Voicing Constraint and Segmental-Tonal Neighborhood Effects on Clusters in Thai

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Abstract

Investigating existing and non-occurring onset clusters in Thai led to the postulation of a voicing constraint. Native speakers were asked to give well-formedness judgments to novel words with and without violations of the constraint. The findings support the argument for the existence of the constraint in the speaker's mind. Furthermore, it was found that within all groups of novel words, categorized by whether or not they obey the constraint and whether or not they contain the existing clusters, there were segmental neighborhood effects. The novel words in dense segmental neighborhoods were rated significantly higher than those in sparse segmental neighborhoods. Finally, the present study puts forward the proposal and evidence that the degree of tonal neighborhood density also influences the speaker's perception of novel words.

1. Clusters in Thai

Putting true Thai words in minimal pairs reveals that the language has 11 possible consonant clusters, which show up exclusively in the onset position (Naksakul 1998). The clusters consist of /pr p^hr pl p^hl tr kr k^hr kl k^hl kw/ and /k^hw/. That is, the second consonant of a legal cluster is restricted to those in the set {r, l, w}. Regarding the first consonant, they are drawn from the set of consonants belonging to the plosive class shown in (1).

(1) Plosives in Thai

Voiceless	Unaspirated	p	t	k
	Aspirated	p^h	t^h	k^h
Voiced	Unaspirated	b	d	

Tumtavitikul (1997: 312) mentions (2a) and (2b) as constraints on the occurrence of clusters in Thai:

(2) a. C_2 = {l, r, w}, and
if C_2 = [w], then C_1 = [k, kh]
b. *[αson] [αson]

It is true that the existing clusters obey the constraints. However, the constraints do not rule out the following plosive and C_2 combinations:

(3) /bl br dl dr tl t^hl t^hr/

In the present work, I am interested in looking at the set of combinations seen in (3) in comparison with the set of legal clusters. The next section presents the issues concerning onset clusters in Thai that I will investigate.

2. Hypotheses

As already seen, no combination in (3) violates (2b). In more general terms, they do not violate the *Sonority Sequencing Principle*, which, for onsets, requires the sonority of the segments to increase toward the nucleus. Since the sequences of sounds in (3) do not surface in the language, we need additional constraints to account for their nonoccurrence. Looking in wider context shows that the sequence of a nasal and an approximant can neither be found. Therefore, I will say that in general the language does not tolerate any sequence of a voiced consonant followed by an approximant. The constraint in (4) is then postulated to account for the data observed.

(4) $*\begin{bmatrix}+\text{cons}\\+\text{voice}\end{bmatrix}\begin{bmatrix}+\text{cons}\\+\text{son}\\+\text{cont}\end{bmatrix}$

For convenience, I will call this *[+voice]. The constraint may be a subpart of the constraint banning the sequence of consecutive voiced consonants in general. This is tentatively formulated for the purpose of the current study. To be explored in future work are effects of similarity in voicing quality of consonants in languages. Putting *[+voice] in a relatively high rank results that the first four clusters in (3), i.e. /bl, br, dl/ and /dr/, become illegal clusters in Thai. As for /tl/, /t^{h}l/ and /t^{h}r/, they obey both the Sonority Sequencing Principle and *[+voice]. The reason why they do not constitute legal onset clusters in the language does not seem obvious. Since the non-coronal plosives do not have any problem preceding /l/ and /r/, one may try to explain this by resorting to articulatory reasons. For example, one may say that the coronal plosives cannot occur with /l/ or /r/, because the sounds share the same place of articulation. However, this type of explanation can be immediately dismissed due to the existence of /tr/ as a legal cluster in the language. Since at the current stage, nothing appears to rule out /tl/, /t^{h}l/ and /t^{h}r/ as illegal clusters but the clusters are still not included in the legal category, I will simply group them under what I will call "Gap". The label reflects their missing distribution. Consequently, we now have three groups of clusters, as seen in (5).

