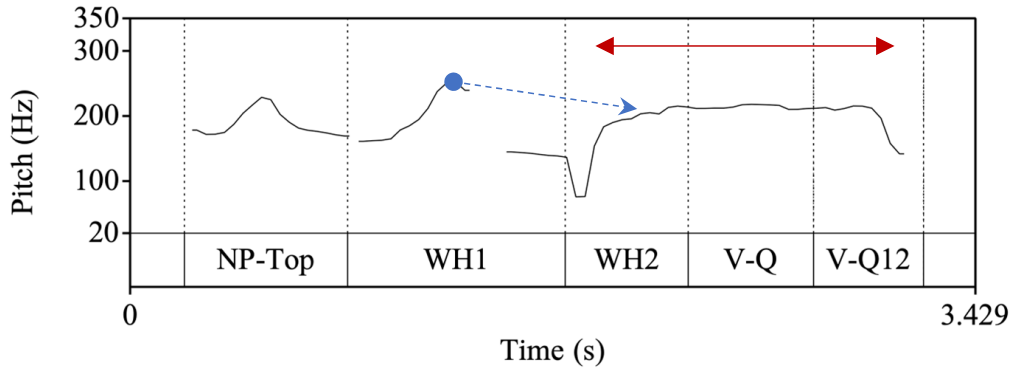


Figure 16. F0 contour of multiple *wh*-questions: two *wh*-phrases in the embedded clause (scope relationship: WH1(matrix) = WH2 (matrix)) in (36d)).

When both *wh*-phrases take the same scope, each *wh*-phrase lies in a different prosodic phrase. As schematically indicated in (37), a *wh*-specific Phonological phrase begins at each *wh*-phrase, and the Phonological phrase, including the second *wh*-phrase, ends at the complementizer that both *wh*-phrases are associated with: the embedded complementizer for (37a) corresponding to Figure 13 and the matrix complementizer for (37b) corresponding to Figure 16.

(37) a. NP [$_{Emb}$ WH1 WH2 V-Q_{12}] V-Q WH1 = WH2 (embedded)
( ) ( )( )( )
b. NP [$_{Emb}$ WH1 WH2 V-Q] V-Q_{12} WH1 = WH2 (matrix)
( ) ( )( )

When two *wh*-phrases have different scopes, the formation of the prosodic domain is different depending on which *wh*-phrase has a wider scope (matrix scope). When the first *wh*-phrase has a narrower scope than the second *wh*-phrase (WH1(embedded scope) < WH2 (matrix scope)) as in (38a) (corresponding to Figure 14), each *wh*-phrase lies in a different prosodic phrase. Each Phonological phrase is initiated at each *wh*-phrase. The prosodic domain, including the second *wh*-phrase, ends with the matrix clause complementizer. However, when the first *wh*-phrase has a wider scope than the second *wh*-phrase (WH1 (matrix scope) > WH2 (embedded scope)) as in (38b) (corresponding to Figure 15), both *wh*-phrases lie in the same prosodic phrase, which begins at the first *wh*-phrase and ends at the matrix clause complementizer.

(38) a. NP [$_{Emb}$ WH1 WH2 V-Q_1] V-Q_2 WH1(embedded) < WH2 (matrix)
( ) ( )( )
b. NP [$_{Emb}$ WH1 WH2 V-Q_2] V-Q_1 WH1 (matrix) > WH2 (embedded)
( ) ( )

The prosodic configurations for *wh*-intonation of the scope relations in (37b) (WH1 (matrix) = WH2 (matrix)) and (38a) (WH1 (embedded) < WH2 (matrix)) are the same. In order to further examine whether the prominence of the *wh*-phrases can be different depending on the scope relations shown in (37b) and (38a), the maximum pitch of the *wh*-phrases was measured. Their averages are in Table 7.

Table 7. The average maximum pitch of the *wh*-phrases.

	WH1	**WH2**	
a. WH1 (matrix) = WH2 (matrix)	259.25 Hz	256.83 Hz	$p = 0.88$
b. WH1 (embedded) < WH2 (matrix)	244.78 Hz	268.79 Hz	$p < 0.05$

When the second *wh*-phrase had a larger scope than the first *wh*-phrase, the phonetic prominence was increased on the second *wh*-phrase. This phenomenon was consistently observed across participants.

The pitch contours of the sentences, including two *wh*-phrases in different clauses in (24e–f) and repeated in (39), are in Figures 17 and 18. Recall that the first *wh*-phrase in the matrix clause always has matrix scope, but the second *wh*-phrase in the embedded clause can take either matrix scope or embedded scope.

(39) *Enu nwuna-ka* [*Mila nwuna-ka* *mwusun kok-ul* *yencwuhayss-nunci*]
Which sister-NOM Mila (sister)-NOM **which song**-ACC played-C(Q)
yencwuhayss-nunci] *mwuless-no?*
played-C(Q) asked-C(WHQ)

a. *which sister* (matrix scope) > *which song* (embedded scope)
'Which sister asked which song Mila played?'

b. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, x asked whether Mila played y?'

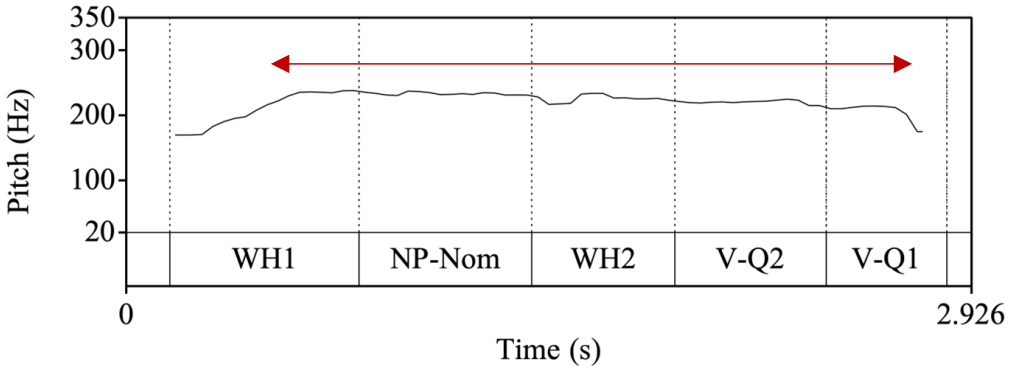


Figure 17. F0 contour of multiple *wh*-questions: two *wh*-phrases in the different clauses (scope relationship: WH1 (matrix) > WH2 (Embedded)).

