



Exploring phonetics–morphology interaction: prosodic encoding of covert case marking in Korean

Richard Hatcher^a, Jiyoung Jang^a, Sahyang Kim^c, Taehong Cho^{a,b,*}

^a Hanyang Institute for Phonetics and Cognitive Sciences of Language, Hanyang University, Seoul, South Korea

^b Department of English Language and Literature, Hanyang University, Seoul, South Korea

^c Department of English Education, Hongik University, Seoul, South Korea

ARTICLE INFO

Article history:

Received 29 August 2025

Received in revised form 7 March 2026

Accepted 1 April 2026

Available online 22 April 2026

Keywords:

Prosodic encoding of morphology

Phonetics-morphology interaction

Covert-overt case marking

Seoul Korean

ABSTRACT

In Korean, suffixal case markers can be omitted, resulting in covert (simplex) forms that are segmentally homophonous with overt (complex) counterparts (e.g., /tʃonj/ 'paper' vs. /tʃonj-i/ 'bell-nom') yet retain their morphosyntactic function. Because both types typically occur at major syntactic junctures that map onto phrasal prosodic boundaries, Korean offers an ideal testbed for examining how morphological distinctions—particularly those lacking overt case marking—are prosodically encoded. Using controlled production tasks in morphological and lexical focus contexts, speech from 21 Seoul speakers was analyzed for prosodic phrasing, duration, and f₀ contour. At the macro (phonological) level, simplex forms were more often realized as independent Accentual Phrases (APs), placing them at prominent phrase edges. Such phrasing not only marks underspecified morphology, albeit in a subtle and probabilistic manner, but also provides access to boundary-related lengthening and tonal shaping. At the micro (phonetic) level, covert case marking recruited AP-final rime lengthening and greater f₀ rise magnitudes, especially for the accusative. These effects, though sometimes context-dependent, indicate prosodic sensitivity to morphosyntactic informativity. The pattern cannot be accounted for by classical or extended Paradigm Uniformity accounts, which predict temporal expansion for morphologically complex forms, but instead by a Covert Morphology Enhancement account: prosodic resources are reallocated when morphological informativity is reduced due to covert case marking. The results thus show how optional case-marker omission in Korean can be compensated for through coordinated prosodic phrasing and fine-grained phonetic adjustments at the right edge of a phrase which is also known to carry prominence. More broadly, the study illustrates how prosodic realization—and phonetics more generally—balances systemic stability with listener-oriented enhancement in morphological encoding across languages, with the balance fine-tuned in language-specific ways, yielding both cross-linguistic commonalities and variation.

© 2026 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

1. Introduction

Surface phonetic forms resulting from morphological concatenation can be segmentally identical to monomorphemic forms sharing the same phonemic sequence (e.g., *bat-er* vs. *batter*), thus creating potential ambiguity. In traditional phonological theories based on modular, feedforward architectures (e.g., Chomsky & Halle, 1968; Kiparsky, 2000), such surface neutralization is expected, as phonetic implementation is assumed to proceed independently of morphosyntactic struc-

ture once phonological representations are specified. This assumption is also central to Levelt's classic psycholinguistic model of speech production (Levelt, 1989; Levelt et al., 1999). However, numerous experimental phonetic studies have shown that morphologically distinct homophones often exhibit systematic phonetic variation across diverse contexts—e.g., stem variants, prefixes, suffixes, word-final segments, gestural overlap, and compound lexicality (e.g., Ben Hedia & Plag, 2017; Cho, 2001; Kemps et al., 2005; Schmitz et al., 2021; Seyfarth et al., 2018; Strycharczuk & Scobbie, 2017; Sugahara & Turk, 2009). As reviewed in Strycharczuk (2019), such findings indicate that phonetic realization can be directly shaped by morphological structure, with

* Corresponding author.

E-mail address: tcho@hanyang.ac.kr (T. Cho).

non-contrastive variation providing subtle but systematic cues to morphosyntactic organization. These results provide rigorous evidence for the *phonetic encoding of morphological structure*, calling for integrative models of speech production in which phonetic realization remains sensitive to morphological distinctions, contra traditional phonological and earlier psycholinguistic theories.

Much of the evidence for direct interactions between phonetics and morphology—especially in relation to segmental homophony in lexical forms—has, however, come from Indo-European languages, particularly West Germanic, with only a few exceptions (cf. Strycharczuk, 2019). One such exception among some others is Gafos et al. (2010), which examines Moroccan Arabic. Although their study does not directly address how surface homophony created by morphological structure can be phonetically resolved, it offers valuable insight into how different morphological systems may engage distinct phonetic mechanisms. Specifically, they report that homorganic consonant clusters in Moroccan Arabic vary in the degree of gestural overlap: clusters arising from morpheme concatenation exhibit some overlap, whereas those formed through template morphology show no such overlap. Cases like this illustrate that examining typologically diverse languages can reveal fundamentally different phonetic strategies for encoding morphological structure. Thus, we are still left with fundamental questions about how languages beyond well-studied families implement the phonetic encoding of morphological structure in resolving surface homophony, particularly when their morphological systems—and the grammatical systems intricately linked to them—differ fundamentally.

Korean, an agglutinative language, offers precisely such a typologically distinct testing ground for investigating the phonetic encoding of morphological structure. Unlike some of the Indo-European languages that dominate the literature, Korean employs overt morphology to mark the grammatical cases of nouns—often analyzed as enclitics (Whitman & Cho, 2019)—and, crucially, these case markers can be optionally omitted, creating a systematic type of morphological ambiguity. Case markers such as the nominative /-i/ and the accusative /-il/, as illustrated in (1a), attach to the end of noun stems to explicitly indicate syntactic function. In casual speech, however, these markers are often dropped (Lee, 2015), as in (1b). The omission of the case marker may result in morphologically distinct forms that are segmentally identical.

-
- (1) a. /minsʌk-i hjetʃin-il tʃohahejo/
 “Minseok likes Hyejin”
 b. /minsʌk-Ø hjetʃin-Ø tʃohahejo/
 “Minseok likes Hyejin”
-

Unlike in West Germanic languages, where lexical ambiguity typically arises through morphological concatenation, in Korean the ambiguity results from omitting an optional case-marking morpheme while still retaining its morphosyntactic function. For example, omission of the nominative case marker in /tʃoŋj/ ‘paper’ yields the same surface form as /tʃoŋj-i/ ‘bell-nom’, creating a homophonous context despite underlying morphosyntactic differences. This ambiguity arises at syntactic junctures (for example, between the subject noun phrase and

the following verb phrase), which are likely to align with phrase-level prosodic boundaries via syntax–prosody mapping (e.g., Bennett & Elfner, 2019; Celle & Pélissier, 2024; Jun, 2009). This interaction between syntax and prosody in the morphological process therefore presents an ideal context for investigating whether phrase-level prosody can signal morphological contrasts, departing from previous studies which have examined phonetic detail primarily in conjunction with word-level prosody (see Section 1.1 for further discussion).

The present study asks whether morphological distinctions in such homophonous forms are systematically differentiated through prosodic structure (e.g., phrasing differences) and/or fine phonetic detail in temporal and f0 cues. By examining Seoul Korean speakers’ production of forms with and without overt case markers, we aim to determine how morphological information is prosodically encoded—at the macro (phonological) level, where phrasings and tonal distributions are determined, and at the micro (phonetic) level, where features such as duration and f0 are adjusted in a gradient manner. In doing so, we assess how findings from a language with typologically distinct morphological and prosodic systems can extend and refine our understanding of the prosodically driven phonetic encoding of morphology, which we will refer to as *the prosodic encoding of morphology*, beyond the Indo-European focus of most previous research. Building on these overarching goals, we next formulate specific research questions and hypotheses, informed by empirical evidence and theoretical considerations relevant to the present study.

1.1. Theoretical backgrounds and specific research questions

Previous research on the phonetic encoding of morphological structure, as discussed in detail below, has focused primarily on temporal variation (e.g., the stem with a Level II suffix in English such as the plural is longer than the corresponding string in the monomorphemic counterpart, as in *laps* vs. *lapse*), but evidence shows that morphological effects also extend to other phonetic domains, including segmental quality and articulatory timing. For instance, English /l/ exhibits greater darkening prevocally at morphological boundaries (Lee-Kim et al., 2013; Strycharczuk & Scobbie, 2017); duration tends to increase at such boundaries (Walsh & Parker, 1983); and gestural coordination across morphemes is more variable than within monomorphemes, reflecting reduced intergestural stability with greater morphological complexity (Cho, 2001). Relatedly, Gafos et al. (2010), as mentioned above, demonstrate that the degree of gestural overlap in Moroccan Arabic clusters depends on their morphological origin. Together, these findings indicate that a wide range of phonetic properties—not only temporal cues—can systematically encode morphological distinctions.

Nevertheless, temporal studies have yielded important insights into how morphological structure may be phonetically encoded across contexts and languages (cf. Strycharczuk, 2019). A consistent finding in many experimental and corpus studies is that morphologically derived segments tend to be longer than their simplex counterparts—for instance, [s] in *laps* (plural) is often longer than in *lapse*, and [t] in *massed* (past tense) is longer than in *mast* (Ben Hedia & Plag, 2017; Losiewicz, 1992; Seyfarth et al., 2018; Sugahara & Turk,

2009; Walsh & Parker, 1983). However, other work reports the opposite pattern. In conversational speech, Plag et al. (2017) found that monomorphemic [s] in *lapse* can be longer than heteromorphemic [s] in *laps*, a result echoed by Tomaschek et al. (2021) and Schmitz et al. (2021). Crucially, these discrepancies appear to depend on speech register and task type: Plag et al. observed that conversational speech showed both durational and spectral differences (longer [s] had a higher spectral center of gravity), news-recorded speech showed only durational effects, and read speech showed neither. Tomaschek et al. further reported a gradient pattern—monomorphemic [s] longer than suffixal [s] (*laps*), which was in turn longer than clitic [s] (*she's*)—with segment duration predicted by the degree of lexical and collocational support for the morphological function: greater support yielded longer segments, greater uncertainty shorter ones. Relatedly, Seyfarth et al. (2018) and Engemann & Plag (2021) show that plural stems are shorter when the corresponding bare stem is more frequent, reflecting frequency-based gradient effects.

Taken together, these studies suggest that the phonetic encoding of morphological distinctions is not uniform across contexts or phonetic dimensions. Factors such as speech register, task type, word-form frequency, and lexical predictability, alongside other, as-yet-unidentified influences, can modulate both the direction and magnitude of durational effects and the possible engagement of non-temporal phonetic domains. Thus, while morphological structure can be systematically reflected in phonetic detail—especially in duration—the specific patterns observed may depend on a constellation of contextual, probabilistic, and yet-to-be-identified factors potentially spanning multiple phonetic dimensions. These complex findings challenge existing theories of the phonetics-morphology interface and underscore the need for theoretical accounts that integrate such variation with structural explanations of how morphology is prosodically and phonetically encoded within and across languages beyond the well-studied language families.

1.1.1. Prosodic parsing account

Building on this need for theoretical explanation, an influential earlier account is that of Sugahara and Turk (2009), who examined how sublexical morphemes are prosodically parsed within morphologically complex words in Scottish English. Using durational evidence, they showed that stems combined with a following Level II suffix as in *passed* were approximately 4–6% longer than phonologically comparable strings in monomorphemic words, such as *past*. They attributed this lengthening to sublexical prosodic organization: in morphologically complex forms with Level II suffixes, the stem constitutes its own prosodic word, introducing a prosodic boundary between stem and suffix. Monomorphemic words, by contrast, are parsed as a single prosodic word and lack such an internal boundary. Consequently, the stem *pass* in *passed* undergoes boundary-related durational lengthening, whereas *past* does not, resulting in a shorter rime duration. This **word-level prosodic parsing account** highlights the role of prosodic constituency in shaping the phonetic realization of morphologically complex forms. However, Sugahara and Turk also found that this effect emerged only at slow speech rates, suggesting that prosodic differences may be masked in casual

or faster speech but become more salient in clear or deliberately articulated contexts, where the word-internal prosodic boundary is more likely to be realized as hypothesized.

1.1.2. Paradigm uniformity account

An alternative account is offered within the framework of paradigm uniformity (cf. Steriade, 2000), which was also acknowledged by Sugahara and Turk (2009) and further elaborated by Seyfarth et al. (2018) and other studies (cf. Strycharczuk, 2019) in explaining the phonetic effects of morphological structure. The notion of phonetically driven paradigm uniformity holds that non-contrastive, fine-grained phonetic details present in a morphological base may systematically carry over to derived forms within the same morphological paradigm. This results in output-output correspondence at the phonetic level, such that related forms exhibit phonetic similarity. In this view, phonetic realization is shaped not only by phonological or prosodic structure, but also by morphological relationships within paradigms, reinforcing cohesion among related forms. Thus, the **paradigm uniformity account** explains the durational lengthening of the stem in a suffixed form (e.g., *passed*) relative to its monomorphemic counterpart (e.g., *past*) as the preservation of the base's phonetic properties (*pass*) in the derived form, thereby maintaining systemic phonetic consistency across paradigm members through their shared morphological identity.

However, Sugahara and Turk (2009) argue that their proposed prosodic parsing account offers greater explanatory power than the paradigm uniformity account. Their key point is that durational differences between morphologically complex and monomorphemic forms emerged only in slow speech. Rather than viewing this as a limitation, they interpret it as evidence in favor of prosodic parsing, since prosodic boundary effects are known to diminish or flatten at faster speech rates. By contrast, if the paradigm uniformity account were operative—transferring fine-grained phonetic properties from a base to its inflected forms—such effects would be expected to hold across speech rates. More broadly, they argue that the uniformity account fails to capture systematic durational variation within phonological representation, which is further shaped by prosodic structure above the word-level, as reflected, for example, in phrase-final lengthening. In contrast, the prosodic parsing account situates these effects within a well-developed theoretical framework of prosodic structure and its interaction with speech rate (cf. Shattuck-Hufnagel & Turk, 1996).

1.1.3. Extended paradigm uniformity integrated with gestural theory

In contrast to Sugahara and Turk's (2009) interpretation, Seyfarth et al. (2018) offer further evidence supporting the paradigm uniformity account. In American English, they found that stems in inflected forms (e.g., *free*s) are produced with longer durations than segmentally identical strings in monomorphemic words (e.g., *freeze*). They attribute this to the co-activation of the longer articulatory gestures associated with the morphological base (e.g., *free*), which are preserved across members of a paradigm. This view holds that phonetic realization is shaped by paradigm-based articulatory consistency. Seyfarth et al. further developed this account within the framework of Articulatory Phonology (Browman & Goldstein, 1990; Goldstein et al., 2006; Iskarous & Pouplier,

2022), integrating it with prosodic theory. In this integrated framework, articulatory lengthening effects arise from interactions between constriction-based articulatory gestures and non-constriction-based prosodic boundary gestures— π -gestures—where the latter modulate the temporal unfolding of the former at prosodic boundaries (Byrd & Krivokapić, 2021; Byrd & Saltzman, 2003).

Seyfarth et al.'s theoretical development of the integrated model is illustrated in Fig. 1, which also incorporates our schematic representation of the paradigm uniformity (PU) effect within the domain of the π -gesture. Note, however, that in their account, the π -gesture aligns with the prosodic word, yielding final lengthening at word boundaries rather than at phrase boundaries. If the π -gesture instead operated at a phrase-level juncture, its domain (as in Fig. 1b) would extend into at least part of the preceding [i]-gesture, consistent with cross-linguistic evidence that phrase-final lengthening reaches into the vowel—even in closed syllables (cf. Byrd & Saltzman, 2003; Cho, 2016, 2025; Fletcher, 2010; Paschen et al., 2022).

The central proposal is as follows: in the stem *free*, the [i]-gesture overlaps with a π -gesture (Fig. 1a), and this overlap is preserved in the derived form *freezes* (Fig. 1c), as indicated by the dotted line linking the two panels. Consequently, the π -gesture's domain extends over the suffixal [z]-gesture to the [i]-gesture, lengthening not only [i] but also [z], whose *complete* overlap, as shown in Fig. 1c, with the π -gesture further enhances its temporal realization. In contrast, in monomorphemic *freeze* (Fig. 1b), the π -gesture overlaps only partially with [z], so that only the part of the consonantal gesture—rather than the entire rime—receives boundary-related lengthening, and to a lesser extent than the suffixal [z] in *freezes*. This

mechanism accounts for why the rime of morphologically complex *freezes* ([i] + [z]) is longer than that of monomorphemic *freeze*. Moreover, because π -gestures vary systematically with prosodic boundary strength—both within and across words—embedding paradigm uniformity within a prosodic framework captures durational variation at both morphological junctures and phrase boundaries. As such, it addresses Sugahara and Turk's (2009) concern that paradigm-based explanations have not been fully integrated with prosodic mechanisms governing temporal variation.

Thus, Seyfarth et al.'s (2018) **extended paradigm uniformity account** integrated with gestural theory, provides a robust framework for investigating how morphological structure shapes the phonetic realization of homophonous words—particularly when their right-edge boundaries align with higher-level prosodic junctures beyond the word-level, which is precisely the focus of the present study. If the paradigm uniformity effect operates in such contexts, it predicts a consistent extension of the π -gesture domain across members of a paradigm, as schematized in Fig. 1c, but here with the domain extending beyond the prosodic word. Under this prediction, not only the stem portion (CVC) of morphologically complex forms (e.g., /tʃoŋ-i/ 'bell-NOM' or /pan-il/ 'class-ACC') but also the final rime associated with the overt case marker (/i/ or /il/) should undergo greater temporal expansion than the corresponding segmental strings in their monomorphemic counterparts (e.g., /tʃoŋil/ 'paper' or /panil/ 'needle'), provided that other factors—such as prosodic boundary strength—are held constant. To test this prediction, the present study examines homophonous words which are expected to occur at one of two phrase-level prosodic boundaries in Korean: the Accentual Phrase (AP), a minor phrase marking a smaller intonational unit and occurring frequently within sentences, or the Intonational Phrase (IP) which is the largest prosodic unit assumed in Korean (Jun, 1996).

1.1.4. Covert morphology enhancement Hypothesis and informativity-driven enhancement

At this point, it is worth recalling that the homophonous status of the Korean target words differs fundamentally from analogous cases in other languages, as noted earlier in the introduction. In English, homophony from morphological convergence typically contrasts a morphologically complex form with a genuinely monomorphemic counterpart, thereby preserving a clear distinction in lexical status. By contrast, the Korean case is more asymmetrical: the morphologically complex form is a noun with a *post-lexically* assigned case marker, forming a syntactic unit—a noun phrase—with an explicit morphosyntactic function. The "monomorphemic" form, however, is not purely monomorphemic; it effectively bears a covert case marker and functions as a noun phrase with the same grammatical role.

