



# The role of focus in accentual lengthening in American English: Kinematic analyses

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## Abstract

Prominent syllables are longer than their non-prominent counterparts. However, it is unclear whether the source of the effect is accentuation or focus structure, and, if it is focus structure, whether different types of focus are differentiated by lengthening. It is also unclear whether these length distinctions are best understood as categorical vs. gradient effects. Here we address these issues by an electromagnetic articulography study of American English.

The test words, embedded in short dialogues, were 1) unfocused, 2) de-accented, or 3) accented under a) broad, b) narrow or c) contrastive focus. The test words were further controlled for length (one, two, three or four syllables) and position of stress (first, second, or third syllable). The durations of the consonant gestures of the stressed syllables were calculated.

Results from eight speakers indicate that regardless of word length and stress position, prominence-related lengthening reflects both accent and focus in American English. Not only were accented gestures longer than their unaccented counterparts, but also the three types of focus presented an increase in lengthening: broad < narrow < contrastive. Unfocused and de-accented gestures were not differentiated. A hierarchy of prominence is proposed and discussed in terms of categorical vs. gradient distinctions.

**Index Terms:** prominence, accentual lengthening, focus, American English, articulation

## 1. Introduction

*Prominence* is one of the two main functions of prosody, the other one being *grouping* linguistic units into larger cognitive constituents, such as words into phrases. The role of prominence is to mark the elements of these constituents that are rhythmically (stressed syllables within words) or conceptually (accented words within phrases) important. This marking is mainly achieved by the means of temporal and tonal events. It needs to be noted though that the list of correlates of prominence also includes intensity, vowel quality, spectral tilt and formant patterns. In the temporal domain, there is evidence indicating that in many stress languages, stressed syllables are acoustically longer than their unstressed counterparts (e.g., [1, 2, 3, 4, 5, 6]), and that accented syllables are in turn longer than unaccented stressed ones (e.g., [3, 7, 8, 9, 10, 11, 12]). Relatedly, in some languages, unstressed vowels are reduced (e.g., [13, 14, 15]). These findings are corroborated by kinematic evidence,

according to which prominent syllables present longer, larger and faster articulatory movements (e.g., [16, 17, 18, 19, 20, 21, 22, 23, 24, 25]), undergoing spatiotemporal expansion, often referred to as strengthening (cf. [19]). At the phrasal level, languages with lexical stress use also pitch movements, called pitch accents, to mark the stressed syllable of the accented words (e.g., [26, 27]). Pitch accents, along with the other types of intonational events, such as boundary tones, are considered morphemes that encode pragmatic information, including focus types (see review in [28]). For example, in Greek declarative constructions, broad focus and narrow focus are shown to be marked by H\* and L+H\* pitch accents respectively ([29, 30]). However, intonational meaning is understudied, and the correspondence between pitch accent types and their meaning function is yet to be determined (see e.g., [28]).

Although languages differ in the number of phonetic dimensions they use to mark stress and/or accent as well as in the degree of each dimension's contribution in this marking, the temporal and tonal dimensions combined seem to reflect a hierarchy of prominence, rising from absence of stress to presence of stress, and then to presence of accent (see [31] for a review). However, this hierarchy of prominence has yet to be defined, since, to date, neither the complete range of degrees of prominence nor the phonetic correlates of these degrees have been established. The few studies on the temporal effect of phrasal prominence, often referred to as accentual lengthening have reached ambiguous conclusions, possibly because typically the different degrees of prominence were not disentangled, or not all of them included, interactions of different prosodic factors were not taken under consideration, and little articulatory data were examined (e.g., [11, 12, 32, 33]). Evidence from the limited work that has examined different degrees of prominence by considering focus structure (i.e., de-accentuation, broad focus, narrow focus and contrastive focus) examined German and concluded that it was focus and not accent that caused strengthening ([34]; see also [35] and [36]). Interestingly, duration is assumed to reflect gradient distinctions of prominence, while F0 reflects both gradient and categorical ones (cf. [36]). The presence of a pitch accent automatically denotes accented status, i.e., is a categorical property, whereas duration, and possibly F0 as well, increase continuously across focus types, although not all focus types might be distinguished via duration and F0 height in a given language. Thus, in order to understand prominence, cross-linguistic differences need to be considered. For instance, as hinted to earlier, not all languages

use duration equally and/or for both stress and accentuation (cf. [4, 37, 38, 39]). Arabic is a representative example, presenting stress-related lengthening, but focus does not further affect duration of the stressed syllable ([4]).