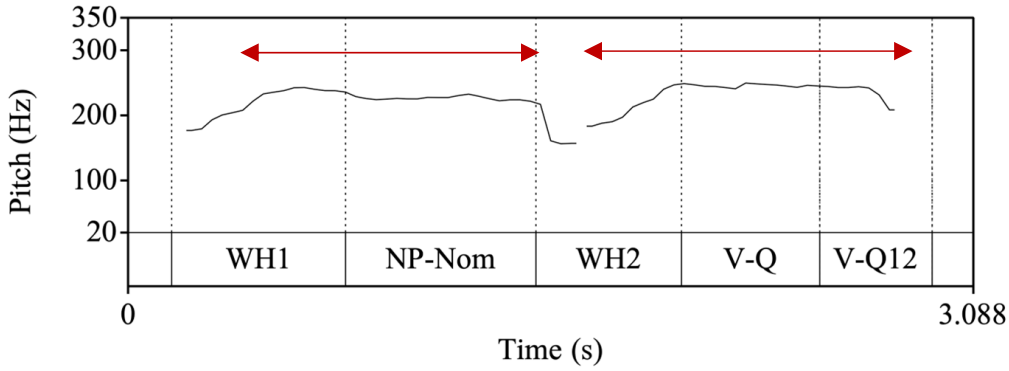


Figure 18. F0 contour of multiple *wh*-questions: two *wh*-phrases in the different clauses (scope relationship: WH1 (matrix) = WH2 (matrix)).

Schematic representations of prosodic phrasing are given in (40). When the second *wh*-phrase has narrower scope (embedded scope) than the first *wh*-phrase (matrix scope), both *wh*-phrases are in one prosodic domain that starts from the first *wh*-phrase and continues to the matrix complementizer as shown in (40a) corresponding to Figure 17. When the second *wh*-phrase has the same scope as the first *wh*-phrase (matrix scope), the two *wh*-phrases are in separate prosodic domains, as shown in (40b), corresponding to Figure 18.

(40) a. WH1 [$_{Emb}$ NP WH2 V-Q_2] V-Q_1 WH1(matrix) > WH2 (embedded)
( )

b. WH1 [$_{Emb}$ NP WH2 V-Q] V-Q_{12} WH1 (matrix) > WH2 (matrix)
( )( )

These results show that the semantic scope relationship between the two *wh*-phrases plays a more important role in deciding their prosodic domains than the syntactic positions of *wh*-phrases (i.e., whether in the matrix clause or in an embedded clause).

In sum, regardless of the positions of *wh*-phrases, when the first *wh*-phrase has a wider scope than the second *wh*-phrase, two *wh*-phrases are phrased together in the same prosodic domain. Otherwise, two *wh*-phrases are in separate prosodic phrases. In the next section, these results will be compared to the predictions by the models introduced in the previous literature.

6. Discussion

The summary of the predictions of each theory and model in Table 5 is repeated in Table 8, incorporating a comparison with the empirical results. It marks the results of the experiment as well as the theories that are consistent with the results by shading.

Table 8. The comparison of model predictions and empirical findings.

The Conditions for Multiple *wh*-Sentences	**EA: E-Agreement MS: Multiple Spell-Out Model CT: Contiguity Theory WM: Wrap-XP Model**			
	EA	**MS**	**CT**	**WM**
a. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_{12}] V-$_{YN}$Q?				
i.( )( )	✓	✗	✗	✓
ii.( )	✗	✓	✗	✗
b. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_1] V-$_{WH}Q_2$?				
i.( )( )	✗	✓	✗	✗
ii.( )	✗	✗	✗	✓
c. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?				
i.( )( )	✗	✗	✗	✗
ii.( )	✓	✓	✗	✓
d. $NP_{\text{-NOM}}$ [$_{Emb}$ $WH_{1\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$?				
i.( )( )	✓	✗	✗	✓
ii.( )	✗	✓	✗	✗
e. $WH_{1\text{-NOM}}$ [$_{Emb}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q_2] V-$_{WH}Q_1$?				
i.( )( )	✗	✗	✗	✗
ii.( )	✓	✓	✗	✓
f. $WH_{1\text{-NOM}}$ [$_{Emb}$ $NP_{\text{-NOM}}$ $WH_{2\text{-ACC}}$ V-Q] V-$_{WH}Q_{12}$?				
i.( )( )	✗	✗	✗	✓
ii.( )	?	✓	✗	✗
The number of correct predictions	4	3	0	5

The experimental results can be summarized as follows. In most cases, multiple *wh*-phrases induce separate prosodic domains for their own (a, b, d, f). The exception is when the linearly preceding *wh*-phrase takes a wider scope (matrix scope) than the next *wh*-phrase. In this case, the second *wh*-phrase does not induce a separate prosodic domain for its *wh*-intonation, whether the two *wh*-phrases are in the same clause (c) or in different clauses (e). The predictions summarized in Table 8 show that none of the theories and models in the previous literature introduced in this paper successfully predict the prosodic domain formation of all multiple *wh*-questions. This calls for the modification of the model.

I propose a new constraint and a new ranking of constraints that can deal with all the results of multiple *wh*-questions in South Kyeongsang Korean, based on the Wrap-XP Model, which seems the most promising among the previous models because it predicts the most cases correctly. The empirical findings reveal distinctive prosodic patterns that align with scope relations, suggesting a more direct interconnection among prosody, syn-

tax, and semantics rather than a sequential relationship where syntax precedes prosody or vice versa. Consequently, an Optimality Theory (OT) approach may be more plausible, as it considers all constraints simultaneously rather than sequentially.