These contrasts invite further theoretical consideration—particularly whether paradigm uniformity effects extend to morphosyntactic contexts in which surface homophony results not from morphological concatenation but from the omission of a *post-lexically assigned grammatical marker*. This raises the possibility that, in Korean, speakers may employ phonetic strategies to preserve or recover the intended grammatical interpretation. In such cases, morphosyntactic pressure for

Schematized Paradigm Uniformity (PU) Effect on π -gesture Domain

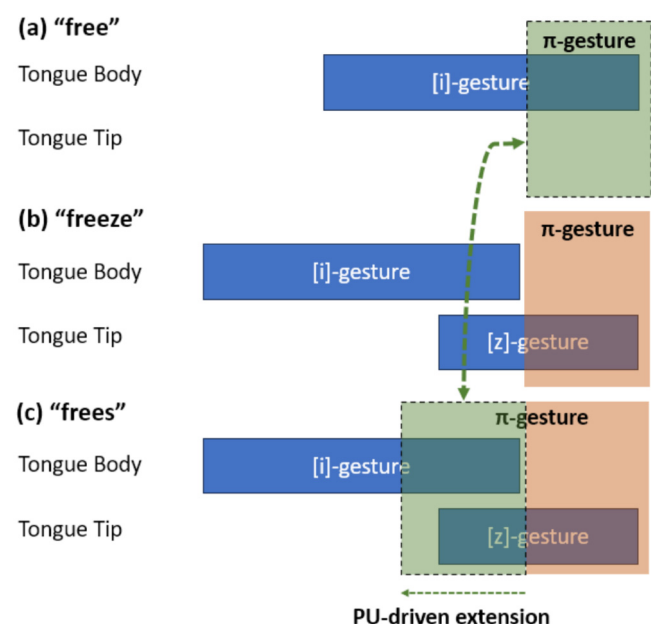


Fig. 1. Schematized Paradigm Uniformity (PU) effect on the domain of the π -gesture, illustrated with partial gestural scores for the rimes of (a) *free*, (b) *freeze*, and (c) *freezes* at the word-level (phrase-internal) prosodic juncture. The figure is adapted in its core conceptual structure from Fig. 1 in Seyfarth et al. (2018), with the PU-driven schematic extension newly added here.

uniformity across paradigms may give way to a communicative drive to maintain interpretive clarity in the absence of overt marking—a possibility we term the **Covert Morphology Enhancement Hypothesis**.

Under this hypothesis, phonetic cues—such as lengthening of the target word or its final syllable—may serve as compensatory signals for the *morphologically underspecified* case marking. These cues would not reflect paradigm uniformity per se, but rather function to reinforce grammatical distinctions that are no longer overtly marked by case morphology. In this view, the Korean case constitutes a qualitatively distinct type of morphosyntactic interface—one in which phonetic enhancement, rather than morphological regularization, may play the primary role in supporting syntactic interpretation. This possibility warrants close empirical investigation, as it suggests that surface homophony need not yield uniform patterns of phonetic convergence or divergence across languages, but may instead prompt language-specific strategies shaped by the structural pressures of the morphosyntactic system.

The Covert Morphology Enhancement Hypothesis is conceptually related to the informativity-driven accounts of phonetic enhancement (Pluymaekers et al., 2010; Smith et al., 2012; see Strycharczuk, 2019 for related discussion). The central claim of informativity-based approaches is that the same phonetic sequence, when differing in morphological composition or structural status, may be realized with different durations in order to facilitate listener comprehension. However, the rationale for how informativity translates into phonetic output appears to vary across authors.

Pluymaekers et al. (2010), for instance, examined Dutch words ending in *-igheid* (roughly comparable to the English suffix *-ness*). When *-igheid* functions as a single suffixal morpheme, the listener's cohort of possible words is largely restricted to those that share the suffix onset, beginning with *-i*. From an information-theoretic perspective, informativeness is defined as the probabilistic degree to which a segment reduces uncertainty about which word is being recognized. At the onset of the suffix, the vowel *-i* alone still leaves many competitors active in the cohort. Crucially, when the sequence *gh* [xh] follows *-i*, it substantially narrows down the candidate set, thereby strongly reducing lexical uncertainty. This reduction of competition makes the *gh* sequence highly informative for identifying the target word. In other words, because the informativeness of *gh* is high, it tends to be phonetically enhanced so as to fulfill its role in resolving the lexical ambiguity that still exists at the suffix onset. By contrast, the same *gh* arises across a morpheme boundary, as in *zuinigheid*, where *g* [x] belongs to the preceding morpheme, thus creating paradigms that are sparse. Here, *zuin* is not a word (or stem), but *zuinig* is, so the *g* in *gh* is parsed as part of the stem. Consequently, the heteromorphemic sequence *gh* contributes little to the recognition of a specific word (or stem) and thus is not phonetically enhanced in duration—i.e., a sequence that carries low informativity for lexical access does not invite phonetic enhancement, since such enhancement would provide little benefit to the listener.

In contrast to Pluymaekers et al. (2010), Smith et al. (2012) discussed “phonetic information” in relation to morphological productivity, proposing that when an affix is highly productive—and therefore offers little predictive value for the stem—

this morphological structure may lead to reinforced phonetic information, especially via durational enhancement, to support lexical access. They found that the prefix *mis-* in true-prefixed words like *mistype* is longer and clearer than in pseudo-prefixed words like *mistake*. In *mistype*, *mis-* (true prefix) is a productive morpheme that transparently signals a separable meaning (“wrongly type”) and can freely combine with other stems such as *mistime* or *mismatch*. This productivity reduces its predictive power over the following stem, making the identity of the whole word less predictable. The resulting uncertainty appears to be compensated for by heightened phonetic information at the morphological boundary and a stronger rhythmic beat on the first syllable, thereby facilitating lexical access. By contrast, in *mistake*, *mis-* (pseudo prefix) is no longer productive: it does not transparently convey a separable meaning (“mistake” ≠ “mis” + “take”) and has greater cohesion with the following stem, which may facilitate access to the word as a whole. This structural support for the whole word recognition reduces the functional need for phonetic enhancement. Thus, within this framework, informativity appears to be linked to phonetic information, which enhances a morpheme's contribution to lexical access. In pseudo-prefixed contexts such as *mistake*, the sequence is less decomposable, and no boundary-related phonetic enhancement appears to be required.

The two studies mentioned above refer to different types of informativity, yet what emerges from both is that phonetic enhancement tends to occur in the presence of lexical ambiguity—whether temporal (Pluymaekers et al., 2010) or structural (Smith et al., 2012). In light of the information-based account of morphology, we consider a similar mechanism in the present case. Specifically, omission of an overt case marker reduces morphological transparency, with such words carrying lower information, thus prompting speakers to enhance the phonetic clarity of the target word—through durational expansion and potentially other prosodic cues such as *f0* (as discussed further below)—to preserve grammatical interpretability despite the underspecified case marking. This possibility, framed here as the Covert Morphology Enhancement Hypothesis, is tested in the present study as a potential alternative to the paradigm-uniformity-driven account.

1.2. Prosodic encoding of morphological structure beyond the temporal domain

In addition to testing the aforementioned hypotheses, which focus primarily on temporal variation, the present study also investigates whether and how morphological structure influences phrase-level prosody—specifically (i) prosodic phrasing and (ii) the dynamics of *f0* realization—in homophonous target words, within the framework of the intonational phonology of Seoul Korean (henceforth Korean). This focus addresses a phenomenon that may be termed the “**prosodic encoding of morphological structure**,” referring to the prosodically driven phonetic realization of morphological distinctions—that is, the use of prosody at both the macro (phonological) and micro (phonetic) levels to signal morphological structure. In Korean, an edge-prominence language (Jun, 2005, 2014), intonation is closely integrated with prosodic phrasing, with phrase edges serving as the primary locus of prominence. This prominence

is realized through distinct boundary tones and durational patterns at the levels of the Accentual Phrase (AP) and Intonational Phrase (IP) (Jun, 1996, 1998, 2005). The canonical AP melody follows an [LH...LH] pattern, with rising contours aligned to both the left and right phrase edges. Given this intonational system—where f_0 primarily marks prosodic boundaries as a cue to phrase-level prominence, rather than lexically defined prominence as in English—Korean offers a particularly informative context for examining how prosody may reflect or compensate for morphological distinctions. Such distinctions are likely to align with prominent phrase edges, which not only function as loci of prominence but also enable enhanced prosodic realization.

Particularly relevant to the present study, case markers in Korean canonically appear at the right edge of noun phrases—positions that coincide with major syntactic junctures, such as between the subject NP and the verb phrase (nominative case) or between the object NP and the verb (accusative case). Given the well-attested alignment between syntactic and prosodic structure (Jun, 2009; Bennett & Elfner, 2019; Celle & Pélissier, 2024), these syntactic boundaries are likely to correspond to major prosodic boundaries, typically at the level of an Accentual Phrase (AP) or, in some cases, an Intonational Phrase (IP). This raises the question of whether morphological structure—specifically, the presence or absence of overt case marking—affects the likelihood of syntactic junctures being mapped onto prosodic boundaries. In other words, do covertly case-marked forms exhibit different prosodic phrasing patterns from their overtly marked counterparts, despite being segmentally identical? If case-marking information must be recovered in the absence of overt morphology, as discussed above, speakers may exploit phrasing to enhance interpretive clarity—particularly in Korean, where prosodic phrasing is known to play a role in signaling prominence (Jang, 2023; Jun, 2005, 2014; cf. Hatcher et al., 2024).

From the macro-level perspective of intonational phonology, a speaker's choice of prosodic phrasing or boundary marking in relation to morphological structure can be viewed as a phonological strategy. Prosodic phrasing reflects phonological decisions about the placement of prosodic boundaries, each associated with distinct tonal specifications (Ladd, 2008; Pierrehumbert, 1980). If the morphological structure under investigation is recoverable through such prosodic boundary marking, this constitutes *the prosodic encoding of morphological structure at the macro (phonological) level*—that is, in the planning of prosodic structure. The same notion applies at the micro-level (phonetic) domain: prosody may signal morphological structure through fine-grained, non-contrastive acoustic cues within the same macro-level prosodic structure. For example, durational properties—often serving as prosodic cues at the word-level—can be adjusted to enhance morphological distinctions, as illustrated earlier. The present study extends this notion to phrase-level prosody, asking whether temporal variation, in conjunction with the π -gesture hypothesized above, similarly encodes morphological structure at a larger prosodic domain. In this sense, the duration-related effects examined here can be regarded as *prosodic encoding of morphological structure at the micro (phonetic) level*, now manifested in the temporal dimension at phrasal junctures.

At the micro-prosodic level, another possible domain of prosodic encoding involves modulation of tonal realization by morphological structure, even when prosodic phrasing is phonologically identical—i.e., when the same boundary marking with the same tonal specification is used. Specifically, when homophonous words with covert versus overt case marking are produced within identical prosodic boundaries, do they nonetheless differ in how the assigned phonological tones are realized at the micro-prosodic level? One may hypothesize that speakers signal morphological distinctions through subtle f_0 adjustments shaped by the *phonetic grammar* of the language, which may reference higher-order structures, including morphosyntactic ones, in a language-specific manner (cf. Cho, 2025), much as the same phonological tones can be realized differently depending on how the tonal peak is phonetically aligned with the segmental string in a language-specific way (Arvaniti et al., 1998; Ladd et al., 2000; see Ladd, 2008, for a review). If, as discussed earlier, the reduced informativity associated with covert case marking prompts enhancement, speakers may increase the phonetic clarity of these forms by manipulating f_0 in perceptually salient ways—such as raising overall pitch level or amplifying tonal peaks—within the same prosodic frame. To test this hypothesis, we analyze the time-course dynamics of f_0 across the target words, since localized f_0 measures alone may fail to capture how such cues are deployed continuously over time.

1.3. Prominence contexts as a methodological testbed for morphological encoding

Finally, to address the research questions and competing hypotheses outlined above, we examine two focus-related factors to assess how the hypothesized phonetic encoding of morphological structure may vary across prominence contexts (see Section 2.1 for details). The first, the *morphological focus* context was designed so that speakers directly confront the morphological contrast—presence versus absence of the case marker—by producing sentence pairs in that order. This arrangement explicitly draws attention to the overt-covert contrast and is motivated by prior findings that phonetic effects of morphosyntactic structure, often subtle or absent in casual speech, tend to emerge more clearly in hyperarticulated contexts such as slow or careful speech (e.g., Sugahara & Turk, 2009). More broadly, as Strycharczuk (2019) notes, phonetic evidence for morphological effects often depends on the nature of the task, contributing to variability in the literature. We therefore adopted a task that explicitly emphasizes the morphological contrast to test how speakers signal morphological distinctions between segmentally identical words when their attention is directed toward the difference.

The second, the *lexical focus* context, involves narrow (corrective) focus on a lexical item, directing attention to a lexical rather than morphological contrast. This allows us to assess whether and how morphological distinctions are phonetically differentiated when prominence is induced primarily for lexical purposes. Although focus-induced prominence of this sort is known to enhance lexical contrasts (de Jong, 1995), it may also enhance grammatical and structural cues. For example, Zhang et al. (2024) found that in both English and Mandarin, focus did not override syntax-driven prosodic phrasing,

suggesting that focus can reinforce boundary marking and structural clarity independently of lexical emphasis. This also aligns with the broader view that prosody encodes meaning at multiple representational levels (Cho, 2025; Cole, 2015; Shattuck-Hufnagel & Turk, 1996). Furthermore, the paradigm uniformity hypothesis discussed above may also be relevant under prominence: when a lexical item is contrastively focused, its realization may be enhanced in a way that strengthens uniformity across related morphological forms, potentially maximizing both lexical contrast and morphological consistency. Thus, even when prominence originates from a lexical contrast, it may enhance the signaling of morphological distinctions. However, previous research also shows that prosodic enhancement under focus can sometimes mask other phonetic cues, such as reducing domain-initial strengthening or attenuating phrase-final lengthening (e.g., Cho, 2016, 2022). These competing possibilities—enhancement versus masking—mean that the effect of focus on morphological signaling cannot be assumed a priori. Moreover, given that the present study examines multiple phonetic correlates of morphological structure—duration, f_0 dynamics, and prosodic phrasing—different cues may show different interactions with focus-induced prominence. Thus, it remains an open question how focus-induced prominence in the lexical focus context will interact with the phonetic encoding of morphological structure across these cues.

2. Methods

2.1. Speech materials

The target words comprised sixteen pairs of homophones or near homophones, differing in their morphological structure. Each homophonous pair included a simplex target (bare noun) and one complex target (noun and case marker). The function of the case marker was to mark either the nominative (*/-i/*) or accusative (*/-il/*) case. The complete list of these (near) homophonous pairs is provided in Table 1. (Notice that, of the sixteen pairs, three—marked with an asterisk in Table 1—are

near-homophonous: $/\Delta rini/-\Delta rin-i/$ and $/nop^hi/-nip^h-i/$, where the vowel in the syllable preceding the case marker [and its corresponding segmental string in the monomorphemic counterpart] differs; and $/kojaŋi/-/kohjaŋi/$, which differ in the presence versus absence of a glottal fricative $/h/$ in the onset of the second syllable.)

The target words were embedded in naturalistic carrier sentences and were always preceded by a disyllabic modifier. The noun phrase's position within the carrier sentence varied as a function of its case: nominative targets appeared early in the carrier sentence immediately following the modifier, while accusative noun phrases occurred approximately mid-sentence, following a four-syllable nominative noun phrase. In addition to the targets, sentences bearing their morphological non-homophonous counterparts were included as fillers. For example, in addition to sentences bearing the homophones $/panil/$ 'needle' and $/pan-il/$ 'class-ACC', filler sentences included the non-homophonous $/panil-il/$ 'needle-ACC' and $/pan/$ 'classroom' (see Table 2). These non-homophonous target words were included to assist participants in producing the correct renditions but were not analyzed in this study.

The speech materials were designed to include two types of contrastive focus: morphological and lexical. The *morphological focus* context aimed to examine the phonetic encoding of morphological distinctions—specifically, the presence versus absence of a case marker, presented in that order. In this condition, participants read pairs of synonymous sentences, the first containing a target noun with an overt case marker (morphologically complex; Table 2a.1), and the second with the same noun lacking the marker (morphologically simplex; Table 2a.2). This fixed sequencing was intended to establish a clear morphological contrast, effectively creating a focus-like context in which the absence of the case marker in the second sentence becomes perceptually salient. By drawing speakers' attention to the missing marker, this setup allows us to examine how they may phonetically signal its absence when it is made contextually prominent—effectively functioning as a form of *morphological focus*, as termed in the present study.

Table 1

List of homophonous target word pairs in nominative and accusative cases. Out of the 16 pairs, three pairs marked by * are near-homophonous in which the preceding vowel before the case marker (or its corresponding segmental string in the simplex context) or presence versus absence of a glottal fricative $/h/$ differs.

Nominative		Accusative	
Simplex	Complex	Simplex	Complex
* $/kojaŋi/$ 'cat'	$/kohjaŋ-i/$ 'hometown-NOM'	$/panil/$ 'needle'	$/pan-il/$ 'class-ACC'
$/tjoŋi/$ 'paper'	$/tjoŋ-i/$ 'bell-NOM'	$/manil/$ 'garlic'	$/man-il/$ 'bay-ACC'
$/koŋi/$ 'pestle'	$/koŋ-i/$ 'ball-NOM'	$/hanil/$ 'sky'	$/han-il/$ 'sorrow-ACC'
* $/\Delta rini/$ 'child'	$/\Delta rin-i/$ 'adult-NOM'	$/papil/$ 'bubble'	$/pap-il/$ 'law-ACC'
$/kili/$ 'length'	$/kil-i/$ 'road-NOM'	$/kakil/$ 'mouthwash'	$/kak-il/$ 'angle-ACC'
* $/nop^hi/$ 'height'	$/nip^h-i/$ 'swamp-NOM'	$/kusil/$ 'marble'	$/kus-il/$ 'exorcism-ACC'
$/p^huli/$ 'solution'	$/p^hul-i/$ 'grass-NOM'	$/kukil/$ 'Google'	$/kuk-il/$ 'soup-ACC'
$/pjaŋi/$ 'variation'	$/pjaŋ-i/$ 'side-NOM'	$/kokil/$ 'goggles'	$/kok-il/$ 'song-ACC'

Table 2

List of example carrier sentences for the target pair, $/panil/$ and $/pan-il/$ in the accusative condition. Target words are provided in bold and the preceding modifier in italics. Note that $/panil/$ (a.2 and c.2) and $/pan-il/$ (b.1 and d.1) serve as homophonous target words, while $/panil-il/$ (a.1 and c.1) and $/pan/$ (b.2 and d.2) serve as fillers. The example sentences in the nominative condition appear in Appendix A1.

