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AN INVESTIGATION OF TWO ALVEOLAR STOP CONSONANTS IN WHITE HMONG[1]

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1. INTRODUCTION

White Hmong has a fairly large inventory of stop consonant phonemes all of which occur in initial position only in the basically CV syllable structure. With only one exception, at each place of articulation where stops (and affricates) occur, the following series is found --- voiceless, voiceless aspirated, pre-nasalized and pre-nasalized with aspiration. The exception is the alveolar set, which has only two members, neither of which belong to any of these four categories. The purpose of this paper is to discuss the auditory, acoustic and articulatory properties of these two alveolar stops in White Hmong.

In the White Hmong orthography, devised in the early 1950's by missionaries working in Laos and Thailand, these stops are symbolized as 'd' and 'dh' (see Smalley (1976)). These are the symbols which will be used to refer to them throughout this paper.

Previous attempts have, of course, been made to characterize the auditory and articulatory qualities of these two stops, although to my knowledge no work has been done on their acoustic properties. In his phonetic transcription of the letters of the White Hmong alphabet, Mottin (1978) symbolizes 'd' and 'dh' simply as [d] and [dh] respectively, and in a brief explanation of each symbol he describes 'd' as "d comme dans doigt" ('d' as in doigt) and 'dh' as "d aspiré" (aspirated 'd'). Smalley (1976) refers to these two stops as "glottalized", but does not explain exactly what he means by this term, which has been used to refer to various types of sounds, including implosives, ejectives and creaky voice, as well as ordinary stops accompanied by glottal stops (Ladefoged 1971: 28). Smalley symbolizes 'd' as [ʔd] and 'dh' as [ʔth]. Heimbach (1979), in his "Guide to Pronunciation", is somewhat more explicit:

> "d like the d in dream but with a glottal stop before it. That is, complete stop of the air flow in the throat before the beginning of the sound.
>
> dh the Hmong sound 'd' with a brief puff of air after it".

My own auditory impressions of these two consonants do not entirely concur with this description. I cannot detect any glottal stop before the beginning of the sound (presumably before the oral closure) as Heimbach suggests. However, what can be detected, particularly in the case of 'dh' but also occasionally in the case of 'd', is the impression of a slight 'catch' in the voice, a momentary hesitation in the flow of the sound, just before the release of the stop, and it is this that I assume both Heimbach and Smalley are trying to capture with their references to "a glottal stop" and "glottalization".

Apart from this very slight sense of a 'catch' in the voice in some tokens, the consonant 'd' sounds simply like a fully voiced alveolar stop. 'dh', on the other hand, is not quite so easily categorized. There is no doubt that, in some cases, 'dh' sounds quite distinctly aspirated. In others, however, no aspiration can be detected. The part of the stop before the release is even more puzzling. Careful listening reveals that there is a fleeting period of whispery voicing, often extremely brief, and then the distinct 'catch' in the voice before the burst.

The experiment, described and discussed below, was designed with a view to investigating these phenomena. As not all scholars with an interest in Hmong language can be expected to have training in acoustic phonetics, I have endeavoured to make the discussion as clear and uncomplicated as possible, with this audience in mind. I apologize in advance to those already familiar with the terminology and concepts explained, and who would perhaps prefer more attention to be devoted to other issues.

2. PURPOSE OF THE INVESTIGATION

- to try to ascertain the acoustic characteristics of the alveolar stops 'd' and 'dh' in White Hmong.
- to try to draw inferences about the articulatory characteristics of these stops from the acoustic data.

3. EXPERIMENTAL PROCEDURE

3.1 The first task in the investigation was to select morphemes exhibiting the relevant stops followed by the three maximally differentiated vowels in White Hmong, namely [i, a, u][2] ('i,a,u'), or the laxer versions of these vowels which occur in diphthongs.

Only morphemes exhibiting the low level tone (orthographically 's'), the mid level tone (orthographically unmarked) and the mid rising tone ('v') were chosen. There were two important reasons for this limitation on the selection. Firstly, there is no great variation in the pitch or voice quality at onset. It was therefore considered unlikely that they would influence the acoustic properties of the syllable initial consonants in different ways. The second reason is the extreme rarity of the consonant 'dh' in the vocabulary. Heimbach (1979) has only twelve entries for it in his Hmong-English dictionary, and it seems that this consonant simply does not co-occur with a certain number of the tones. The need to select minimal or near-minimal pairs for the study meant that the least common of the two consonants dictated the range of choice.