The main observation from the results is that (i) when the linearly preceding *wh*-phrase takes wider scope than the following *wh*-phrase, the prosodic phrase for the *wh*-intonation starts at the first *wh*-phrase and the pitch accents of the following elements, including the second *wh*-phrase are deleted, and (ii) in all other cases, a *wh*-specific phonological phrase is initiated at each *wh*-phrase. Based on this observation, I suggest a new *Align-L* constraint in (41), which can initiate a new phonological phrase at each *wh*-phrase depending on the scope relationship between *wh*-phrases. *Align-L-Scope (wh, PoP)* takes the linear order of two *wh*-phrases and their scope relationship into account. Specifically, this constraint considers only two adjacent *wh*-phrases at once.

(41) A new constraint:

Align-L-Scope (*wh*, PoP)	Align the left edge of some PoP when it takes a wider scope than a linearly preceding *wh*-phrase.

I also propose that *Align-R* constraints should be posited in the grammar. In the original Wrap-XP Model (Smith 2011), *Align-R* constraints are not included because the model assumes that the right edge of a Phonological phrase for *wh*-intonation is aligned with the associated complementizer by the constraint *Wrap-C*. However, according to the definition of *Wrap-C*, it does not require the right edge to align with a complementizer and a Phonological phrase. It is satisfied as long as a *wh*-phrase and an associated complementizer are in the same phrase.

(42) The definition of Wrap-C constraint:

Wrap-C	Every $C_{[+wh]}$ must be in the same phrase as some associated *wh* element.

Since Smith (2011) considered only two candidates (43a) and (43b) in her study, the right edge alignment did not stand out. However, as seen in (43), when another possible candidate (43c) is added, the constraints suggested by Smith (2011) are not sufficient to choose the right result (43a).

(43)

Input: **WH1…WH2…C(Q12)…C(Q)**	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH
☞ a. ( )( )( )			*
b. ( )( )		*!	*
☞ c. ( )( )			*

To rule out the wrong candidate (43c), *Align-R(C, PoP),* as shown in (44), should be included but low-ranked.

(44) The definition of Aligh-R constraint:

Align-R(C, PoP)	The right edge of every C element is aligned with the right edge of some PoP.

As seen in (45), the revised ranking *Wrap-C >> Align-L (wh, PoP) >> Wrap-WH, Align-R (C, PoP)* draws the right result.

(45)

Input: **WH1…WH2…C(Q12)…C(Q)**	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH	Align-R (C, PoP)
☞ a. ( )( )( )			*	
b. ( )( )		*!	*	
c. ( )( )			*	*!

Let us now take a look at whether the newly revised constraint ranking, including the new suggested constraints *Align-L-Scope (wh, PoP)* and *Align-R (C, PoP,)* extracts the correct results.

(46) The new ranking of constraints:
Aligh-L-Scope (*wh*, PoP) >> Wrap-C >> Align-L (*wh*, PoP) >> Wrap-WH, Align-R (C, PoP)

In the following tableaux, a simplified configuration is given as an input. The semantic scope relationship is indicated with numbers. The observed phonetic realization of *wh*-intonation is shaded.

Let us first consider the cases where two *wh*-phrases take the same scope. In (47), since both *wh*-phrases have embedded scope (WH1: Embedded = Wh2: Embedded), none of the candidates violate the highest ranked constraint *Align-L-Scope (wh, PoP)*. The more general *Align-L (wh, PoP)* constraint induces the presence of a phrase break at each *wh*-phrase. As a result, (47b) and (47d) are ruled out. The comparison between (47a) and (47c) shows that *Align-R (C, PoP)* brings about the presence of a phrase break at the associated complementizer, and (47c) is ruled out.

(47)

Input: …**WH1**…**WH2**…**C(Q12)**…**C(Q)**	Align-L-Scope (*wh*, PoP)	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH	Align-R (C, PoP)
☞ a. ( )( )( )				*	
b. ( )( )			*!		
c. ( )( )				*	*!
d. ( )			*!		*

When two *wh*-phrases have matrix scope (WH1: Matrix = Wh2: Matrix), as shown in (48), *Wrap-WH*, a constraint ranked higher than *Align-R (C, PoP)*, militates against the presence of a phrase break at the embedded complementizer which is not associated with any of the two *wh*-phrases.

(48)

Input: …**WH1**…**WH2**…**C(Q)**…**C(Q12)**	Align-L-Scope (*wh*, PoP)	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH	Align-R (C, PoP)
a. ( )( )( )		*!		**	
b. ( )( )		*!	*	**	
☞ c. ( )( )				*	*
d. ( )			*!		*

Let us now take a look at the cases where two *wh*-phrases take different scopes. In (49), the second *wh*-phrase has a wider scope than the first *wh*-phrase (WH1: Embedded < Wh2: Matrix). The highest-ranked constraint *Align-L-Scope (wh, PoP)* induces the presence of a phrase break at each *wh*-phrase. In evaluating candidates (a) and (c), (a) is ruled out due to the severe violation of the second-highest-ranked Wrap-C. While candidate (c) violates *Wrap-C* once due to the phasing of C(Q1) in a separate domain from WH1, candidate (a) doubly violates the Wrap-C as neither C(Q1) nor C(Q2) resides in the same phrase with their corresponding *wh*s. Thus, with the second-highest-ranked *Wrap-C*, closing a Phonological phrase at the embedded complementizer is avoided.

(49)

Input: …**WH1**…**WH2**…**C(Q1)**…**C(Q2)**	Align-L-Scope (*wh*, PoP)	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH	Align-R (C, PoP)
a. ( )( )( )		**!		**	
b. ( )( )	*!	*	*		
☞ c. ( )( )		*		*	*
d. ( )	*!		*		*

In (50), the first *wh*-phrase has a wider scope than the second *wh*-phrase (WH1: Matrix > Wh2: Embedded). *Align-L-Scope (wh, PoP)* is not applied here. The second highly ranked *Wrap-C*, thus, forces two *wh*-phrases and two complementizers to be phrased together.