Morphological Focus Context		
Example sentences		English translations
a.	1. /ʃ.ʌŋmani-ka uli panil-il tʰaʃaʃuʌtt*ɛ/ 2. /ʃ.ʌŋmani-ka uli panil tʰaʃaʃuʌtt*ɛ/	Youngman found <i>our</i> needle . Youngman found <i>our</i> needle .
b.	1. /ʃ.ʌŋmani-ka uli pan-il tʰaʃaʃawas*ʌtt*ɛ/ 2. /ʃ.ʌŋmani-ka uli pan tʰaʃaʃawas*ʌtt*ɛ/	Youngman visited <i>our</i> class . Youngman visited <i>our</i> class .
Lexical Focus Context		
Example sentences		English translations
c.	1. /ʃ.ʌŋmani-ka uli kolmu-lil tʰaʃaʃuʌtt*ɛ/ /ani. ʃ.ʌŋmani-ka uli panil-il tʰaʃaʃuʌtt*ɛ/ 2. /ʃ.ʌŋmani-ka uli kolmu tʰaʃaʃuʌtt*ɛ/ /ani. ʃ.ʌŋmani-ka uli panil tʰaʃaʃuʌtt*ɛ/	Did Youngman find our thimble? No. Youngman found <i>our</i> needle . Did Youngman find our thimble? No. Youngman found <i>our</i> needle .
d.	1. /ʃ.ʌŋmani-ka uli tʃip-il tʰaʃaʃuʌtt*ɛ/ /ani. ʃ.ʌŋmani-ka uli pan-il tʰaʃaʃuʌtt*ɛ/ 2. /ʃ.ʌŋmani-ka uli tʃip tʰaʃaʃuʌtt*ɛ/ /ani. ʃ.ʌŋmani-ka uli pan tʰaʃaʃuʌtt*ɛ/	Did Youngman visit our house? No. Youngman visited <i>our</i> class . Did Youngman visit our house? No. Youngman visited <i>our</i> class .

For the *lexical focus* context, as illustrated in Table 2c–d, participants read answer sentences in response to yes–no questions, where the target word in the answer corrected the noun presented in the question—thereby establishing a contrast between two lexical items. In this context, the presence or absence of the case marker was systematically controlled: if the noun in the question included the case marker, so did the corrective answer (Table 2c.1), forming a morphologically complex condition; conversely, if the question omitted the marker, the answer did too, resulting in a morphologically simplex condition (Table 2c.2). Thus, while the primary manipulation in this *lexical (corrective) focus* context involved lexical contrast, the dataset featured the same target words as in the *morphological focus* context, thereby also embedding two morphological conditions—i.e., *complex* with a case marker and *simplex* without. This design allowed us to examine whether—and if so, how—speakers may also signal morphological distinctions when their attention is directed primarily to lexical contrast rather than to the presence or absence of the case marker.

2.2. Participants

Twenty-one native Seoul Korean speakers (12 females, 9 males), all students at Hanyang University, participated in the study. The participants were in their early to mid-twenties ($M_{\text{age}} = 23$ years) at the time of the recordings. All reported residing in Seoul or the surrounding Gyeonggi Province and had lived abroad for no more than two years ($M = 5.5$ months). None of the participants reported any hearing or communication disorders. All participants were compensated for their involvement in the study.

2.3. Procedure

To elicit variation in the factors as naturally as possible within a controlled laboratory setting, the two focus contexts were presented in separate blocks. In each block, participants saw the carrier sentence on a computer screen accompanied by a visual aid illustrating the meaning of the target. They were instructed to read the sentence so that the target words would occur in connected speech. Each block was repeated three times in three lists with different randomized orders. To ensure that participants were familiar with all target items and clearly understood their meanings, they took part in a familiarization session of approximately 30 minutes before the actual recording sessions. During this session, participants went through the entire list of test words at least once in carrier sentences across all experimental contexts, with accompanying visual aids illustrating the intended meanings. No participant reported difficulty understanding or producing any of the target words. In addition, target pair was included as a random effect in the statistical analyses (see Section 2.6), ensuring that any potential item-specific variability did not drive the reported results. The practice session familiarized the participants with the procedure and the two focus contexts. The experimenter monitored each utterance for errors in focus placement—defined only for the *lexical (corrective) focus* condition, in which narrow focus was required on the target word and an error consisted of focal prominence realized on a non-target word—as well as for inadvertent pause insertion, hesitation, or other disfluencies.

Focus-placement errors were not directly relevant to the *morphological focus* condition, as this condition concerned an overt-covert contrast and did not itself require differences in focal prominence. If an error was detected during the recording, the speaker was immediately prompted to repeat the utterance. Acoustic recordings of the productions were collected in a sound-attenuated room at Hanyang Institute for Phonetics and Cognitive Sciences of Language using a Tascam HC-P2 digital recorder and a SHURE KSN44 condenser microphone at a sampling rate of 44.1 kHz with 32-bit quantization.

A total of 4032 tokens were collected: 16 target pairs $\times$ 2 morphological structures (simplex/complex) $\times$ 2 focus types (morphological/lexical) $\times$ 3 repetitions $\times$ 21 speakers. Two pairs consisting of trisyllabic targets (504 tokens), /kojaŋji/ ‘cat’ vs. /kohjaŋ-i/ ‘hometown-NOM’ and /ʌrini/ ‘child’ vs. /ʌrin-i/ ‘adult-NOM’, were later excluded as the words evidenced substantial differences in duration and fundamental frequency contours from the other pairs. All recordings were first screened for disfluencies and production errors by the first two authors, both trained in Korean ToBI. Tokens with hesitations and/or production errors (32 tokens) were also excluded. This yielded a total of 3496 tokens for further acoustic analysis. TextGrids were created in Praat (Boersma & Weenick, 2025) for the tokens to be analyzed, segmenting the onset and rimes for both the target word and its preceding modifier.

2.4. Prosodic phrasing analysis

To examine how morphological complexity interacts with prosodic phrasing, and how the phonetic encoding of morphological structure manifests within a controlled prosodic context, we analyzed how the target word was prosodically grouped with surrounding contextual words—that is, how it was phrased with the preceding and following words. This analysis aimed to identify three phrasing patterns, marked by a prosodic boundary (‘#’): (i) no phrasal boundary (i.e., a prosodic word boundary), (ii) an Accentual Phrase (AP) boundary, and (iii) an Intonational Phrase (IP) boundary—each of which could occur before and/or after the target word. For example, in a sentence such as /ʌŋmani-ka uli # panil # tʰatʃatʃuʌtte/ (‘Youngman found our needle’), the target word /panil/ could be phrased together with the following word /tʰatʃatʃuʌtte/ (i.e., no prosodic boundary), or separated from it by either an AP or an IP boundary. A similar range of phrasing patterns was expected to occur between the target word and the preceding word /uli/ (‘our’); however, since /uli/ functions as a modifier within the noun phrase, it is expected to be more frequently phrased with the following target noun.

At this point, it is worth noting that recent revisions to the K-ToBI framework have proposed an intermediate phrase (ip) level between the AP and the IP in Korean (Jun, 2011; Kang & Kong, 2022). At the same time, the phonological status of the ip—particularly when invoked to explain focus-related effects—remains a matter of debate, as prosodic strengthening under focus can be realized through gradient phonetic enhancement of focused elements and intonational contours without necessitating a categorical prosodic boundary such as an AP or a hypothetical ip (Hatcher et al., 2024; Cho et al., 2026). In light of this debate, we do not assume a priori that focus realization in Korean necessarily entails the inser-

tion of an ip boundary, and therefore do not annotate focus using an ip-level category in the present analysis. Instead, our prosodic transcription is purely *intonation-based*, adopting an earlier version of the K-ToBI framework. This approach is also consistent with Jun's (1998) original intonation-based conception of the Korean prosodic hierarchy and aligns with the general assumptions of Autosegmental-Metrical (AM) theory of intonational phonology, which treats prosodic structure as emerging from intonational patterning (Ladd, 2008), rather than as being determined by fixed categorical structural units such as a particular focus type or a specific syntactic juncture. However, even if certain focus configurations were assumed to introduce an ip boundary, such a boundary could only explain effects tied to focus realization (Focus Type), not systematic differences between simplex and complex forms observed within the same focus condition—which is the core empirical target of the present study. That is, even under an ip-based analysis of focus, simplex and complex targets within the same focus condition would belong to the same prosodic category, such that the observed differences must be attributed to morphological structure rather than to prosodic constituency.

Phrasing analyses were conducted based on the K-ToBI transcription conventions (Jun, 2005). The initial annotations were carried out by one of the authors and cases that were difficult to classify were reviewed by the remaining co-authors, and final labels were determined by consensus. The initially identified ambiguous cases constituted about 1% of the entire corpus (44 out of 4032 tokens). In these cases, all four authors examined the tokens, and classifications were adopted when at least three of the four authors agreed. All authors involved were experienced K-ToBI transcribers.

The resulting phrasing patterns were first analyzed in their own right to examine how morphological complexity and focus structure interact with prosodic phrasing. Prosodic phrasing was initially coded with multiple possibilities, including cases where the target word and its preceding modifier occurred within the same AP, in separate APs, or were separated by an IP boundary. However, as detailed below in Section 3.1, the majority of tokens fell into two patterns: (i) the target phrased as a separate AP and (ii) the target phrased together with the preceding modifier (combined AP), for both of which the right edge of the target words aligns with an AP boundary. Accordingly, the statistical analysis of how target words varied in phrasing as a function of morphological structure was limited to these two patterns. These patterns were also included in the statistical analyses, with phrasing treated as a variable to control for potential effects of prosodic boundaries on the phonetic measures under investigation.

2.5. Acoustic measures

2.5.1. Temporal measures

The duration of the final rime of the target word (Rime Duration)—/i/ in the nominative context and /il/ in the accusative context—was measured, as it corresponds to the morphologically ambiguous segmental string of the word. That is, this final rime contains the case marker in morphologically complex targets (e.g., /tʃoŋ-i/ or /pan-il/) or the corresponding segmental material in the simplex context (e.g., /tʃoŋ/ or /panil/). The duration was measured manually by inspection of the wave-

form and spectrogram. In particular, boundaries between onsets and rimes were determined by identifying the onset of the vowels, especially on the basis of second formant cues. For object targets containing /il/, the vowel and the following lateral consonant were labeled together as a single unit to define the rime duration. The duration of the segmental string preceding the rime (Pre-Rime Duration)—that is, the portion of the target word comprising the initial syllable and the onset of the second syllable—was also measured to assess how the temporal structure of the entire word is influenced by its morphological structure. Specifically, in the complex word, this duration corresponds to the *stem*, whereas in the monomorphemic word, it represents only a tautomorphemic portion of the word.

2.5.2. Tonal measures

Continuous f0 contour values for the target and pre-target words were extracted from the acoustic recordings using the STRAIGHT algorithm (Kawahara et al., 2005) in VoiceSauce (Shue et al., 2011). To control for cross-speaker differences in overall pitch height and pitch range, all f0 values were z-score normalized by speaker. Similarly, given that the durations of the target and pre-target words differed across tokens, the time variable was normalized to be between 0 and 1 and then centered so that timepoint zero refers to the midpoint of the measured region. These data were then submitted to a generalized additive mixed model (GAMM) analysis (Wood, 2017) described in detail below, to determine whether the realization of the intonational melody differed significantly as a function of the morphological structure of target words, and how such effects may vary across different conditions.

As a complement to the contour-based analysis, we also measured the magnitude of the f0 rise in target words belonging to the two frequent phrasing types. Since all such tokens were AP-final, with the characteristic AP-final rise beginning in the penultimate syllable, rise magnitude was defined as the difference between the local minimum f0 before the final syllable and the subsequent maximum, typically occurring in or near the final rime. This supplementary measure allowed us to assess not only whether the AP-final rise itself varied as a function of morphological structure, but also whether the effects identified in the GAMM analyses could be further interpreted in terms of differences in rise magnitude, which serves as a key cue to AP-finality.

2.6. Statistical analysis

The data were analyzed using a combination of logistic regression, linear mixed-effects models, and generalized additive mixed models, depending on the dependent measure. Statistical analyses were conducted in R (v.4.5.0; R Core Team, 2025) using packages lme4 (Bates et al., 2015) and mgcv (Wood, 2011). Unless otherwise noted, all categorical predictors were sum-coded using centered contrasts (± 0.5).

To investigate how Morphological Structure (*simplex/complex*) and Focus Type (*morphological/lexical*) influence the prosodic phrasing of target words, we fitted a logistic regression model predicting whether the target was realized as an independent AP or grouped with the preceding modifier. As discussed in Section 2.4 (and further in Section 3.1), the

analysis was restricted to these two most frequent phrasing types (*separate AP* and *combined AP*). In addition to the fixed effects of Morphological Structure and Focus Type and their interaction, the model included random intercepts and slopes for both predictors by speaker and target pair.

The effects of Morphological Structure (*simplex/complex*), Focus Type (*morphological/lexical*), Prosodic Phrasing (*separate AP/combined AP*), Case (*nominative/accusative*) and their interactions on Rime and Pre-Rime Duration were tested with linear mixed-effects models, with random intercepts for speaker and target pair. Significant interactions were followed up with pairwise comparisons using *emmeans* (Lenth et al., 2022) with Bonferroni adjustment. Because duration measures were strongly right-skewed, confirmed by a Shapiro–Wilk test on Final Rime Duration ($W = 0.9867$, $p < 0.001$), models were fitted with gamma regression and a log link to ensure appropriate fit (Lo & Andrews, 2015).

These same predictors were also examined with respect to the f0 contour of the target word using generalized additive mixed models (GAMMs). Unlike linear mixed-effects models, GAMMs do not assume a strictly linear relationship between predictor and response variables (Sóskuthy, 2021; Wieling, 2018; Wood, 2017). Because f0 varies continuously and non-linearly over the duration of a word, GAMMs are particularly well suited to model the temporal trajectory of pitch contours, with both fixed effects and random effects modeled as non-linear smooths.

In Seoul Korean, the shape of the AP melody varies with the phonological category of the phrase-initial segment (Jun, 1996): APs beginning with aspirated or tense stops or fricatives start with a high (H) tone, while all others start with a low (L) tone, the default pattern. To control for this segmental effect, we excluded two target pairs predicted to induce an AP-initial H tone (/p^huli/ ‘grass-NOM; solution’ and /hani/ ‘sorrow-ACC; sky’), leaving 12 pairs with L-initial APs expected to exhibit the canonical LH rise for the f0 analyses.

Time-normalized f0 contours of the target words were analyzed over a scaled interval from -0.5 to 0.5 , excluding the initial consonant since it was often voiceless and lacked measurable f0. This ensured contour modeling reflected only voiced segments. Fixed effects were modeled using factor-smooth interactions of normalized time by condition (e.g., $s(\text{time}, \text{by} = \text{condition})$), allowing contour shape to vary by factor level. Random reference and difference smooths were added for speaker and target pair to capture individual variation in pitch range and contour shape (Sóskuthy, 2021). These models were used to generate predicted contours and visualize non-linear fixed effects.

For hypothesis testing, separate GAMMs were fitted for *nominative* and *accusative* targets for three reasons: (i) the two cases occur in different sentence positions (earlier for *nominative*, later for *accusative*), affecting f0 declination; (ii) they are marked by different case markers, which, together with position, may induce distinct microprosodic effects; and (iii) durational analyses revealed interactions of Morphological Structure with Case, suggesting case-specific effects. Following Wieling (2018) and Sóskuthy (2021), factor smooths were evaluated using binary difference smooths rather than visual inspection alone. A binary difference smooth models the pointwise difference between two contours over normalized time,

with the grouping factor coded binarily (e.g., *complex* = 0, *simplex* = 1), thereby estimating the magnitude and direction of condition differences at each time point. Significance is determined by the p-value of the difference smooth in the GAMM output, with plots inspected to identify intervals where the 95% confidence band excluded zero, indicating the temporal extent of the effect. To address temporal autocorrelation in the residuals—expected from f0 sampling at closely spaced time points—an AR(1) error structure was incorporated via the rho parameter in the bam() function, with rho estimated from the data. Model adequacy was assessed by comparing models with and without interaction terms and by inspecting the autocorrelation function (ACF) and fitted-versus-residuals plots. This was necessary because hypothesis testing of f0 within a GAMM framework using binary difference smooths requires explicit decisions about the inclusion of higher-order interaction smooths due to their substantial impact on model complexity and interpretation. This procedure differs from the duration analyses, which were conducted using parametric mixed-effects models in which higher-order interactions can be specified a priori and evaluated directly via model coefficients. Accordingly, we compared GAMMs that included a three-way interaction between Morphological Structure, Focus Type, and Prosodic Phrasing with otherwise identical models that excluded this term while retaining all lower-order effects. Model comparison was conducted using maximum likelihood estimation, and model fit was evaluated using AIC. The model including the three-way interaction provided a substantially better fit to the data ($\Delta \text{AIC} = 1573$) and was therefore retained for subsequent analyses.

Finally, the f0 rise magnitude—defined as the difference between the local minimum and the subsequent f0 maximum—was analyzed as a complementary measure to the GAMM analysis, using a linear mixed-effects model with the same predictors as the previous models and random intercepts for speaker and target pair.

3. Results

3.1. Prosodic phrasing results

Before statistically examining the effect of morphological structure on phrasing, we first analyzed how the target words—pooled across morphological conditions—were phrased with their neighboring words. The overall phrasing patterns are summarized in Table 3, which is divided into two Focus Contexts: (a) the target words were produced in pairs differing in the presence versus absence of a case marker (*morphological focus*), and (b) the target words were produced under focus in a lexical (corrective) focus contrast (*lexical focus*). In both contexts, two phrasing patterns predominated as indicated by the gray shading in the table: most target words were either phrased together with the preceding modifier (/uli/ ‘our’) within a single AP (*combined AP*), or produced as an independent AP (*separate AP*). However, the distribution of these patterns differed across focus contexts: they, with the two patterns combined, accounted for over 95% of tokens in the *morphological focus* context (Table 3a) but only just over 68% in the *lexical focus* context (Table 3b). Notably, in the *lexical (corrective) focus* context, focused target words were more

Table 3

Frequency counts of prosodic boundary strengths preceding and following the target word. The left table (a) reports data from the *morphological focus* context, while the right table (b) presents data from the *lexical (corrective) focus* context. Shaded cells denote the two most frequent phrasings.

(a) Target words produced in pairs in the morphological focus context						(b) Target words produced in the lexical (corrective) focus context					
Preceding boundary	Following boundary	Word	AP	IP	Total	Preceding boundary	Following boundary	Word	AP	IP	Total
Word	Simplex	2 (0.1)	518 (29.8)	29 (1.7)	549 (31.5)	Word	Simplex	45 (2.6)	147 (8.4)	14 (0.8)	206 (11.7)
	Complex	5 (0.3)	601 (34.5)	6 (0.3)	612 (35.2)		Complex	50 (2.8)	172 (9.8)	13 (0.7)	235 (13.4)
	Subtotal	7 (0.4)	1119 (64.3)	35 (2.0)	1162 (66.7)		Subtotal	95 (5.4)	319 (18.2)	27 (1.5)	441 (25.1)
AP	Simplex	0 (0)	292 (16.8)	19 (1.1)	311 (17.8)	AP	Simplex	99 (5.7)	447 (25.5)	67 (3.8)	613 (34.9)
	Complex	1 (0.1)	256 (14.7)	9 (0.5)	266 (15.3)		Complex	104 (5.9)	430 (24.5)	53 (3.0)	587 (33.5)
	Subtotal	1 (0.1)	548 (31.5)	28 (1.6)	577 (33.1)		Subtotal	203 (11.6)	877 (50.0)	120 (6.8)	1200 (68.4)
IP	Simplex	0 (0)	0 (0)	2 (0.1)	2 (0.1)	IP	Simplex	5 (0.3)	29 (1.7)	21 (1.2)	55 (3.1)
	Complex	0 (0)	1 (0.1)	0 (0)	1 (0.1)		Complex	9 (0.5)	27 (1.5)	22 (1.2)	58 (3.3)
	Subtotal	0 (0)	1 (0.1)	2 (0.1)	3 (0.2)		Subtotal	14 (0.8)	56 (3.2)	43 (2.4)	113 (6.4)
Total	Simplex	2 (0.1)	810 (46.5)	50 (2.9)	862 (49.5)	Total	Simplex	149 (8.5)	623 (35.5)	102 (5.8)	874 (49.8)
	Complex	6 (0.4)	858 (49.3)	15 (0.8)	879 (50.5)		Complex	163 (9.3)	629 (35.9)	88 (5.0)	880 (50.2)
	Grand Total	8 (0.5)	1668 (95.8)	65 (3.7)	1741 (100)		Grand Total	312 (17.8)	1252 (71.4)	190 (10.8)	1754 (100)

frequently produced as an independent AP—i.e., preceded and followed by an AP boundary—than in the *morphological focus* context (50% vs. 31.5%). Moreover, target words in the *lexical focus* context were also more frequently followed by an IP boundary (10.8%), compared to 3.7% in the *morphological focus* context. These patterns suggest that corrective focus promotes the formation of an independent Accentual Phrase and may even trigger stronger prosodic boundaries—such as a following IP boundary.