3.2 Five tokens of the English translations of each of the morphemes chosen were written on cards, first ensuring that the informant was able to confidently translate the words into Hmong. The words were written in English rather than Hmong in order to avoid any possibility of the spelling of the word influencing the informant's pronunciation.

3.3 The cards were then presented to the informant one by one in random order, and high quality recordings[3] made of each token , uttered first in insolation and then in a frame. The frame used was: [haĭ˩____dŏa˧] (hais____dua) ('say____again'). The cards were presented in random order *to decrease the likelihood of list intonation being used.*

3.4 The informant was asked to check the recordings for acceptability as normal Hmong utterances.

3.5.1 Wide band bar spectrograms were produced with both high shaping (to examine the general spectral characteristics of the utterances recorded, particularly in the higher frequency range) and flat shaping (to examine voice onset time and other low frequency features of glottal activity).

3.5.2 Wide band spectra[4] (with flat shaping) were taken just after the release of the stops in order to examine the spectral properties of the bursts.

3.5.3 Average amplitude tracings were made to check if the consonants were responsible for any difference in amplitude at vowel onset.

3.5.4 High speed oscillograms[5] of the wave forms were photographed with a polaroid camera, to check the fundamental frequency at vowel onset.

(Steps 3.5.2 - 3.5.4 are not discussed in detail below. Some of the inferences drawn from them simply serve to confirm those which could also be drawn from the bar spectrograms (3.5.1), while others are somewhat beyond the scope of the present discussion.)

3.5.5 Finally, the results were checked by following the same procedure (steps 3.3 - 3.5) with another informant, but recording only one token of each morpheme.

4. THE INFORMANTS

The choice of informants available for the experiment was extremely restricted, simply due to the scarcity of adult Hmong in the region (Canberra, Australia). However, although further acoustic analysis was not possible, it seems from auditory impressions that other speakers of White Hmong, now living both in other parts of Australia and in America and originally from different provinces, do pronounce the stops in question in basically the same way.

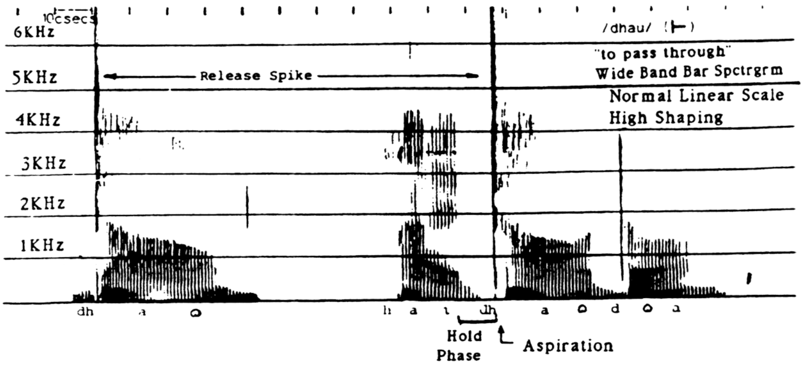
The main informant recorded for the experiment was Ntxawg Lis (known in English as Yeu Lee), a 24 year old male from Xieng Khouang province in Laos. The second informant was Yeu's mother Maiv Yaj (May Yang), also from Xieng Khouang.

5. EXAMINATION AND DISCUSSION OF BAR SPECTROGRAMS

5.1 High Shaped Wide Band Bar Spectrograms

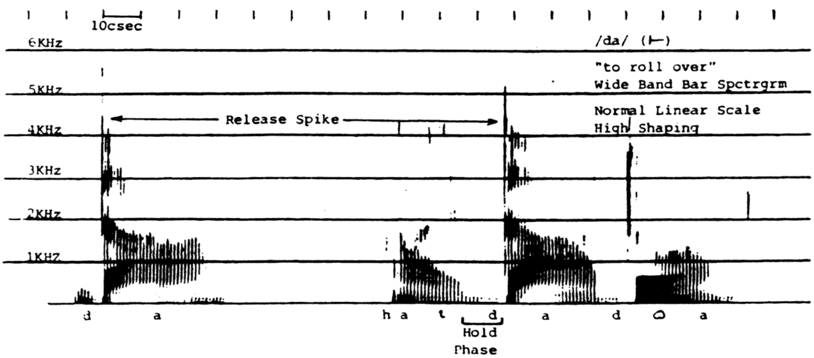
In order to observe the general spectrographic features of the utterances recorded we will begin by examining representative examples of the bar spectrograms with high shaping --- that is, with pre-emphasis designed to enhance the upper frequency range.

