PHONETIC IMPLICATIONS FOR AN HISTORICAL ACCOUNT OF TONOGENESIS IN THAI[1]

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The question of how it is that tones developed in the Thai language looms large in the minds of many scholars. It is indeed an interesting question that seems not to have a simple answer. Various scholars have addressed themselves to this question, and their answers seem complicated to the extent that they only raise more questions. At times one wonders if indeed there is an answer to this question, or even if it is reasonable to try to speculate about the tones in the prehistory of the Thai language. For one thing, it is not known whether the parent language of Thai, i.e., Proto-Tai[2], had tonal distinctions or not. According to many comparatists (Gedney In press, Haudricourt 1972, Li 1970), the parent language of Thai had three tones[3] and these consequently split up into allophonic variations of the original small set of tones. In this way the modern-day tonal inventory of five tones in Standard Thai came about. However, it is not inconceivable that there might have been a time in the prehistory of the Thai language when there were no tones, although such a period might be very difficult, if not impossible, to reconstruct (Gedney In press). In this paper since I am concentrating on the phonetic implications of tonal development in Thai, I will theorize about how tones might have developed from an originally non-tonal language. The theoretical arguments discussed here, however, can be applied also to the theories of tonogenesis from tonal splittings.

A brief account of the development of tones in a language which originally had no tones is dealt with in Matisoff (1973). I will now summarize this acount as it might be applied to Thai.

In the beginning, the forerunner of Proto-Tai was monosyllabic and had no tonal distinctions. Gradually, however, tones developed. This came about due to a complex interaction of the acoustic and physiological characteristics of the syllabic vowel, the initial consonant, and the final consonant. Among other things the intrinsic pitch of the vowels and consonants of the syllable is related in some way to the development of the phonemic tones seen in the dialects of Thailand today. Specifically, the pitch of the initial consonants was important in bringing about tonal distinctions in the Thai language.

In most of the literature which actually discusses the development of tones in Proto-Tai (due to tone splitting), the pitch of initial consonants *per se* is not mentioned. Rather the literature refers to the voicing state of the initial consonants (Haudricourt 1954, Maspero 1911). To state the theory very briefly and simply, voiceless initial consonants gave rise to high tones, and voiced initial consonants gave rise to low tones. Many complications and later developments came about with the evolution of the daughter languages that interfered with this simple state of affairs, so that if one reads Li (1948), for instance, one sees that voiceless initial consonants gave rise to mid level or rising tones in Thai, and voiced initial consonants, to mid level tones[4].

What I intend to do in this paper is first to show how the two things, intrinsic pitch and the voicing states of consonants, are related. I then intend to speculate, using certain specific examples of Thai consonants, about why and how the pitch characteristics associated with the voicing states of the initial consonants of the syllable might have helped to bring about tonogenesis in Thai.

The consonants I will discuss are the bilabial stop phonemes, that is, /b/, /p/, and /ph/[5]. The phonetic characteristics of these phonemes in Standard Thai are generally defined in the following way. /ph/ is an aspirated voiceless stop for which voicing (vibration of the vocal folds) begins some time after the release of the stop; /p/ is an unaspirated voiceless stop for which voicing begins at about the same time the stop is released; and /b/ is a voiced stop for which voicing begins some time before the release of the stop. (See Lisker and Abramson 1964 for more explanation of voicing timing of stops).

At this time, I wish to discuss the relationship between voicing and pitch. Pitch, or more specifically fundamental frequency (f_0), is generally defined as the rate of the quasiperiodic vibration of the vocal folds. F_0 is determined primarily by two factors: the state of the larynx, and the subglottal air pressure. That is, assuming that subglottal air pressure is kept constant, changing the tension of the vocal folds would change the rate of laryngeal vibration. Similarly, assuming that vocal fold tension is kept constant, changing the subglottal air pressure would bring about a change in f_0 (Van den Berg 1958, Atkinson 1973). One way of changing the air pressure difference across the glottis would be to close the mouth during phonation. This would quickly bring the pressure below the glottis close to the pressure above the glottis, and would cause the air to flow very slowly across the glottis, and gradually stop flowing altogether. If, on the other hand, the mouth is open during phonation, the pressure difference across the glottis will be rather great and air will continue to flow out at a relatively rapid rate.

