

Laryngeal features for Korean obstruents revisited*

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Kang, Kyung-Shim. 2004. Laryngeal features for Korean obstruents revisited. *Studies in Phonetics, Phonology and Morphology*. 10.2. 169-182. It is generally assumed that the three-way lexical distinction of Korean obstruents is characterized by two laryngeal features – [spread glottis] and [constricted glottis]. Lax obstruents have been regarded as unmarked with no laryngeal feature, whereas tense and aspirated counterparts have the marked features of [+constricted glottis] and [+spread glottis], respectively (Ahn 1983, Sohn 1987, and Kim 1987). However, Halle and Stevens (1971) and Ladefoged and Maddieson (1996) point out that the stiff vocal cords are attributed to a number of distinctive phonetic properties of Korean tense obstruents. Besides, Iverson (1983) demonstrates how the stiff vocal cords is necessary for the characterization of Korean /s/. In line with those phonetic theories, a recent psycholinguistic study by Kang (2004) found that there exists asymmetry in manipulating laryngeal mechanisms with the highest variations for the lax, intermediate for the aspirated, and the least for the tense. The unproductive and restricted slips for the tense hints that a tense be involved with a different type of laryngeal setting other than the size of glottis. Kang's slips data showing unusual interactions between /s/ and /c^h/ also corroborate the claim by Iverson (1983) and Kang (2000) that Korean /s/ is a lax but aspirated. Moreover, the active interactions between a tense and aspirated obstruent also imply that the fortis be grouped together with the shared feature [+stiff vocal cords]. Therefore, based on prior phonetic accounts and psycholinguistic evidence, I suggest that [stiff vocal cord] needs to be defined in the representation of Korean obstruents for the optimal characterization of the tense in particular and laxness in general. (Busan College of Information Technology)

Keywords: Korean obstruents, laryngeal features, stiff vocal cords, speech errors

1. Introduction

Korean has lax (or plain), tense (or voiceless unaspirated), and aspirated phonemes in its complex obstruent system. As the obstruents are all voiceless word-initially, a simple contrast by the voice parameter hardly provides an adequate distinction among the three types. Thus, to identify the three-way lexical contrast of Korean obstruents has been one of the most intriguing issues in Korean phonology.

An early theory by Martin (1951) contrasted lax consonants with tense and aspirated counterparts by differentiating the latter as a sequence of the lax plus /q/ (glottal tension) and /h/ (aspiration) respectively. Martin's single vs. cluster analysis received intense criticism from other phonologists, as Korean disallows consonant clusters in word-initial position unless the second element is a glide, and /q/ for tense segments is not a phoneme at

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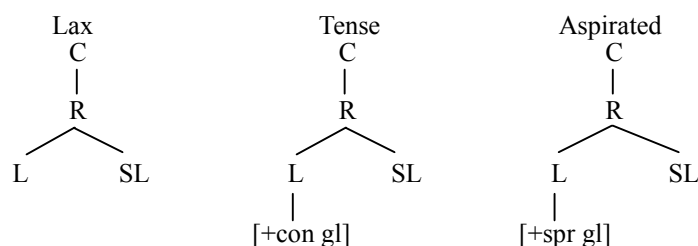
all. However, Martin's (1951) account was insightful in the sense that he drew a fundamental difference between the lax and the fortis, i.e. tense and aspirated phonemes, in their phonetic and phonological realizations.

A subsequent approach by Kim (1965) and Kim-Renaud (1974) treated each category as underlyingly singleton, and defined them with features such as [tense]¹, [aspirated], and [voice]. The two accounts were much in common, except that Kim (1965) regarded lax obstruents as [+aspirated] in response to their moderate aspiration in initial position, whereas Kim-Renaud (1974) labeled the lax as [-aspirated] in contrast to the aspirated series, which are heavily aspirated irrespective of the position they occur.