FIGURE ONE



High shaped wide band bar spectrogram illustrating the alveolar stop 'dh'.

FIGURE TWO

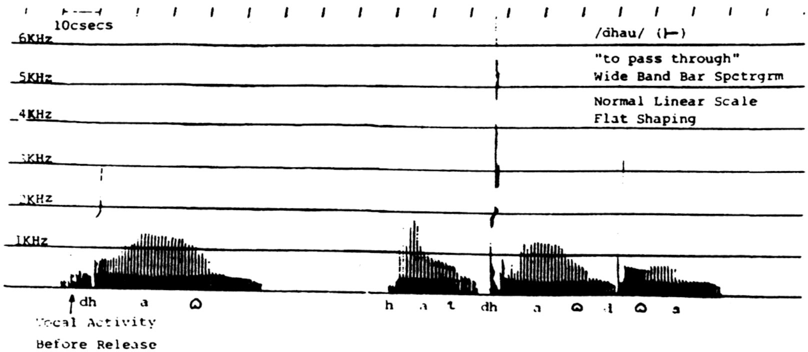


High shaped wide band bar spectrogram illustrating the alveolar stop 'd'.

5.2 Flat Shaped Wide Band Bar Spectrograms

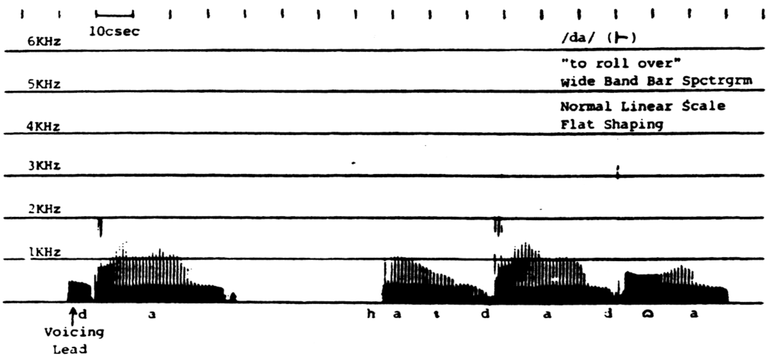
In order to examine voice onset time and other aspects of glottal activity in more detail, we will now turn to the bar spectrograms with flat shaping. Flat shaped spectrograms record a true impression of the relative amounts of energy throughout the frequency range, with no pre-emphasis of the upper frequencies. Thus they provide more detail in the lower frequency range, where vocal activity occurs, than do their high shaped counterparts.

FIGURE THREE



Flat shaped wide band bar spectrogram illustrating the alveolar stop 'dh'.

FIGURE FOUR



Flat shaped wide band bar spectrogram illustrating the alveolar stop 'd'.

Figure One shows two tokens of the word dhau (˧) 'to pass through'. As in all other examples below the left hand side of the spectrogram shows the word uttered in isolation, and the right hand side shows the word in the frame 'hais_____dua' ('say_____again'). Thus the word in question constitutes the central portion of the longer utterance on the right in each case. The similarity of this portion to the isolated example of the word on the left should be clear.

The horizontal axis of each spectrogram represents the time domain, the vertical strokes along the upper edge marking intervals of 10 centi-seconds. The fairly regular vertical striations seen particularly clearly below the 2KHz line indicate phonation --- each striation caused by one glottal pulse.

The vertical axis of the spectrograms represents the frequency domain, and shows the distribution of energy throughout the frequency range to 6000 Hz. The slightly darker bands running roughly horizontally throughout each word show the principal vowel formants. For example, the first four formants of the last part of the diphthong [aɪ̯] in the word hais [haɪ̯˩] in Figure One can be seen at approximately 650 Hz, 2000 Hz, 3000 Hz and 4000 Hz.