As noted in the Methods (Section 2.4), in both focus contexts the vast majority of tokens ended in an AP and fell into one of two phrasing patterns: the target forming a combined AP with the preceding modifier (*combined AP*) or forming an independent AP (*separate AP*). Accordingly, subsequent statistical analyses of morphological structure were restricted to these two patterns. To verify the differences in phrasing patterns suggested by the counts, we analyzed this subset with a logistic regression, including focus type and morphological structure as fixed effects, and random intercepts and slopes for speaker and pair, where a pair refers to two morphologically distinct target words that are homophonous. (The detailed tabular results of the logistic regression analysis predicting the likelihood of the target word occupying an independent AP is provided in the Appendix, Table B1.) First, the results, as shown in Fig. 2, confirmed the general observation in Table 3 regarding the more frequent formation of independent APs in the *lexical focus* context. Specifically, the odds of the target word being phrased as an independent AP were 7.11 times higher in the *lexical (corrective) focus* context than in the *morphological focus* context (OR = 7.11, 95% CI [4.921, 10.279], $p < 0.001$), as also reflected in the higher predicted probability of AP formation in the former than in the latter context, as shown in Fig. 2.

More importantly, with respect to morphological structure, the odds of the target word being phrased as an independent AP were about 1.3 times higher in the *simplex* condition (i.e., without a case marker) than in otherwise homophonous *complex* counterparts (i.e., with a case marker) (OR = 1.296, 95% CI [1.059, 1.587], $p = 0.012$). This difference is also evi-

dent in the predicted probabilities shown in Fig. 2, where AP formation is generally more likely for the former than for the latter in both focus contexts. There was no interaction between Focus Type and Morphological Structure (OR = 0.8823, 95% CI [0.618, 1.259], $p = 0.490$), indicating that the greater likelihood of forming an independent AP in the *simplex* condition held across both focus contexts. In other words, speakers were more likely to form an independent AP when the target word ended with a tautomorphic rime (i.e., the *simplex* condition with covert case marking) than when it ended with a heteromorphic rime (i.e., the *complex* condition with overt case marking), thereby signaling morphological structure through phrasing—albeit in a subtle and probabilistic manner.

3.2. Temporal results

3.2.1. Final rime duration

Statistical results on the effect of Morphological Structure on the duration of the target words' final rimes (measured at an

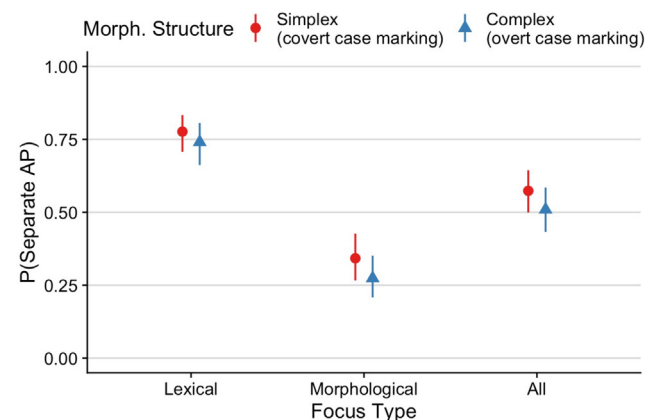


Fig. 2. Predicted probabilities indicating the likelihood of the target word being phrased as an independent (separate) Accentual Phrase (AP). Red circles represent simplex forms (covert case marking), and blue triangles represent complex forms (overt case marking). Error bars indicate 95% confidence intervals based on model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

AP boundary in all conditions) are summarized in Fig. 3. The regression analysis revealed a significant main effect of Morphological Structure on rime duration ($\hat{\beta} = 0.06$, $SE(\hat{\beta}) = 0.009$, $t = 6.911$, $p < 0.001$), with *simplex* target words exhibiting, on average, approximately 6% longer rimes than *complex* target words, as shown in Fig. 3a. In other words, speakers produced longer rimes in the *simplex* condition (i.e., with covert case marking) than in the *complex* condition (i.e., with overt case marking), thereby signaling Morphological Structure through rime duration.

There were also significant main effects of Focus Type ($\hat{\beta} = 0.22$, $SE(\hat{\beta}) = 0.009$, $t = 24.40$, $p < 0.001$) and Prosodic Phrasing ($\hat{\beta} = 0.036$, $SE(\hat{\beta}) = 0.009$, $t = 3.95$, $p < 0.001$). As for the Focus Type effect, final rimes in the *lexical focus* context (under corrective focus) were, on average, 25% longer than in the *morphological focus* context, as shown in Fig. 3b. As for the Prosodic Phrasing effect, final rimes were approximately 3.6% longer when target words were phrased as an independent AP (*separate AP*) than when phrased together with the preceding modifier (*combined AP*), as shown in Fig. 3c. The two-way interaction between Morphological Structure and Phonological Phrasing was not significant ($p > 0.05$).

More importantly, there were significant interactions between Morphological Structure and other factors. First, there was a Morphological Structure $\times$ Focus Type interaction ($\hat{\beta} = -0.043$, $SE(\hat{\beta}) = 0.017$, $t = -2.488$, $p < 0.001$). As shown in Fig. 3b, this interaction was driven by a larger difference in rime duration due to Morphological Structure in the *morphological focus* context ($\sim 8.4\%$) than in the *lexical focus* context ($\sim 3.9\%$). In other words, speakers made the morphological

distinction—producing a longer final rime in the *simplex* condition with covert case marking—more robust in the *morphological focus* context than in the *lexical focus* context under corrective focus.

There was also a three-way interaction among Morphological Structure, Case, and Prosodic Phrasing ($\hat{\beta} = 0.077$, $SE(\hat{\beta}) = 0.035$, $t = 2.213$, $p = 0.027$). As shown in Fig. 3d, this interaction was driven in part by the absence of a Morphological Structure effect on rime duration in the *nominative* case with the *combined AP* phrasing pattern. In contrast, in the *accusative* case, the morphological effect was evident for both phrasing patterns, indicating a more consistent effect than in the *nominative* condition.

In summary, rime-duration results showed that morphological distinctions in the homophonous target words were clearly marked but in the opposite direction of English. Whereas English *complex* forms (e.g., *freezes*) typically have longer suffixes than monomorphemic forms (e.g., *freeze*), here the final rime in the *complex* condition was shorter. This indicates temporal expansion in the *simplex* condition with covert case marking. The effect was stronger in *morphological focus* than in *lexical focus* and was most robust in the *accusative*, while in the *nominative* it emerged only with the *separate AP* phrasing pattern.

3.2.2. Pre-rime duration (corresponding to the stem duration in the complex condition)

The regression analysis on pre-rime duration (i.e., the initial CVC that corresponds to the stem in the *complex* condition), summarized in Fig. 4, revealed significant main effects of Focus Type ($\hat{\beta} = 0.35$, $SE(\hat{\beta}) = 0.005$, $t = 66.87$, $p < 0.001$) and Prosodic Phrasing ($\hat{\beta} = 0.04$, $SE(\hat{\beta}) = 0.005$, $t = 7.69$,

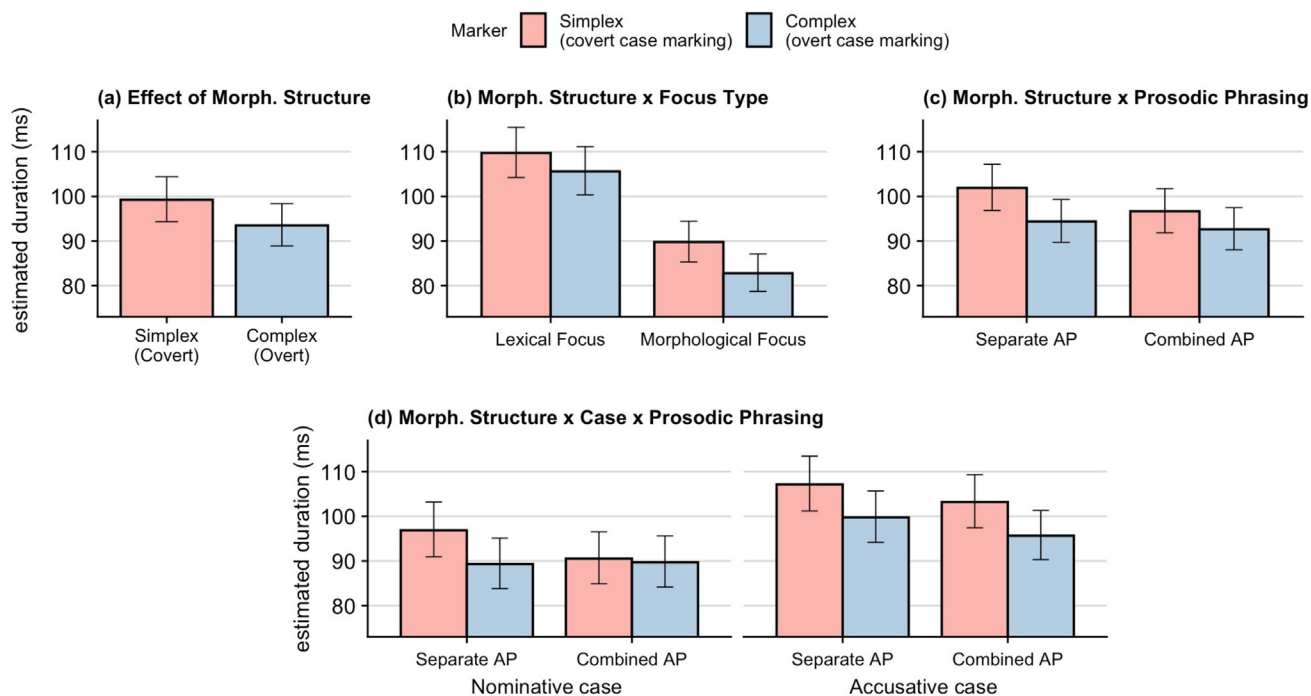


Fig. 3. Distribution of target final-rime durations across four panels. Panel (a) illustrates the main effect of Morphological Structure; panel (b), the interaction between Morphological Structure and Focus Type; panel (c), the interaction between Morphological Structure and Prosodic Phrasing; and panel (d), the three-way interaction among Morphological Structure, Case, and Prosodic Phrasing. In each pair of bars, the left bar represents simplex forms (covert case marking; shown in red), whereas the right bar represents complex forms (overt case marking; shown in blue). Error bars indicate 95% confidence intervals based on model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

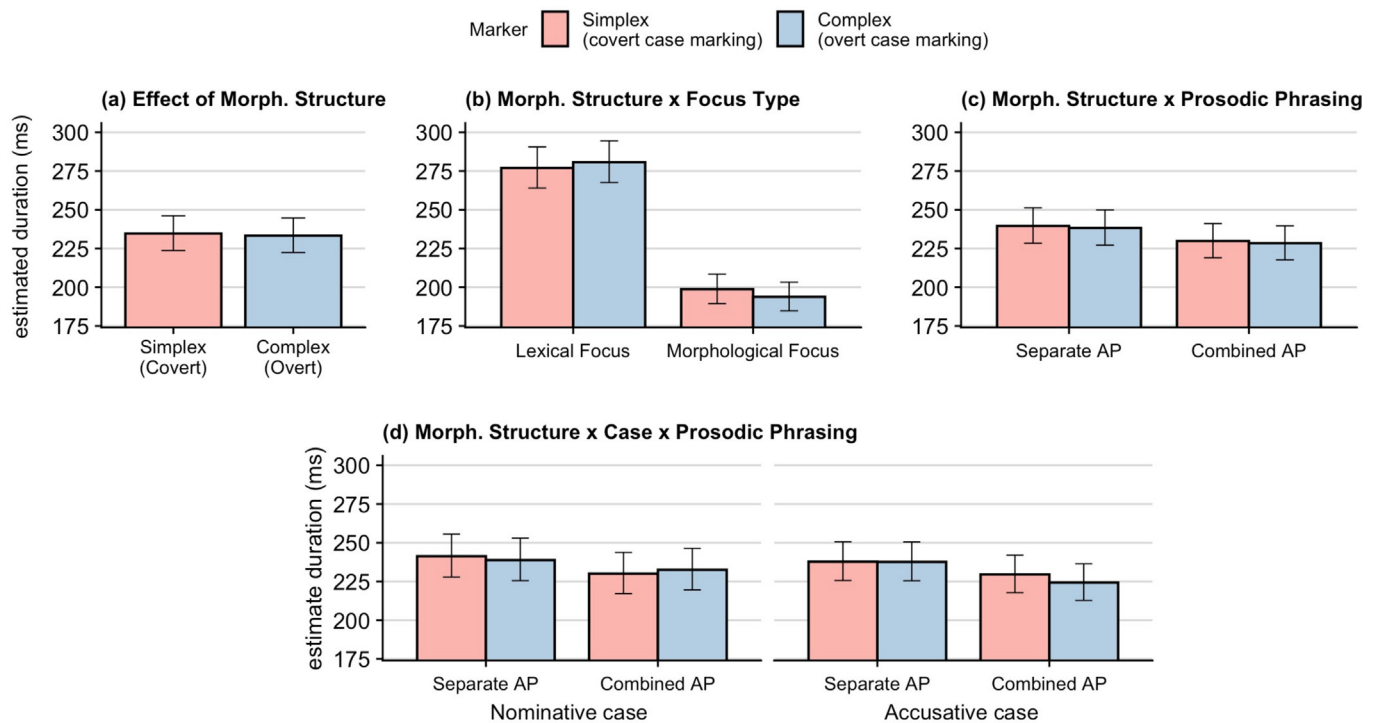


Fig. 4. Distribution of pre-rime duration (i.e., CVC duration before the final rime which corresponds to the stem duration in the complex condition) across four panels. Panel (a) illustrates the main effect of Morphological Structure; panel (b), the interaction between Morphological Structure and Focus Type; panel (c), the interaction between Morphological Structure and Prosodic Phrasing; and panel (d), the three-way interaction between Morphological Structure, Case, and Prosodic Phrasing. In each pair of bars, the left bar represents simplex forms (covert case marking; shown in red), whereas the right bar represents complex forms (overt case marking; shown in blue). Error bars indicate 95% confidence intervals based on model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

$p < 0.001$), but no effect of Morphological Structure ($\hat{\beta} = 0.006$, $SE(\hat{\beta}) = 0.005$, $t = 1.13$, $p = 0.26$). The Focus Type effect reflects an approximately 42% longer pre-rime duration in the *lexical focus* context than in the *morphological focus* context—unsurprising given that *lexical focus* involved corrective focus on the entire target word, leading to durational expansion across the word (see Fig. 4b). The Prosodic Phrasing effect, with the pre-rime duration about 4% longer in a *separate AP* than in a *combined AP*, is also expected, as more syllables within a single AP generally result in shorter syllable durations (see Fig. 4c).

Crucially, a significant interaction between Morphological Structure and Focus Type was observed ($\hat{\beta} = -0.04$, $SE(\hat{\beta}) = 0.01$, $t = -3.75$, $p < 0.001$). This interaction is partly attributable to a significant Morphological Structure effect on pre-rime durations in the *morphological focus* context, but not in the *lexical focus* context, as shown in Fig. 4b. Specifically, in the *morphological focus* context, pre-rime duration in the *simplex* condition (with covert case marking) was 2.6% longer than in the *complex* condition (with overt case marking) where the pre-rime corresponds to the stem. There was also a significant three-way interaction among Morphological Structure, Case, and Prosodic Phrasing ($\hat{\beta} = 0.04$, $SE(\hat{\beta}) = 0.02$, $t = 2.10$, $p = 0.04$). As shown in Fig. 4d, this interaction indicates that the Morphological Structure effect observed in the *morphological focus* context was further restricted to the *accusative* condition with the *combined AP* pattern, as confirmed by pairwise post hoc tests ($\hat{\beta} = 0.02$, $SE(\hat{\beta}) = 0.01$, $t = -2.53$, $p = 0.011$). No other Case $\times$ Prosodic Phrasing combinations showed a significant effect (all $p > 0.05$).

In summary, the pre-rime results—i.e., the initial CVC strings corresponding to the stem in the *complex* condition—show that morphological structure generally did not affect the portion of the word preceding the final rime. That is, contrary to what has been reported for English, stems in the *complex* condition were not longer than in the *simplex* condition. In fact, the opposite appeared in one specific case: in the *accusative* with the *combined AP* context, pre-rime duration was *shorter* in the *complex* condition. As with rime duration, the directionality contrasts with English where suffixed stems (i.e., in the *complex* condition) are often reported to be longer than their monomorphemic counterparts. Here, by contrast, temporal expansion emerged in the *simplex* condition with covert case marking.

3.3. F0 results

3.3.1. GAMM results in the nominative condition

The first model tested whether Morphological Structure of the target word affected its f0 contour when the word was in the *nominative* case. To interpret this interaction, we examined the effect of Morphological Structure within each Focus Type $\times$ Prosodic Phrasing context. Specifically, we fitted four binary difference smooths, one for each combination of Focus Type (*morphological focus/lexical focus*) and Prosodic Phrasing (*separate AP/combined AP*). Each binary difference smooth represents the partial effect of Morphological Structure on the f0 contour of the target word for that particular Focus–Phrasing combination, allowing us to visualize and test how morphological effects on f0 vary across prominence and phrasing contexts.

The GAMM results are illustrated in Fig. 5 (see the figure caption for details on data interpretation). In the *morphological focus* context with the target word forming a *separate AP* (Fig. 5a), the effect was significant (edf = 5.634, $F = 3.010$, $p = 0.004$). The f_0 contour in this condition shows a clear rise in the second half of the word, with the peak further differentiated to be higher in the *complex* condition (overt case marking) than in the *simplex* condition (covert case marking). In other words, the presence of the case marker appears to enhance the typical AP-final f_0 rise, causing it to culminate at an even higher peak.