A problem in the early singleton accounts was that they tried to distinguish the lax from the fortis with respect to the feature [tense], whose phonetic definition is still vague and controversial. A number of phonetic properties – air pressure, duration, intensity, contact area, and so forth – have been applied to explain the contrast by tenseness or force of articulation. However, many argue against the use of tenseness, as it is a loosely-fitting abstract terminology, lacking in consistent and inherent correlates of its own (see Pike 1943, Lisker and Abramson 1964, 1967, and Malécot 1970).

Afterwards, there has been a great deal of effort in representing the internal structure of speech sounds in such a way as to integrate phonetics with phonology. Within the framework of underspecification and feature geometry, Kim (1987) proposed that lax obstruents are the least marked or underspecified segments with a bare laryngeal node, whereas tense and aspirated obstruents have a specified laryngeal node underlyingly with the features [+constricted glottis] and [+spread glottis], respectively, as shown in (1).

- (1) Kim's (1987) underspecified singleton analysis
(R=root, L=laryngeal, SL=supralaryngeal)



In an attempt to complement Kim's approach with durational difference, Kim (1990) identified both tense and aspirated segments as geminates by

¹ In Chomsky and Halle (1968:324), [tense] was defined as the manner in which the entire articulatory gesture of a given sound is executed by the supraglottal musculature. So far, no one has ever been successful in proving the phonetic validity of the tense feature.

aligning them with two timing slots on the skeletal tier, while Han (1992), and Silva (1992) claims only the tense to be a geminate of lax consonants. Those three accounts are alike in that they view the tense to be a geminate lax underlyingly without a marked laryngeal feature, and that the feature [+constricted glottis] for a surface tense will be derived later by a rule. As a consequence, the timing-tier analyses give a questionable impression that the laryngeal feature is less fundamental than length in tense obstruents.

Kang (1999) also made an analogous approach in characterizing Korean obstruents with reference to phonetic parameters such as VOT, duration, and vocal cord tension. She suggests that tense and aspirated segments are marked not only with their own laryngeal features but also with the durational feature [+long], and that the feature [long] is crucial in defining a lax-like property among the three obstruent types. As the evidence, she points out that Korean /s/, in spite of being a lax, is found to have a large aspiration almost equivalent to aspirated stops, but that its durational properties are in line with the rest of the lax category, as a [-long] segment.

Nevertheless, questions still arise regarding the nature of laryngeal features and role of duration in the phonological representation of Korean obstruents. First, are the Korean obstruents best characterized by the two features, i.e. [spread glottis] and [constricted glottis], which happen to be in charge of controlling the size of the glottis? Or is there any other feature that gives a better account for Korean obstruents? Second, is duration an independent property of a speech segment with no relation to the laryngeal feature in association? Or is it a subordinate component to the larynx, most clearly marked and easiest to be measured?

For those questions, a series of phonetic reports and recent psycholinguistic study by Kang (2004) hint that Korean obstruents might be better represented with laryngeal features of [spread glottis] and [stiff vocal cords], instead of [constricted glottis].

2. Phonetic implications

From a phonetic viewpoint, Ladefoged and Maddieson (1996) describe in detail a stiff voice that Korean tense obstruents manifest. As the evidence, they note a high *F₀* (Dart 1987), undampened harmonics at voice onset (Han and Weitzman 1970, Hardcastle 1973), and long closure with almost occluded glottis before release (Kagaya 1974).

An electromyographic study by Hirose, Lee, and Ushijima (1974) also demonstrate the importance of stiff vocal cords operated by a markedly increased activity of the vocalis and lateral cricoarytenoid muscles in characterizing the tense type. They further indicate that the distinctive activity of the vocalis muscles may result in constriction of the glottis. Their assumption of the glottal constriction by stiff vocal cords stands in accordance with Halle and Stevens's (1971) report that an increased stiffness of the vocal cords, i.e. [+stiff vocal cords], tends to narrow the

range of glottal apertures.