Our particular interest is in the region just before and after the release of the consonantal stricture (e.g. of 'dh' in Figure One) --- that is, the brief 'burst' of energy throughout the frequency range, shown on the spectrograms by a dark vertical line. This line is sometimes referred to as the release 'spike'.

The hold phase of the stop can be seen directly to the left of the release spike, beginning about 10 csecs before, from the abrupt cessation of the second and higher formants of the preceding vowel. Notice, however, that at the beginning of the hold phase some energy is still present in the very low frequency range, below 300 Hz. This shows that some phonation continues even after the closure for the stop has been made. In a voiceless or voiceless aspirated stop (like 't' or 'th' in Hmong) we would expect virtually no energy to be present during the hold phase.

If we now examine the period after the release of 'dh' in the frame in Figure One, we can see that the regular striations indicative of voicing do not begin again until after a lapse of approximately 3 csecs. This lapse, accompanied by the random stippling evident in the higher frequencies, can be attributed to a short period of aspiration after release, before the onset of the vowel, and is known as "Voicing Lag". Notice that there is almost no voicing lag in the accompanying example of the same morpheme uttered in isolation.

Turning to the representative example of a morpheme beginning with 'd' in Figure Two (da (˧) 'to roll over'), we can see that there is no voicing lag at all, the voicing resuming immediately after the burst. In fact, phonation continues virtually unbroken throughout the articulation of the stop, and can be clearly observed before the burst. This activity before the release of a stop is known as "Voicing Lead". (The decreasing amplitude and small break in the glottal pulse striations directly before the release of 'd' will be explained below (see 6.1).)

5.2.1 Voice Onset Time

Following Lisker and Abramson (1964), the Voice Onset Time (V.O.T.) of an occlusive is defined as the time between the release of the supra-glottal stricture and the onset of voice. Voicing lag, characteristic of aspirated stops, is seen on spectrograms as a period between the release spike and the (re-)commencement of the regular glottal pulse striations. Voicing lead, associated with voiced stops, is seen as a period before the release spike where the only energy present is in the lowest frequency range, where glottal activity is recorded.[6]

For each token of each morpheme recorded, both in isolation and in the frame, this period was measured from the flat shaped spectrograms, and the time it represented was calculated in centiseconds. (Voicing lag is recorded as a positive value, and voicing lead as a negative value.) An average was then taken of the voice onset time of the five tokens of each morpheme, both in the frame and in isolation, giving a mean V.O.T. value for each morpheme in both environments. These values, along with the standard deviation (S) from the mean in each case, are recorded in Table One.

TABLE ONE

Morpheme Recorded	Average V.O.T. in Isolation	S	Average V.O.T. in Frame	S
di	-9.0	1.6	-11.6	0.6
duas	-6.4	0.9	-10.4	0.8
dua	-6.1	0.8	-10.0	0.7
da	-7.3	0.7	-10.4	1.0
dhia	+4.6	1.9	+ 6.9	1.4
dhuas	+1.8	0.5	+ 3.3	1.0
dhuav	+3.7	1.8	+ 6.2	2.3
dhau	+2.0	2.2	+ 3.6	1.5

Table One. Mean Voice Onset Time values for five tokens of each morpheme, in isolation and in the frame hais_____dua [haĭ˩_____dŏa˧] ('say_____ again'). Values are in centiseconds, rounded off to one decimal place, reflecting the degree of accuracy of the measurements.

Returning briefly to the representative example of the consonant 'd' in the flat shaped spectrogram above, we can clearly see the voicing lead, confirming the auditory impression of 'd' as a voiced stop. The mean values for the voicing lead of 'd', shown in Table One, vary predictably between -11.6 and -6.1 csecs, depending on the vocalic environment and on whether the morpheme occurred in isolation or in the frame. The reasons for this variation will not be discussed here, but explanations can be found elsewhere in the liturature.

Examining the flat shaped spectrogram illustrating 'dh' above, we can see a clear voicing lag when the morpheme occurs in the frame, but in isolation almost no lag is evident. In other spectrograms however, this consonant exhibits voicing lag sometimes in both environments and sometimes in neither. The range recorded for the mean values of voice onset time for 'dh', shown in Table One, was from +1.8 to +6.9 csecs. The overall mean V.O.T., disregarding environment, was +4 csecs with a standard deviation of 1.7 csecs.