(50)

Input: …**WH1**…**WH2**…**C(Q2)**…**C(Q1)**	Align-L-Scope (*wh*, PoP)	Wrap-C	Align-L (*wh*, PoP)	Wrap-WH	Align-R (C, PoP)
a. ( )( )( )		*!		*	
b. ( )( )		*!	*		
c. ( )( )		*!		*	*
☞ d. ( )			*		*

To summarize, the ranking for *wh*-intonation in Korean should be *Align-L-Scope (wh, PoP) >> Wrap-C >> Align-L (wh, PoP) >> Wrap-WH, Align-R (C, PoP).* This conclusion shows that more fine-grained constraints in terms of the scope relationships of multiple *wh*-phrases play a crucial role in determining the initiation of new prosodic boundaries of *wh*-phrases. In addition, even though *Align-R (C, PoP)* is low-ranked, it is necessary to determine the end of the prosodic domain of *wh*-intonation.

As we have seen, the competing approach to the correlation between prosody and syntactic structure, particularly for *wh*-scope, ends up working well only with the limited data. The newly added data in this paper show that the semantic scope relations of multiple *wh*-phrases influence prosodic phrasing of *wh*-intonation. The insertion of the left edge of *wh*-intonation is decided by the scope relations of *wh*-phrases. The proposed constraint Align-L-Scope (*wh*, PoP) reflects the semantic scope relations to phonological phrasing. This informs that prosodic structure has to do with semantics as well as syntax. Future studies are required to see if this left-edge alignment constraint can be stretched to new types of structures other than *wh*-questions, such as the old-new information structure or the focus structure that involves changes in prosodic phrasing.

7. Conclusions

This study shows that South Kyeongsang Korean stands as evidence that the syntax-phonology interface is sensitive to the scope relationship between *wh*-phrases. The evidence from multiple *wh*-questions has shown that the syntax-semantics-prosody interface constraint that determines the initiation of *wh*-intonation in South Kyeongsang Korean is *Align-L-Scope (wh, PoP)*, repeated in (51a). *Align-R (C, PoP)* as well as *Wrap-C* contribute to determining the end of *wh*-intonation.

(51) Newly added constraints:

a. Align-L-Scope (*wh*, PoP)	Align the left edge of some PoP when it takes a wider scope than a linearly preceding *wh*-phrase.
b. Align-R(C, PoP)	The right edge of every C element is aligned with the right edge of some PoP.

In fact, Smith (2011) pointed out that regarding *wh*-prosodic constructions, the Fukuoka Japanese data do not serve as unambiguous evidence for the existence of the constraint *Wrap-WH*. South Kyeongsang Korean data also provide no evidence that the constraint *Wrap-WH* is required to construct the proper prosodic phrases for *wh*-intonation. In Korean, the proper prosodic phrasing for *wh*-intonation is imposed by the relationship between *wh*-phrases and the complementizer Rather than *Wrap-WH.*

Most previous studies on *wh*-scope have paid attention only to the syntax-phonology interface, mainly investigating, for example, which aspects of syntactic structure have phonological consequences or what kind of phonological information is responsible for the syntactic operation. However, the current study finds that the prosodic structures for *wh*-scope interpretations are not the direct outcome of syntax and phonology but the aggregation of syntax, phonology, and semantics.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of NAME OF INSTITUTE (protocol code 781188).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data is unavailable due to privacy or ethical restrictions.

Conflicts of Interest: The author declares no conflicts of interest.

Appendix A

The stimuli for a single *wh*-question are listed below.

Set A

영우는 미라 누나가 무슨 곡을 연주했는지 물었나? (물었노 for (b))

Yengwu-nun	[Mila *nwuna-ka*	*mwusun kok-ul*
Yengwu-NOM	Mila sister-NOM	**which song**-ACC
yencwuhayss-nunci]	*mwuless-na?*	(*mwuless-no?* for (b))
played-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

a. 'Did Yengwu ask which song Mila's sister played?
b. 'For which x, x a song, Yengwu asked Mila's sister palyed x'.

영우는 어느 누나가 모짜르트를 연주했는지 물었나? (물었노 for (b))

Yengwu-nun	[*enu nwuna-ka*	*moccaluthu-lul*
Yengwu-NOM	**which sister**-NOM	Mozart-ACC
yencwuhayss-nunci]	*mwuless-na?*	(*mwuless-no?* for (d))
played-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

c. 'Did Yengwu ask which sister played Mozart?'
d. 'For which x, x a sister, Yengwu asked x played Mozart?'

Set B

영미는 민우 삼촌이 무슨 채소를 먹었는지 물었나? (물었노 for (b))

Yengmi-nun	[*Minwu samchon-i*	*mwusun chayso-lul*
Yengmi-NOM	Minwu-NOM	**which vegetable**-ACC
mekess-nunci]	*mwuless-na?*	(*mwuless-no?* for (b))
ate-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

a. 'Did Yengmi ask which vegetable Minwu uncle ate?
b. 'For which x, x a vegetable, Yengmi asked Minwu uncle ate x'.

영미는 어느 삼촌이 오이를 먹었는지 물었나? (물었노 for (d))

Yengmi-nun	[*enu samchon-i*	*oi-lul*
Yengmi-NOM	**which uncle**-NOM	cucumber-ACC
mekess-nunci]	*mwuless-na?*	(*mwuless-no?* for (d))
ate-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

c. 'Did Yengmi ask which uncle ate a cucumber?
d. 'For which x, x an uncle, Yengmi asked x ate a cucumber'.

Set C

유나는 은이 고모가 무슨 음식을 만들었는지 물었나? (물었노 for (b))

Yuna-nun	[*Uni komo-ka*	*mwusun umsik-ul*
Yuna-NOM	Uni aunt (father's side)-NOM	**which dish**-ACC
mantuless-nunci]	*mwuless-na?*	(*mwuless-no?* for (b))
made-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

a. 'Did Yuna ask which dish Uni aunt made ?
b. 'For which x, x a dish, Yuna asked Uni aunt made x'.