All of these remarks points out the necessity of [stiff vocal cords] as a distinctive feature for Korean tense consonants, which have been defined as [+constricted glottis] instead. In fact, the feature [constricted glottis] previously characterizing a Korean tense is used for describing glottalized consonants such as ejectives and implosives in phonology. On the other hand, a typical voiceless unaspirated consonant is identified by [+stiff vocal cords] with neither spread nor constricted glottis. Therefore, before we decide a feature appropriate to the tense, we need to decide which helps capture an optimal generalization of the tense series between a glottalization and unaspiration.

Prior acoustic studies of Korean stops have noticed the least VOT or unaspiration of a tense irrespective of the position it occurs, and assumed the nonaspiration might be served as a reliable cue for the tense. An acquisition study by Kang (1998) corroborates the assumption by finding that the Korean child (2;8) in a case study produced a tense with an adult-like unaspiration in contrast with a lax and aspirated, while the VOT values of the lax and aspirated were considerably collapsed without a clear distinction. In addition, the child's different pattern of intensity measurements implies that she didn't acquire a mother-like vocal cords tension (or glottalization) expected for a tense spoken in a Kyung-Sang dialect yet. Thus, manipulating [+stiff vocal cords] associated with a voiceless unaspirated may precede the acquisition of a constricted glottis. To put it a different way, the feature [stiff vocal cords] itself might result in a natural contraction of the vocalis muscles to form a glottal constriction.

Besides, it should also be noted that the feature [constricted glottis] alone cannot capture the complex laryngeal mechanism of tense obstruents. Unless accompanied by [+stiff vocal cords], the constricted glottis will allow vibration in a way that a voiced implosive induces. However, a Korean tense never initiates a voicing even in a voiced environment. Furthermore, distinctively long durations for the tense series (Silva 1992, Kang 1999) can be better explained in terms of stiff vocal cords. According to Mårtensson and Skoglund (1964), the adducting maneuver of the glottis is faster than the abducting one. In addition, Stevens (1998) estimates that the required interval for the adducting maneuver from an open position to a closed one would be about 50 ms for an aspirated consonant.

However, closure duration for a tense usually take the longest among the three phonemic categories, typically over 100 ms intervocalically (see Silva 1992, Kang 1999)². This largest closure length of a tense reflects that

² In Silva (1992), mean closure durations for word-initial bilabial stops were measured $p=50$ ms, $p^h=77$ ms, and $p'=81$ ms after a vowel, whereas $p=32$ ms, $p^h=53$ ms, and $p'=60$ ms after a nasal. (Please note that closure lengths of word-initial stops cannot be measured unless they are preceded by another segment.) The average closure durations for medial bilabials were also measured $p=48$ ms, $p^h=84$ ms, and $p'=123$ ms after a vowel, while $p=25$ ms, $p^h=57$ ms, and $p'=83$ ms after a nasal. On the other hand, in Kang (1999), mean closure durational values for word-medial stops and affricates in an intersonorant context were lax=51 ms,

its laryngeal setting may not be determined by the simple act of glottal adduction, but by the stiffness of the vocal cords, whose rates of muscle contraction can be achieved slowly in about 200 to 300 ms (Stevens 1998).

3. Phonological implications

Only lax obstruents undergo various phonological processes such as voicing, tensification, and aspiration. That explains why lax consonants have been considered to differ from the tense and aspirated series in such a way that the former lacks any marked glottal feature in the underlying form. However, when we take a closer look at the voicing rule, we encounter the alveolar fricative /s/, which is categorized as a lax but disallows to be voiced in an intersonorant environment. To account for this exception, Iverson (1983) hypothesizes that /s/ be associated with [+spread glottis] as well as [-stiff vocal cords], as given in (2).