Thus, when considering the initial f_0 of stop consonants, it is important to consider the pressure difference across the glottis (the "transglottal pressure difference") at the time the stop is released. If voicing begins at the same time the mouth is closed--say for a Thai prevoiced /b/--the pressure below the glottis and above the glottis rapidly approaches equilibrium, i.e., the transglottal pressure difference becomes rather small. At the moment the mouth opens for the release of the stop, the transglottal pressure difference is still small, and the flow of air at the release of the /b/ stop is relatively slow. Hence, one would expect to see an initially low f_o just after the release of the prevoiced /b/.

On the other hand, for the voiceless stops /p/ and /ph/, the mouth is open at the time voicing begins, and the transglottal pressure difference is relatively large. Hence, air tends to flow out rapidly and it would seem that the initial f_o of these stops is generally higher than that of the prevoiced stop /b/.

This rationale holds true for stops in other languages as well, of course, and is supported by acoustic studies done on English stops (Lehiste 1970, Ojamaa et al 1970). My own current work on initial f_o of stops in Standard Thai concurs with these theoretical speculations. Briefly, I conducted the following experiment. I recorded the utterances /buu/, /puu/, and /phuu/ as spoken by eleven different speakers of Standard Thai. Each speaker repeated each utterance eight times. I then measured the initial f_o values from spectrograms and arrived at an average value for each of the stops for each speaker. The data as presented in the table below show that /b/ has the lowest initial f_o values, while the two voiceless phonemes /p/ and /ph/ have the highest. More specifically, out of a sample of eleven speakers, 73% of the speaker showed /ph/ as having a higher f_o than /p/, and 27% of the speakers showed /p/ as having a higher f_o than /ph/.

TABLE OF INITIAL AVERAGE F_o VALUES FOR BILABIAL STOPS /b p ph/, on the syllable /uu/ BANGKOK SPEAKERS

Male:	DT	SP*	PT*	CT	MJ	
/ph/	148 hz	146 hz	151 hz	153 hz	163 hz	
/p/	145 hz	147 hz	161 hz	149 hz	156 hz	
/b/	121 hz	122 hz	149 hz	142 hz	147 hz	
Female:	**KT**	**SB**	**P**	**PP***	**CC**	**SS**
/ph/	266 hz	215 hz	277 hz	259 hz	244 hz	275 hz
/p/	248 hz	208 hz	255 hz	266 hz	222 hz	265 hz
/b/	228 hz	179 hz	225 hz	236 hz	217 hz	258 hz

* Indicates speakers for whom /ph/ does not have a higher fo than /p/.

From this it can be seen that in Standard Thai the voiced stop /b/ has an intrinsically low f_o, while the voiceless stops /ph/ and /p/ have intrinsically high fo values. As for the latter pair, /ph/ tends to have a higher intrinsic f_o value than /p/. (For further discussion of initial pitch differences of bilabial stops in Thai, see Erickson 1974).

Thus, it seems that pitch and the voicing state of consonants are related. The question now is, how did the initial pitch characteristics associated with the voicing states of the ancestor language help bring about tones in Thai. At this point, then, it is necessary to describe the Proto-Tai inventory of bilabial stop phonemes. In this I will rely on what historical linguists have uncovered with the standard methods of historical comparison and reconstruction. Charted below are the bilabial stop phonemes usually reconstructed for Proto-Tai. These reconstructed phonemes will be referred to as proto-phonemes and written with an asterisk in front of them. Below each protophoneme is its reflex phoneme in Standard Thai, written in phonemic transcription and Thai script.

