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Phonetic Stress Cues in Noun-Verb Pairs in American English vs. Indian English*

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1. Introduction

The linguistic system of Indian English differs from other varieties of English in many ways, including its sound system. Many studies focus on the segmental differences, as Indian English uses a distinct set of consonants and vowels in the phonetic inventory (retroflexes rather than alveolars, [ʋ] vs. [v], etc., as discussed in Sahgal and Agnihotri 1988, Chaudhary 1993, Coelho 1997, and others). Research on the prosodic properties of Indian English have focused on intonation patterns (e.g., Gumperz 1982, Kachru 1983), though some have discussed the rules of stress placement for Indian English, pointing out that this system also differs from other varieties of English. Only a few exceptions that we know of, such as Vijayakrishnan (1978), attempt to measure the phonetic properties of stress in Indian English. However, in an evaluation of the intonation system of Indian English teaching assistants, Pickering (1999) noted that the acoustic correlates of word stress may also distinguish this nativized variety of English from American dialects. A pilot study by Pickering and Wiltshire (2000), described in section 1.2, seems to confirm this suggestion; they conclude that the difference in amplitude between stressed and unstressed syllables in Indian English is rather small, while pitch changes are large and in the opposite direction to that of American English. The study, however, failed to take into consideration differences in the location of stress in the Indian English variety. Wiltshire and Moon (2000), described in section 2.3, used Indian English stress locations to analyze their data, and while they confirmed that the differences in amplitude are small, they also found pitch differences that are comparable to American English in both magnitude and direction. Durational differences too were comparable to American English; stressed syllables in Indian English were longer than unstressed syllables.

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The differences in the phonetic realization of stress between Indian English and American English may thus overall be small (Wiltshire and Moon, 2000); however, speakers of each variety are generally aware of the difficulties of understanding a speaker of the other variety, especially when the speaking rate is fairly brisk (Bush 1968). Part of the problem of processing a different dialect could well be the prosodic characteristics, including the location and phonetic realization of the stress. In this research, we look at how these two differences in stress, location and phonetic realization, together lead to differences in the acoustic realization of words. We use pairs of words which differ primarily in the location of stress in American English, to illustrate the potential problems in communication that may arise due to differences in phonological and phonetic stress.

We begin with a discussion of stress in general and in Indian English, followed by a description of our data collection procedures and previous findings. We then analyze the correlates of phonetic stress in a set of words produced by Indian English and American English speakers and find that the productions are dramatically different. Where the Americans have an increase in amplitude and duration, the Indian English speakers have significantly smaller increases. Where the Americans increase pitch, the Indian English speakers lower it, and vice versa, so that the movement of pitch on the same syllables tends to go in opposite directions in the two varieties. We conclude with a discussion of how the combined differences of the position of stress and its implementation can lead to possibilities for miscommunication.

1.1. Correlates of Phonetic Stress

The term stress is used for different kinds of prominence, and in this sense, stress is known to differ phonetically in different languages. In American and British English, stressed syllables are normally longer, louder and at a higher pitch than unstressed syllables (Fry 1955). In Japanese, however, the accented syllable of a word is higher in pitch but no louder or longer than unstressed syllables (Beckman 1986). Beckman in fact uses different terms: 'stress accent' for languages such as American English, which include an increase in loudness and possibly other correlates such as higher pitch and greater duration for stressed syllables, and 'pitch accent' for languages such as Japanese, which use only an increase in pitch and no other cues for prominent syllables. As Indian English does not seem to use large increases in amplitude, it may be a 'pitch accent' variety; however, we will continue to use the term 'stress' for prominent syllables to make the comparison with American English easier.

1.2. Previous work on Indian English Stress

In a study of Tamilian English, Vijayakrishnan (1978) suggests that increased duration is the primary cue to stress, and he connects this with increased duration in Tamil stressed syllables as well. Tamil stressed syllables have been shown not to increase in amplitude (Balasubramanian 1972, cited in Vijayakrishnan 1978), but neither work attempts to measure amplitude or pitch increases in Tamilian English.