In the second case (Fig. 5b), still within the *morphological focus* context but with the target word forming a *combined AP* with the preceding modifier, the effect was marginal (edf = 4.856, $F = 2.020$, $p = 0.061$). In this configuration, as seen in Fig. 5b, the typical AP-final rise—usually aligned with the latter part of the phrase—appears to occur quite earlier, so that the final rise is less prominent. Nevertheless, there is some indication of a difference resembling the clearer pattern in Fig. 5a: the presence of the case marker tends to yield slightly higher f_0 values toward the end of the word, although the effect is weaker.

In the third and fourth cases (Fig. 5c–d), both in the *lexical focus* context, there is a clear f_0 rise characteristic of the AP-final position. This suggests that *lexical (corrective) focus* enhances the f_0 rise, marking the AP-final position more distinctly than in the *morphological focus* conditions (Fig. 5a–b) where only the morphological contrast was emphasized. As for the effect of Morphological Structure, however, only the fourth case (Fig. 5d) in the *combined AP* condition showed a significant effect (edf = 6.159, $F = 3.563$, $p = 0.001$)—i.e., the AP-final f_0 rise was much higher, but this time in the *simplex* condition (covert case marking). In contrast, when the target word formed a *separate AP* (Fig. 5c), no such morphological effect emerged.

In summary, in the *nominative* context—where targets occur early in the sentence—GAMM results show some significant effects of Morphological Structure on f_0 , in a context-dependent manner. In the *morphological focus* context, only when the target formed a *separate AP*, f_0 rise was heightened in the *complex* condition (overt case marking) relative to the *simplex* condition (covert case marking). Thus, the f_0 elevation pattern is not a compensation for covert case marking, but rather reflects the presence of overt case marking. In the *lexical focus* context, compared to the *morphological focus* context, the f_0 rise was more sharply peaked toward the end in both the *simplex* and *complex* conditions. Within this context, the Morphological Structure effect was confined to the *combined AP* condition, suggesting possible compensation for covert case marking, with the peak higher in the *simplex* condition.

3.3.2. GAMM results in the accusative condition

As in the *nominative* analysis, for *accusative* targets we then fitted four binary difference smooths to examine the effect of Morphological Structure within each Focus $\times$ Prosodic Phrasing context.

The GAMM results, illustrated in Fig. 6 (see figure caption for details), show significant effects of Morphological Structure only in the *morphological focus* context, in both Prosodic Phrasing conditions: *separate AP* (edf = 2.000, $F = 5.380$, $p = 0.005$) and *combined AP* (edf = 7.625, $F = 8.113$, $p < 0.001$). As shown in Fig. 6a–b, both conditions display a noticeable f_0 rise toward the end of the AP in both *simplex* and *complex* conditions, but in the *complex* condition (with overt case marking), marked by the blue ribbons in the figure, f_0 is generally higher starting from the beginning up to near the peak. That is, in the *separate AP* condition (Fig. 6a), this elevation spans from word onset through roughly two-thirds of the word, ending just before the f_0 peak, whereas in the *combined AP* condition (Fig. 6b) it extends further to the peak itself.

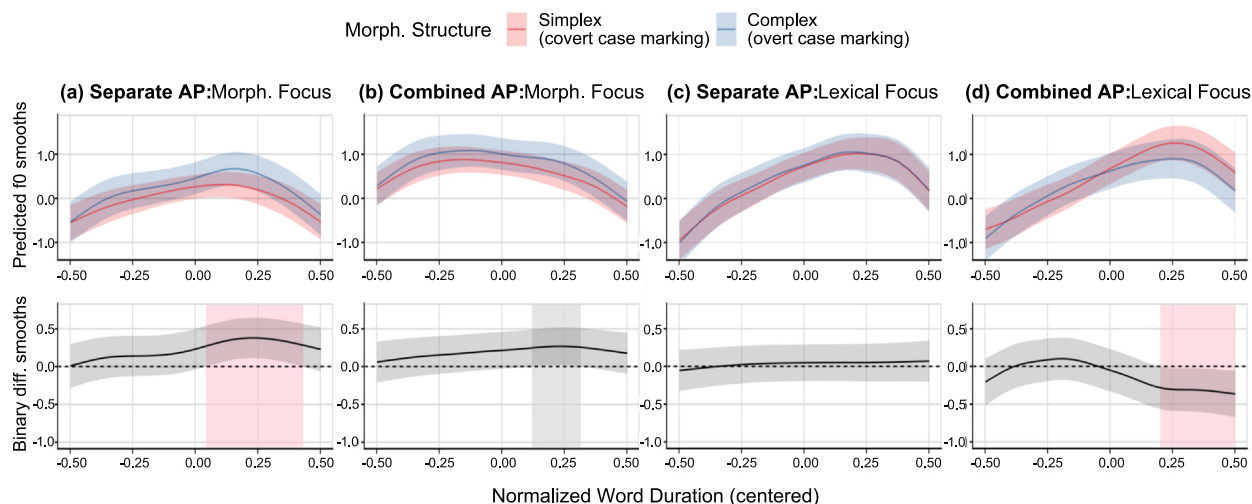


Fig. 5. Predicted f_0 smooths (top row) and binary difference smooths for Morphological Structure (bottom row) for target words in the nominative case. Each panel (a–d) corresponds to one of the four Focus Type $\times$ Phrasing conditions. In the top row, smooths curves show the model-predicted f_0 trajectory for complex forms with clitics (blue) and simplex forms without clitics (red). In the bottom row, the curve represents the predicted difference between these two trajectories (overt case marking – covert case marking). The shaded ribbon indicates the 95% confidence interval around the estimate and pink shaded boxes mark time intervals where the predicted difference is statistically significant, while the grey shaded box marks the time interval where the predicted difference is marginally significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

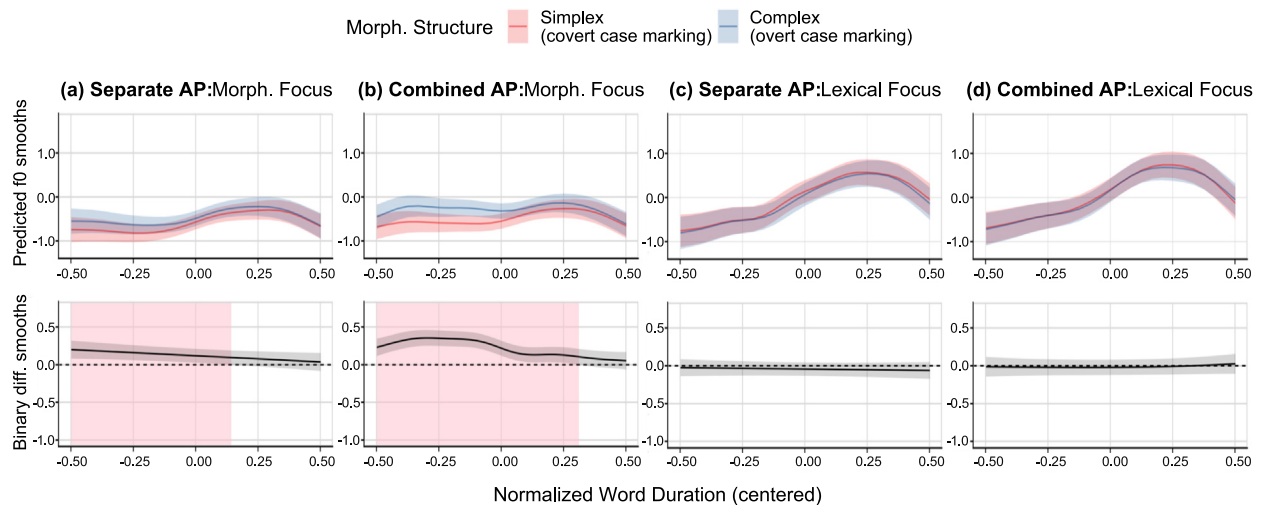


Fig. 6. Predicted f0 smooths (top row) and binary difference smooths for Morphological Structure (bottom row) for target words in the accusative case. Each panel (a–d) corresponds to one of the four Focus x Phrasing conditions. In the top row, smooths curves show the model-predicted f0 trajectory for complex forms with clitics (blue) and simplex forms without clitics (red). In the bottom row, the curve represents the predicted difference between these two trajectories (overt case marking – covert case marking). The shaded ribbon indicates the 95% confidence interval around the estimate and pink shaded boxes mark time intervals where the predicted difference is statistically significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Compared with the *nominative* case, where f0 elevation effects emerged later in the word, the *accusative* case—in which the effect of Morphological Structure started earlier—can thus be characterized by a more global elevation of f0. Nevertheless, both cases share the pattern of elevated f0 in the *complex* condition—i.e., the presence of a case marker (*nominative* or *accusative*) raises f0 over at least part of the target word.

Crucially, however, these patterns take on a different interpretation when viewed from a different angle. The early elevation of f0 in the *complex* condition (with overt case marking) necessarily means a relative lowering in the *simplex* condition (with covert case marking). Since the later portion of the f0 contour—at or near the peak—shows no significant difference, this pattern indicates that, in relative terms, the magnitude of the f0 rise is actually greater in the *simplex* condition, where f0 begins at a lower value, with covert case marking.

In contrast, in the *lexical focus* context (Fig. 6c–d), there is no evidence of Morphological Structure effects on the f0 contour. Nevertheless, as in the *nominative* case, the f0 rise is markedly heightened in this context under corrective focus for both *simplex* and *complex* conditions, likely overriding the morphological effects observed in the *morphological focus* context.

In summary, for *accusative* targets, Morphological Structure effects on f0 were confined to the *morphological focus* context, appearing in both *separate AP* and *combined AP* conditions. The *complex* condition (overt case marking) showed higher f0, especially early in the contour, though differences diminished later near the peak. Thus, compared with the *nominative* case, the effects for *accusative* targets were more global. Crucially, however, the early f0 elevation in the *complex* condition also means that the *simplex* condition (covert case marking) begins with a lower f0, thereby exhibiting a relatively greater f0 rise magnitude, suggesting possible compensation for covert case marking. In the *lexical focus* context, no Morphological

Structure effects emerged, presumably because the pronounced f0 rise under corrective focus overrode any morphological effects.

3.3.3. Results on f0 rise magnitude

For the analysis of f0 rise magnitude, included as a complementary measure to the GAMM analyses, the dataset was divided by Case (*nominative/accusative*), as in the GAMM analyses. For the *nominative* case, no main effect of Morphological Structure on rise magnitude was observed ($\hat{\beta} = -0.005$, $SE = 0.042$, $t = -0.12$, $p = 0.905$; Fig. 7a). The only significant predictors in this condition were Focus Type ($\hat{\beta} = 0.822$, $SE = 0.043$, $t = 19.17$, $p < 0.001$) and Prosodic Phrasing ($\hat{\beta} = -0.164$, $SE = 0.045$, $t = -3.69$, $p < 0.001$), neither of which interacted with Morphological Structure. This indicates that rise magnitude in the *nominative* condition was unaffected by the presence or absence of case marking across focus and phrasing patterns.

For the *accusative* case, in line with the GAMM analyses, there was a significant main effect of Morphological Structure ($\hat{\beta} = 0.105$, $SE = 0.035$, $t = 3.05$, $p = 0.002$), with *simplex* forms (covert case marking) exhibiting larger rise magnitudes than *complex* forms (Fig. 7b). Importantly, this effect did not interact with Focus Type or Prosodic Phrasing, indicating that the greater f0 rise magnitude associated with *simplex* forms (with covert case marking) was robust across focus and phrasing contexts.

In summary, for *nominative* targets, Morphological Structure had no effect, whereas for *accusative* targets, it significantly influenced f0 rise magnitude, with *simplex* forms (covert case marking) exhibiting larger rises than *complex* forms, broadly in alignment with the GAMM findings. This effect was even more robust than the difference indicated by the GAMM results, as it held consistently across Focus and Prosodic Phrasing contexts.

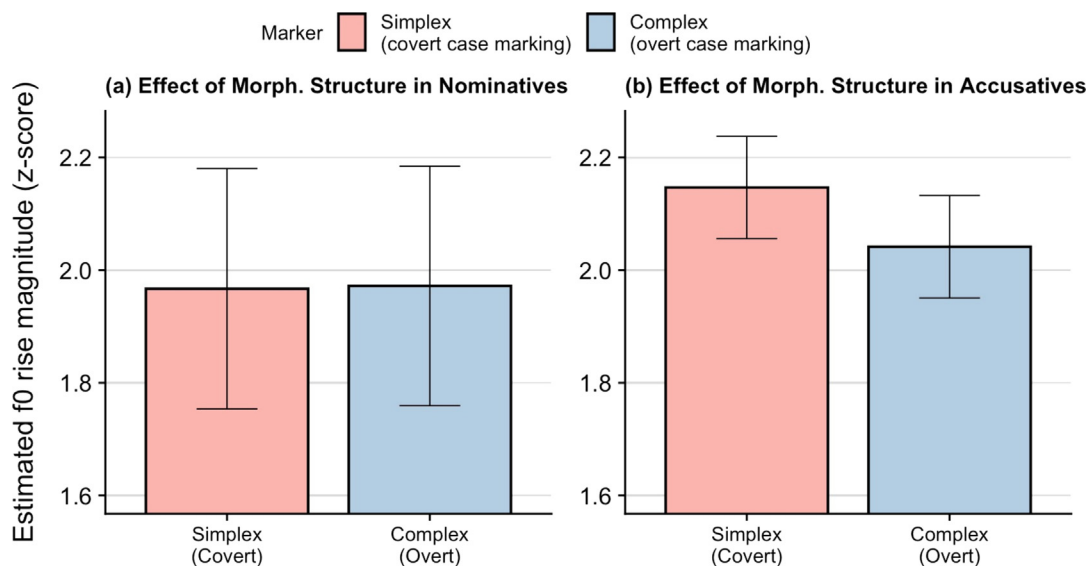


Fig. 7. Estimated magnitude of AP-final f0 rise (z-score normalized) as a function of Morphological Structure for *nominative* (a) and *accusative* (b) targets. In each pair of bars, the left bar represents simplex forms (covert case marking; shown in red), whereas the right bar represents complex forms (overt case marking; shown in blue). Error bars represent 95% confidence intervals from the model estimates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. General discussion

This study set out to address a central question in phonetics-morphology interaction: how morphological structure is encoded in phonetics and shaped by various other factors (cf. Strycharczuk, 2019). Most prior work has focused on word-level morphology in Indo-European—especially West Germanic—languages (e.g., Sugahara & Turk, 2009; Seyfarth et al., 2018; see Strycharczuk, 2019 for a review), with only limited evidence from other languages, nonetheless revealing language-specific tuning (e.g., Gafos et al., 2010). In Korean, case marking aligns with major syntactic junctures, and syntax-prosody mapping often places the right edge of an overtly or covertly case-marked word at a phrase-level boundary. Such boundaries, defined by intonational-phonological structure and fine suprasegmental detail, offer an ideal context for investigating what we term *the prosodic encoding of morphology*—that is, the use of prosody at both the macro (phonological) and micro (phonetic) levels to signal morphological structure.

We tested whether Seoul Korean distinguishes segmentally identical *simplex* forms (covert case marking) from *complex* forms (overt case marking) at phrasal junctures aligned with these syntactic boundaries. Target words were elicited in two prominence contexts: *morphological focus*, contrasting the presence versus absence of the case marker in otherwise identical sentence pairs, and *lexical (corrective) focus*, in which speakers corrected a misstatement of the word's lexical identity while keeping its morphological structure constant. We then examined whether duration and f0 patterns differentiated these forms and how such cues interacted with prosodic phrasing. This approach assesses how macro-level prosodic organization and micro-level suprasegmental detail jointly signal morphosyntactic distinctions—phrasing providing the structural scaffolding, and fine-grained cues supplying the detail—together constituting the prosodic encoding of morphology.

4.1. Main findings

At the macro-level of prosody, prosodic phrasing showed clear sensitivity to morphological structure. Across both prominence contexts, two patterns predominated: the target either formed an Accentual Phrase (AP) with the preceding modifier (*combined AP*) or stood as an independent AP (*separate AP*), with the right edge of the target word in both cases consistently aligning with an AP boundary. Crucially, *simplex* forms—lacking an overt case marker—were more often phrased as *separate APs* than *complex* forms. This phrasing bias toward morphologically *simplex* forms emerged in both *morphological-* and *lexical-focus* contexts. It is also worth noting that, while the bias was realized primarily through AP formation, in some cases it involved the insertion of an Intonational Phrase (IP) boundary superimposed on an AP boundary following the target. These macro-level phrasing patterns therefore constitute a prosodic correlate of morphological structure, albeit in a probabilistic manner, illustrating how covert morphology can be encoded prosodically—rather than segmentally—within the language's intonational grammar. Crucially, the results suggest that *simplex* forms more often occur in prosodically prominent positions by virtue of forming an independent (*separate*) AP, given that in Korean, as an edge-prominence language, prosodic phrasing itself is taken to mark prominence (e.g., Jun, 2005, 2014; Jang, 2023; Kim et al., 2024; cf. Hatcher et al., 2024). This positional, or phrasing, advantage may serve to compensate for the absence of overt morphology in their covert, morphologically underspecified case marking.

At the micro-level of prosody, duration provided a robust cue to morphological structure, particularly at the AP-final rime, reflecting local fine-grained phonetic modulation at an AP edge in spite of the generally limited magnitude of AP-final lengthening. It is important to note that covert case marking is encoded through gradient timing differences within the temporal domain

consistent with the AP edge, rather than through amplification of boundary-related lengthening beyond the AP-related effect. The observed pattern therefore reflects within-category temporal modulation at the AP level and does not involve a categorical shift to the stronger lengthening associated with a higher prosodic constituent such as the IP edge. That is, the effect is gradient within the same AP category, while the morphologically conditioned difference remains statistically robust. Across conditions, final rimes were consistently longer in *simplex* than in *complex* targets, indicating temporal enhancement for covert case marking. This effect was amplified under *morphological focus* and was most consistent in the *accusative* case, appearing in both *separate*- and *combined*-AP conditions. In *nominatives*, however, the effect disappeared in *combined* APs, raising the possibility that a preceding boundary—here, a prosodic-word rather than an AP boundary—may attenuate the realization of morphological contrasts compared to target words forming an independent AP, a possibility warranting further investigation. Although this direction contrasts with some reports from English, cross-linguistic evidence suggests that suffix-related lengthening patterns are highly sensitive to contextual and structural factors. Notably, the direction of this pattern—longer rimes for monomorphemic words (with covert marking)—contrasts with suffixal lengthening patterns often reported for English (e.g., Sugahara & Turk, 2009; Seyfarth et al., 2018). Recall, however, that the opposite pattern has also been observed in English (e.g., Plag et al., 2017; Schmitz et al., 2021), likely reflecting the influence of additional conditioning factors on suffix realization, such as speech register, task type, word-form frequency, and lexical predictability (Pluymaekers et al., 2010; Plag et al., 2017; Engemann & Plag, 2021; see also Strycharczuk, 2019). Overall, the present findings suggest that morphologically underspecified covert case marking in monomorphemic target words prompts speakers to lengthen the word's right edge at the phrasal juncture, presumably to preserve morphosyntactic clarity in the absence of overt case marking.