TABLE OF CORRESPONDENCES BETWEEN PROTO BILABIAL STOPS AND BILABIAL STOPS IN STANDARD THAI

*ph	*p	*b	*ʔb
ph ผ	p ป	ph พ	b บ

The above correspondences are proposed on the basis of the historical reconstruction done by Maspéro (1911), as presented in Haudricourt (1954). A brief review of the literature indicates that these correspondences are the ones proposed for the most part by other comparatists (see e.g., Brown 1965, Li 1948).

However, there is some disagreement in the literature as to how *ʔb should be symbolized. Maspéro does not in fact write ʔb but rather ƀ (1911). In modern Vietnamese orthography the ƀ character is used for the /b/ phoneme which is generally described as imploded. Haudricourt (1954) interprets Maspéro's ƀ to be some type of preglottalized b--represented by the symbol ʔb. However, there seems to be a strong feeling shared by many historical scholars that this was actually an imploded [ɓ] (e.g., Christopher Court, personal communication). Li (1947) and Haudricourt (1954) also suggest that the ʔb might have been realized as an imploded stop. Brown (1965), however, reconstructs this as a sonorant, with some type of preglottalization, and suggests the symbol ʔm. Along these lines, J.G. Harris has found /b/ and /m/ in free variation in some Thai dialects and suggests that this may be evidence that the proto-phoneme could well have been a prenasalized stop mb (personal communication). Thus, *ʔb is variously referred to as ʔb, ƀ, or ɓ, ʔm or mb. At this point I have no clear means of deciding which proto-phoneme is most likely to be correct. I have used the symbol ʔb since it seems to occur more frequently in the literature. The phonetic reconstruction of this particular proto-phoneme and its consequent initial f_0 will be discussed later on.

As for the phonetic description and initial f_0 values of the other proto-stops--*ph, *p, *b--the following statement may be made, based on the measured initial f_0 of the reflex phonemes in Standard Thai. The voiceless stops *ph and *p most likely had high initial f_0 values, and the voiced stop *b most likely had an initially low f_0 value. It would seem that these reconstructions of initial f_0 lend further support to the theory concerning the effect of initial consonant on tone; namely, that the voiceless initial consonants gave rise to the high tone, and that the voiced consonants gave rise to the low tone (Haudricourt 1954, Maspéro 1911).

As concerns the historical theory dealing with *ʔb and its effect on tones, the best account is given in Li (1947), although it was Maspéro (1911) who apparently first noted the peculiar characteristics of *ʔb on tones. To summarize briefly, *ʔb is regarded as some type of voiced stop which however acted as a voiceless one with respect to its effect on tone, i.e., it brought about a high tone instead of a low tone which one might expect from a voiced consonant. Li explains this anomaly in the following way. He postulates that the *ʔb was a glottalized sound and that the initial glottalization acted like the initial consonant in consonant clusters, that is, it controlled the tone of the word. Furthermore, he proposed that this initial stop of the *ʔb was most likely treated by the speakers of Proto-Tai as a voiceless consonant. In other words, Li argues that the initial glottalization was heard as a voiceless glottal stop and that since this voiceless state controlled the tone, the voiced *ʔb behaved as a voiceless stop with regard to tone.

Li's explanation for this seems highly speculative and leaves room for further work. However, it is true that it is a difficult phoneme to assess. For one thing, this phoneme does not occur in Standard Thai today, and therefore its initial f_0 value cannot be estimated by its spectrographically analyzed modern Thai reflex. An additional problem is that it is not at all clear what this *ʔb might have been phonetically. Li (1947) calls it a "strongly preglottalized stop", and suggests that it might have had a certain implosive quality. Haudricourt (1950) postulates that the glottal onset might have involved a sudden and sharp glottal attack, which may have been indistinguishable from an imploded stop. That is to say, it is possible for the larynx to descend rapidly at the beginning of prevoicing and for this sudden downward movement of the larynx to create an air pressure differential across the glottis sufficient for a sharp onset of prevoicing. Theoretically, then, this would be an imploded sound, since the air pressure differential would be such that air would tend to flow into the lungs.