To understand the significance of these figures it is helpful to compare the voicing lag of 'dh' with that of two other stops in Hmong, which have a similar place of articulation. The data for these stops were recorded using an identical experimental procedure. The voiceless aspirated dental stop 'th' [t̪^{h}] in Hmong, a stop which is invariably perceived as aspirated, was found to have an overall mean V.O.T. value of 6.2 csecs with a standard deviation of 1.4 csecs. The overall mean V.O.T. of the voiceless unaspirated counterpart of this stop, 't' [t̪], was 1.2 csecs with a standard deviation of 0.4 csecs. These figures are summarized in Table Two.

<u>TABLE TWO</u>

Stop	Overall Mean V.O.T. Value	Standard Deviation
d	-8.9	1.9
t	+1.2	0.4
dh	+4.0	1.7
th	+6.2	1.4

<u>Table Two</u>. Overall Mean Voice Onset Time Values for four dent-alveolar consonants. Values are in centiseconds, rounded off to one decimal place, reflecting the degree of accuracy of the measurements.

It should be clear from the information recorded in Table Two that the V.O.T. lag of the alveolar stop 'dh' falls roughly between that of the voiceless unaspirated and voiceless aspirated dental stops in Hmong. This concurs with the auditory impression, mentioned in the introduction, that some tokens of 'dh' seem aspirated while others do not. The t-Test indicates that the mean V.O.T. value is significantly different at the 5% level from that of both 't' and 'th'. As there are no obvious enviromental factors which seem to determine the length of V.O.T. for 'dh', it is tentatively concluded that a relatively short period of aspiration is optional for this consonant.

5.2.2 Glottal Activity During the Hold Phase

Although the consonant 'dh' was observed to have an optional voicing lag, it is also clear from the spectrograms (Figures One and Three) that some glottal activity also takes place during the hold phase of this stop. Comparing this with the activity observed during the hold phase of 'd' (Figure Four), two important differences can be noted.

The first obvious difference is in the nature of this glottal activity. Whereas the striations recorded during the hold phase of 'd' are clear and regular, those of 'dh' are messy, uneven and irregular. This is particularly obvious in the examples of the morphemes uttered in isolation, where the vocal cords have not already been vibrating in a regular pattern before the closure of the stop. Secondly, while the voicing during the hold phase of 'd' is maintained almost to the point of release, that of 'dh' tends to die out much more quickly, often well before the burst. The significance of both of these aspects of the glottal activity during the hold phases of the two consonants will be discussed in the following section.

6. ARTICULATORY INFERENCES AND EXPLANATIONS
(Why a 'catch' in the voice?)

6.1 'd'

From the evidence of the spectrograms, discussed above, it is concluded that the consonant 'd' is simply a fully voiced alveolar stop. The auditory impression of a slight 'catch' in the voice in some tokens of this stop can be attributed to a very brief cessation of voicing before the release of the oral stricture. This was observed in the spectrograms as a small break in the glottal pulse striations directly before the release spike. Only in those tokens of 'd' where this break is long enough to be audible will a 'catch' in the voice be perceived.

The brief cessation of voicing described can be attributed to an interruption to the air flow caused by an equalization of air pressure above and below the larynx. This will occur sooner or later in any voiced stop if the oral stricture is not released within a certain length of time, and can be explained as follows. The process of voicing can begin when the vocal cords are sufficiently tense and slightly parted. The air, flowing from the sub-laryngeal vocal tract (an area of higher pressure) to the supra-laryngeal vocal tract (an area of lower pressure) is accelerated as it passes through the narrow opening between the two vocal cords (or 'folds'). This acceleration causes a slight reduction in pressure along the edges of the folds, which are consequently drawn together (the Bernoulli effect).

