Tensification as a General Marker of Compound Boundary in Korean

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1 Introduction

Korean obstruents exhibit a typologically unusual three-way laryngeal contrast that does not involve a voicing distinction: aspirated, tense (fortis), and plain (lenis). Aspirated consonants are produced with a spread glottis, leading to long aspiration, while tense consonants are produced with reinforced articulation, characterized by a stiffening of the laryngeal muscles and increased glottal tension. Plain stops have a more neutral glottal setting compared to aspirated or tense consonants, allowing for greater variation in their surface realizations: Word-initially, they are weakly aspirated (Cho & Keating 2001, Cho et al. 2002, Shin et al. 2013); word-medially, they can undergo voicing (Silva 1992, Jun 1993); and after another obstruent, they can surface as tense through post-obstruent tensification (POT). Most relevant to this study, a plain consonant may become tense at the juncture of two nouns forming a compound, a process known as compound tensification or *sai-sios*.

The example in (1) illustrates this morphophonological process: the plain /p/ in the second noun surfaces as tense [p*] when combined with the preceding noun. However, when the noun /pi/ 'rain' stands alone, its initial sound is realized as [p].

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(1) /pom + pi/
[pom p*i]
'spring' 'rain'
'spring rain'

A traditional account attributes compound tensification to a historical genitive marker. This marker, attested as the genitive particle =*s* in Middle Korean (Cho & Whitman 2020), is believed to have left a reflex, typically realized as /s/ or [t] (Chung 1980, Ahn 1985). The insertion of this reflex is thought to trigger POT in the following plain obstruent, causing it to become tense. However, tensification is not entirely predictable based on linguistic context alone. For example, the compounds in (2) and (3) differ in their realization of the medial obstruent, even though their component nouns share a similar semantic relationship and occur in comparable phonological environments.

(2) /son + tɕil/
[son dʑil]
'hand' 'using a tool'
'trimming'

(3) /son + tɕit/
[son tɕ*it]
'hand' 'gesture'
'pointing gesture'

Both examples represent subordinate compounds, where the first component word modifies the meaning of the second noun. Despite their structural similarity, the plain affricate /tɕ/ in (2) likely undergoes intersonorant voicing, surfacing as [dʑil] (Silva 1992, Cho & Whitman 2020), whereas the plain /tɕ/ in (3) undergoes tensification, surfacing as [tɕ*it].

The fact that not all nominal compounds undergo tensification, even when the expected conditions are met, has led to extensive investigations into the factors influencing the application of tensification (Zuraw 2011, Ito 2014, Kim 2016, Jeon 2023). Ito (2014) examined potential factors such as age and gender in Yanbian Korean but found no significant correlation. Instead, she confirmed Zuraw's (2011) finding that the familiarity of the word increases the likelihood of *sai-sios*. Phonological factors, including the length of component nouns, the first component noun's coda segment type, and the presence of laryngeally marked consonants, also affected tensification patterns. Kim (2016) confirmed these findings in Seoul Korean, incorporating token frequency data and weighted optimality-theoretic constraints that successfully predicted observed tensification patterns.

Building on these studies, Jeon (2023) conducted a production study investigating the relationship between the above contributing factors and stop duration. She concluded that these factors and the phonetic patterns of stop duration are not linearly related but instead reflect the strength of the boundary between the two nouns, as evidenced by the effect of compound plausibility on duration. This work is particularly meaningful in demonstrating that compound boundary strength is not a fixed property but a fluid one.

On the other hand, Kwon et al. (2023) and Kwon (2024) investigate the phonetic realization of plain and tense stops in simplex nouns and compounds, focusing on how tense stops derived from compound tensification are produced. Kwon et al. (2023) analyze corpus data and find that plain stops in compounds exhibit longer duration and lower F0 on the following vowel, consistent with canonical tense stops. In contrast, tense stops in compounds are shorter and have lower F0 compared to tense stops in simplex nouns, suggesting that tense stops in compounds are neutralized in the direction expected for a plain stop. Expanding on this, Kwon (2024) conducts a controlled production study considering preceding phonological context. This study finds that stop duration is longest when following a sonorant sound, reflecting the greater likelihood of tensification when a plain stop precedes a sonorant.