Pre-rime (CVC) durations, corresponding to the stem in *complex* forms, showed neither a general leftward spread of morphological effects nor evidence of stem enhancement in *complex* forms, indicating that temporal enhancement is strongest in the final rime, although a smaller effect was also observed in the initial CVC under certain conditions. This also runs counter to the stem-lengthening patterns often reported for West Germanic languages and, if anything, reinforces the broader tendency for *simplex* forms to receive temporal enhancement—here extending to the entire word—to bolster morphologically underspecified case marking.

Taken together, the temporal results indicate that morphological structure is prosodically encoded at the micro-level of timing, with its strongest effect at the morphologically informative right edge of the word—aligned with the AP boundary—enhancing covert case marking at that edge. In some contexts, particularly under *morphological focus* when the covert-overt contrast was emphasized, temporal expansion extended beyond the final rime to the initial CVC portion of the word, though this effect was smaller in magnitude than the rime-based effect. These findings further support the idea that prosodic timing can compensate for the absence of overt morphological marking.

Dynamics of f0 contours over the time course of the target words revealed additional micro-level prosodic encoding of morphological structure, though the patterns differed by case type.

For *nominatives*—occurring early in the sentence—GAMM analyses revealed significant morphological effects under both *morphological* and *lexical focus* conditions, modulated by focus type and prosodic phrasing. However, the nature of the morphological effects (i.e., overt-covert distinctions) differed between the *morphological* and *lexical focus* conditions.

- Under *morphological focus*, *complex* forms (i.e., with overt case marking) exhibited some elevation of final f0, but only when realized as *separate* APs. This pattern contrasts with the temporal results, where final-rime duration was greater for *simplex* forms (i.e., without an overt *nominative* marker) showing some compensatory enhancement. In the f0 domain, by contrast, enhancement surfaced on the *complex* form, specifically as elevated f0 in the latter half of the word. Thus, this pattern, as it occurs with overt case marking, is likely tied to boundary realization rather than compensatory enhancement per se. Since AP boundaries in Korean are commonly realized with final f0 raising, and because overt case marking is more frequent for the *nominative* than for the *accusative* (Lee, 2006), *nominative* markers are typically aligned with AP-final position. Their segmental presence is therefore naturally associated with the canonical AP-final f0 rise. As a result, when the *nominative* marker is overt (i.e., physically present)—especially in contexts where it coincides with an independent AP—speakers may be more likely to realize the characteristic AP-final rise clearly than when the marker is absent.
- Under *lexical (corrective) focus*, speakers produced sharper f0 rises toward the end of the target words than under *morphological focus*, regardless of overt or covert marking—that is, for both *simplex* and *complex* forms. This pattern is consistent with the general focus-induced enhancement of AP-final f0 rises in Korean (cf. Cho et al., 2019; Hatcher et al., 2024). This focal prominence appears to attenuate morphological effects associated with the overt-covert distinction. In fact, morphological effects in this context were restricted to the *combined* AP condition, where *simplex* (covert) forms showed a slightly but significantly higher f0 peak than *complex* forms. This morphological effect, although limited to the *combined* AP condition, is notable because corrective focus in Korean typically drives f0 rises toward their maximal range, leaving limited room for additional modulation. Thus, speakers' further enhancement of an already near-maximal rise in *simplex* forms under *lexical (corrective) focus* suggests a deliberate strengthening of prosodic cues, potentially to reinforce morphosyntactic distinctiveness when overt marking is absent.

For *accusatives*, morphological effects on f0 revealed by the GAMM analyses emerged only under *morphological focus*. Unlike *nominatives*—where f0 peak enhancement toward the end of the AP in *complex* (overt) forms was observed only in *separate* APs—the effects for *accusatives* involved f0 enhancement earlier in the AP in *complex* (overt) forms relative to *simplex* (covert) forms and occurred in both *separate* and *combined* AP conditions.

- Under *morphological focus*, *complex* forms (i.e., with overt case marking) displayed higher f0 early in the contour, with the difference disappearing before or near the peak—a pattern that contrasts with the *nominative* case, where *complex* forms exhibited higher f0 peaks at the end of the word. The higher early f0 in *complex* forms (relative to *simplex* forms) prior to the end of the AP effectively

reduces the magnitude of the f0 rise. Because peak f0 toward the end of the AP remains largely constant across forms, this lower starting point yields a larger f0 rise in *simplex* forms. This pattern suggests that enhancement may lie in a deeper trough corresponding to the low tone of *simplex* forms, which in turn produces the greater excursion of the rise in *simplex* forms rather than early f0 raising in *complex* forms—an effect that, in this context, serves to enhance covert case marking.

- Under *lexical focus*, no morphological effects were found.

As such, morphological effects on f0 in *accusatives*—relative to *nominatives*, where effects were limited to the f0 peak—extended across the f0 contour (i.e., emerging earlier, prior to the peak). Nevertheless, both case types exhibited a similar underlying relationship, namely enhancement of f0 rise associated with *simplex* (covert) case marking: in both contexts, *simplex* forms showed greater overall f0 rise magnitude. This enhancement was observed under *lexical (corrective) focus* for *nominatives*, where it was restricted to *combined* APs, and more robustly under *morphological focus* for *accusatives*, where it occurred in both *combined* and *separate* APs.

Taken together, these results show that prosodic encoding of morphological structure in Korean emerges from an interplay between boundary placement and fine-grained phonetic enhancement, with temporal and tonal cues working in tandem and shaped by prosodic phrasing. Across contexts, *nominative* and *accusative* alike, *simplex* forms—lacking overt case markers—were more often phrased as independent APs than *complex* forms, positioning them at phrase edges where boundary-related temporal lengthening and tonal shaping are available. This positional bias was often accompanied by final-rime lengthening and, in some cases, steeper AP-final f0 rises, indicating that phrasing, timing, and pitch modulation function jointly as compensatory resources for covert marking.

Crucially, while case marking in both *nominatives* and *accusatives* naturally aligned with AP boundaries, the two cases diverged in how case marking was prosodically encoded, particularly in the absence of overt (physical) case marking. In *nominatives*, whereas overt marking elicited localized f0 boosts at the phrase edge, covert marking effects were comparatively weak and emerged only under specific prosodic conditions—namely, when phrasing and focus combined to create an optimal environment for enhancement (*lexical focus* with a *combined* AP). In *accusatives*, by contrast, covert marking consistently recruited multiple prosodic channels—greater likelihood of independent AP phrasing, robust final-rime lengthening, and larger f0 rise magnitudes—yielding a more global and redundant enhancement profile. Although the precise mechanism underlying the case asymmetry remains unclear, the consistent differences observed between *nominatives* and *accusatives* across prosodic measures suggest that this contrast is not incidental. One plausible contributing factor is the well-documented asymmetry in case marker ellipsis, whereby *accusative* marking is omitted more frequently than *nominative* marking (Lee, 2006). This asymmetry may place greater pressure on speakers—particularly in cases of covert *accusative* marking—to recruit prosodic resources such as temporal and tonal modulation to support morphosyntactic interpretation, thereby systematically shaping prosodic implementation beyond segmental realization. Structural factors

may also play a role. Under canonical SOV order in Korean, nominative subjects are typically clause-initial and thus structurally prominent, whereas accusative objects lack this positional advantage and may therefore depend more directly on overt case marking for reliable argument identification, particularly in contexts where multiple arguments are present or where discourse structure or word order variation reduces the predictability of argument roles. When accusative marking is covert, the informational load associated with object interpretation may therefore be greater, increasing pressure for redundant prosodic encoding. The present findings are consistent with both usage-based and structural accounts of this asymmetry. Distinguishing between these possibilities remains a task for future work.

These patterns suggest that Korean speakers flexibly redistribute prosodic resources depending on the availability of overt morphological material: when overt marking is present, alignment with phrase-level boundaries may suffice; when it is absent, especially in the *accusative*, speakers draw on a coordinated set of boundary placement, durational extension, and tonal rise to maintain the perceptual salience of morphosyntactic contrasts.

4.1.1. Interpreting prosodic enhancement under morphological focus: alternative accounts

An important interpretive issue raised by a reviewer concerns the source of the prosodic enhancement observed for covertly case-marked nouns in the *morphological focus* condition. Specifically, the question is whether this enhancement genuinely reflects focus based on a morphological contrast—namely, the absence of overt case marking—or whether it instead arises from the elicitation procedure itself. Recall that in the *morphological focus* condition, speakers produced two consecutive sentences that were truth-conditionally identical, differing only in whether the target noun carried an overt case marker in the first sentence or a covert case marker in the second, target-bearing sentence. Because such repetition can, in natural discourse, prompt emphatic or confirmation-seeking prosody, it is necessary to consider whether the observed enhancement could be attributed to these procedural factors rather than to *morphological focus* per se.

In particular, two alternative explanations warrant careful consideration: (i) that the second target-bearing sentence may have been produced with a sentence-wide emphatic confirmation-seeking intonation due to truth-conditional repetition, and (ii) that speakers may have projected a longer temporal frame from the overtly case-marked noun in the first sentence onto the corresponding covertly case-marked noun in the second sentence.

With respect to the first possibility, repetition of truth-conditionally identical sentences in natural discourse can signal emphatic confirmation or repair, often accompanied by broad, sentence-level prosodic enhancement. If such an effect were operative here, temporal and tonal enhancement would be expected to be distributed relatively uniformly across the second sentence. However, the observed patterns do not support this interpretation. As reported in Section 3.2.2 (Pre-rime duration), temporal enhancement under *morphological focus* was not uniform across the target word, but was substantially stronger on the final rime (approximately an 8.4% increase

for the rime, compared to approximately a 2.6% increase for the pre-rime). Notably, this is the position at which an overt case marker would otherwise be realized, indicating that temporal enhancement was largely concentrated at the morphophonological locus of the overt-covert contrast.

To further assess whether emphatic confirmation-seeking prosody associated with sentence repetition might have affected words beyond the target noun, we conducted an additional durational analysis of the word immediately preceding the target. The results, reported in the [Appendix](#) (Table B8), revealed no significant effects of Morphological Structure or its interaction with Focus Type. If the second sentence had been produced with a sentence-wide emphatic prosody, temporal expansion would be expected to extend to neighboring words as well; this was not observed.

Additional evidence against an emphatic confirmation-seeking account comes from the fact that durational enhancement of covertly case-marked nouns was also observed under the *lexical (corrective) focus* condition, where the target sentence was not truth-conditionally redundant with a preceding sentence and therefore does not plausibly invite emphatic repetition.

We also considered the alternative possibility that speakers projected a longer temporal frame from the overtly case-marked noun in the first sentence onto the covertly case-marked noun in the second sentence. However, this account likewise finds little support in the data. As noted above, the enhancement was selectively localized to the final rime, with no evidence of word-level expansion (cf. [Section 3.2.2](#)), as would be expected under a simple word-based temporal-template projection. Moreover, the presence of comparable enhancement under *lexical (corrective) focus*—where no preceding overtly case-marked noun is available from which a longer temporal frame could be copied—further argues against a temporal-template projection account.

Taken together, these converging lines of evidence indicate that the prosodic enhancement observed under *morphological focus* cannot be adequately explained by either emphatic confirmation-seeking intonation or memory-based temporal frame copying. Instead, the findings support an interpretation in which speakers selectively recruit prosodic resources at the morphophonological locus of contrast to signal covert case marking. While the elicitation procedure necessarily involved controlled discourse contexts, it was methodologically necessary—as described in the Methods section ([Section 2.1](#))—to create a focus-like environment in which the absence of overt case marking was made perceptually salient, thereby maximizing the overt-covert contrast and allowing us to examine how speakers phonetically encode covert morphological distinctions. Although such a procedure may introduce side effects that warrant caution in interpretation, the resulting prosodic patterns appear to be structurally grounded and to reflect morphological effects of the overt-covert distinction, rather than epiphenomenal consequences of repetition or temporal inertia.

4.2. Some theoretical considerations

At the outset of this study, we considered several theoretical accounts for the phonetic encoding of morphology, including the Prosodic Parsing Account, the Extended Paradigm Uniformity framework integrated with Gestural Theory, and

the Covert Morphology Enhancement Hypothesis, which seeks to explain the phonetic encoding of morphologically underspecified forms in an informativity-driven manner. The present findings allow us to revisit each of these accounts in turn, positioning Korean case marking as a revealing testbed for exploring how prosodic structure and fine-grained phonetic detail operate together to preserve morphosyntactic distinctiveness from multiple theoretical perspectives.

The **Prosodic Parsing Account** proposed by [Sugahara and Turk \(2009\)](#), as outlined in [Section 1.1.1](#), posits that morphologically complex forms with suffixes in English can exhibit stem-final temporal expansion because the stem constitutes its own prosodic word, and the resulting word-internal boundary triggers boundary-related lengthening. By analogy, one might expect that in Korean, morphological concatenation with an overt case marker could similarly prompt the stem to form an internal prosodic word and undergo final lengthening, as in the English suffixal cases. However, the present results show no evidence of such stem-level temporal expansion in complex forms under any condition.

One might assume that the absence of a suffixal effect here could arise in a context where such an effect might otherwise be expected—namely, when the case marker occurs at the right edge of a word aligning with a higher-level prosodic boundary. From the perspective of hierarchical prosodic structure—where phonetic effects of higher-level boundaries can override those of lower levels (e.g., [Jun, 1996](#); [Shattuck-Hufnagel & Turk, 1996](#))—this outcome is perhaps unsurprising, as AP-level effects could dominate and mask any potential word-level enhancement. For this explanation to hold, however, at least two conditions would need to be met. First, AP-boundary final lengthening would have to extend into the preceding syllable beyond the final rime to the string corresponding to the stem portion, thereby overriding any durational effect from word-level final lengthening. Yet prior work on Korean shows that AP-boundary lengthening is confined to the final syllable, and even then is quite small ([Cho, 2022](#); [Cho & Keating, 2001](#)) or often unobservable ([Jun, 1996](#)), making this unlikely. Second, alignment of complex words with a higher-level boundary would need to erase word-internal prosodic structure entirely. But under general assumptions of phrasal phonology, word-internal prosodic structure is ‘contained’ within larger prosodic constituents ([Selkirk, 1984](#); [Shattuck-Hufnagel & Turk, 1996](#)), making this scenario also improbable. Taken together, these considerations suggest that the kind of word-internal durational expansion described by Sugahara and Turk for certain English suffixes does not straightforwardly extend to Korean case marking at phrase edges.

We did, however, observe evidence of morphological conditioning in prosodic phrasing: *simplex* forms were more likely than *complex* forms to be realized as independent APs. This effect is subtle, as both forms generally align with AP boundaries and the phrasing patterns surface only probabilistically. Nonetheless, in a broader sense, the Prosodic Parsing Account remains relevant insofar as morphological structure influences prosodic constituency. Crucially, however, its scope and motivation here differ from the original word-level formulation proposed by Sugahara and Turk. In our data, AP-level parsing—sometimes reinforced by an IP boundary—occurred more often for monomorphemic target words, precisely when

overt case marking was absent and morphological informativity was therefore reduced. We interpret this as evidence that, under covert, morphologically underspecified case marking, speakers tend to align the word's edges with salient AP boundaries to bolster the perceptual salience of case marking and thereby compensate for impoverished informativity. In this way, prosodic parsing operates as part of the phonetic encoding of morphology, shaped—at least in part—by morphological structure, with the overt-covert contrast modulating the informativity that guides such prosodic decisions. This underscores the role of prosodic parsing as an important underlying process in the phonetic encoding of morphology in a broader sense.

This interpretation accords with the **Covert Morphology Enhancement Hypothesis** (Section 1.1.4), which shares its theoretical foundation with informativity-driven accounts of phonetic enhancement (Pluymaekers et al., 2010; Smith et al., 2012; see Strycharczuk, 2019), yet represents a distinctive case in which the optional absence of an overt morpheme is systematically compensated for through prosodic enhancement. Whereas informativity-driven accounts emphasize the enhancement of morphological elements for lexical access, based on the informativeness of a given morphological structure or paradigm, our case extends the notion of informativity to the level of morphosyntactic function. Specifically, when overt case marking is absent and morphosyntactic informativity is thereby reduced, speakers enhance the form through both macro-level prosodic phrasing and micro-level durational and tonal adjustments. As discussed in the preceding section, support for the Covert Morphology Enhancement Hypothesis comes from converging evidence at both the macro (phonological) level of prosody (phrasing or prosodic parsing) and the micro (phonetic) level of prosody (temporal and tonal enhancement), demonstrating that prosodic encoding of morphology operates through a coordinated interplay of structural and fine-grained prosodic cues.

Now, let us consider how the present results may be understood in relation to the *paradigm uniformity* (PU) account. In its classical formulation, PU predicts that the phonetic properties of a base form carry over to its morphological derivatives, promoting output-output correspondence across members of a paradigm (cf. Steriade, 2000). This often manifests as temporal expansion of the stem in morphologically complex forms, relative to their monomorphemic counterparts, even when the two are segmentally identical. **The Extended PU model** proposed by Seyfarth et al. (2018), as discussed in Section 1.1.3, builds on this idea by incorporating the gestural phonology notion of the π -gesture, a prosodically triggered temporal expansion mechanism that can apply not only at word-level junctures but also at higher prosodic boundaries (see Fig. 1). Within this model, temporal lengthening associated with paradigm uniformity could be expected for both the stem and suffixal material, as the gestures associated with these elements overlap with the π -gesture, and may therefore be mediated or amplified by prosodic boundary effects operating uniformly at either the word- or phrase-level.

This extended formulation is particularly relevant to the present study, as our materials systematically aligned the case-marked forms with phrase-level prosodic junctures, most often AP boundaries. Such alignment creates a context in which π -

gesture-driven temporal expansion could, in principle, operate in tandem with prosodic boundary effects to yield robust temporal enhancement in morphologically complex forms. Importantly, if PU effects are evaluated relative to higher-level prosodic structure rather than strictly at the word-level, the bare form—when produced at a phrasal boundary—may already incorporate phrase-level lengthening. Under this scenario, all members of the paradigm—whether bare or suffixal—produced at that same prosodic juncture would inherit this phrase-level effect, just as they inherit word-level lengthening. Thus, when a morphologically complex form is aligned with a higher-level boundary, any additional lengthening observed could reflect not only morphological structure per se but also the propagation of phrase-level boundary effects across the paradigm. If the Extended PU account were uniformly applicable at both word- and higher-level prosodic boundaries, we would therefore expect *complex* forms (with overt case markers) to exhibit stem lengthening relative to their monomorphemic (*simplex*) counterparts, and potentially additional lengthening of the affixal case marker itself—an effect that could be further magnified by AP-level boundary alignment.

Yet such temporal expansions in *complex* forms did not emerge across the examined contexts in the present study. This absence is noteworthy, given that the experimental design provided ample opportunity for word-final stems in *complex* forms to undergo both paradigm-uniformity-driven lengthening and phrase-edge-driven boundary lengthening. Instead, durational enhancements appeared more robustly for *simplex* forms in certain contexts—most notably in the *accusative*, where covert case marking was systematically associated with final-rime lengthening and greater f0-rise magnitude. One might argue that any potential temporal expansion in *complex* forms could have been masked by the extended domain of the π -gesture associated with an AP boundary. However, as discussed above, AP-final lengthening in Korean is generally confined to the final syllable and is often small in magnitude, making this explanation unlikely.