However, the build-up of pressure beneath the glottis, in conjuction with the natural elasticity of the vocal folds themselves, causes them to spring apart again a fraction of a second later, allowing the process to begin once more. This process can often go on repeating itself, as long as the speaker's breath lasts, each repetition corresponding to one of the glottal pulses we observed in the spectrograms. However, if it occurs in conjunction with an oral stop, it will not be long before the air pressure begins to build up behind this closure. The flow of air can be made to continue for a short while longer by strategies such as larynx lowering, which increases the volume and hence decreases the pressure in the supra-laryngeal vocal tract. Even so, unless the oral stricture is released it will not be long before the pressure above and below the larynx equalizes totally, the air flow ceases and voicing dies out. The hold phase of the stop may then continue long enough for this cessation of voicing to be perceived as a brief 'catch' in the voice, before the release of the stop allows the air flow, and hence the voicing, to begin again.

6.2 'dh'

The information obtained from the spectrograms concerning the acoustic properties of 'dh' is more difficult to interpret than in the case of 'd'. However, the data do seem to support the auditory impressions that 'dh' is a whispery voiced alveolar stop, with optional aspiration. The feature of optional aspiration has already been discussed at some length (5.2.1). However, the suggestion of a whispery voice quality for this consonant will require further explanation.

It will be helpful to begin by comparing the articulatory gestures involved in modal (normal) voice with those used to produce whispery voice. It should first be noted that scholars disagree somewhat both about the terminology that should be used (some using the terms "breathy voice" or "murmur" for what is here referred to as "whispery voice") and about the exact features relevant in the production of this phonation type. Such differences would not effect the general conclusions.

The vocal cords consist of two parts -- the ligamental vocal cords towards the front of the larynx, and the cartilaginous vocal cords (the arytenoid cartilages) towards the back. In modal voice both sections of the vocal cords vibrate as one unit. However, whispery voice is produced, according to one hypothesis, by drawing the arytenoid cartilages apart, so that vibration occurs only along the ligamental vocal cords. The irregular tension of the vocal cords results in irregular vibration and the gap between the arytenoid cartilages allows direct current flow through the larynx, unlike the regular alternating current flow of modal voice.

The suggestion that whispery voice is involved in the production of the consonant 'dh' can account for the two main acoustic differences noted on the spectrograms between 'd' and 'dh'. Firstly, it accounts for the 'messiness' or irregularity of the vocal activity evident during the hold phase of 'dh', unlike the neat, regular striations of 'd'. Secondly, it accounts for the far more rapid cessation of vocal activity during the hold phase of 'dh' than of 'd'. Recall that the cessation of voicing before the release of 'd' was attributed to the equalization of air pressure above and below the larynx. Naturally this equalization will take place much more quickly in the case of 'dh', due to the direct current flow between the cartilaginous vocal cords.

The reader may wonder how this whispery voiced stop in Hmong differs from the so-called "voiced aspirates" in languages like Hindi and Marathi. These stops are often referred to as "breathy" or "murmured" but, as mentioned above, these terms are sometimes used to describe what is here termed whispery voice. Lisker and Abramson (1963) give the following description of their auditory and acoustic characteristics:

> "Auditory impressions suggest that the voiced aspirates are released with breathy voice or murmur. These impressions are supported by the spectrograms in which, upon release of the stop, the voicing is seen to take on a special character. There is a period of glottal periodicity, sometimes intermittent, mingled with random noise in the formant regions, all at relatively low amplitude." (Lisker and Abramson 1963:418 - 419)

Unfortunately it is not possible to say to what extent the "sometimes intermittent" glottal periodicity Lisker and Abramson describe differs from the vocal activity observed for 'dh' in Hmong. However, whereas it is during the hold phase of the stop that whispery voice apparently occurs in Hmong 'dh', it is after the release that it is evident in Hindi. Furthermore, while the effect of this phonation type is very brief in Hmong, so that 'dh' occurs with modally voiced vowels, the effect of the Hindi "breathy" consonants may last well into the following vowel.

7. COMMENTS ON THE LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FURTHER INVESTIGATION

The approach used in this study has been to examine information about the acoustic characteristics of the stops in question, principally that encoded on wide band bar spectrograms, and to draw inferences from this data as to the physical processes involved in their articulation. While this approach has enabled us to make several important statements, with a reasonable degree of confidence, about the articulation of 'd' and 'dh' in White Hmong, there are some significant limitations on this study which should be noted. These observations naturally also serve to point to several avenues for further research.