(2) Glottal feature assignment by Iverson (1983)³

	Lax	Tense	/s/	Aspirated
Spread glottis	–	–	+	+
Constricted glottis	–	+	–	–
Stiff vocal cords	–	+	–	+
Slack vocal cords	–	–	–	–

He views that although both /s/ and aspirated consonants are involved

aspirated=119 ms, and tense=162 ms. In either study, tense obstruents were found to have the longest closure duration among the three categories. According to Silva (1992), durational differences by a tense stop were reported to be maximized when it occurs word-internally after a vowel.

³ Iverson's (1983) feature assignments for Korean obstruents are much in agreement with Halle and Stevens' (1971) proposal, except that he labeled lax obstruents as [-spread glottis] based on Kagaya's (1974) fiberoptic evidence on the lax's involvement with narrow glottal width. By contrast, Halle and Stevens (1971) interpreted a moderate aspiration of initial lax obstruents in Lisker and Abramson (1964) and Kim (1965), as being associated with [+spread glottis]. The original feature assignment by Halle and Stevens (1971) can be illustrated as follows:

	Lax	Tense	Asp.
Spread glottis	+	–	+
Constricted glottis	–	–	–
Stiff vocal cords	–	+	+
Slack vocal cords	–	–	–

Regarding the [spread glottis] feature for lax obstruents, it is generally assumed that lax segments are [-spread glottis], as their VOT amounts are distinctively smaller than those of the aspirated and more importantly lax obstruents are voiced in medial position. Iverson (1983) also contrasts the tense type with [+constricted glottis], while Halle and Stevens defined voiceless unaspirated consonants including a Korean tense as [-constricted glottis].

with spread glottis, the degree of glottal opening would be larger and the length of aspiration longer for the aspirated. That's because having stiff vocal cords would further result in the increase of glottal opening through stiffening the vocalis and cricothyroid muscles for the aspirated. As a result, the feature [stiff vocal cords] needs to be specified in the underlying form for a precise characterization of lax obstruents.

With respect to the tensification and aspiration processes, a keen attention has been paid to the fact that a post-obstruent lax surfaces as a tense, but not as an aspirated unless one of the [C.C] sequence happens to be /h/. In other words, there exists a sense of structural intimacy between the lax and tense category, as lax segments become converted into tense counterparts, not by the presence of a tense in vicinity like the aspiration rule, but by the only condition that they follow another consonant.

Nevertheless, Kim's (1987) proposal on the laryngeal assignment of obstruents fails to provide such a prediction of the lax and tense's closeness. In this model, a tense consonant is linked to its own glottal feature, just like the aspirated, as a marked segment in distinction with a lax. By contrast, the geminate analyses for the tense by Kim (1990), Han (1992), and Silva (1992) reflect a structurally closer relationship between a lax and tense by assigning the latter with only an extra timing slot in the absence of a glottal feature. However, they resort to stipulating a rule in a later stage to obtain tense segments with constricted glottis from the underlying lax in postlexical contexts.

Then, is there any other way to illustrate the appropriate distinction among the three types from the very beginning? To use the feature [stiff vocal cords] in place of [constricted glottis] would be the necessary option. When we employ the two features of [spread glottis] and [stiff vocal cords], we can further indicate a structural or intrinsic relationship among the three types by denoting the lax with no marked glottal feature, the tense with [+stiff vocal cords], and the aspirated with two marked features, i.e. [+spread glottis] and [+stiff vocal cords]. The following section will add psycholinguistic evidence that helps justify the use of the [stiff vocal cords] feature.