While these studies highlight the complex nature of compound tensification as well as its relation to phonetic variation, another interesting aspect of this phenomenon is its potential extension beyond traditionally expected environments. The historical account suggests that only subordinate compounds, such as those in (1)–(3), should be subject to compound tensification due to the semantic relationship between component nouns. However, casual observations indicate that Korean L1 speakers also tensify beyond subordinate compounds. Specifically, coordinate compounds, where two component nouns form a conjuctive relationship, also exhibit tensification. For instance, when asked whether the coordinate compound /pom+kɯl/ 'spring and fall' should be pronounced as [pomkaɯl] or [pomk*aɯl], Korean speakers showed preference for the former but stated the latter is also allowed. This raises the question of whether compound tensification has evolved into a more general way to mark morphological boundaries in complex words.

This study explores whether some speakers generalize tensification beyond subordinate compounds, particularly to coordinate compounds. To test this hypothesis, data from a prior production experiment (Kwon & Tilsen 2024) was analyzed by assessing the occurrence of tensification based on listener judgments and measuring the target stop duration in both compound types. The results indicate that compound tensification occurs more broadly across different compound types, suggesting that it may have become an emergent phonological process extending beyond its historical origin.

2 Methods

2.1 Data

The data were drawn from a previous production experiment in which 33 native speakers of Seoul Korean (20 female, 13 male) read sentences containing either simplex nouns or compounds (Kwon & Tilsen 2024). For the analysis of this study, only tokens with compounds were included. Each compound contained an underlyingly plain stop at the onset of the second noun (referred to hereafter as the 'target stop'), preceded either by a vowel or a sonorant and always followed by a non-high vowel. The compounds ranged from two to three syllables in length, with some four-syllable coordinate compounds included, as they tend to be longer. Each compound was embedded in a carrier sentence structured as follows: a proper name with a topic marker *-nun*, followed by the target compound, a case marker for the compound, and a verb providing meaningful context for the compound. A total of 1,779 tokens were analyzed, including 8 subordinate compounds and 7 coordinate compounds. The full word list is provided in Appendix Table A.

2.2 Judgement by Seoul Korean L1 Listeners

To determine whether the target stop (i.e. the initial stop of the second noun) was realized as plain or tense, all tokens were initially assessed by the experimenter, a native speaker of Seoul Korean. To verify the reliability of these judgments, two additional native speakers of the same regional variety and age group (in their 30s) evaluated a subset of tokens. They listened to isolated words extracted from sentences to focus on pronunciation within the word. Tokens were presented via MATLAB Graphics User Interface (The MathWorks, Inc. 2023), where each word appeared on the screen alongside two buttons showing the two possible pronunciations: one with tensification and one without. Listeners selected the option that best matched their perception of the pronunciation. Each listener took about 20 minutes to complete the judgement.

The subset consisted of 350 tokens, representing 15.2% of the total dataset. These included tokens the experimenter identified as differing from their dictionary pronunciations, along with a randomly selected set of tokens to ensure a balanced number for each word. To assess the inter-rater agreement among the listeners, Fleiss' kappa was performed (Fleiss 1971). It is a statistical measure of agreement for categorical ratings across multiple raters. A value of 1 indicates perfect agreement, while 0 indicates agreement no better than change, and negative values indicate systematic disagreement. After the judgments were made, the occurrence of compound tensification was determined based on majority agreement, where at least two out of three listeners classified a token as exhibiting tensification. The tensification rate was then calculated as the proportion of tokens judged to undergo compound tensification relative to the total number of tokens for each variable.

2.3 Analysis of Stop Duration

To provide further evidence of tensification in coordinate compounds, stop duration was measured and compared between stops perceived as plain and tense in both subordinate and coordinate compounds. Stop duration was defined as the total duration, including stop closure, burst, and release. This measurement was extracted from Praat's (Boersma & Weenick 2025) TextGrid files containing segmentation information obtained through forced alignment (Povey et al. 2011), followed by manual correction. After measurement, 80 tokens were removed as outliers using the interquartile range (IQR) method, where values outside the range defined by the first and third quartiles were identified as outliers and excluded.

Linear mixed regression was fitted using the *lme4* package (Bates et al. 2015) in *R* (R Core Team 2023) to analyze the significance of the durational differences between subordinate and coordinate compounds. The best performing model was found by comparing different regression models in a top down fashion, starting with the maximally specified model including the following factors: perceived pronunciation judged by listeners, compound type, and their interactions. The model also included the place of articulation, random subject intercept and slope, and random word intercept and slope. The selected model is shown in (4) below.

(4) Duration ~ Perceived Pronunciation * Compound Type + Stop POA + (1|Subject) + (1|Word)

Post-hoc analyses were conducted to further investigate the interaction between perceived pronunciation and compound type, using the *emmeans* package (Lenth 2023). Specifically, pairwise comparisons were performed within tokens perceived as plain and tense to assess the degree of similarity in perceived sounds across compound types.