With regard to the topic of the phonetic characteristics of ʔb in general, Greenberg (1970) states that the glottalized ʔb also may be described as an imploded b, or even as a laryngealized b. It seems to me that these stop phonemes are indeed related to each other phonetically. However, I suggest that one think of these sounds as lying along a continuum of prevoiced bilabial stops. The reason for this is that they each involve a period during which there is voicing before the occlusion of the stop is released. However, the manner of implementing the onset of prevoicing varies for each of these stops. For instance, a glottalized ?b might be heard as a type of prevoiced stop for which the prevoicing was begun with a hard or sharp glottal attack. Or, it could be a type of prevoiced stop which was heard as an imploded sound due to a downward movement of the larynx at the onset of voicing, as described above. On the other hand, the onset of prevoicing might also be heard as a creaky glottal attack, and hence identified as a laryngealized b. Also lying along this continuum of prevoiced stops I suggest are the prenasalized stop and the preglottalized nasal. For example, a prevoiced stop which has an extremely long period of prevoicing might be heard as a type of nasalized stop. That is, a long period of prevoicing may be accompanied by some audible velar leakage in order to maintain the necessary transglottal pressure differential for phonation. To carry it one step further, one might speculate that such a nasalized stop might also have a hard glottal attack at the onset of the velar leakage, and hence be heard as a preglottalized nasal.

In this way, then, ?b may be viewed as a symbol which represents a continuum of sounds. From this point of view, it could be argued that the various symbols suggested by historical scholars to represent the proto-stop *?b--more specifically, the symbols *?m, *mb, *?b, and *b--also lie along a single phonetic continuum, and are but different realizations of the one phoneme. It would follow from this that an examination of the initial f_0 of the sounds represented by these various symbols would be of interest in an investigation of the initial f_0 of *?b. At this point I propose to examine briefly the matter of the initial f_0 of these four sounds.

Unfortunately, acoustic data were not available for the initial f_0 of ?b, mb or ?m. However, certain statements may be hazarded concerning the f_0 of these sounds, based on theoretical knowledge and other indirect data. For instance, let us look at the initial f_0 of ?b. Assuming that ?b is phonetically realized as a variant of a prevoiced stop with a hard glottal attack, I would say offhand that its initial f_0 is low. This is based on the knowledge that prevoiced stops in general have low initial f_0. Unfortunately, however, there are no measurements available to substantiate this.

As for the initial f_0 of the ?m and mb sounds, again no acoustic data are available. On theoretical grounds I suggest that these sounds might have a lower initial f_0 than the voiceless stops, but perhaps higher than that of the voiced one. This is based on some of my own studies done on English nasals and voiced and voiceless consonants (Ojamaa et al 1970) as well as from reports by Lehiste

(1970). It might be possible at some future time to make instrumental measurements of [ʔm] and [mb] if speakers can be found. Clearly, such a study would be of interest in reconstructing Proto-Tai.

As for the imploded stop, an attempt was made to measure its initial f_o, but the results, as described below, are discouraging. This is mainly because the sampling was too small to allow for confident interpretation of the data. In short, I made some spectrographic analyses of a small sample of imploded [ɓ] and prevoiced [b] stops as spoken by two different speakers. Both were trained linguists. One was a native speaker of Sindhi, a language in which there is a five-way contrast in the bilabial series of stops: /b/ and /ɓ/, as well as /ph/, /p/, and breathy /bʰ/. The other speaker was an American who, of course, did not have the contrast /b/ and /ɓ/ in his native language, but displayed a high degree of phonetic virtuosity and produced reasonable tokens of both an imploded and a prevoiced stop. The results show that for the Sindhi speaker the average initial f_o of three repetitions of /ɓuu/ was 185 Hz. This compared with an initial f_o of /b/ at 145 Hz, of /p/ at 188 Hz, and of /ph/ at 291 Hz. For the American linguist, the average initial f_o for the imploded stop was 101 Hz. For the prevoiced stop, it was 105 Hz. The average was of five repetitions of the nonsense utterance [tʰikibu]. For both imploded and prevoiced stops, the measurements were made at the release of the stop.