(5) a. Legal: no constraint violation - /pr p^{h}r pl p^{h}l tr kr k^{h}r kl k^{h}l kw k^{h}w/
b. Illegal: violation of *[+voice] - /bl br dl dr/
c. Gap: no constraint violation, but not in Legal - /tl t^{h}l t^{h}r/

A number of studies have come out with the objective of investigating the relationship between neighborhood density, i.e. the number of neighbors a given word has after changing one segment of the word, and word processing and judgment of well-formedness. On one side, research has shown that lexical neighborhood influences word perception in English, e.g. Luce & Pisoni (1998), Newman, Sawusch & Luce (1997), and Vitevitch & Luce (1998). On the other side, Frisch and Zawaydeh (2001) demonstrated that in Arabic similarity to existing words does not have significant effects on speakers' well-formedness judgments of novel forms. Instead, their results support the psychological reality of the so-called OCP constraint. In this paper, I will investigate the relationship between degrees of wordlikeness and well-formedness judgments of nonwords, having in mind the following hypotheses:

Hypothesis 1: If speakers are aware of the constraint *[+voice] while performing well-formedness judgments, given a comparable amount of neighborhood density, the ratings for novel words with no violation of *[+voice] should be consistently higher than those incurring a violation of the constraint. That is, to argue for the psychological reality of *[+voice], novel words with illegal clusters are expected to be less acceptable than those containing legal clusters or 'Gap' clusters.

Hypothesis 2: If lexical statistics turn out to be a crucial factor influencing well-formedness judgments, the mean rating of novel words in high-density neighborhoods should be significantly

higher than the mean rating of novels words that are similar to a smaller amount of existing words in the lexicon. As will be seen in the next section, the stimuli are constructed in such a way that each of the three groups, i.e. Legal, Illegal, and Gap, contains both dense- and sparse-neighborhood novel words. If this hypothesis is valid, we should be able to observe neighborhood effects across the board.

Hypothesis 3: Since Thai is a tone language, it would be interesting to see whether or not tone is involved when speakers make judgments on the well-formedness of novel words. To investigate this, I will make a distinction between segmental and tonal neighborhood. If tonal neighborhood density does affect speakers' well-formedness judgments, keeping other things constant, novel words in dense tonal neighborhoods should be given significantly higher ratings than those in sparse tonal neighborhoods.

The next section presents the design of the experiment and how the experiment was carried out. It is expected that the results from this experiment will provide the answer to the question regarding the status of the constraint postulated, that is whether (4) exists in the speaker's mind. Moreover, another objective of the experiment is to obtain additional findings concerning segmental and tonal neighborhood effects on speakers' well-formedness judgments of novel words.

3. Method

3.1. Material

I constructed 96 novel words to represent the clusters in the Legal, Illegal, and Gap groups. Within each group, the words were equally divided into two subgroups. The first subgroup had high segmental neighborhood density while the other had low segmental neighborhood density. Table 1 provides a summary of all the subgroups regarding their segmental neighborhood density. Each subgroup consisted of 16 novel words.

	LEGAL	ILLEGAL	GAP
DENSE	8-13	5-6	4-6
	(M = 10.5625)	(M = 5.5625)	(M = 4.8125)
SPARSE	0	0	0

Table 1. Segmental neighborhood density

Neighborhood density is measured by counting the number of existing words that match when one segment in a novel word is substituted. The transcriptions of stimuli were compared to all other transcriptions in Thiengburanathum's (1998) *Thai-English Dictionary*. I restricted the scope of existing words which the novel words can match after single segment substitution to those words that were familiar or still in use. I did not count any ancient or poetic words or words from a particular dialect that speakers may not know or may be unfamiliar with. To maximize the neighborhood density of the dense groups, only one-syllable novel words were used in the experiment. Despite the effort to make the neighborhood density as high as possible, the numbers of neighbors the stimuli in the dense subgroups had still turned out to be not very high, especially for Illegal Dense and Gap Dense. I then tried to expand the difference between the dense and sparse subgroups by defining stimuli in sparse neighborhoods as any novel words that match to none of the existing words when a segment is substituted.