3 Results

3.1 The Tensification Rate

The tensification rate represents the percentage of tokens of a given word that listeners perceived as undergoing tensification, determined by dividing the number of such tokens by the total tokens for that word. The average tensification rate was significantly higher for subordinate compounds than for coordinate compounds: 291 out of 941 subordinate tokens (30.92%) were judged to have tense stops, compared to 59 out of 838 coordinate tokens (7%). This aligns with the traditional assumption that compound tensification occurs only in subordinate compounds. However, the presence of tensification in coordinate compounds is unexpected, suggesting that the process may not be as strictly constrained as previously thought.

For a more detailed analysis, Figure 1 shows the tensification rates of individual subordinate compounds. Each bar represents a compound, with the orange portion indicating the proportion of tokens perceived as tense. The white text labels the total number of tokens perceived as plain, while the black text shows those perceived as tense. The words that most frequently exhibited tensification were *mal-pelus* ‘speech habit’, *porum-tal* ‘full moon’, and *pom-pam* ‘spring night’. The word *mal-pelus* consistently surfaced with a tense medial stop (100% of occurrences), while *porum-tal* exhibited tensification in 91.05% of instances, and *pom-pam* in 71.31%. For the remaining words, only a few tokens were judged to have undergone tensification.

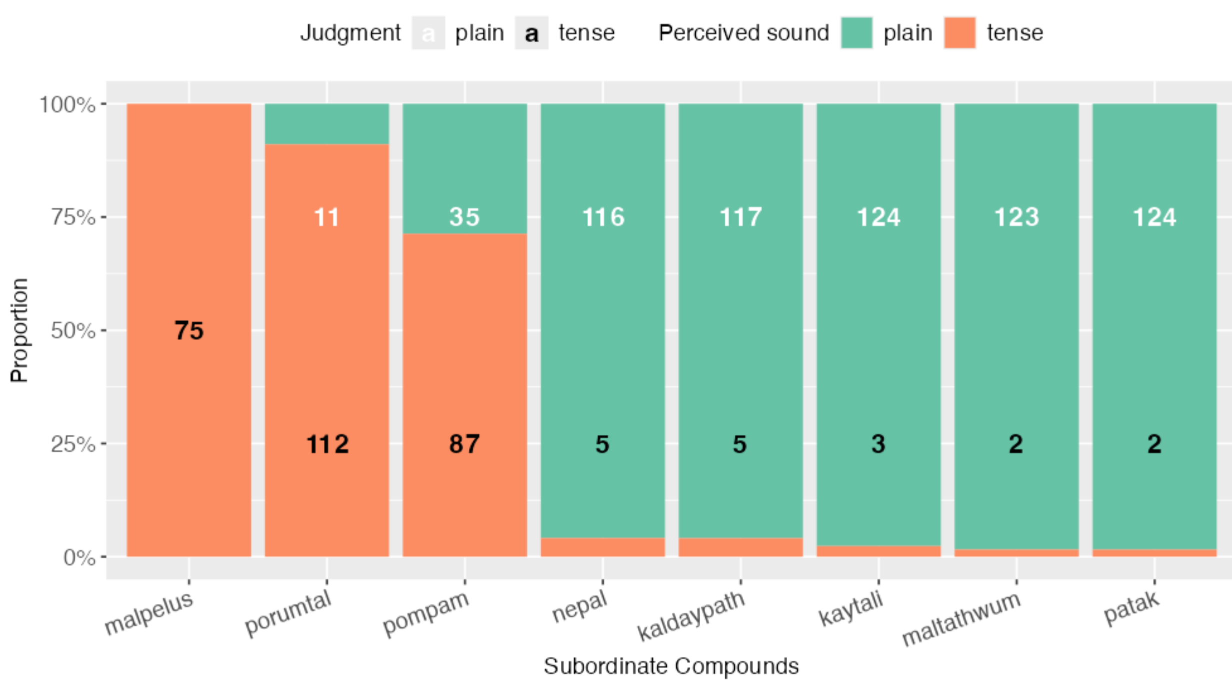

Figure 1: Tensification Rate of Subordinate Compounds

In contrast, coordinate compounds exhibited tensification less frequently, as illustrated in Figure 2. The word that most commonly underwent tensification was *pom-kaul* ‘spring and fall’, with its medial stop perceived as tense in 38% of occurrences. A few other words, such as *pal-tali* ‘arm and leg’ at 5.5%, *swul-tampay* ‘alcohol and cigarette’ at 4.1%, and *son-pal* ‘hand and foot’ at 0.8%, were also judged to have undergone tensification, though at much lower rates. However, compound tensification did not occur in longer words, such as *chentwung-penkay* ‘thunder and lightening’, *kunsim-kekceng* ‘trouble and worry’, and *kay-koyangi* ‘dog and cat’. This pattern may be influenced by factors such as word length or lexical frequency, as noted in previous studies, since these words tend to be longer and of lower frequency.