In terms of interactions of accentual lengthening with other prosodic dimensions, two factors emerge from the literature as relevant, namely the position of lexical stress and word boundaries. Accentual lengthening has been found to affect mainly the stressed syllable and the one following it – the *spill over effect* ([11, 12, 32, 33]). Accentual lengthening has also been detected at the boundaries of the word – the *demarcation effect* ([32]).

The goal of the current study is to disentangle the degrees of prominence reflected in accentual lengthening in American English, and to examine the role of focus structure in defining them by means of an electromagnetic articulography (EMA) study. We also consider the contribution of word boundaries/length and stress position in the effect. Our expectation is that, regardless of the length of the word and the position of stress in it, accentual lengthening distinguishes at least three degrees of prominence with absence of accent being related to the lowest degree and contrastive focus to the greatest degree (cf. [34, 35, 36]).

## 2. Methods

### 2.1. Participants and recording apparatus

Eight native speakers (2 male, 6 female; mean age: 23, age range: 19-37) of American English participated in the study. Participants were naïve to the purpose of the experiment, and reported no speech, hearing or vision problems. They received financial compensation for their participation.

Data were collected using the AG501 electromagnetic transduction device (Carstens Medizintechnik). Receiver coils were attached to the tongue dorsum, tongue body's center, tongue tip, upper lip, lower lip, upper incisor, lower incisor, left ear, right ear, and nose. Audio recordings were performed simultaneously to the kinematic recordings by the means of a Sennheiser shotgun microphone set at a sampling rate of 16 kHz.

### 2.2. Stimuli and experimental design

Nine English words that combined four word lengths and three stress positions served as test words. In particular, these words were one (L1), two (L2), three (L3) or four (L4) syllable long, with stress on the first (S1), second (S2) or third (S3) syllable. Table 1 lists the test words by experimental factor.

Table 1: *Test words by experimental factor. Gray cells correspond to impossible combinations.*

		Word Length			
		L1	L2	L3	L4
Stress Position	S1	bee	baby	melody	military
	S2		design	banana	humanity
	S3			matinee	salmonella

Target frame sentences were constructed that were appropriate to the meaning of each word. In addition, prompt sentences were used which, paired with the frame sentences, elicited the test words with the following combinations of focus type and accent: 1) unfocused, following a narrowly

focused item (UF), 2) de-accented by virtue of following a contrastively focused item (DA), 3) accented under broad focus (BF), 4) accented under narrow focus (NF), or 5) accented under contrastive focus (CF). Table 2 contains the pair of prompt and target sentences for the test word *bee* for each focus type. The stimuli were presented on a monitor, positioned roughly 1.5 meter away from the participant. The participant read the prompt sentence silently, and the target sentence aloud.

Table 2: *Test stimuli for the test word bee. PS stands for prompt sentence and TS for target sentence.*

<p><u>Pair (a): Target word <i>bee</i> bears contrastive focus</u></p> <p>PS: <i>Is the botanist going to test the fly with the stripes?</i></p> <p>TS: <i>No, the botanist will be testing the bee with the stripes.</i></p>
<p><u>Pair (b): Target word <i>bee</i> bears narrow focus</u></p> <p>PS: <i>What is the botanist going to test?</i></p> <p>TS: <i>Oh, the botanist will be testing the bee with the stripes.</i></p>
<p><u>Pair (c): Target word <i>bee</i> bears broad focus</u></p> <p>PS: <i>What is the botanist going to do?</i></p> <p>TS: <i>Oh, the botanist will be testing the bee with the stripes.</i></p>
<p><u>Pair (b): Target word <i>bee</i> is de-accented</u></p> <p>PS: <i>Is it the zoologist who will be testing the bee with the stripes?</i></p> <p>TS: <i>No, the botanist will be testing the bee with the stripes.</i></p>
<p><u>Pair (b): Target word <i>bee</i> is unfocused</u></p> <p>PS: <i>Who is going to test the bee with the stripes?</i></p> <p>TS: <i>Oh, the botanist will be testing the bee with the stripes.</i></p>

### 2.3. Data analysis

The consonant (C) gestures of the stressed syllables of the target words were detected and semi-automatically labeled using custom software (Mark Tiede, Haskins Laboratories). Specifically, the following timepoints were marked on the basis of velocity criteria: onset, peak velocity, target, constriction maximum and release of the gesture's formation, and peak velocity and offset of the gesture's release (see Figure 1). Based on these timepoints, several kinematic measures were calculated. The measure relevant to the analyses reported here is the duration of the formation phase, which is defined as the interval between the onset and the release, as illustrated in Figure 1.