Pickering and Wiltshire (2000) examined both amplitude and pitch cues for prominence in the classroom productions of three Indian English TAs. They concluded that

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the Indian English speakers used pitch accent rather than stress accent, because the syllables that Pickering and Wiltshire considered to be prominent were produced with lower pitch and without a reliable increase in loudness compared to adjacent syllables in Indian English. Thus, the use of both cues contrasts with American English, which has higher pitch and a reliable increase in loudness on stressed syllables.

Their study had numerous limitations however: only three Indian English and three American English subjects were used; all were male; a limited number of words (six per speaker) was chosen; all were nouns and adjectives; and these words were produced in natural (uncontrolled) contexts, so that the intonational contexts and position in a phrase were different in different cases. Limited measurements were taken for each syllable: only maximum amplitude and pitch in the middle of the syllable. Furthermore, since for the most part different words were chosen from the natural speech of the subjects, there was no controlled comparison between vowels of the same quality and in the same consonantal context but differing only in being accented vs. unaccented.

Most importantly, the location of stress in Indian English was assumed to be the same as in American English, though they did attempt to corroborate this with judgments from Indian English speakers by asking them to circle the syllable they considered stressed. The words used from the Indian English subjects were:

(1) Subject's L1 Words chosen for analysis in Pickering and Wiltshire (2000)

Bengali:	<u>amplitude</u>	<u>Bode</u>	<u>different</u>
	<u>frequency</u>	<u>omega</u>	<u>versus</u>
Tamil:	<u>active</u>	<u>careful</u>	<u>equation</u>
	<u>input</u>	<u>normally</u>	<u>output</u>
Hindi:	<u>cathode</u>	<u>current</u>	<u>diode</u>
	<u>junction</u>	<u>passive</u>	<u>voltage</u>

The syllables considered to be stressed in Pickering and Wiltshire (2000) are underlined. We believe that many of these are stressed in different syllables in Indian English, which may explain some of the results found in that study. For example, following the rules given in Vijayakrishnan (1978), we expect that a final or penultimate syllable with a tense vowel or lax vowel followed by a cluster of consonants would be stressed, giving different, frequency, and voltage. Furthermore, drawing these words out of different contexts, such as different positions in a phrase, with perhaps different focus, also leaves open the possibility that factors other than stress were involved, such as intonation.

2. Methodology

In the current study, we replicate one aspect of Pickering and Wiltshire (2000), in that we use the American English location of stress, so that we are comparing the same syllables in the American and Indian English productions, regardless of whether the Indian English speakers consider the syllable stressed or unstressed. However, we also tried to avoid the previously mentioned shortcomings of Pickering and Wiltshire (2000). Thus, we gathered data from

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more subjects, both male and female, and used a frame to control for the segments adjacent to the target word and its position in the phrase.

2.1. The Subjects

In the study described here, we have recorded data from thirty speakers of Indian English and ten speakers of American English. Of these, twenty subjects have been analyzed for the results reported here: fifteen Indian English and five American English speakers. The five Americans included three females and two males, ranging in age from 19-22. All grew up primarily in Florida¹, in the United States, with English L1 and no special knowledge of or experience with Indian languages. All use English 100% of the time, at work and home

The fifteen Indian English speakers are a more heterogeneous group. The seven females and eight males ranged in age from 21-34. Their length of stay in US ranged from five days to seven years and nine months, with the average length of stay in the US about one year and seven months. The average time for which they had studied English was about eleven years three months, and they tend to use English 75-100% of the time at work in the US, and less at home (in the US). The first languages of our subjects include Tamil (4), Kannada (3), Telugu (3), Hindi (4), Gujarati (3), Marathi (2), Sindi (1), Punjabi (1), Bengali (1). The total exceeds fifteen because several subjects spoke more than one language natively.