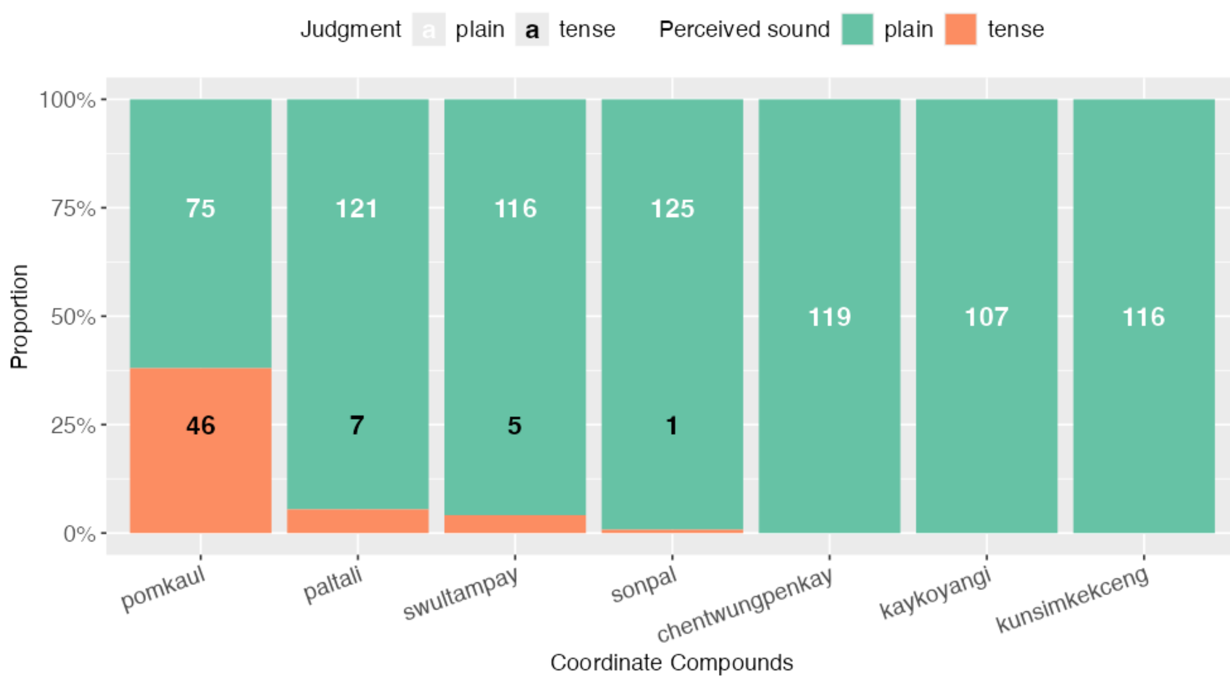

Figure 2: Tensification Rate of Coordinate Compounds.

3.2 Stop Duration in Subordinate and Coordinate Compounds

The analysis of stop duration provides further evidence for the occurrence of compound tensification in coordinate compounds, as comparing stop duration between subordinate and coordinate compounds indicates that the durations of stops perceived as plain and tense were similar across both compound types. Mean durations and standard deviations are presented in Table 1 below. The difference in duration between perceived sound categories (plain vs. tense) is more salient than the difference between compound types (subordinate vs. compound), which is visualized in Figure 3.