4. Psycholinguistic implications

In Kang (2004)⁴, consonantal substitutions in error were found to reveal a

⁴ The slips data in Kang (2004) were collected from talks on the radio and TV, and from natural dialogues participated or overheard. It took almost 2 years to gather a total of 280 consonantal errors. For an unbiased data selection, the substitution errors were chosen randomly in chronological order. To make a precise encoding, part of the errors were tape-recorded and transcribed carefully after multiple listening. Of 280 slips, 177 errors (63%) occurred in spontaneous speech, and the remaining 103 (37%) in a reading mode. However, whether a spontaneous talk or reading, the speakers showed almost identical substitution patterns in distribution. The speakers were also well aware of their slips during the production, as indicated by 172 slips (61%) with an immediate correction right after the slips.

distinctive pattern according to the type of the laryngeal features associated. Of 280 errors of consonants, lax obstruents showed the highest number of substitution errors both as the target and intrusion segment (T: 139, I: 144), as illustrated in (4)⁵. Lax consonants were also found to show the highest interactions with a lax of a different articulatory place or manner, second highest with a sonorant, intermediate with an aspirated, and the least with a tense. The examples of lax obstruent substitution are provided as in the following:

- | | | | |
|-----|-----------------|----------------|---------------------------------|
| (3) | Target | | Error |
| a. | saŋ.sa-wa | no.tɔŋ.ɕa-ii | saŋ.sa-wa no.ɕɔŋ.ɕa-ii |
| | superiors-and | workers-of | 'of superiors and workers' |
| b. | si.ɕaŋ-saŋ-il | ʰa-nin ke | si.ɕʰaŋ-saŋ-il ʰa.nin ke |
| | major-prize-Obj | win-Comp thing | 'to win a prize from the major' |

A lax stop and affricate /t, c/ as the target in (3a) and (3b) were substituted into /c, c^h/ respectively, in anticipation of the intrusion segments /c/ and /t^h/ during the speech production. The errors in (3) reveal that not only a segment but also a feature can affect the target in slips.

That the lax type was involved with the highest number of speech errors either as the target or intrusion indicates lax obstruents are the most susceptible type of segments to substitution. In addition, it also suggests that the lax would be the most unmarked category of consonants from the perspective of phonology. Furthermore, the fact that lax obstruents interacted with sonorants much more often than aspirated and tense consonants combined hints that [voice] might be less marked than the other glottal features.

- (4) Consonantal errors relative to the target and intrusion (based on Kang 2004)

<i>Target</i>	<i>Intrusion</i>				Total of T
	Lax	Aspirated	Tense	Sonorant	
Lax	88	19	0	32	139 (49%)
Aspirated	20	12	3	1	36 (13%)
Tense	3	2	2	1	8 (3%)
Sonorant	33	2	0	62	97 (35%)
Total of I	144	35	5	96	280

Aspirated consonants had an intermediate number of errors by frequently interacting with a lax and heterorganic aspirated segment, but seldom with a tense and sonorant. In contrast, tense obstruents were concerned with the least substitution errors, exhibiting an almost equal interaction with each

⁵ The target segment means the consonant that the speaker was intended to produce, whereas the intrusion segment refers to the triggering consonant that replaced the target.

obstruent type (lax=3, tense=4, aspirated=5), but the least with sonorants.

Part of this asymmetry in the rate of occurrence relative to the phonation type might be attributable to the rate of frequency. Lexical items that carry the lax series in the base form are the most common, and thus most frequently spoken and heard during a speech, which maximizes the possibility of engaging in slips of the tongue. In contrast, lexical words including a fortis consonant in the underlying representation are relatively small in number, and thus, tense as well as aspirated segments will have a relatively low chance of being substituted for another in speech production. However, the apparent fewer violations by the tense than the aspirated sounds remain unresolved due to the lack of a full-scaled research on the frequency bias in relation to the segment type.

Another plausible account can be made in terms of the markedness of the phonological structures. Many has argued that lax obstruents are unmarked in the sense that they lack in glottal features, while aspirated and tense counterparts have [+spread glottis] and [+constricted glottis], respectively, in their phonological structures (Ahn 1985, Sohn 1987, Kim 1987). As the lax category is unspecified with regards to any marked glottal feature, substitutions of lax obstruents are expected to occur most frequently, and they were found as such, just as mentioned before.