To some extent, these measurements give conflicting results. For the Sindhi speaker, /ɓ/ has a considerably higher f_o than /b/, and it is just slightly lower than the f_o for /p/. For the American speaker, on the other hand, /ɓ/ has a lower f_o than /b/, but only slightly lower. It may be that /ɓ/ has a number of phonetic variation, which again lie along a continuum of imploded sounds. The phonetic variations are not yet fully understood, and it seems they may vary from speaker to speaker, or from language to language. Clearly more investigation is needed in this area.[6]

In summary, then, with respect to *ʔb, I have theorized that *ʔb may have a number of phonetic realizations which lie along a single phonetic continuum, namely ʔb, ɓ, mb, ʔm. However, I am unable to reconstruct the initial fo value of these sounds with any degree of certainty at all, and therefore am unable to say anything conclusive about the initial f_o of *ʔb, nor its possible effect on tone in the historical evolution of the language. I have suggested that if *ʔb were phonetically reconstructed as some type of nasal or even as an imploded stop, it might have an initial f_o whose value was rather high compared to that for the prevoiced stop. Especially would this be true if the imploded stop were similar to that produced by the Sindhi speaker for which the initial f_o was extremely high, on a par with that of the voiceless unaspirated stop. If such were the case, then, there would be support for the theory that historically *ʔb acted as a voiceless consonant with regard to its effect on tones. However, at this point more measurements of f_o of the possible variant phonetic realizations of *ʔb--i.e., ʔb, mb, ʔm, and ɓ--are needed in order to arrive at even a tentative reconstruction of the phonetic nature of the *ʔb. Until this is done, no conclusive acoustical phonetic evidence can be offered by way of support of the historical theory concerning *ʔb and its effect on tone.

With this preliminary explanation of the possible values for the intrinsic f_o of the Proto-Tai bilabial stop consonants, I now propose the following points to account for the emergence of tones in Thai.

In the beginning, there were the four proto-phonemes *ph, *p, *b, and *ʔb. Each of these stops had either a high or low intrinsic f_o. Gradually this intrinsic f_o developed as a separate feature; it became independent of the consonant. At the same time, however, the consonant retained its intrinsic f_o and other f_o characteristics. Thus, in addition to the intrinsic high or low fo of the consonant, there was a further feature of high or low tone. Presumably, in the initial stages of this development, the high tone was always associated with the consonants with high intrinsic pitch; and the low tone, with those with low intrinsic pitch. Gradually, however, the tones became completely independent from the initial pitch of the consonants to the extent that high and low tone could occur with all syllables, regardless of the pitch of the initial consonant of the syllable. This might have happened for instance, when new words and borrowings came into the vocabulary and these tones were available.

Hence the origin of tones--an outgrowth of the intrinsic pitch of the consonants. I have treated the problem of tonogenesis as if tones developed from a non-tonal period of the language. The more usual theory of tonogenesis, however, treats tone development in Thai as having evolved from splits in an original tonal system of three tones (Haudricourt 1972). Basically, however, the process of tonal splits is conditioned by the same phonetic characteristics as the process of tonal development from a stage of no tones in the language. That is, in both cases, voiceless consonants, i.e., those with initial high f_o, tended to bring about high tones, and voiced consonants, i.e., those with initial low f_o, tended to bring about low tones. Thus, Haudricourt (1972) shows how it was possible to have the original three tones of Proto-Tai split into a high and low series due to the voicing state, i.e., pitch, of the initial consonant. He suggests that in the evolution of the present day Thai tonal inventory, these splits into a high and low series occurred in stages as the consonants themselves evolved into different states of voicing. That is, according to Haudricourt, the first split at least in certain Thai dialects, might have occurred with words beginning with aspirated consonants which had newly emerged from voiced consonants, and the other consonants did not effect a tonal change at this time. Then subsequent splits as well as tonal mergers occurred, until in Standard Thai today there are five tones. This process of tone splitting and tone merging is pursued to much greater lengths elsewhere, see e.g., Haudricourt 1972, Matisoff 1973, and Brown (in this volume).