Although /br/, /dr/ and /tʰr/ do not constitute legal clusters in the language, the following words are listed in Thiengburanathum's (1998) dictionary: *blก́k* 'block', *blu:* 'blue', *brè:k* 'brake', *drá:f* 'draft', *tʰrè:t* 'trade', and *tʰre:n* 'train(v.)'. When constructing novel words, these English loanwords and any forms that would match or remind the participants of English words were avoided.

In addition, I did not include novel words with the onset /tl/ in the stimuli set because the Thai script representing this sequence of sounds may mislead the speakers when they perform well-formedness judgments. There exist a number of Thai words that begin with the Thai letter representing /t/ followed by the letter for /l/. However, they are not pronounced together as a cluster. The vowel /a/ is always inserted between /t/ and /l/ in speaking. When seeing this sequence in writing, the participants may give a relatively high rating to a novel word containing the sequence because the writing appears familiar to them.

Regarding the issue of tone, only the novel words in Legal Dense were set up in such a way that they had different degrees of tonal neighborhood density. As Thai does not possess a large number of one-syllable words beginning with clusters, I found it very difficult to construct novel words having high tonal neighborhood density. For some subgroups, it is impossible to do the task. In the current experiment, sparse tonal neighborhood stimuli refer to those novel words which do not match any existing words after tone replacement. As for those in dense tonal neighborhoods, the range of existing words sharing with them all the phonemes except for the tone is one to two (M = 1.5). Both dense and sparse tonal neighborhood density groups have a comparable amount of segmental neighborhood density.

		Segmental Neighborhood Density
DENSE	1-2	8-12
	(M = 1.5)	(M = 10)
SPARSE	0	10 – 13
		(M = 11.125)

Table 2. Tonal neighborhood density of two subgroups in Legal Dense, shown with their segmental neighborhood density

Finally, another 60 novel words were added to the stimulus set as fillers. They were one-syllable words without any consonant cluster. Together with those beginning with clusters, the number of novel words added up to 156 in total.

3.2. Participants

Ten native speakers of Thai living in the Washington DC metro area took part in the study on a volunteer basis. Their age ranged from 23 to 30 years old. All of them had a bachelor's degree from home. They came to the US to continue their studies. At the time of this study, the time of the participants' stay in the US ranged from 6 months to 4 years.

3.3. Procedure

The list of 156 novel words was presented both orthographically and auditorily to the participants in an acceptability rating task. The stimuli were written in Thai script. Each stimulus was associated with a 1-5 scale. For the audio, I digitally recorded myself saying each novel form. All the 156 digital files were then arranged into a playlist with 5-second silence added between each file. In the experiment, the playlist was presented to them over headphones. The participants were instructed to judge each novel word using a 1-5 scale. A rating of 1 was described as 'This is least likely to be a word of Thai'. The degree of acceptability increased gradually to a rating of 5, which was described as 'This is most likely to be a word of Thai'. While performing the task, the participants were allowed to press the Stop button any time they would like to take a break or if they needed more time to think about a particular item before rating it. If they were not sure about any item, they were told to rate it according to their first impression. It took about 20 minutes to complete the task.

4. Results and Discussion

In this section, I will discuss the results of the experiment in the order of the hypotheses given in Section 2. That is, I will start from the discussion on the psychological reality of the constraint *[+voice]. Next, the results concerning segmental neighborhood effects on the speakers' well-formedness judgments of the novel words will be examined. Finally, it will be shown whether or not some items are rated better than the others if they have higher tonal neighborhood density.