유나는 은이 고모가 무슨 음식을 만들었는지 물었나? (물었노 for (d))

Yuna-nun	[*enu komo-ka*	*mandwu-ul*
Yuna-NOM	**which aunt** (father's side)-NOM	dumpling-ACC
mantuless-nunci]	*mwuless-na?*	(*mwuless-no?* for (d))
made-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

c. 'Did Yuna ask which aunt made dumplings?
d. 'For which x, x an aunt, Yuna asked which aunt made dumplings'.

Set D

연우는 은이 이모가 무슨 주스를 마셨는지 물었나? (물었노 for (b))

Yenwu-nun	[*Uni imo-ka*	*mwusun cwusu-lul*
Yenwu-NOM	Uni (mother side)-NOM	**which juice**-ACC
masyess-nunci]	*mwuless-na?*	(*mwuless-no?* for (b))
drank-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

a. 'Did Yenwu ask which juice Uni aunt drank?
b. 'For which x, x juice, Yenwu asked Uni aunt drank x'.

연우는 어느 이모가 매실 주스를 마셨는지 물었나? (물었노 for (d))

Yenwu-nun	[*enu imo-ka*	*maysil cwusu-lul*
Yenwu-NOM	**which aunt** (mother side)-NOM	**plum juice**-ACC
masyess-nunci]	*mwuless-na?*	(*mwuless-no?* for (d))
drank-C(Q)	asked-C(YNQ)	(asked-C(WHQ))

c. 'Did Yenwu ask which aunt drank plum juice?
d. 'For which x, x an aunt, Yenwu asked which aunt drank plum juice'.

Appendix B

The stimuli for the experiment are listed below.

Set A

1. 영우는 어느 누나가 무슨 곡을 연주했는지 물었노? (물었나 For (a))

Yengwu-nun	[*enu nwuna-ka*	*mwusun kok-ul*
Yengwu-NOM	**which sister**-NOM	**which song**-ACC
yencwuhayss-nunci]	*mwuless-no?*	(*mwuless-na?* for (a))
played-C(Q)	asked-C(WHQ)	(asked-C(YNQ))

a. *which sister* (embedded scope) = *which song* (embedded scope)
'Did Yengwu ask which sister played which song?'
b. *which sister* (embedded scope) < *which song* (matrix scope)
'For which y, y a song, Yengwu asked which sister played y?'
c. *which sister* (matrix scope) > *which song* (embedded scope)
'For which x, x a sister, Yengwu asked which song x played?'
d. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, Yengwu asked whether x played y?'

2. 어느 누나가 미라 누나가 무슨 곡을 연주했는지 물었노?

Enu nwuna-ka	[*Mila nwuna-ka*	*mwusun kok-ul*
Which sister-NOM	Mila (sister)-NOM	**which song**-ACC
yencwuhayss-nunci]	*mwuless-no?*	
played-C(Q)	asked-C(WHQ)	

a. *which sister* (matrix scope) > *which song* (embedded scope)
'Which sister asked which song Mila played?'
b. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, x asked whether Mila played y?'

Set B

1. 영미는 어느 삼촌이 무슨 채소를 먹었는지 물었노? (물었나 for (a))

Yengmi-nun	[*enu samchon-i*	*mwusun chayso-lul*
Yengmi-NOM	**which uncle**-NOM	**which vegetable**-ACC
mekess-nunci]	*mwuless-no?*	(*mwuless-na?* for (a))
ate-C(Q)	asked-C(WHQ)	(asked-C(YNQ))

a. *which uncle* (embedded scope) = *which vegetable* (embedded scope)
'Did Yengmi ask which uncle ate which vegetable?'
b. *which uncle* (matrix scope) > *which vegetable* (embedded scope)
'For which x, x an uncle, Yengmi asked which vegetable x ate?'
c. *which uncle* (embedded scope) < *which vegetable* (matrix scope)
'For which y, y a vegetable, Yengmi asked which sister ate y?'
d. *which uncle* (matrix scope) = *which vegetable* (matrix scope)
'For which x, y, x an uncle, y a vegetable, Yengmi asked whether x ate y?'

2. 어느 삼촌이 민우 삼촌이 무슨 채소를 먹었는지 물었노?
   Enu samchon-i [*Minwu samchon-i* *mwusun chayso-lul*
   Which uncle-NOM Minwu (uncle)-NOM **which vegetable**-ACC
   mekess-nunci] *mwuless-no?*
   ate-C(Q) asked-C(WHQ)
   a. *which uncle* (matrix scope) > *which vegetable* (embedded scope)
   'Which uncle asked which vegetable Minwu ate?'
   b. *which uncle* (matrix scope) = *which vegetable* (matrix scope)
   'For which x, y, x an uncle, y a vegetable, x asked whether Minwu ate y?'

Set C

1. 윤아는 어느 고모가 무슨 음식을 만들었는지 물었노? (물었나 for (a))
   Yuna-nun [*enu komo-ka* *mwusun umsik-ul*
   Yuna-NOM **which aunt** (father side)-NOM **which dish**-ACC
   mantuless-nunci] *mwuless-no?* (*mwuless-na?* for (a))
   made-C(Q) asked-C(WHQ) (asked-C(YNQ))
   a. *which aunt* (embedded scope) = *which dish* (embedded scope)
   'Did Yuna ask which aunt made which dish?'
   b. *which aunt* (embedded scope) < *which dish* (matrix scope)
   'For which y, y a dish, Yuna asked which aunt made y?'
   c. *which aunt* (matrix scope) > *which dish* (embedded scope)
   'For which x, x an aunt, Yuna asked which dish x made?'
   d. *which aunt* (matrix scope) = *which vegetable* (matrix scope)
   'For which x, y, x an aunt, y a vegetable, Yuna asked whether x made y?'