However, it should be noted that although the lax type is assumed to have an equal amount of accessibility to each of the fortis categories, substitutions between a lax and tense (/lax/ ↔ /tense/: 3 times) were extremely lower in occurrence than between a lax and aspirated (/lax/ ↔ /aspirated/: 39 times). Moreover, errors by a tense segment were always rare irrespective of the source type, as seen in (4), whereas aspirated consonants showed a productive interaction with other aspirated segments or with a lax. Therefore, it might be the case that a different nature of glottal features might influence the rate of speech error to vary in substitution. In other words, as tense segments are produced with stiff vocal cords rather than constricted glottis, the required glottal adjustment into the stiff state of vocal cords hinders the tense from being subject to many slips. Contrastively, aspirated segments with widely abducted glottis might facilitate in controlling the glottis and become more vulnerable to errors.

Besides, the slips data in Kang (2004) corroborate the claim by Iverson (1983) and Kang (2000) that Korean /s/ is a lax but aspirated through the errors involved with /s/. For instance, the lax fricative /s/ exhibited the most frequent interactions with /c/ (30 times) and second highest with /c^h/ (9 times), as in (5).

(5)	Target		Error		Gloss
a.	mo.pəm	çæ.so.çə-ka	mo.pəm	çæ.so.çə-ka	model inmate-Subj
b.	ki.ç ^h o	co.çə	ki.ç ^h o	co.ç ^h a	basic examination

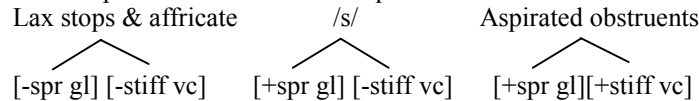
A lax fricative /s/ was perseverated at the onset of the adjacent syllable, and substituted for /c/ in (5a). On the other hand, the /s/ in (5b) was replaced with an aspirated affricate /c^h/ in perseveration of the /c^h/ in the preceding word.

Considering the large differences in manner, voice, and place of articulation between /s/ and /c^h/, the only plausible account would be that /s/ is produced with [+spread glottis] but the size of glottis is not as large as an ordinary aspirated due to [-stiff vocal cords] that a typical lax segment possesses. Thus, the feature [stiff vocal cords] is again found to be necessary from the psycholinguistic study by Kang (2004), as the feature provides a better explanation for a bias relative to the type of laryngeal features in association. And more importantly, the stiffness of vocal cords seems to be the feature that defines the laxness in a clear manner in distinction with the fortis. Only the lax series are [-stiff vocal cords], and without the feature, an accurate representation for /s/ against aspirated consonants would be unlikely to be handled.

5. Laryngeal features for Korean obstruents

Using the two laryngeal features from Halle and Stevens (1971), Korean lax obstruents and aspirated segments can be represented as the following:

(6) Surface representation of lax and aspirated obstruents

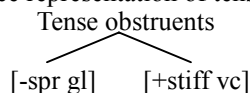


The reason to choose only two features from Halle and Stevens's (1971) laryngeal system is that their original assignments of [constricted glottis] and [slack vocal cords] features for Korean obstruents were all minus valued and thus nondistinctive in function. Moreover, subsequent phonetic studies have noted the importance of the features [spread glottis] and [stiff vocal cords], as mentioned before. The slips data in Kang (2004) also point out that the [constricted glottis] feature pertinent to the tense exhibited the least involvement among the 4 laryngeal features, whereas [stiff vocal cords] participated in errors over five times more often than it⁶. In addition, of 11 slips relevant to the tense series, interactions between aspirated and tense segments took up almost a half (5 errors, 45%). To put it differently, tense consonants, traditionally represented as [+constricted glottis], substituted well with aspirated counterparts with spread glottis. Since the two features are mutually incompatible, active correlations between the

⁶ Among the 4 laryngeal features, [spread glottis] was the feature most frequently involved in speech errors with 80 violations in total, while [constricted glottis] was the least violated and thus most marked (n=8). The features [voice] and [stiff vocal cords] were associated with intermediate numbers of errors, with 59 and 44 violations respectively, in Kang (2004).