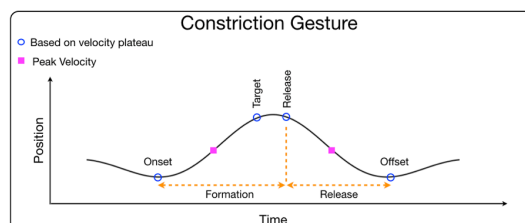


Figure 1: *Schematic representation of constriction gestures along with the gesture's labeled timepoints.*

For the statistical analysis, linear mixed effects models were fitted for the test consonant constriction, using the lmerTest package [40] in R. Formation duration was the response variable and focus type (UF, DA, BF, NF, CF), word length (L1, L2, L3, L4) and stress position (S1, S2, S3) were

the fixed effects. Random effects of speaker and word were included. The `relevel` function in R was used to derive pairwise comparisons from the `lmer` output. Additional evaluations of fixed factors were compensated for using a Bonferroni correction.

### 3. Results

The statistical analysis detected main effects of focus type ( $\chi^2(4) = 564.89, p < 0.001$ ), word length ( $\chi^2(6) = 42.86, p < 0.001$ ) and stress position ( $\chi^2(5) = 43.01, p < 0.001$ ). An interaction effect was found between the factors word length and stress position ( $\chi^2(3) = 41.59, p < 0.001$ ). There was no interaction of focus type with either word length or stress position.

With respect to focus type, pairwise comparisons indicated that the effect was such that accented C gestures were longer than unaccented ones, with lengthening further differentiating among broad, narrow and contrastive focus types. The pairwise comparisons are listed in Table 3, and Table 4 summarizes the mean durations (along with standard deviations) of the stressed C gestures' formation phase by focus type.

Table 3: The pairwise comparisons by focus type.

	NF	BF	UF	DA	
Reference Level	CF	$\beta = -18$ SE = 1.641 $p < 0.001$	$\beta = -25$ SE = 1.642 $p < 0.001$	$\beta = -35$ SE = 1.645 $p < 0.001$	$\beta = -34$ SE = 1.641 $p < 0.001$
	NF		$\beta = -6.9$ SE = 1.638 $p < 0.001$	$\beta = -17$ SE = 1.642 $p < 0.001$	$\beta = -16$ SE = 1.636 $p < 0.001$
	BF			$\beta = -10$ SE = 1.642 $p < 0.001$	$\beta = -9$ SE = 1.637 $p < 0.001$
	UF				<i>n.s.</i>

Table 4: The mean duration and standard deviation in ms of C gesture's formation by focus type.

	Mean	SD
CF	154	48
NF	136	35
BF	129	34
UF	119	31
DA	120	33

As Tables 3 and 4 suggest, the C gestures of the stressed syllables presented an increase in lengthening from the unfocused and de-accented conditions to broad focus to narrow focus and finally to contrastive focus. No significant difference was detected between the unfocused condition and the de-accented one. These results are illustrated in Figure 2.

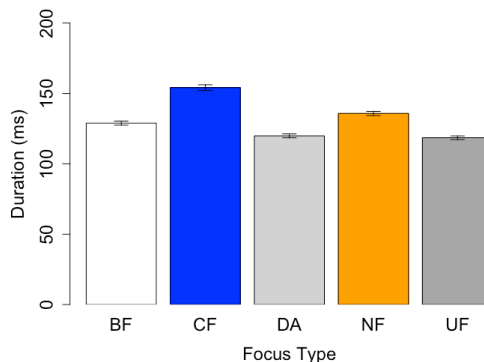


Figure 2: Stressed C gesture's formation duration (in ms) by focus type (DA, UF, BF, NF, CF).

The statistical analyses did not detect any interaction effect between focus type and word length and/or stress position. This is illustrated in Figures 3 and 4, which demonstrate the duration of the stressed C gesture's formation per word length and stress position respectively. It is obvious from these figures that focus types presented the same patterns of lengthening across all word lengths and all stress positions.

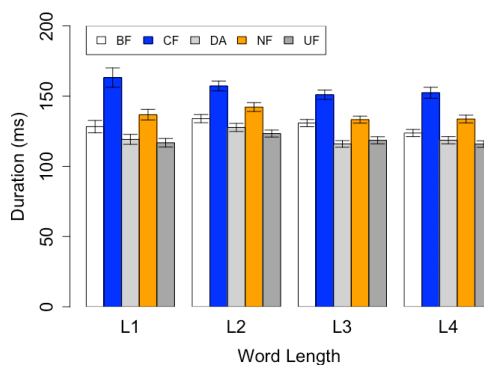


Figure 3: Stressed C gesture's formation duration (in ms) by focus type (DA, UF, BF, NF, CF) and Word Length (L1, L2, L3, L4).