2.2. Data Collection

Each speaker produced a set of sixty two-syllable words in a controlled context. The context was the frame sentence, "I will say X again". The use of the frame allows us to avoid complications from the pitch and duration changes that occur at the beginning and end of a sentence or phrase. Two syllable words are used for direct comparison between a stressed syllable and an unstressed one in the same utterance. The 60 words form 30 pairs which are similar except for having initial vs. final stress placement in American English, which has numerous pairs of such words which differ in stress between nouns and verbs, for example:

(2) Word pairs collected

Initial Stress - Noun	Final stress - Verb
cónduct	condúct
récord	recórd
próject	projéct

The use of such pairs allowed us to measure the same vowel in a stressed and unstressed version in the same position in the word, at least for most words for the American English speakers. Unfortunately, we could not do the same for the Indian English speakers, since for many of them both members of these pairs, noun and verb, are pronounced the same.

¹ This was true except for one male subject, who spent two to three years each in Kentucky, DC, and London, and the rest of his youth in Florida.

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Since the words are generally spelled the same, production of the correct form was triggered by a priming sentence, as shown in (3).

(3) Priming sentences and frames for members of word pairs

Illegal drugs have the power to *addict*. I will say *addict* again.

If you smoke for a long time, you will become an *addict*. I will say *addict* again.

The order of the sentences was randomized. The data was recorded in a quiet room using a Shure Professional Unidirectional head-worn dynamic microphone Model SM 10A, with the microphone at a distance of approximately 2 inches from mouth, and the recordings were made on a Sony TCD-D8 digital audio tape-corder, using digital audio-tapes.

2.3. Acoustic Analysis

The data were acoustically analyzed using Speech Analyzer Version 1.5, Test version 10.6, from the Summer Institute of Linguistics. Fifteen word pairs of the thirty were chosen for analysis (see Appendix). We took three kinds of measurement for each syllable: amplitude (loudness), vowel duration, and frequency (pitch). For the amplitude, we measured the peak amplitude of the vowel in deciBels. Vowel duration was measured in seconds using vowel periodicity as a guide to the beginning and end. For pitch, we measured the initial pitch as the value in Hz at 10ms after the beginning of the vowel, the medial pitch half way between the beginning and end as measured for duration, and the final pitch 10ms before the end. We also noted the highest and lowest values for pitch within the vowel, as well as their location.

(4) Measurements taken for each syllable

amplitude:	peak value of syllable
duration:	beginning to end of vowel periodicity
frequency:	initial (P1): 10 ms after beginning of vowel
	medial (P2): center of vowel, based on duration
	final (P3): 10 ms before end of vowel
	highest (PH): the highest pitch value and its location
	lowest (PL): the lowest pitch value and its location

After recording the data, we had given the subjects a list of the priming sentences, on which they circled the syllable in the target word that they considered stressed. We later found this to be an unreliable indication of stress. For example, the American subjects ranged from a score of 100% agreement with our expectations to about 40% agreement. The Indian English subjects not only differed from our expectations, but differed from each other, even those with similar L1 backgrounds. For example, half the subjects reported stress on the first syllable of *import* (noun), and half reported stress on the second syllable. Given the American subjects' unreliability, we concluded that asking subjects to circle the syllable they believed to be stressed was not a reliable or valid indicator of the syllable which is stressed.

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We have elsewhere analyzed a subset of the data using judgments from some of the native speaker subjects on a tapping test, combined with the predicted location of Indian English stress from Vijayakrishnan (1978), and we report on the findings in Wiltshire and Moon (2000). The results differ greatly from those of Pickering and Wiltshire (2000); though we agree that amplitude is not greatly increased on the stressed syllable in Indian English, the increases in pitch and duration on those syllables strongly resemble the increases found in American English, as summarized in (5).

(5) Results of Wiltshire and Moon (2000)

stressed syllable in Indian English		in American English	Different?
amplitude:	increase: .52dB	3.27dB	yes
frequency:	PH: increase: 3.44Hz	3.86Hz	no
	PL: increase: 3.28Hz	2.42Hz	no
	P2: increase: 3.59Hz	1.71Hz	no
duration:	increase: 22ms	19ms	no

The amplitude increases on stressed syllables are indeed significantly smaller in Indian English than in American English, while the differences in pitch measured at various points were not significantly different from American English, nor were the differences in duration. Thus, both pitch and duration increase in the stressed syllables of American English and Indian English, and by similar amounts.