4.1. Voicing constraint

The mean ratings for all the stimuli within the six subgroups of Legal Dense, Legal Sparse, Illegal Dense, Illegal Sparse, Gap Dense, and Gap Sparse are given in the following figure:

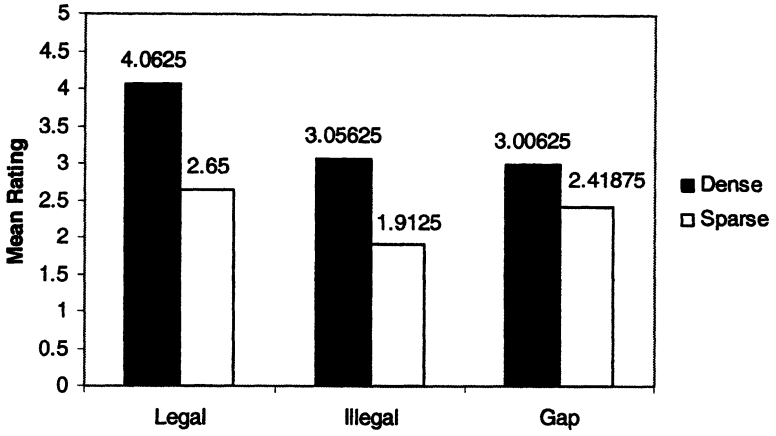

Figure 1. Comparison of mean ratings for all categories

As seen in the figure, the comparison between the mean ratings for the stimuli in Legal and Illegal group appears to support the hypothesis that speakers are aware of the constraint *[+voice]. However, one may argue that the effect may arise from the high segmental neighborhood density of the stimuli in Legal Dense (M = 10.5625 as opposed to M = 5.5625 for Illegal Dense). Therefore, only the subgroups with a comparable amount of segmental neighborhood density, i.e. Legal Sparse and Illegal Sparse (M = 0 for both), were considered. One-way repeated measures ANOVA, with segmental neighborhood density as a factor, revealed that novel words without any violation of the constraint *[+voice] were rated more likely to be Thai words than novel words with violations of the constraint at a significant level ($p < 0.05$).

The picture seems to be less clear for Gap versus Illegal stimuli. To decide whether there exists a significant effect of *[+voice] violation on the mean ratings for these two groups across subjects, I conducted two-way repeated measures ANOVA on the data. It turned out that there was a very significant interaction between constraint violations and neighborhood density ($p < 0.001$). Nevertheless, when neighborhood density was factored out, the effect of constraint violation became insignificant.

Although the mean rating for the Gap stimuli was not significantly higher than that for the Illegal group, the *p* value was not too far from being significant ($p = 0.056$). The fact that the difference between the mean ratings for the two groups was not statistically significant may arise from a relatively small number of subjects taking part in the study ($n = 10$). If the number of subjects increases, the psychological reality of *[+voice] may gain additional support. That is what left to be investigated in future work. At present, there is sufficient evidence to argue for the existence of the constraint *[+voice] in the speakers' mind, at least in the case of the existing legal clusters versus the illegal ones. In addition, the difference between the ratings for the stimuli in Legal Sparse and Gap Sparse (only the sparse groups were compared as the stimuli in Legal Dense have higher

neighborhood density than those in Gap Dense) was not significant. This can be interpreted that neither *[+voice] nor any other constraints play a role in distinguishing the legal clusters from the gap clusters.

4.2. Segmental neighborhood effects

As already said in the above discussion after comparing the mean ratings for the stimuli in the Gap and the Illegal group, constraint violations alone cannot account for the highly significant difference observed between the two groups of ratings. When two-way repeated measures ANOVA was applied to the data, the result revealed that segmental neighborhood density had significant effects on the overall ratings for the novel words in the Gap and Illegal groups ($p < 0.05$). The significant difference did not come from only one of the groups. After running one-way repeated measures ANOVA on the mean rating for each of the two groups, the results demonstrated that the stimuli in higher segmental neighborhood were rated significantly higher than those in low segmental neighborhood ($p < 0.05$ for each group). Segmental neighborhood effects also gained support from the Legal group. The difference between the mean acceptability ratings for the dense-neighborhood stimuli and the sparse-neighborhood ones was greater than would be expected by chance ($p < 0.05$).