2. 어느 고모가 은이 고모가 무슨 음식을 만들었는지 물었노?
   Enu komo-ka *Uni komo-ka* *mwusun umsik-ul*
   Which aunt (father side)-NOM Uni (aunt)-NOM **which dish**-ACC
   mantuless-nunci] *mwuless-no?*
   made-C(Q) asked-C(WHQ)
   a. *which aunt* (matrix scope) > *which dish* (embedded scope)
   'Which aunt asked which dish Uni made?'
   b. *which aunt* (matrix scope) = *which dish* (matrix scope)
   'For which x, y, x an aunt, y a dish, x asked whether Uni made y?'

Set D

1. 연우는 어느 이모가 무슨 주스를 마셨는지 물었노? (물었나 for (a))
   Yenwu-nun [*enu imo-ka* *mwusun cwusu-lul*
   Yenwu-NOM **which aunt** (mother side)-NOM **which juice**-ACC
   masyess-nunci] *mwuless-no?* (*mwuless-na?* for (a))
   drank-C(Q) asked-C(WHQ) (asked-C(YNQ))
   a. *which aunt* (embedded scope) = *which juice* (embedded scope)
   'Did Yenwu ask which aunt drank which juice?'
   b. *which aunt* (embedded scope) < *which juice* (matrix scope)
   'For which y, y a juice, Yenwu asked which aunt drank y?'
   c. *which aunt* (matrix scope) > *which juice* (embedded scope)
   'For which x, x an aunt, Yenwu asked which juice x drank?'
   d. *which aunt* (matrix scope) = *which juice* (matrix scope)
   'For which x, y, x an aunt, y a juice, Yenwu asked whether x made y?'

2. 어느 이모가 유미 이모가 무슨 주스를 마셨는지 물었노?
   Enu imo-ka *Yumi imo-ka* *mwusun cwusu-lul*
   Which aunt (mother side)-NOM Yumi (aunt)-NOM **which juice**-ACC
   masyess-nunci] *mwuless-no?*
   drank-C(Q) asked-C(WHQ)
   a. *which aunt* (matrix scope) > *which juice* (embedded scope)
   'Which aunt asked which juice Yumi drank?'
   b. *which aunt* (matrix scope) = *which juice* (matrix scope)
   'For which x, y, x an aunt, y a juice, x asked whether Yumi drank y?'

Appendix C

The provided contexts for the example set of stimuli are listed below.

영우는 어느 누나가 무슨 곡을 연주했는지 물었노? (물었나 For (a))

Yengwu-nun	[*enu nwuna-ka*	*mwusun kok-ul*
Yengwu-NOM	**which sister**-NOM	**which song**-ACC
yencwuhayss-nunci]	*mwuless-no?*	(*mwuless-na?* for (a))
played-C(Q)	asked-C(WHQ)	(asked-C(YNQ))

a. *which sister* (embedded scope) = *which song* (embedded scope)
'Did Yengwu ask which sister played which song?'

c. *which sister* (embedded scope) < *which song* (matrix scope)
'For which y, y a song, Yengwu asked which sister played y?'

b. *which sister* (matrix scope) > *which song* (embedded scope)
'For which x, x a sister, Yengwu asked which song x played?'

d. *which sister* (matrix scope) = *which song* (matrix scope)
'For which x, y, x a sister, y a song, Yengwu asked whether x played y?'

Context a. (*which sister* (embedded scope) **=** *which song* (embedded scope))

Yengwu was wondering which sister played which song. He asked you about it but you did not tell him. Thus, Yengwu asked about it to your friend who was on the balcony since you were in the kitchen so you could not hear him. When your friend came to the kitchen, you asked your friend:

[target sentence]

Context b. (*which sister* (embedded scope) **<** *which song* (matrix scope))

Yengwu asked his mom, "Which sister played Mozart?" You and your friend overheard what Yengwu was asking his mom. However, you could not clearly hear which song he was asking about. Thus, you asked your friend:

[target sentence]

Context c. (*which sister* (matrix scope) **>** *which song* (embedded scope))

Yengwu asked his mom, "Which song did Mila (sister) play?" You and your friend overheard what Yengwu was asking his mom. However, you could not clearly hear which sister he was asking about. Thus, you asked your friend:

[target sentence]

Context d. (*which sister* (matrix scope) **=** *which song* (matrix scope))

Yengwu asked his mom, "Did Mila (sister) play Mozart?" You and your friend overheard what Yengwu was asking his mom. However, you could not clearly hear which sister and which song he was asking about. Thus, you asked your friend:

[target sentence]

Context e. (*which sister* (matrix scope) **>** *which song* (embedded scope))

Some sister asked Yengwu, "Hey Yeongwu, which song did Mila (sister) play?" You and your friend overheard what some sister was asking Yengwu. However, you could not clearly hear which sister it was. You were also curious who asked the question. Thus, you asked your friend-

[target sentence]

Context f. (*which sister* (matrix scope) **=** *which song* (matrix scope))

Some sister asked Yengwu, "Hey Yeongwu, did Mila (sister) play Mozart?" You and your friend overheard what some sister was asking Yengwu. However, you could not clearly hear which song it was. Also, you were curious who asked the question. Thus, you asked your friend:

[target sentence]

Appendix D

a. **The variation between pitch compression and high plateau**: This pattern emerged exclusively within the embedded scope of a single *wh*-phrase, in the scope relation (WH1 (embedded) = WH2 (embedded)) of multiple *wh*-questions and in the scope relation (WH1 (matrix) = WH2 (matrix)) of multiple *wh*-questions. Specifically, one participant (P1, female) demonstrated pitch compression across all four sentences of a single *wh*-question as shown in Figure A1. For multiple *wh*-questions (WH1 (embedded) = WH2 (embedded)), pitch compression was observed in three sentences, with a high plateau pattern appearing in one sentence from the same participant (P1) as shown in Figures A2 and A3. In the scope relations (WH1 (matrix) = WH2 (matrix)), a combination of pitch compression and high plateau was also observed in a sentence from another participant (P6, female), as illustrated in Figure A4.