We here analyze the data based on our knowledge of which syllable is stressed in American English and compare the same syllables in American English to those in Indian English to illustrate the differences in realization between the two. The results therefore do not show what Indian English speakers do on the syllables that they consider stressed vs. unstressed, but only the differences in the production of words in American English vs. Indian English, where those differences result from a combination of differences in the position of stress and differences in the phonetic realizations of stress. These results can thus be taken as an indication of sources of potential miscommunication between American English and Indian English speakers.

3. Results

Comparing the productions of American English and Indian English speakers by comparing the same syllables for the different properties associated with stress gives us an indication of how these prosodic differences result in massive differences between American English and Indian English, which might lead to misunderstandings between the two groups of speakers. We examine the most robust differences here. In the comparisons that follow, we ignore whether or not the Indian English variety considers a syllable to be stressed, and compare syllables to each other using the American English speaker's expectation of where the stress is.

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3.1. Amplitude

For each speaker, we calculated the amplitude difference within each word between the syllables considered stressed vs. unstressed in American English. Since we were using the stress patterns of American English, for nouns we subtracted the second syllable from the first, and for verbs, the first syllable from the second.

Not surprisingly, the results showed significant differences across all words when we compare the Indian English speakers to the American English speakers. The American English speakers thus have an increase in amplitude for the stressed syllable (3.27dB), while the average increase for Indian English is rather small (.15dB). When compared to the findings of Wiltshire and Moon (2000), which found the Indian English speakers averaged an increase of .52dB on stressed syllables, the two results are not significantly different. Thus, for Americans listening to Indian English speech, amplitude does not provide much of a clue as to which syllable is stressed; if an American listener expects stress on a particular syllable, and expects an amplitude increase of about 3dB, the Indian English speakers' lack of amplitude increase on either syllable will not help.

(6) Amplitude Differences, Stressed -Unstressed within same word (using AE location of stress)

Across all words:	IE speakers	AE speakers
mean	0.15dB	3.27dB
standard dev.	2.725	3.095
t-test ²	p = .0001 <.05,	significant.

Thus American English listeners would probably have trouble identifying the main stress of these words based on amplitude differences, since the Indian English amplitude increase on the syllable that Indian English speakers considered stressed is already small (.52), and probably not enough to offset American English listeners expectation of which syllable is stressed. As the results of using the incorrect location of stress (based on American English) to analyze Indian English here are fairly comparable to the results obtained using the stressed syllables of Indian English (Wiltshire and Moon 2000), the suggestion that Indian English might use loudness at all as a correlate of stress is weakened.

3.2. Frequency

There is evidence that pitch is the primary cue to stress in American English (Fry 1955). When we analyzed pitch, using the American English definition of which syllable is stressed on the Indian English words, we find a major difference between the correlates in American English stressed syllables and the Indian English production of the same syllable.

²Throughout the analysis, the t-test refers to a two-tailed t-test for two samples with unequal variance.

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To see differences more clearly, we analyzed nouns, with initial stress in American English, and verbs, with final stress in American English, separately. Here we find significant differences between Indian and American English in High pitch on the stressed-unstressed syllables for each group, nouns and verbs. The difference, however, is going in opposite directions for the two word classes. That is, where Americans produce a large increase in pitch on the first syllable of a noun, instead there is on average a small decrease on the first syllable in Indian English, probably because we are combining cases in which there is no increase or even a decrease in pitch on the first syllable because stress is on the second syllable of the noun for the Indian English speaker.

(7) Highest Pitch Differences, Stressed-Unstressed within same word

Nouns		IE speakers	AE speakers
	mean	-1.94Hz	15.01Hz
	standard dev.	7.476	9.186
	t-test	p = 7.24E-06 <.05,	significant.
Verbs		IE speakers	AE speakers
	mean	3.45Hz	-3.85Hz
	standard dev.	6.805	9.203
	t-test	p = 0.02 <.05,	significant.