Compound Type	Perceived Sound	Count	Mean duration (ms)	Standard deviation
Subordinate	Plain	650	54.5	14.8
Coordinate	Plain	779	49.1	18.2
Subordinate	Tense	291	79.9	19.8
Coordinate	Tense	59	87.6	15.9

Table 1: Mean Duration and Standard Deviation of Stops in Subordinate and Coordinate Compounds

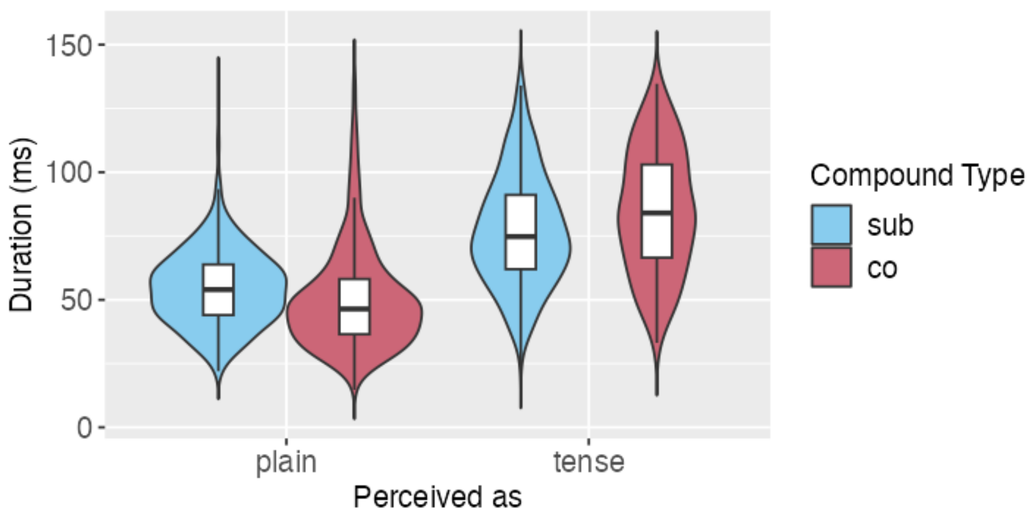

Figure 3: Stop Duration in Subordinate Versus Coordinate Compounds

The regression model supports this observation. No significant difference was found between plain or tense stops in subordinate compounds, and those in coordinate compounds (Coordinate compound estimate = -12.33±4.56, t(11.09) = -1.714, p = 0.114). However, the difference between perceived sound categories was significant (Tense estimate = 24.15±1.73, t(1616.3)=13.95, p < 0.0001), with tense stops consistently showing longer duration than plain stops. This durational difference is expected, given that Korean word-medial plain stops tend to be shorter than word-medial tense stops due to voicing (e.g. Silva 1992).

Moreover, an interaction effect of perceived sound categories and compound type was found (Coordinate compound×Tense estimate = 12.70±2.62, t(1734.08)=4.93, p <0.0001). To further investigate this interaction, Figure 4 presents model estimates of stop duration. The left panel illustrates the estimated duration of plain stops in both subordinate ('sub') and coordinate ('co') compounds. Interestingly, the durations of plain stops were estimated to be shorter in coordinate compounds compared to subordinate compounds. Notably, plain stops were estimated to be shorter in coordinate compounds than in subordinate compounds. Given that the estimated duration of plain stops in subordinate compounds remains around 60 milliseconds, which is within the expected range for word-medial plain stops, this finding suggests that plain stops in coordinate compounds may have been frequently voiced, although further investigation is needed.

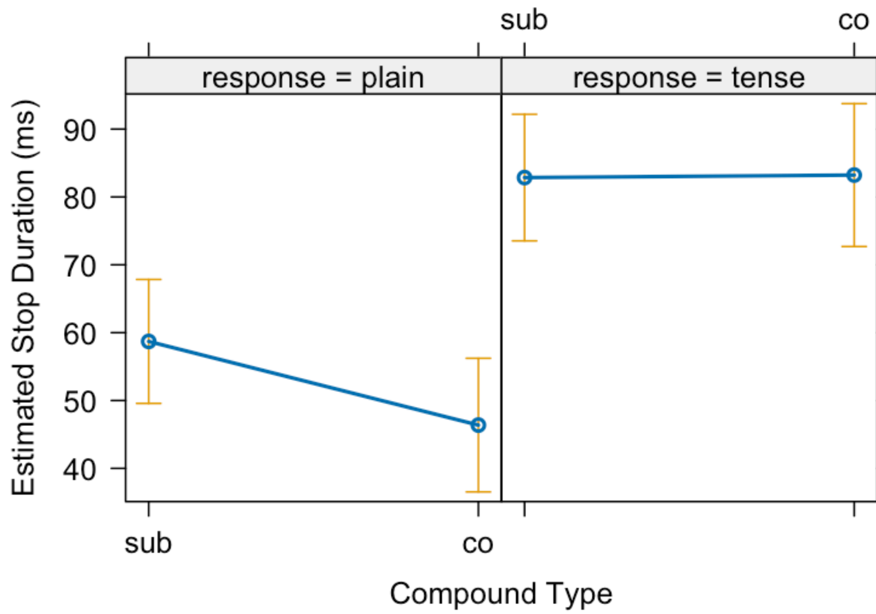

Figure 4: Model Estimate of the Interaction Effect between Compound Type and Perceived Sounds