This asymmetry suggests that the Extended PU account, at least in its straightforward application, does not fully capture the present patterns. Instead of the predicted carry-over from the bare form to the morphologically richer complex forms, the enhancement patterns are reversed: morphologically impoverished *simplex* forms—those lacking overt case markers—exhibit greater prosodic strengthening. This reversal points to a shift in functional motivation. Whereas the Extended PU account emphasizes maintaining phonetic stability across paradigm members and could, in principle, operate uniformly across both word- and phrase-level contexts, the present data point toward a compensatory enhancement strategy, in which speakers bolster the perceptual salience of forms with reduced morphological informativity. Such enhancement may, in turn, obscure or suppress any paradigm uniformity effects that might otherwise surface.

That said, the π -gesture component of the Extended PU account—originally proposed by Seyfarth et al. (2018) and further developed and extended here—still offers a useful lens for understanding the temporal scope of the observed effects. The enhanced final-rime lengthening in *simplex* forms, particularly

when realized as independent APs, can be interpreted as a stronger activation of a π -gesture at the phrase boundary. What departs from the standard PU prediction is not the presence of a π -gesture, but its functional trigger: rather than being activated by morphological complexity and the drive for uniformity across a paradigm, it is recruited here in response to the absence of overt morphological material, driven by the informativity of the covert case marking, thus serving a perceptual enhancement function. In this way, the π -gesture mechanism (e.g., Byrd & Saltzman, 2003; Byrd & Krivokapić, 2021) not only regulates temporal effects in reference to paradigm uniformity, but it is also co-opted to implement the Covert Morphology Enhancement Hypothesis, operating at the prosodic junctures, to boost the temporal salience of morphosyntactic distinctions lacking segmental marking.

In summary, while the Extended PU account in its original form cannot straightforwardly explain why enhancement is concentrated in morphologically impoverished rather than morphologically complex forms, its gestural foundation nonetheless provides a viable framework for modeling the temporal scope and prosodic conditioning of the observed effects. The present findings invite a reconceptualization of the Extended PU account, as suggested above, such that the morphological conditioning factors for π -gesture activation and scope are extended to include cases where overt morphological material is absent but morphosyntactic distinctions still need to be signaled. Under such conditions, speakers appear to recruit prosodic structure and fine-grained phonetic detail as compensatory resources.

5. Summary and conclusion

The present study has provided new empirical evidence for how morphosyntactic exponents—particularly those lacking overt segmental realization—are prosodically encoded in speech. By examining Seoul Korean case marking, where overt morphology can be omitted and its absence yields surface homophony, we have demonstrated that speakers deploy a constellation of prosodic resources to preserve morphological distinctiveness. The findings reveal that prosodic encoding in this domain is neither uniformly bound to morphological complexity nor reducible to a single phonetic cue. Instead, it emerges from a coordinated interaction between macro-level prosodic organization and micro-level temporal and tonal enhancement, with the configuration of cues adapting to the functional demands of the morphological context.

At the macro-level, morphological structure influenced prosodic phrasing: *simplex* forms without overt case marking were more often realized as independent Accentual Phrases, though in a subtle and probabilistic manner, placing them in prosodically prominent, phrase-edge positions. This positioning also provided access to boundary-related lengthening and tonal shaping—structural resources that enhance perceptual salience in the absence of overt morphology. At the micro-level, covert marking systematically recruited final-rime lengthening and, in some contexts, greater f_0 rise magnitude. These effects, though often context-dependent, imply that the prosodic encoding of morphology is sensitive to morphosyntactic informativity, enhancing morphologically underspecified forms through fine-grained prosodic adjustments.

Theoretically, these findings challenge the core assumption of both the classical and Extended Paradigm Uniformity accounts—that enhancement is anchored to morphologically complex forms. While the Extended PU model formalizes temporal expansion via π -gestures and their interaction with prosodic boundaries, our results show that these same mechanisms can be repurposed. In Korean case marking, enhancement is often triggered not by the presence of morphological material but by its absence. This inversion supports the Covert Morphology Enhancement Hypothesis, in which prosodic enhancement compensates for reduced morphological informativity. Such enhancement can still be modeled within the gestural framework, with the π -gesture activated in response to the morphological informativity.

Typologically, Korean illustrates how prosodic encoding of morphology operates in an edge-prominence language, where syntax-prosody alignment places morphological cues at prominent phrase boundaries. In this configuration, boundary phenomena themselves serve as signaling resources, allowing speakers to reallocate prosodic cues when overt morphology is absent. Morphological realization is thus shaped not only by segmental content and internal morphological composition, but also by prosodic positioning within the phrase, which in turn permits subtle, micro-level adjustments to enhance contrast.

Overall, the findings highlight the prosodic encoding of morphology as a flexible, functionally adaptive system. Prosodic structure not only mirrors morphological form but also actively shapes its communicative realization, adjusting phrasing, duration, and pitch to morphosyntactic and informational needs. This flexibility reflects a core property of prosodic grammar, enabling interaction with morphology and regulating the balance between structural constraints from paradigm uniformity and the functional imperative to preserve contrast in morphologically impoverished contexts. Extending the inquiry to other types of morphological complexity, prominence contexts, and languages will clarify whether these mechanisms reflect universal communicative principles or language-specific strategies (e.g., Cho, 2025). The latter may be governed by a language-specific phonetic grammar (Cho, 2025; Cho & Ladefoged, 1999; Keating, 1984) that mediates top-down influences from higher-order linguistic and non-linguistic structures—including morphology's interaction with prosody and syntax—and fine-tunes phonetic detail to produce outputs optimal for that language. Such a fine-tuning nevertheless is expected to emerge within the range favored by the human linguistic system. The Seoul Korean patterns examined here illustrate how such a system can reallocate prosodic resources to enhance morphologically underspecified forms, while the underlying principles—balancing systemic stability with listener-oriented enhancement—remain broadly relevant to understanding how prosody, and phonetics more generally, encode morphology across the world's languages.

CRedit authorship contribution statement

Richard Hatcher: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Jiyoung Jang:** Writing – review & editing, Validation, Methodology, Data curation. **Sahyang Kim:** Writing – review & editing, Validation, Resources, Project administration, Methodology,

Funding acquisition, Conceptualization. **Taehong Cho**: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank all the Seoul Korean speakers for their participation in the experiment. We also thank the Editor, Natasha Warner, and the three anonymous reviewers for their insightful and constructive comments. This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2021S1A5C2A02086884) awarded to T. Cho (corresponding author). This work was also supported by the research fund of Hanyang University (HY-202400000003709) awarded to R. Hatcher (first author).

Appendix A

Table A1

List of example carrier sentences for the target pair, /tʃoŋi/ and /tʃoŋ-i/ in the nominative condition. Target words are provided in bold and the preceding modifier in italics. Note that /tʃoŋi/ (a.2 and c.2) and /tʃoŋ-i/ (b.1 and d.1) serve as homophonous target words, while /tʃoŋi-ka/ (a.1 and c.1) and /tʃoŋ/ (b.2 and d.2) serve as fillers.

Morphological Focus Context		
Example sentences		English translations
a.	1. /monun tʃoŋi-ka pule tʰasʌ ʌpsʌtʃʌs*ʌ/ 2. /monun tʃoŋi pule tʰasʌ ʌpsʌtʃʌs*ʌ/	The <i>graph</i> paper burned up. The <i>graph</i> paper burned up.
b.	1. /kjohwe tʃoŋ-i pule tʰasʌ ʌpsʌtʃʌs*ʌ/ 2. /kjohwe tʃoŋ pule tʰasʌ ʌpsʌtʃʌs*ʌ/	The <i>church</i> bell burned up. The <i>church</i> bell burned up.
Lexical Focus Context		
Example sentences		English translations
c.	1. /monun tʃaŋpʰan-i pule tʰasʌ ʌpsʌtʃʌs*ni/ /ani. monun tʃoŋi-ka pule tʰasʌ ʌpsʌtʃʌs*ʌ/ 2. /monun tʃaŋpʰan pule tʰasʌ ʌpsʌtʃʌs*ni/ /ani. monun tʃoŋi pule tʰasʌ ʌpsʌtʃʌs*ʌ/	Did the grid board burn up? No. The <i>graph</i> paper burned up. Did the grid board burn up? No. The <i>graph</i> paper burned up.
d.	1. /kjohwe tap-i pule tʰasʌ ʌpsʌtʃʌs*ni/ /ani. kyohwe tʃoŋ-i pule tʰasʌ ʌpsʌtʃʌs*ʌ/ 2. /kjohwe tap pule tʰasʌ ʌpsʌtʃʌs*ni/ /ani. kyohwe tʃoŋ pule tʰasʌ ʌpsʌtʃʌs*ʌ/	Did the church tower burn up? No. The <i>church</i> bell burned up. Did the church tower burn up? No. The <i>church</i> bell burned up.

Appendix B

Table B1

Summary of the mixed-effects logistic regression model predicting prosodic phrasing. Random intercepts were included for speaker and target pair and random slopes for both predictor variables. The model was fitted using the binomial family with a logit link function. Odds ratios were also computed to aid in interpretation.

Fixed effects					
Term	$\hat{\beta}$ (log-odds)	SE($\hat{\beta}$)	Odds Ratio	95% CI (OR)	p
(Intercept)	0.167	0.145	1.181	[0.889, 1.571]	0.251
Focus (corrective-morphological)	1.96	0.188	7.112	[4.921, 10.279]	< 0.001
Morph.Structure (simplex-complex)	0.260	0.103	1.296	[1.059, 1.587]	0.012
Focus x Morph.Structure	-0.125	0.181	0.882	[0.618, 1.259]	0.490

Number of observations: 2863, groups: speaker (21), pair (14), *p*-values/df calculated using the Satterthwaite approximation.

Model formula: Preboundary ~ Focus * Morph.Structure + (1+Focus+Morph.Structure|Speaker) + (1+Focus+Morph.Structure|Pair).

Marginal $R^2 = 0.20$, adjusted $R^2 = 0.31$.

Table B2

Summary of the mixed-effects linear regression model predicting target words' final rime duration. Random intercepts were included for speaker and target pair. The model was fitted using the gamma family with a logit link function.

Fixed effects				
Term	$\hat{\beta}(\log \text{ ms})$	$SE(\hat{\beta})$	t	p
(Intercept)	4.568	0.050	90.640	< 0.001
Morph.Structure (simplex-complex)	0.060	0.00862	0.060	< 0.001
Focus (corrective-morphological)	0.222	0.00874	0.222	< 0.001
Case (nominative-accusative)	-0.102	0.064	-0.102	0.112
Phrasing (separate AP-combined AP)	0.036	0.00905	0.036	< 0.001
Morph.Structure x Focus	-0.043	0.0172	-0.043	0.013
Morph.Structure x Case	-0.029	0.0172	-0.029	0.098
Focus x Case	0.075	0.0173	0.075	< 0.001
Morph.Structure x Phrasing	0.034	0.0174	0.034	0.051
Focus x Phrasing	-0.089	0.0177	-0.089	< 0.001
Case x Phrasing	-0.008	0.0176	-0.008	0.650
Morph.Structure x Focus x Case	-0.021	0.0343	-0.021	0.538
Morph.Structure x Focus x Phrasing	-0.037	0.0351	-0.037	0.291
Morph.Structure x Case x Phrasing	0.077	0.0346	0.077	0.027
Focus x Case x Phrasing	-0.045	0.035	-0.045	0.196
Morph.Structure x Focus x Case x Phrasing	-0.062	0.0701	-0.062	0.378

Number of observations: 2863, groups: speaker (21), pair (14), p -values/ df calculated using the Satterthwaite approximation.

Model formula: $\text{Duration} \sim \text{Morph.Structure} * \text{Focus} * \text{Case} * \text{Phrasing} + (1 | \text{Speaker}) + (1 | \text{Pair})$.

Marginal $R^2 = 0.32$, adjusted $R^2 = 0.38$.

Table B3

Summary of the mixed-effects linear regression model predicting target words' initial CVC duration. Random intercepts were included for speaker and target pair. The model was fitted using the gamma family with a logit link function.

Fixed effects				
Term	$\hat{\beta}(\log \text{ ms})$	$SE(\hat{\beta})$	t	p
(Intercept)	5.455	0.048	114.406	< 0.001
Morph.Structure (simplex-complex)	0.006	0.005	1.128	0.259
Focus (corrective-morphological)	0.351	0.005	66.867	< 0.001
Case (nominative-accusative)	0.015	0.054	0.269	0.788
Phrasing (separate AP-combined AP)	0.042	0.005	7.691	< 0.001
Morph.Structure x Focus	0.042	0.00544	7.69	< 0.001
Morph.Structure x Case	-0.039	0.0103	-3.75	0.244
Focus x Case	-0.012	0.0104	-1.17	0.001
Morph.Structure x Phrasing	0.034	0.0104	3.31	0.940
Focus x Phrasing	-0.001	0.0104	-0.0754	< 0.001
Case x Phrasing	-0.172	0.0106	-16.2	0.376
Morph.Structure x Focus x Case	-0.009	0.0106	-0.886	0.521
Morph.Structure x Focus x Phrasing	-0.013	0.0206	-0.642	0.156
Morph.Structure x Case x Phrasing	0.030	0.0211	1.42	0.036
Focus x Case x Phrasing	0.044	0.0208	2.1	0.351
Morph.Structure x Focus x Case x Phrasing	-0.020	0.021	-0.933	0.272

Number of observations: 2863, groups: speaker (21), pair (14), p -values/ df calculated using the Satterthwaite approximation.

Model formula: $\text{Duration} \sim \text{Morph.Structure} * \text{Focus} * \text{Case} * \text{Phrasing} + (1 | \text{Speaker}) + (1 | \text{Pair})$.

Marginal $R^2 = 0.68$, adjusted $R^2 = 0.72$.

Table B4

Summary of the generalized additive mixed model predicting f0 across nominative target words. The upper table provides the parametric coefficients and the lower table the coefficients for the smooths. Random reference and difference smooths were included for speaker and target pair. Binary difference smooths occupy the final four rows and are identified by the "IsComplex" prefix.

Fixed effects				
Parametric Terms	$\hat{\beta}$	$SE(\hat{\beta})$	<i>t</i>	<i>p</i>
(Intercept)	0.439	0.155	2.836	0.005
Morphological:Combined	0.109	0.130	0.841	0.400
Corrective:Separate	-0.077	0.071	-1.082	0.279
Morphological:Separate	-0.472	0.143	-3.299	< 0.001
Fixed effects				
Smooth Terms	edf	ref.edf	F	p
s(timeWordScaled):corrective.combined	7.142	7.577	13.601	< 0.001
s(timeWordScaled):morphological.combined	7.407	7.636	36.276	< 0.001
s(timeWordScaled):corrective.separate	7.897	8.052	96.460	< 0.001
s(timeWordScaled):morphological.separate	6.977	7.312	9.562	< 0.001
s(timeWordScaled):IsComplex.MorphologicalSeparate	5.634	6.720	3.010	0.004
s(timeWordScaled):IsComplex.MorphologicalCombined	4.856	5.782	2.020	0.061
s(timeWordScaled):IsComplex.CorrectiveSeparate	3.293	3.816	0.571	0.567
s(timeWordScaled):IsComplex.CorrectiveCombined	6.159	7.362	3.563	0.001

Number of observations: 58331, groups: speaker (21), pair (12), *p*-values/df calculated using the Satterthwaite approximation.

Model formula: $zFO \sim \text{Focus:Phrasing} + s(\text{timeWordScaled}, \text{by} = \text{Focus:Phrasing}) +$

$s(\text{timeWordScaled}, \text{by} = \text{IsComplex.MorphologicalSeparate}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.MorphologicalCombined}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.CorrectiveSeparate}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.CorrectiveCombined}) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Morph.Struct}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Focus}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Phrasing}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Morph.Struct}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Focus}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Phrasing}, \text{bs} = "fs", m = 1) +$
 $s(\text{timeWordScaled}, \text{tone01}, \text{bs} = "fs", m = 1).$

Adjusted $R^2 = 0.60$.

Table B5

Summary of the generalized additive mixed model predicting F0 across accusative target words. The upper table provides the parametric coefficients and the lower table the coefficients for the smooths. Random reference and difference smooths were included for speaker and target pair. Binary difference smooths occupy the final four rows and are identified by the "IsComplex" prefix.

Fixed effects				
Parametric Terms	$\hat{\beta}$	$SE(\hat{\beta})$	<i>t</i>	<i>p</i>
(intercept)	0.039	0.118	0.330	0.742
Morphological:Combined	-0.530	0.114	-4.654	< 0.001
Corrective:Separate	-0.083	0.047	-1.763	0.078
Morphological:Separate	-0.627	0.121	-5.201	< 0.001
Fixed effects				
Smooth Terms	edf	ref.edf	F	p
s(timeWordScaled):corrective.combined	8.122	8.321	42.932	< 0.001
s(timeWordScaled):morphological.combined	7.298	7.556	23.369	< 0.001
s(timeWordScaled):corrective.separate	8.230	8.355	39.743	< 0.001
s(timeWordScaled):morphological.separate	7.085	7.383	13.834	< 0.001
s(timeWordScaled):IsComplex.MorphologicalSeparate	2.000	2.000	5.380	0.005
s(timeWordScaled):IsComplex.MorphologicalCombined	7.625	8.759	8.113	< 0.001

Table B5 (continued)

Fixed effects				
s(timeWordScaled):IsComplex.CorrectiveSeparate	2.000	2.000	0.618	0.539
s(timeWordScaled):IsComplex.CorrectiveCombined	2.613	3.006	0.301	0.833

Number of observations: 34601, groups: speaker (21), pair (12), *p*-values/*df* calculated using the Satterthwaite approximation.

Model formula: $\Delta f_0 \sim \text{Focus:Phrasing} + s(\text{timeWordScaled}, \text{by} = \text{Focus:Phrasing}) +$

$s(\text{timeWordScaled}, \text{by} = \text{IsComplex.MorphologicalSeparate}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.MorphologicalCombined}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.CorrectiveSeparate}) +$
 $s(\text{timeWordScaled}, \text{by} = \text{IsComplex.CorrectiveCombined}) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Morph.Struct}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Focus}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Speaker}, \text{by} = \text{Phrasing}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Morph.Struct}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Focus}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{Pair}, \text{by} = \text{Phrasing}, \text{bs} = \text{"fs"}, \text{m} = 1) +$
 $s(\text{timeWordScaled}, \text{tone01}, \text{bs} = \text{"fs"}, \text{m} = 1).$

Adjusted $R^2 = 0.74$.

Table B6

Summary of the mixed-effects linear regression model predicting the magnitude of the f_0 rise on nominative targets. Random intercepts were included for speaker and target pair.

Fixed effects				
Term	$\hat{\beta}(\log \text{ ms})$	$SE(\hat{\beta})$	<i>t</i>	<i>p</i>
(Intercept)	1.969	0.210	9.396	< 0.001
Morph.Structure (simplex-complex)	−0.005	0.042	−0.119	0.905
Focus (corrective-morphological)	0.822	0.043	19.167	< 0.001
Phrasing (separate AP-combined AP)	−0.164	0.045	−3.687	< 0.001
Morph.Structure x Focus	0.105	0.084	1.242	0.214
Morph.Structure x Phrasing	0.012	0.086	0.143	0.886
Focus x Phrasing	0.476	0.085	5.577	< 0.001
Morph.Structure x Focus x Phrasing	−0.089	0.176	−0.507	0.612

Number of observations: 1057, groups: speaker (21), pair (12), *p*-values/*df* calculated using the Satterthwaite approximation.