For the verbs, there is much more consistently an increase in pitch on the second syllable for the Indian English speakers, while the American English speakers mysteriously average a drop in pitch in these forms. This seems to indicate that the highest pitch in American English speakers' stressed syllables in nouns are much higher in pitch than their unstressed syllables, while the highest pitch in the stressed syllables in verbs are slightly lower in pitch than the unstressed syllables. It is worth pointing out here that the stressed syllable is the first one in nouns and the second one in verbs; hence the data together suggest that the first syllable is slightly higher in pitch than the second for American English speakers. For Indian English speakers' nouns, we see a slight decrease in pitch in the syllable American English speakers consider to be stressed relative to the unstressed, and for Indian English speakers' verbs, we see a slight increase in pitch on the syllable which American English speakers consider to be stressed relative to the unstressed. In both cases, these differences are probably not indicative of different pitch cues for the stressed syllable, as suggested in Pickering and Wiltshire (2000), but only cues for the difference in the location of stress.

The results for the lowest pitch and for the medial pitch on the stressed vs. the unstressed syllables show a similar pattern to that of the highest pitch, and are given in (8) and

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(8) Lowest Pitch Differences, Stressed-Unstressed within same word

Nouns		IE speakers	AE speakers
	mean	-4.85 Hz	4.13Hz
	standard dev.	5.864	7.622
	t-test	p = 3.81E-08<.05,	significant.
Verbs		IE speakers	AE speakers
	mean	5.62Hz	-7.13Hz
	standard dev.	5.123	9.417
	t-test	p = 0.0001<.05,	significant

(9) P2 (Medial Pitch) Differences, Stressed-Unstressed within same word

Nouns		IE speakers	AE speakers
	mean	-4.17 Hz	10.69Hz
	standard dev.	7.547	9.246
	t-test	p = 4.97E-05<.05,	significant.
Verbs		IE speakers	AE speakers
	mean	4.90Hz	-6.58Hz
	standard dev.	6.073	9.682
	t-test	p = 0.001<.05,	significant.

Thus the American's expectations of the pitch increase of a given stressed syllable are often going to be confounded by the fact that the Indian English speaker is stressing a different syllable of the word. Given the small amplitude cues, an American English listener may not be able to correctly identify the stressed syllable.

The pitch of a vowel can also be affected by the identity of the vowel and its surrounding consonants. To control for these factors, we also used our word pairs to compare a stressed and unstressed version of the same vowel in the same context, at least for the American English speakers. That is, using pairs such as *réject* and *rejéct*, we compare the vowels in the first syllable of each word, and the vowels in the second syllable of each, measuring the differences of *ré* vs. *re* and *jéct* vs. *ject*. Comparing the results for Indian and American English, we found a significant difference for the medial pitch(P2) of the second syllable, though the differences for the first syllable did not reach significance.

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(10) P2 (Medial pitch) Differences of same syllable, Stressed-Unstressed in different words

First syllable (ré-re)	IE speakers	AE speakers
mean	-1.66Hz	1.41Hz
standard dev.	3.965	9.565
t-test	p = 0.266 >.05,	not significant.
Second syllable (jéct-ject)	IE speakers	AE speakers
mean	2.79Hz	9.25Hz
standard dev.	4.583	9.355
t-test	p = 0.03 <.05,	significant.

Controlling for vowel quality, consonantal context, and position in the word thus provides us with an indication that pitch is consistently relatively higher in stressed syllables for the American English Speakers. For Indian English speakers, the large increase in pitch on a stressed syllable is not evident when we use the American location of stress. Again, this must be considered the result of the differences in location of stress, as we saw in (5) that Indian English speakers do increase the pitch on the syllable which they consider stressed.