The first and most obvious of these limitations is the small number of informants. The acoustic data used in the analysis were based on material recorded from only one speaker, and the 'normality' of these measurements was checked with material from only one other speaker, closely related to the first. As noted above, however, fairly extensive checks were made to ensure that the auditory impressions of the relevant consonants in these two idiolects matched those of other speakers. It is relevant to note, parenthetically, that although all the speakers thus observed were presumable aiming at approximately the same auditory target, and achieving a similar output, it is not necessarily the case that we can therefore assume invariance at the productional level. Furthermore, as Ladefoged and

Antoñanzas-Barroso (1985) clearly demonstrate, distinctions involving voice quality may be relative rather than absolute --- what is distinctly "breathy" for one speaker may fall within the range of modal voice for another, who normally has a slightly "breathy" articulation. A large number of informants would be needed in order to investigate phenomena such as these.

Another important limitation on the present study is the fact that some of the central conclusions, notably concerning the random noise element in the hold phase of 'dh', depend on visual impressions only of the spectrographic data. Ideally these impressions should be supported by accurately quantifiable forms of measurement, along the lines suggested for the "breathy"-modal distinction by Ladefoged and Antoñanzas-Barroso (1985).

Finally, it is extremely important to realize that the tentative conclusions drawn concerning the articulatory gestures involved in the production of the two consonants are inferences only. In order to ascertain the exact configuration of the vocal cords during the production of these or any other sounds, it would be necessary to undertake direct physiological observation. For example, fiberscopic study would be appropriate in this case.

8. CONCLUSION

The auditory impression of a slight 'catch' in the voice during the articulation of the alveolar consonants 'd' and 'dh' in White Hmong has previously been misinterpreted as a "glottal stop" or "glottalization". The experiment described above has shown that it can actually be correlated with a brief cessation of vocal cord activity immediately before the release of these stops, which was attributed to an equalization of air pressure above and below the larynx.

The auditory impression noted is more marked in the case of 'dh', because the vocal activity during the hold phase of this stop dies out more quickly than in the case of 'd'. It has been suggested that this extremely rapid cessation can be attributed to the whispery voiced quality of this vocal activity. The whispery voiced phonation type may involve a fairly large opening at the back of the larynx, allowing air to escape more rapidly than in the case of the modal (normal) phonation type used for 'd'.

On the basis of this study it is recommended that the White Hmong orthographic 'd' be described as a fully voiced alveolar stop (symbolized phonetically as[d]) and orthographic 'dh' as a whispery voiced alveolar stop with optional aspiration (symbolized phonetically as [d̤⁽ʰ⁾]).

NOTES

1. An earlier version of this paper was presented at the Southeast Asia Summer Studies Institute Conference (Hmong Linguistics Panel), Ann Arbor, Michigan, 2 August, 1985. My attendance at the Institute was made possible by a tuition fellowship from the University of Michigan and a grant from the Faculty of Arts, Australian National University.

   The experimental work for this study was conducted at the Department of Linguistics, School of General Studies, Australian National University, under the guidance of Dr. Philip Rose. Sincere thanks are due to him for his invaluable help.

   I am extremely grateful to Dr. Leo Papademetre, Dr. Philip Rose and Dr. Michael Walsh for reading and commenting on earlier drafts of this paper. I would also like to thank Ntxawg Lis and Maiv Yaj for acting as informants for the study, and Honorine Jarkey for typing the paper for me.

2. The symbol [a] is here used to refer to a low central vowel rather than a low front vowel, there being no more suitable symbol available in the International Phonetic Alphabet.

3. Recorder: Nagra 4.2; Microphone: Nakamichi CM300; Recording Speed: 7.5 ips; Recording level: 85db; Approximate distance of speakers mouth from microphone: 150cm.

4. 300 Hz ½power bandwidth.

5. Oscilloscope: Tektronix 5441 Storage Oscilloscope; Amplifier: 5A18N Dual Trace Amplifier; Time Base: 5B12M Time Base.

6. It is suggested in this paper (see 5.5.2) that some tokens of the consonant 'dh' exhibit both the feature of voicing lag and of voicing lead. However, it should be noted that this is not consistent with the conventional use of these terms, which regards voicing lag and lead to be mutually exclusive. Perhaps some new terminology, such as 'intermittent voice onset' is required for consonants such as 'dh', but for the purposes of this paper the conventional terminology is used, in a slightly unconventional way.

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