Model formula: $\Delta f_0 \sim \text{Morph.Structure} * \text{Focus} * \text{Phrasing} + (1 | \text{Speaker}) + (1 | \text{Pair}).$

Marginal $R^2 = 0.27$, adjusted $R^2 = 0.60$.

Table B7

Summary of the mixed-effects linear regression model predicting the magnitude of the f_0 rise on accusative targets. Random intercepts were included for speaker and target pair.

Fixed effects				
Term	$\hat{\beta}(\log \text{ ms})$	$SE(\hat{\beta})$	<i>t</i>	<i>p</i>
(Intercept)	2.094	0.089	23.470	< 0.001
Morph.Structure (simplex-complex)	0.105	0.035	3.048	0.002
Focus (corrective-morphological)	0.862	0.035	24.504	< 0.001
Phrasing (separate AP-combined AP)	−0.007	0.037	−0.189	0.850
Morph.Structure x Focus	−0.097	0.069	−1.400	0.162
Morph.Structure x Phrasing	0.073	0.069	1.062	0.288
Focus x Phrasing	0.450	0.073	6.162	< 0.001
Morph.Structure x Focus x Phrasing	−0.153	0.139	−1.097	0.273

Number of observations: 1400, groups: speaker (21), pair (12), *p*-values/*df* calculated using the Satterthwaite approximation.

Model formula: $\Delta f_0 \sim \text{Morph.Structure} * \text{Focus} * \text{Phrasing} + (1 | \text{Speaker}) + (1 | \text{Pair}).$

Marginal $R^2 = 0.32$, adjusted $R^2 = 0.45$.

Table B8
Summary of the mixed-effects linear regression model predicting the duration of the word immediately preceding the target word. Random intercepts were included for speaker and target pair.

Fixed effects				
Term	$\hat{\beta}(\log \text{ ms})$	$SE(\hat{\beta})$	t	p
(Intercept)	5.677	0.070	80.474	< 0.001
Morph.Structure (simplex-complex)	0.003	0.005	0.555	0.5791
Focus (corrective-morphological)	0.006	0.005	1.307	0.191
Case (nominative-accusative)	0.068	0.085	0.801	0.4230
Phrasing (separate AP-combined AP)	−0.070	0.005	−12.814	< 0.001
Morph.Structure x Focus	0.020	0.010	1.880	0.060
Morph.Structure x Case	0.057	0.010	5.434	< 0.001
Focus x Case	0.058	0.010	5.534	< 0.001
Morph.Structure x Phrasing	0.005	0.011	0.456	0.649
Focus x Phrasing	−0.075	0.011	−6.964	< 0.001
Case x Phrasing	−0.028	0.011	−2.648	0.008
Morph.Structure x Focus x Case	0.018	0.021	0.880	0.379
Morph.Structure x Focus x Phrasing	−0.012	0.021	−0.575	0.565
Morph.Structure x Case x Phrasing	−0.040	0.021	−1.926	0.054
Focus x Case x Phrasing	−0.036	0.021	−1.674	0.094
Morph.Structure x Focus x Case x Phrasing	0.050	0.042	1.187	0.235

Number of observations: 2869, groups: speaker (21), pair (12), p -values/df calculated using the Satterthwaite approximation.
Model formula: word_dur ~ Morph.Structure * Focus * Case * Phrasing + (1 | Speaker) + (1 | Pair).
Marginal $R^2 = 0.16$, adjusted $R^2 = 0.30$.

References

Arvaniti, A., Ladd, D. R., & Mennen, I. (1998). Stability of tonal alignment: The case of Greek prenuclear accents. *Journal of Phonetics*, 26(1), 3–25. <https://doi.org/10.1006/jpho.1997.0063>.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1). <https://doi.org/10.18637/jss.v067.i01>.

Ben Hedia, S., & Plag, I. (2017). Gemination and degemination in English prefixation: Phonetic evidence for morphological organization. *Journal of Phonetics*, 62, 34–49. <https://doi.org/10.1016/j.wocn.2017.02.002>.

Bennett, R., & Elfner, E. (2019). The syntax-prosody interface. *Annual Review of Linguistics*, 5(1), 151–171. <https://doi.org/10.1146/annurev-linguistics-011718-012503>.

Boersma, P., & Weenick, D. (2025). *Praat: Doing phonetics by computer [Computer program]* (Version 6.4.40) [Computer software].

Browman, C. P., & Goldstein, L. (1990). Tiers in articulatory phonology, with some implications for casual speech. In J. Kingston & M. E. Beckman (Eds.), *Papers in Laboratory Phonology* (1st ed., pp. 341–376). Cambridge University Press. <https://doi.org/10.1017/CBO9780511627736.019>.

Byrd, D., & Krivokapić, J. (2021). Cracking prosody in articulatory phonology. *Annual Review of Linguistics*, 7, 31–53. <https://doi.org/10.1146/annurev-linguistics-030920-050033>.

Byrd, D., & Saltzman, E. (2003). The elastic phrase: Modeling the dynamics of boundary-adjacent lengthening. *Journal of Phonetics*, 31(2), 149–180. [https://doi.org/10.1016/S0095-4470\(02\)00085-2](https://doi.org/10.1016/S0095-4470(02)00085-2).

Celle, A., & Pélissier, M. (2024). Non-canonical questions at the syntax-prosody interface. *Journal of Linguistics*, 60(1), 1–6. <https://doi.org/10.1017/S002226723000312>.

Cho, T. (2001). Effects of morpheme boundaries on intergestural timing: Evidence from Korean. *Phonetica*, 58(3), 129–162. <https://doi.org/10.1159/000056196>.

Cho, T. (2016). Prosodic boundary strengthening in the phonetics-prosody interface. *Language and Linguistics Compass*, 10(3), 120–141. <https://doi.org/10.1111/lnc3.12178>.

Cho, T. (2022). The phonetics-prosody interface and prosodic strengthening in Korean. *The Cambridge Handbook of Korean Linguistics* (pp. 248–293). <https://doi.org/10.1017/9781108292351.010>.

Cho, T. (2025). Advancements of phonetics in the 21st century: Phonetic universals, language variation, and phonetic grammar. *Journal of Phonetics*, 111. <https://doi.org/10.1016/j.wocn.2025.101426>.

Cho, T., & Keating, P. A. (2001). Articulatory and acoustic studies on domain-initial strengthening in Korean. *Journal of Phonetics*, 29(2), 155–190. <https://doi.org/10.1006/jpho.2001.0131>.

Cho, T., Kim, D. J., & Kim, S. (2019). Prosodic strengthening in reference to the lexical pitch accent system in South Kyungsang Korean. *The Linguistic Review*, 36(1), 85–115. <https://doi.org/10.1515/tlr-2018-2008>.

Cho, T., Kim, S., & Mitterer, H. (2026). Linguistic and cognitive functions of fine phonetic detail underlying sound systems and sound change. *Journal of Phonetics*, 114, 101470. <https://doi.org/10.1016/j.wocn.2025.101470>.

Cho, T., & Ladefoged, P. (1999). Variation and universals in VOT: Evidence from 18 languages. *Journal of Phonetics*, 27(2), 207–229. <https://doi.org/10.1006/jpho.1999.0094>.

Chomsky, N., & Halle, M. (1968). *The sound pattern of English*. Harper & Row.

Cole, J. (2015). Prosody in context: A review. *Language, Cognition and Neuroscience*, 30(1–2), 1–31. <https://doi.org/10.1080/23273798.2014.963130>.

de Jong, K. (1995). The supraglottal articulation of prominence in English: Linguistic stress as localized hyperarticulation. *Journal of the Acoustical Society of America*, 97(1), 491–504. <https://doi.org/10.1121/1.412275>.

Engemann, M., & Plag, I. (2021). Phonetic reduction and paradigm uniformity effects in spontaneous speech. *The Mental Lexicon*, 16(1), 165–198. <https://doi.org/10.1075/ml.20023.eng>.

Fletcher, J. (2010). The prosody of speech: Timing and rhythm. *The Handbook of Phonetic Sciences* (pp. 523–602). Wiley-Blackwell. <https://doi.org/10.1002/9781444317251.ch15>.

Gafos, A., Hoole, P., Roon, K. D., Zeroual, C., Fougeron, C., Kühnert, B., D’Imperio, M., & Vallée, N. (2010). Variation in overlap and phonological grammar in Moroccan Arabic clusters. In C. Fougeron, B. Kühnert, M. D’Imperio, & N. Vallée (Eds.), *Laboratory Phonology 10*. <https://doi.org/10.1515/9783110224917>.

Goldstein, L., Byrd, D., & Saltzman, E. (2006). The role of vocal tract gestural action units in understanding the evolution of phonology. In M. A. Arbib (Ed.), *Action to Language via the Mirror Neuron System* (pp. 215–249). Cambridge University Press. <https://doi.org/10.1017/CBO9780511541599.008>.

Hatcher, R., Joo, H., Kim, S., & Cho, T. (2024). Focus-induced tonal distribution in Seoul Korean as an edge-prominence language. *Journal of Phonetics*, 107. <https://doi.org/10.1016/j.wocn.2024.101353>.

Iskarous, K., & Pouplier, M. (2022). Advancements of phonetics in the 21st century: A critical appraisal of time and space in articulatory phonology. *Journal of Phonetics*, 95, 101195. <https://doi.org/10.1016/j.wocn.2022.101195>.

Jang, J. (2023). *Functions of prosodic boundaries in an edge-prominence language: Marking focus and phrasing in Seoul Korean* (PhD thesis). Santa Barbara: University of California.

Jun, S.-A. (1996). The phonetics and phonology of Korean prosody: Intonational phonology and prosodic structure. *Garland Pub.* <https://doi.org/10.4324/9780429454943>.

Jun, S.-A. (1998). The accentual phrase in the Korean prosodic hierarchy. *Phonology*, 15(2), 189–226. <https://doi.org/10.1017/S0952675798003571>.

- Jun, S.-A. (2005). *Korean intonational phonology and prosodic transcription*. In Prosodic Typology: The Phonology of Intonation and Phrasing. Oxford University Press.
- Jun, S.-A. (2009). Prosody in sentence processing. *Ping Li (General Ed.), Handbook of East Asian Psycholinguistics* Chungmin Lee, Greg B. Simpson & Youngjin Kim (Eds.), Part III: Korean Psycholinguistics, 423–432.
- Jun, S.-A. (2011). Prosodic markings of complex NP focus, syntax, and the pre-/post-focus string. In *Proceedings of the 28th west coast conference on formal linguistics* (pp. 214–230). MA: Cascadia Press Somerville.
- Jun, S.-A. (2014). Prosodic typology: By prominence type, word prosody, and macro-rhythm. In S.-A. Jun (Ed.), *Prosodic Typology II: The Phonology of Intonation and Phrasing* (pp. 520–539). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199567300.001.0001>.
- Kang, S.-M., & Kong, E. (2022). The realization of the Korean intermediate phrase in spontaneous speech. *Studies in Phonetics. Phonology and Morphology*, 28(1), 3–31. <https://doi.org/10.17959/sppm.2022.28.1.3>.
- Kawahara, H., de Cheveigné, A., Banno, H., Takahashi, T., & Irino, T. (2005). Nearly defect-free F0 trajectory extraction for expressive speech modifications based on STRAIGHT. Ninth European Conference on Speech Communication and Technology. <https://doi.org/10.21437/Interspeech.2005-335>.
- Keating, P. A. (1984). Phonetic and phonological representation of stop consonant voicing. *Language*, 286–319. <https://doi.org/10.2307/413642>.
- Kemps, R. J. J. K., Wurm, L. H., Ernestus, M., Schreuder, R., & Baayen, H. (2005). Prosodic cues for morphological complexity in Dutch and English. *Language and Cognitive Processes*, 20(1–2), 43–73. <https://doi.org/10.1080/01690960444000223>.
- Kim, J. J., Kim, S., & Cho, T. (2024). Preboundary lengthening and articulatory strengthening in Korean as an edge-prominence language. *Laboratory Phonology*, 15(1), 1–36. <https://doi.org/10.16995/labphon.9880>.
- Kiparsky, P. (2000). Opacity and cyclicity. *The Linguistic Review*, 17(2–4), 351–366. <https://doi.org/10.1515/tlir.2000.17.2-4.351>.
- Ladd, D. R. (2008). *Intonational phonology* (2nd ed.). Cambridge University Press.
- Ladd, D. R., Mennen, I., & Schepman, A. (2000). Phonological conditioning of peak alignment in rising pitch accents in Dutch. *The Journal of the Acoustical Society of America*, 107(5), 2685–2696. <https://doi.org/10.1121/1.428654>.
- Lee, H. (2006). Parallel optimization in case systems: Evidence from case ellipsis in Korean. *Journal of East Asian Linguistics*, 15(1), 69–96. <https://doi.org/10.1007/s10831-005-3004-1>.
- Lee, H. (2015). Case Particle Ellipsis. In *The Handbook of Korean Linguistics* (pp. 196–211). John Wiley & Sons Ltd. <https://doi.org/10.1002/978111837008.ch11>.
- Lee-Kim, S.-I., Davidson, L., & Hwang, S. (2013). Morphological effects on the darkness of English intervocalic /l/. *Laboratory Phonology*, 4(2), 475–511. <https://doi.org/10.1515/lp-2013-0015>.
- Lenth, R. V., Buerkner, P., Herve, M., Love, J., Miguez, F., Riebl, H., & Singmann, H. (2022). *emmeans: Estimated Marginal Means, aka Least-Squares Means* (Version 1.7.3) [Computer software]. <https://CRAN.R-project.org/package=emmeans>.
- Levelt, W. J. (1989). *Speaking: From intention to articulation*. MIT press.
- Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22(1), 1–38. <https://doi.org/10.1017/S0140525X99001776>.
- Losiewicz, B. L. (1992). *The effect of frequency on linguistic morphology* (Ph.D., The University of Texas at Austin). <https://www.proquest.com/docview/304017730/abstract/E1BD7469C235444BPQ/1>.
- Lo, S., & Andrews, S. (2015). To transform or not to transform: Using generalized linear mixed models to analyse reaction time data. *Frontiers in Psychology*, 6, 1171. <https://doi.org/10.3389/fpsyg.2015.01171>.
- Paschen, L., Fuchs, S., & Seifart, F. (2022). Final Lengthening and vowel length in 25 languages. *Journal of Phonetics*, 94. <https://doi.org/10.1016/j.wocn.2022.101179>.
- Pierrehumbert, J. B. (1980). *The phonology and phonetics of English intonation* (PhD Thesis). Massachusetts Institute of Technology.
- Plag, I., Homann, J., & Kunter, G. (2017). Homophony and morphology: The acoustics of word-final S in English. *Journal of Linguistics*, 53(1), 181–216. <https://doi.org/10.1017/S0022226715000183>.
- Pluymaekers, M., Ernestus, M., Baayen, R. H., & Booij, G. (2010). *Morphological effects on fine phonetic detail: The case of Dutch-igheid*. *Laboratory phonology* (Vol. 10). Mouton de Gruyter Berlin.
- R Core Team. (2025). *R: A Language and Environment for Statistical Computing* [Computer software]. R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Schmitz, D., Baer-Henney, D., & Plag, I. (2021). The duration of word-final /s/ differs across morphological categories in English: Evidence from pseudowords. *Phonetica*, 78(5–6), 571–616. <https://doi.org/10.1515/phon-2021-2013>.
- Selkirk, E. O. (1984). *Phonology and syntax: The relation between sound and structure*. MIT Press.
- Seyfarth, S., Garellek, M., Gillingham, G., Ackerman, F., & Malouf, R. (2018). Acoustic differences in morphologically-distinct homophones. *Language, Cognition and Neuroscience*, 33(1), 32–49. <https://doi.org/10.1080/23273798.2017.1359634>.
- Shattuck-Hufnagel, S., & Turk, A. E. (1996). A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research*, 25(2), 193–247. <https://doi.org/10.1007/BF01708572>.
- Shue, Y.-L., Keating, P. A., Vicens, C., & Yu, K. (2011). Voicesauce: A program for voice analysis. *Proceedings of International Congress of Phonetic Sciences*, 1846–1849.
- Smith, R., Baker, R., & Hawkins, S. (2012). Phonetic detail that distinguishes prefixed from pseudo-prefixed words. *Journal of Phonetics*, 40(5), 689–705. <https://doi.org/10.1016/j.wocn.2012.04.002>.
- Sósuthy, M. (2021). Evaluating generalised additive mixed modelling strategies for dynamic speech analysis. *Journal of Phonetics*, 84. <https://doi.org/10.1016/j.wocn.2020.101017>.
- Steriade, D. (2000). Paradigm uniformity and the phonetics-phonology. *Papers in laboratory phonology*, Vol. 5, 313–334.
- Strycharczuk, P. (2019). Phonetic detail and phonetic gradience in morphological processes. In *Oxford Research Encyclopedia of Linguistics*. <https://doi.org/10.1093/acrefore/9780199384655.013.616>.
- Strycharczuk, P., & Scobbie, J. M. (2017). Whence the fuzziness? Morphological effects in interacting sound changes in Southern British English. *Laboratory Phonology*, 8(1). <https://doi.org/10.5334/labphon.24>.
- Sugahara, M., & Turk, A. (2009). Durational correlates of English sublexical constituent structure. *Phonology*, 26(3), 477–524. <https://doi.org/10.1017/S0952675709990248>.
- Tomaschek, F., Plag, I., Ernestus, M., & Baayen, R. H. (2021). Phonetic effects of morphology and context: Modeling the duration of word-final S in English with naïve discriminative learning. *Journal of Linguistics*, 57(1), 123–161. <https://doi.org/10.1017/S0022226719000203>.
- Walsh, T., & Parker, F. (1983). The duration of morphemic and non-morphemic/s/in English. *Journal of Phonetics*, 11(2), 201–206. [https://doi.org/10.1016/S0095-4470\(19\)30816-2](https://doi.org/10.1016/S0095-4470(19)30816-2).
- Whitman, J., & Cho, S. (2019). Phonology and phonetics. In J. Whitman & S. Cho (Eds.), *Korean: A Linguistic Introduction* (pp. 63–95). Cambridge University Press. <https://doi.org/10.1017/9781139048842.005>.
- Wieling, M. (2018). Analyzing dynamic phonetic data using generalized additive mixed modeling: A tutorial focusing on articulatory differences between L1 and L2 speakers of English. *Journal of Phonetics*, 70, 86–116. <https://doi.org/10.1016/j.wocn.2018.03.002>.
- Wood, S. N. (2011). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 73(1), 3–36. <https://doi.org/10.1111/j.1467-9868.2010.00749.x>.
- Wood, S. N. (2017). *Generalized additive models: An introduction with R* (2nd ed.). CRC Press/Taylor & Francis Group.
- Zhang, W., Clayards, M., & Wagner, M. (2024). Prosodic effects of focus and constituency in mandarin and in English. *Laboratory Phonology*, 15(1), 1. <https://doi.org/10.16995/labphon.9704>.