3.3. Vowel Duration

Duration is reported to be a correlate of stress in American English: stressed vowels are longer than unstressed vowels. This is one reason that American English has been classified as a stress-timed language rather than syllable timed, in the dichotomy of Pike (1946). Indian English has been classified as a syllable timed language by Kachru (1983) and others. For example Crystal (1995) says that the use of English as a World language has in general “resulted in varieties of Modern English in which the syllable timing has been transferred from the contact languages, producing a natural variety of isosyllabic English as a mother tongue by large numbers of people”, and he goes on to say that “This situation is most dramatic in the subcontinent of India, where one of the most noticeable features of Indian English - and the one which contributes most to the difficulty British speakers have in understanding Indian speech - is the failure to preserve traditional stress distinctions because of the isosyllabic rhythm” (Crystal, 1995; p. 176). If Indian English is isosyllabic, or syllable timed, a syllable containing the same segments should take the same amount of time regardless of whether it is stressed or not.

In Wiltshire and Moon (2000), we already showed that Indian English stressed syllables are significantly longer than their unstressed syllables, and that the lengthening is comparable to that of American English. The question remains, why do speakers of American and British varieties judge Indian English to be more isosyllabic than other varieties? Our comparison of the Indian English data analyzed using the location of stress from American English helps to provide an answer.

We first compared the difference in duration between stressed and unstressed syllables in each word, using the American English location of stress. Though the increase in length of the stressed syllables seems much smaller in Indian English, the results were not significantly

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different, as shown in (11). The results for nouns and verbs analyzed as separate groups were not significantly different either and are not given here.

(11) Duration Difference, Stressed-Unstressed within same word

Across all words:	IE speakers	AE speakers
mean	.0015secs	.0195secs
standard dev.	0.043	0.036
t-test	$p = 0.086 > .05,$	not significant.

As with pitch, however, length is also an intrinsic property of vowel identity. Therefore, as with pitch, we evaluated the difference between the same syllable (first or second), when it was stressed vs. unstressed (*ré -re* and *jéct-ject*). We find the American English speakers have a consistently greater duration in the stressed version, while the Indian English speakers show little durational increase

(12) Duration Difference of same syllable, Stressed-Unstressed in different words

First syllable	IE speakers	AE speakers
mean	.0033 secs	.0269 secs
standard dev.	0.01055	0.02150
t-test	$p = 0.001 < .05,$	significant
Second syllable	IE speakers	AE speakers
mean	-.0003secs	.0111 secs
standard dev.	0.01002	0.01464
t-test	$p = 0.02 > .05,$	significant

Here the differences were significant. In American English, the stressed version of a particular vowel was longer than its unstressed version by 15-27ms, while in Indian English the differences between those same two vowels was much smaller. Thus an American English speaker would find no lengthening of the vowel they expect to be stressed. Again, though the different phonological stress system of Indian English is probably to blame, the results have been interpreted by native speakers of other varieties to indicate that Indian English does not lengthen its stressed syllables.

3.4. Summary of results

There are significant differences in the acoustic correlates of stressed syllables in American English vs. those of the same syllables in Indian English. These differences are summarized in (13).

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because they are searching based on a syllable that is not stressed in their own variety of English. We plan perception studies for future research, to see whether Indian English words are correctly identified by American English listeners, whether American English words are correctly identified by Indian English listeners, and whether the processing time is affected.

With the current population of India now over one billion people, a conservative estimate that about 3% of this population is fluent in English, following (Kachru 1983), places the current number of Indian English speakers at about 30 million, and both the population and the English speaking proportion of it continue to grow. As the quantity of international communication is also rapidly growing, the success of this communication becomes increasingly important. The use of English as an international language does not guarantee successful communication when different dialects of English show such divergent characteristics, unless the differences between dialects are well understood. We hope this line of research will help to develop a better awareness of the differences, and, ultimately, facilitate more successful inter-dialectal and international communication.

Appendix

The fifteen words pairs analyzed, with the syllable stressed in American English underlined

Nouns: $\acute{\sigma}$ - σ addict, affix, combines, compound, convict, defect, desert, dispatch, present,
produce, project, record, refuse, survey, torment

Verb: σ - $\acute{\sigma}$ addict, affix, combines, compound, convict, defect, desert, dispatch, present,
produce, project, record, refuse, survey, torment

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