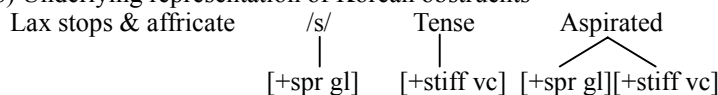
tense and aspirated series imply that there might be an inherent, shared feature further denoting the fortis in contrast to lax consonants. For such a feature, I propose again to employ [stiff vocal cords], as indicated in (7).

(7) Surface representation of tense obstruents



Then, how should we represent the underlying form of Korean obstruents in conjunction with phonetic findings and current psycholinguistic facts? I claim to specify the [spread glottis] and [stiff vocal cords] features in the lexical representation of Korean obstruents in such a way as shown in (8):

(8) Underlying representation of Korean obstruents



(9) Context-free redundancy rules:

- [] → [-spread glottis]
- [] → [-stiff vocal cords]
- [] → [-voice]
- etc.

Lax stops and an affricate differ from the rest of the obstruents in that they lack any marked glottal feature in the underlying form. A full specification of laryngeal features will be provided later on the surface by context-free redundancy rules in (9) as the default. In contrast, /s/ is marked with [+spread glottis], while a tense with [+stiff vocal cords]. Aspirated obstruents are the most marked in the sense that they are assigned with more than one laryngeal feature, i.e. [+spread glottis] and [+stiff vocal cords]. Although /s/ and aspirated consonants are both hypothesized to involve spread glottis, the degree of glottal opening would be larger and the length of aspiration longer for the aspirated, as discussed in Iverson (1983).

On the contrary, when a tense is produced with narrow glottis, the accompanied stiff vocal cords would rather reduce the range of glottal widths to the extent that there might be a slight degree of glottal constriction. This implies that the feature [stiff vocal cords] seems to play diverse roles in relation to the feature denoting the state of the glottis. It is also predictable that the stiff vocal cords of the tense series is not only intrinsically different from that of the aspirated, but also incompatible with spread glottis, so that the insertion of [+spread glottis] into the tense or [+stiff vocal cords] to /s/ would never be realized as an aspirated with the

two positive laryngeal features.

The structural distinctions proposed in (8) have an advantage in explaining phonological processes like voicing, tensification and aspiration; Only lax stops and affricate, which lack any marked laryngeal feature, are affected by the voicing assimilation rule. The [+voice] feature spread from an adjacent sonorant will change a lax voiceless noncontinuant to be voiced. The lax /s/'s incompatibility with voicing is due to its association with spread glottis, which blocks the spreading of [+voiced] from adjacent sonorants. However, the prior theories treating /s/ as the same as a lax stop or affricate with [-spread glottis] are unable to give a satisfactory account for /s/'s being immune to voicing.

Tensification that changes a lax into a corresponding tense appears to be correlated with the tense's structural intimacy to the lax than the aspirated. Aligned with the feature [+stiff vocal cords] in a post-consonantal position, a lax consonant will surface as a tense across the board. The optional tensification in initial syllable would be operated in the same manner as well. These two types of tensification seem to result from a physiological reason that relatively slack vocal cords of a lax might be unable to endure a lengthened duration after an unreleased consonant or optionally after a word boundary⁷. The aspirated category will not undergo tensification as the feature [+stiff vocal cords] is already filled-in as part of their inherent values. The lax fricative /s/, however, allows the tensification rule to be applied, as its vocal cords are not stiff. Nevertheless, when it becomes [+stiff vocal cords] in a post-consonantal context, /s/'s alignment with [+spread glottis] is no longer effective, as Korean disallows a genuine aspirated fricative carrying the two marked laryngeal features. Therefore, the insertion of [+stiff vocal cords] into /s/ will further necessitate the deletion of the [spread glottis] feature.