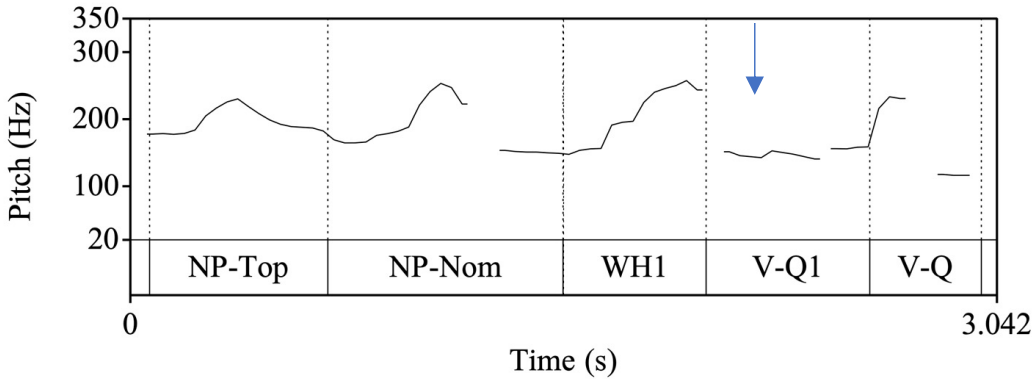


Figure A1. F0 pitch compression of a single *wh*-question from P1.

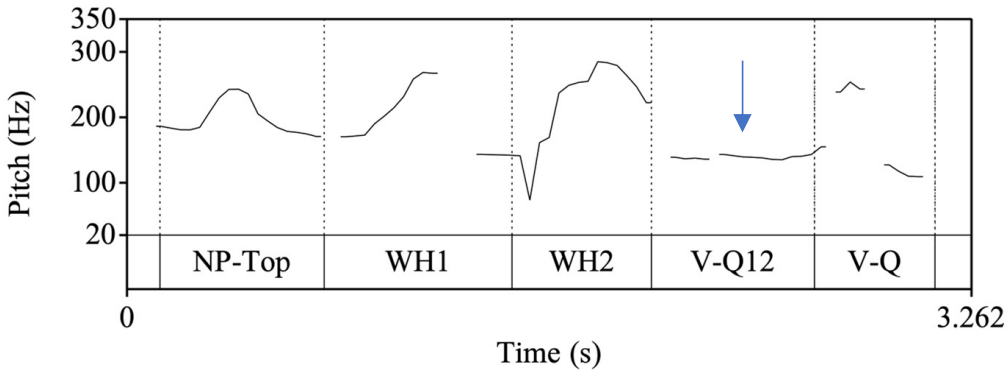


Figure A2. F0 pitch compression of multiple *wh*-questions from P1: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) = WH2 (embedded)).

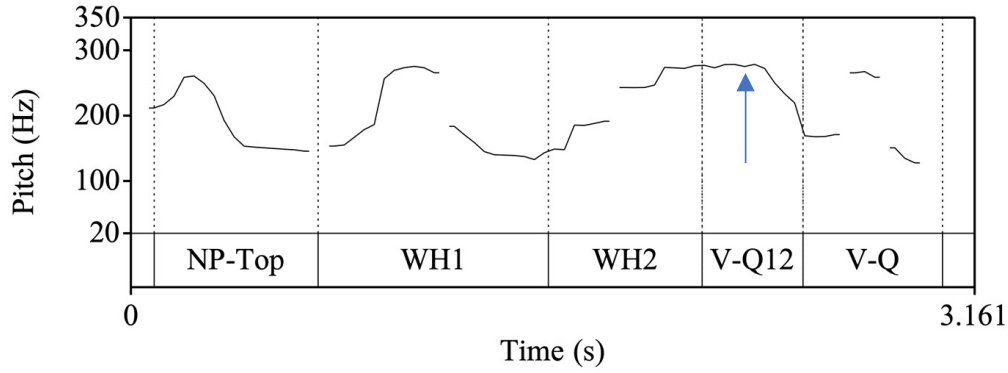


Figure A3. F0 pitch high plateau of multiple *wh*-questions from P1: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) = WH2 (embedded)).

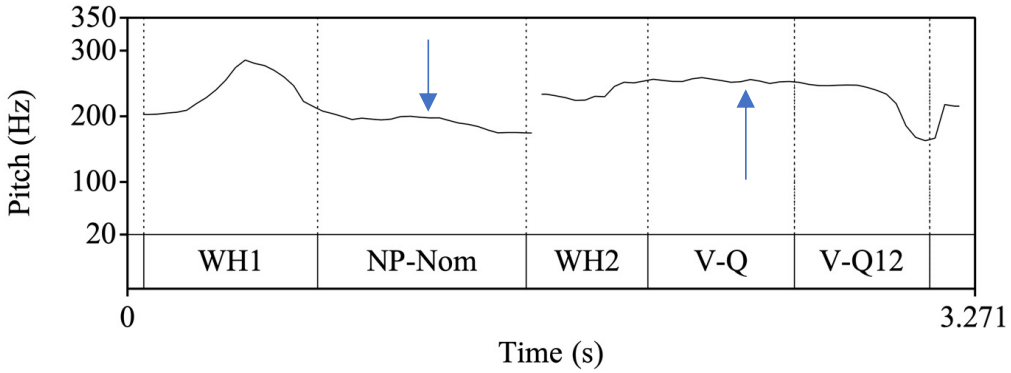


Figure A4. F0 pitch high plateau of multiple *wh*-questions from P6: two *wh*-phrases in different clauses (scope relationship: WH1 (matrix) = WH2 (matrix)).

b. **The variation between downstep and pitch reset across NP-Top and WH1**: The downstep across NP-Nom and WH1 is mainly observed across participants as shown in Figure A5. However, the pitch reset on WH1 was also found from one participant (P3, male) as shown in Figure A6.