However, in this paper, I have concentrated on the effect of initial consonants on tonogenesis in Thai, and have limited my discussion primarily to a hypothetical period in the prehistory of the Proto-Tai language when conceivably there may have been no tones. My essay is not extremely original since others have previously suggested an interaction between pitch, tone, and initial consonant (Haudricourt, Li, Matisoff, Maspéro); however, in this paper are presented for the first time actual measured values of the initial f_o of modern Thai (Standard Thai) bilabial stops, and these data for the most part support the hypothesis of tonogenesis as put forth by historical linguists. In addition, I have summarized some of these historical theories concerning the interaction of the stops and the emergence of tones, and have attempted to give a detailed outline as to how tonogenesis might have happened in light of acoustic data. It is hoped that this account will serve as a basis for further work along these lines, and perhaps motivate additional studies of the complex acoustic and physiological interaction among the initial and final consonants and vowels of the Thai syllable which played such an important role in tonogenesis in the Thai language.

NOTES

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2 "Proto-Tai" generally refers to the parent language of a group of Tai languages and dialects spoken in Thailand and Laos, and found also in Burma, Assam, North Vietnam, and southern China (Gedney, In press). This proto-language consists of three branches--the Northern, Central, and Southwestern Branches. (Whether the Northern Branch should be included among the Proto-Tai languages is a matter of current dispute, Gedney In press). The Thai language spoken in Thailand falls under the Southwestern Branch. In discussing the parent language of Thai some scholars, for instance, Brown (1965), prefer to begin with the Southwestern Branch itself. Brown calls this Ancient Thai, and dates it at approximately 700 A.D. He describes it as having five tones. Other scholars, e.g. Li, Haudricourt, Maspéro, prefer to refer to the larger and more ancient grouping as the ancestor of the Thai language.

3 Li (1970) refers to four tones in Proto-Tai. This fourth tone, however, is the one that occurs only in checked syllables; that is, syllables which end in a short vowel or with a consonant other than a nasal. Gedney (In press) refers to this fourth tone as the "undifferentiated tone" and prefers to regard it as a predictable variant of the basic three tones.

4 This is on an open syllable with no orthographic tonal markers.

[5] The present paper forms part of a larger project (Erickson Forthcoming) in which the complexities of the electromyographic procedures used made it expedient to restrict the investigation to the most readily accessible place of articulation.

[6] From a theoretical standpoint also it is difficult to speculate about the height of the initial f_0 of an imploded stop. According to Ladefoged (personal communication to John Ohala 1973), implosives would cause elevated pitch because of the fast rate of air flow through the glottis generated by the rapidly descending larynx. However, studies done on the height of the larynx during pitch changes--notably the study done by Ohala (1972)--seem to indicate that a lowered larynx tends to be associated with a low pitch. From this one might speculate that the lowered larynx during an imploded stop would yield a low initial f_0. The physiological mechanisms and associated pitch characteristics of the imploded stop might be further clarified by the study of the laryngeal muscle activity during production of the stop. A study of this type using electromyographic techniques has been done on Sindhi implosives by Abramson et al (Forthcoming) and although f_0 measurements are not available, there are indications that the sternohyoid muscle--thought to be possibly a pitch lowering muscle--is particularly active for the production of the imploded stop. This would suggest then that the initial f_0 of an imploded stop is low. However, the data remain to be processed in order for any definite conclusion to be reached.

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