Although segmental neighborhood effects were prominent within each group, the same type of effects could not be observed between the given groups. Consider the case of Illegal Dense and Legal Sparse. If there were segmental neighborhood effects, the mean rating for the former group should have been significantly higher than the mean rating for the latter. As seen in Figure 1, it is true that the mean rating for Illegal Dense was higher but not to the extent that the difference between the mean ratings became statistically significant. The same situation went for Gap Dense and Legal Sparse. The stimuli in Gap Dense were not rated high enough over those in Legal Sparse to be considered significant. Therefore, it can be said that segmental neighborhood effects gain support only when the difference of mean ratings within, not across, groups is taken into consideration.

4.3. Tonal neighborhood effects

The mean ratings for the two subgroups under Legal Dense were calculated. The value for the dense tonal neighborhood group was 4.1625 and that for the sparse counterpart was 3.9625. As can be predicted from the values, there was no statistically significant difference after one-way repeated measures ANOVA was applied to the participants' ratings of the relevant items.

That the data did not show any tonal neighborhood effects may come from the fact that the difference in tonal neighborhood density between the two subgroups was not large enough. As shown in Table 2, the mean value of the dense tonal neighborhood stimuli was 1.5, which may be considered too low to affect the speakers' judgments. The low tonal neighborhood density was due to the fact that the experiment was designed to focus on the case of clusters. As already mentioned, the language does not have a large amount of one-syllable words containing clusters. This partly made it difficult to come up with novel words having very high tonal neighborhood density. In addition, other factors needed to take into account during the experiment design made it impossible to expand the difference between the dense and the sparse tonal neighborhood stimuli. For example, some items had higher tonal neighborhood density than the stimuli used in the experiment, but their segmental neighborhood density was not high enough for them to be included in a dense segmental neighborhood group.

In Thai, there are five tones. That means the maximum number of tonal neighborhood density for a stimulus is 4. Since the results from the present experiment showed that neighborhood effects could be obtained when the difference in the mean between dense and sparse neighborhood stimuli is 4.8125 (for the Gap group), it would be very interesting to see the results of the experiment in which the mean of the dense tonal neighborhood stimuli is expanded to the maximum. Another experiment was then set up to exclusively investigate the issue of tonal neighborhood effects.

To maximize the amount of tonal neighborhood density of the dense group, one-syllable novel words without clusters were used as stimuli. By including in the dense group only novel words

with the maximum amount of tonal neighborhood density and keeping the density mean value of the sparse tonal neighborhood stimuli to 0, the difference between the mean values of the two groups became 4. Also, the stimuli in both groups were constructed in such a way that they had a comparable amount of segmental neighborhood density.

		Segmental Neighborhood Density
DENSE	4	4 – 18 (M = 9.9231)
SPARSE	0	4 – 17 (M = 9.615385)

Table 3. Tonal neighborhood density of novel words without clusters, shown with their segmental neighborhood density

Each of the two groups was represented by 13 stimuli. The list was presented to 22 native speakers aged between 25 and 60 living in Bangkok, Thailand in an acceptability rating task using a 1-5 scale as in the previous experiment. It turned out that the mean rating for the dense tonal neighborhood group was 2.87762 while the value for the sparse group was 2.71832. One-way repeated measures ANOVA revealed that there was a significant difference between the ratings ($p < 0.001$). The experiment thus provided evidence for tonal neighborhood effects.

5. Conclusions

In this study, I set forth three hypotheses concerning the existence of a voicing constraint, segmental neighborhood effects and tonal neighborhood effects on clusters in Thai. After conducting an acceptability rating task with native speakers, I found that the results supported the voicing constraint postulated. This gave evidence for the psychological reality of the constraint. Next, the study demonstrated that within each category, defined by whether or not the stimuli obey the postulated voicing constraint and whether or not the clusters exist in the language, there were segmental neighborhood effects. The findings gave support to the argument in the literature that the degree of neighborhood density influences metalinguistic well-formedness judgments of nonwords. Across categories, it appeared that the constraint had priority over the segmental neighborhood density. Finally, this paper puts forward the proposal that tonal neighborhood density plays a role in the perception of novel words. In the future, a similar kind of experiment can be set up to investigate whether or not this holds true in other tone languages. Also, as the work here provided basic results, future experiments in a larger scale are called for.

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