4 Discussion

In summary, the results indicate that coordinate compounds undergo compound tensification, although they do so much less frequently than subordinate compounds. The analysis of tensification rates revealed a significant difference between the two compound types, with subordinate compounds exhibiting a substantially higher tensification rate. The stop duration analysis further supports the occurrence of tensification in coordinate compounds in a manner similar to subordinate compounds. Although the lower frequency of tensification in coordinate compounds aligns with the traditional assumption that this process primarily occurs in subordinate compounds, its presence in coordinate compounds is surprising given the historical environment of compound tensification.

These findings suggest that compound tensification may be an ongoing sound change, with some speakers extending the process beyond its original morphological domain. If this reanalysis continues, tensification is expected to spread to new compound words and potentially across broader morphological boundaries, evolving into a more generalized process. As the change progresses, the acoustic cues signaling compound tensification may shift in their relative promi-nence (Lee & Jongman 2018, Schertz & Clare 2020). For example, intervocalic or intersonorant voicing of word-medial plain stops, initially a phonetic process of assimilation from neighboring voiced sounds, could be reinterpreted as a phonological cue. This would create a clearer distinction between plain stops, which shorten due to voicing, and tense stops, which lengthen under the influence of compound tensification. Such developments could lead to a more categorical contrast between plain and tense stops, though this remains an empirical question.

This study has several limitations. First, a larger pool of listeners is needed to assess the occurrence of tensification more reliably. However, increasing the sample size alone does not fully resolve the issue of listener judgment reliability. Linguistic judgments often reflect metalinguistic awareness, making it difficult to disentangle the influence of listener biases, particularly those shaped by their prior knowledge of the word. Moreover, while this study measured compound tensification primarily through stop duration, multiple phonetic dimensions likely contribute to its realization. For instance, analyzing F0 onset in the vowel following medial stops could help determine whether duration differences result from a broader enhancement process, where stops lengthen and raise F0 at the word boundary, ultimately making plain stops surface as tense stops.

To overcome these limitations, a promising direction for future research is an artificial grammar learning experiment, in which participants are exposed to novel compounds with varying meaning associations. This approach would enable precise control over key factors that influence the rate of tensification, such as etymology and the plausibility of compounds, and that bias the listeners' perception. By examining how speakers generalize tensification in a controlled setting, this method could offer deeper insight into the phonetic realization of a sound change in progress and its implications for the nature of compound tensification.

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Appendix

Compound Type	Word (Yale-Romanized)	Noun 1	Noun 2	Meaning
Subordinate	*kaltay-path*	/kalte/ ‘reed’	/patʰ/ ‘field’	‘reed field’
	kay-tali	/ke/ ‘dog’	/taɾi/ ‘leg’	‘dog leg’
	mal-pelus	/mal/ ‘speech’	/pʌɾɯt/ ‘habit’	‘speech habit’
	mal-tathwum	/mal/ ‘speech’	/tatʰum/ ‘fight’	‘argument’
	ney-pal	/ne/ ‘four’	/pal/ ‘foot’	‘four feet/legs’
	pha-talk	/pʰa/ ‘spring oninon’	/tak/ ‘chicken’	‘chicken with sliced spring onion’
	polum-tal	/poɾɯm/ ‘fifteen days’	/tal/ ‘moon’	‘full moon’
	pom-pam	/pom/ ‘spring’	/pam/ ‘night’	‘spring night’
Coordinate	*chendwung-penkay*	/tɕʰʌntuŋ/ ‘thunder’	/pʌnke/ ‘lightening’	‘thunder and lightning’
	kay-koyangi	/ke/ ‘dog’	/kojaŋi/ ‘cat’	‘dog and cat’
	phal-tali	/pʰal/ ‘arm’	/taɾi/ ‘leg’	‘arm and leg’
	pom-kaul	/pom/ ‘spring’	/kaɯl/ ‘fall’	‘spring and fall’
	son-pal	/son/ ‘hand’	/pal/ ‘foot’	‘hand and foot’
	swul-tampay	/sul/ ‘alcohol’	/tampe/ ‘cigarette’	‘alcohol and cigarette’

Table A: List of Compounds Used in the Analysis