On the other hand, the aspiration process seems to operate through the insertion of the sequence [+spread glottis, +stiff vocal cords] into a bare laryngeal node. Thus, only lax stops and affricate are subject to the aspiration rule, whereas /s/ and tense counterparts remain intact due to the condition that a part of the aspirational features is already present in the underlying form, or that the marked feature keeps them from overriding. However, the aspiration of a lax occurs when it becomes conjoined with an /h/. In other words, aspiration is a result of combining a lax with [+spread glottis] from /h/. Even though /h/ is produced with relatively slack vocal cords, the process of adding an aspiration to a lax causes an inevitable increase in durational property, and consequently a change in the stiffness of vocal cords during the process.

Lastly, regarding the occasional interaction between tense and aspirated segments in speech errors, the current proposal provides a better account than the previous theories using the [constricted glottis] feature. The two

⁷ For the motivation of tensification, one of the reviewers made it clear that word-initial tensification arises from a sociolinguistic reason in distinction to post-consonantal one.

laryngeal features, i.e. [spread glottis] and [stiff vocal cords], are concerned with a totally different manner and property of the larynx. The former is relevant to the size of the glottis, and the latter to the stiffness of vocal cords. Both play an independent role in laryngeal manifestation, but not completely exclusive to each other unlike [spread glottis] and [constricted glottis] features. Thus, erroneous mix-ups of the two features can change a tense to an aspirated or vice versa in actual speech. For instance, the aspiration rule is hypothesized to involve the spreading of a bundle of two laryngeal features. However, in a normal conversation, a speaker might happen to split the combined features of an aspirated and insert [+spread glottis] only to the laryngeal node of a tense, eventually producing an aspirated other than a tense as the target. By contrast, the prior theories using [constricted glottis] fail to render a satisfactory account with respect to the slips between the tense and aspirated series, as each is associated with a mutually exclusive feature.

6. Conclusion

Concerning the glottal features for Korean obstruents, lax obstruents are generally assumed to be in contrast with the aspirated and tense in the sense that the former lack any laryngeal feature, while the latter are marked with [+spread glottis] and [+constricted glottis] respectively (Ahn 1983, Sohn 1987, Kim 1987). However, the traditional characterization in Korean phonology disregard phonetic viewpoints by Halle and Stevens (1971) and Ladefoged and Maddieson (1996) that Korean tense obstruents are produced with stiff vocal cords. It is also unable to achieve an adequate generalization for Korean /s/, which is phonetically aspirated but phonologically lax (Kagaya 1974, Iverson 1983, Kang 2000). In this context, a recent speech error study by Kang (2004) strengthens the importance of phonetic details. First of all, the least and unusually fewer slips with tense consonants than the aspirated hint that the laryngeal mechanism associated with the tense may involve a totally different laryngeal configuration, i.e. stiffness of the vocal cords, other than the simple abduction or adduction of the glottis. Secondly, frequent but less substitutions between /s/ and /c^h/ than /s/ and /c/ highlight the proper underlying representation of /s/ to be related not only to the [spread glottis] feature concerning aspiration but also to [-stiff vocal cords] denoting the laxness in distinction with the fortis. Moreover, the fact that almost half of the tense-related slips were caused by interactions between a tense and aspirated obstruents implies that the tense and aspirated series, i.e. the fortis, need to be grouped together with a shared feature. For such a feature, I assert to use [stiff vocal cords], instead of the [tense] feature by Kim (1965) and Kim-Renaud (1974), as the former is a phonetically relevant and specific, while the latter loosely-fitting and obscure in application yet.

In conclusion, I hypothesize that lax obstruents are unmarked in the lack

of a glottal feature, whereas the tense marked with [+stiff vocal cords] and the aspirated with a sequence of [+spread glottis] and [+stiff vocal cords].

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