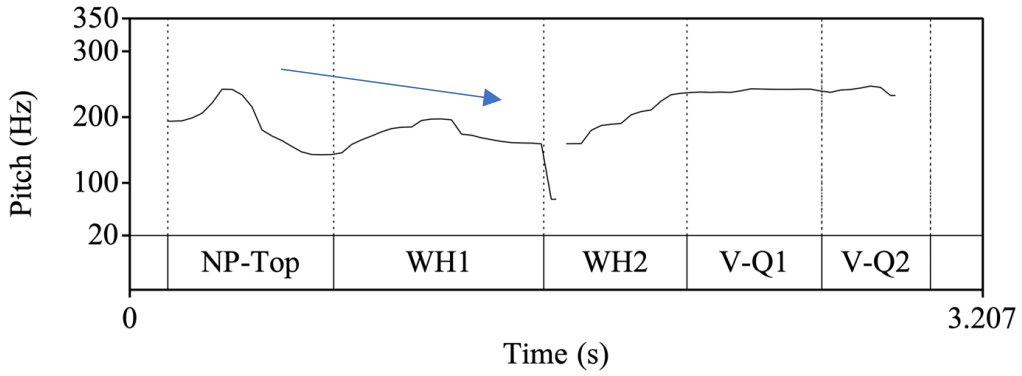


Figure A5. F0 downstep from NP to WH1 from P1: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) < WH2 (matrix)).

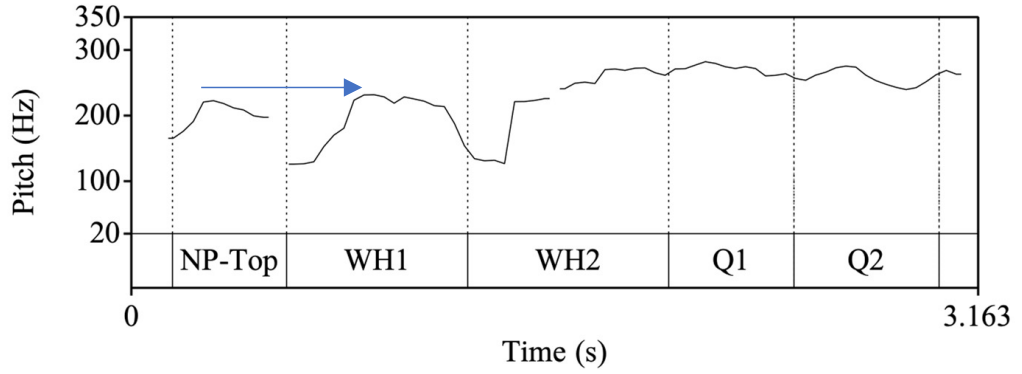


Figure A6. F0 pitch reset at WH1 from P3: two *wh*-phrases in the embedded clause (scope relationship: WH1 (embedded) < WH2 (matrix)).

Notes

[1] The range of sentence-final particles in Kyeongsang Korean is even broader than those presented in the table above, which are selectively chosen from the list of sentence-final particles in M. Choi (2019) based on their frequency. All sentence-final particles in the table are the most frequently and widely used ones by contemporary Kyeongsang Korean speakers.

[2] According to Kim and Jun (2009), an ip (intermediate phrase), which is immediately dominated by IP (Intonation phrase), is the domain of downstep or pitch range reset and can have one or more APs. An AP can have one pitch accent, and a Low boundary

tone (La) is realized at the beginning of the phrase. Even though each prosodic word has a lexical pitch accent. At the level of AP, only one of them survives as the pitch accent of the whole AP. Regarding the *wh*-intonation, which this paper is interested in, following their analysis, the domain of *wh*-intonation consists of a single ip consisting of a single AP: … ($_{ip}$($_{AP}$ *wh* …)). Therefore, in SKK, the distinction between an Intermediate Phrase and an Accentual Phrase for the discussion on *wh*-intonations seems unnecessary.

[3] According to Deguchi and Kitagawa (2002), "The *wh*-phrase as the goal then covertly moves to the Spec of the matrix IEP to undergo E-agreement with the uninterpretable E-feature on the head IE. It then moves to the matrix Spec-CP to have the *wh*-feature checked".

[4] According to Richards' (2016) Contiguity Theory, "There are universal conditions on morphology and phonology, in how the prosodic structures of language can be built", and a *wh*-question is one of its examples.

[5] Note that Korean *wh*-expressions are lexically ambiguous. The SKK example below clearly shows the lexical ambiguity of a *wh*-phrase. The lexicon *mwues* can be interpreted in two ways: an indefinite pronoun in the yes/no question or a *wh*-pronoun in the *wh*-question.

a.	*Mila-ka*	*mwu(es)-ul*	*yencwuhayss-na?*
	Mila-NOM	**something**-ACC	played-C(YNQ)?
	'Did Mila play something?'		
b.	*Mila-ka*	*mwu(es)-ul*	*yencwuhayss-no?*
	Mila-NOM	**what**-ACC	played-C(WHQ)?
	'What did Mila play?'		

This study is interested in how SKK speakers process *wh*-scope when a *wh*-phrase is interpreted as a *wh*-pronoun, not as an indefinite pronoun. Accordingly, the target sentences exclusively use D-linked *wh*-phrases, which are less likely to be construed as *wh*-indefinite. However, acknowledging that D-linked *wh*-phrases do not guarantee interpretation as *wh*-pronouns, explicit instructions were provided at the beginning of each experiment, alongside practice sessions, to promote the intended interpretation of *wh*-phrases as *wh*-pronouns.

[6] This occurred while participants read long filler sentences. These filler sentences had the same level of syntactic structure complexity as the target sentences. However, some were quite long, with as many as three additional adjuncts, so participants sometimes put unusually long pauses between lexical items or mispronounced items such as proper nouns.

[7] Note that the prosodic patterns of the provided answers can affect the processing of *wh*-scopes. Even though two NPs are overtly pronounced in the answer, the different degrees of prosodic prominence of NPs can misguide the participant to the unintended scope relations. For this reason, in the experiment, the answers were provided with the plain intonation without giving any pause between NPs or putting any prosodic prominence on either NP.

[8] See notes 7 above.

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