As for the factors of word length and stress position, their effects are not directly related to the topic of the current study, since they do not interact with focus structure. We will thus mention here just their most systematic effects due to space limitations. Our analyses showed that the stressed C's gesture's formation was the shortest in words with three syllables (L1 > L3:  $\beta = -12, SE = 2.1, p < 0.001$ ; L2 > L3:  $\beta = -7.7, SE = 2.1, p < 0.001$ ; L4 > L3:  $\beta = -7.9, SE = 2.1, p < 0.001$ ). With respect to stress position, stressed C gesture's formation was the shortest when stress was on the first syllable (S2 > S1:  $\beta = 16, SE = 2.1, p < 0.001$ ; S3 > S1:  $\beta = 36, SE = 2.1, p < 0.001$ ) and the longest when stress was on third syllable (S3 > S1:  $\beta = 35.6, SE = 2.1, p < 0.001$ ; S3 > S2:  $\beta = 44.5, SE = 2.1, p < 0.001$ ). It is interesting to note that the words which were three syllable long stressed either on the first or second syllable (i.e., *melody, banana*) had among the shortest stressed C gesture formations, while *matinee* that had three syllables with the final one being stressed had the longest stressed C gesture.

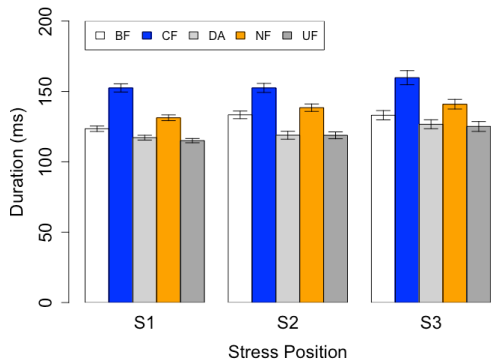


Figure 4: *Stressed C gesture's formation duration (in ms) by focus type (DA, UF, BF, NF, CF) and Stress Position (S1, S2, S3).*

## 4. Discussion

To summarize, our results indicate that accented constriction gestures are longer than their unaccented counterparts, and furthermore that prominence-related lengthening varies with type of focus, increasing from broad focus to narrow focus and then to contrastive focus. These patterns hold regardless of how long the accented word is and which of its syllables is stressed.

Our findings further support the function of lengthening as a marker of prominence (cf. [16, 17, 18, 19, 20, 21, 22, 23, 24, 25]). More importantly, however, our findings suggest that it is focus structure, and not *solely* the presence of accent, that is encoded in the amount of the so-called accentual lengthening, being in general agreement with patterns shown in German data ([34, 35, 36]). In [34 and 35], it was shown that in German, accented words in broad focus were not systematically different from unaccented words, but words produced in narrow or contrastive focus presented prosodic strengthening. In [36], which included a large pool of acoustic and kinematic data of German, all three types of focus, i.e., broad, narrow and contrastive, were differentiated from the unaccented condition but also from each other in terms of both tonal onglide (F0 height) and duration. Similarly to our findings here, the effects showed an increase from unaccented to broad focus to narrow focus to contrastive focus. Given that stress languages have traditionally been considered as employing three degrees of prominence, namely 1) absence of stress, 2) presences of stress, and 3) presence of accent, the findings from American English reported here and the previous findings from German taken together point to more than three degrees of prominence. The number of these degrees is affected by focus structure. It is possible that the exact number is language-specific (or even speaker-specific); a hypothesis yet to be tested by future research. For instance, we show here that American English uses prominence-related lengthening to mark four degrees of phrasal prominence, i.e., contrastive focus, narrow focus, broad focus and absence of accent. Based on evidence in [34 and 35], German marks two levels of phrasal prominence via lengthening: a higher level that includes contrastive focus and narrow focus, and a lower level that includes broad focus and absence of accent. These conclusions are overwritten, however, by the larger study in [36], which indicates four degrees of prominence in German

as well – the same as in American English. Although future research needs to directly assess cross-linguistic comparisons in order for more concrete conclusions to be drawn, assuming the existence of cross-linguistic differences would make sense, since languages are known to differ in how they use duration to mark stress and accent (cf. [4; 37, 38, 39]). For instance, Arabic presents stress-related lengthening, but focus does not further affect duration of the stressed syllable ([4]).

In further assessing the findings reported here, we need to keep in mind that all languages with lexical stress are assumed to use pitch accents to mark the stressed syllable of the accented words (e.g., [26, 27]). Additionally, these pitch accents might differ in type, partially in order to encode different focus types (see e.g., [28, 29, 30]). One possible interpretation of this parallel prominence-related modification of the intonational and temporal dimensions is that languages make both categorical and gradient distinctions in marking prominence (cf. [36]). The categorical distinction is binary and separates between accented and unaccented conditions: presence of pitch accent marks the former, while absence of pitch accent marks the latter. Gradient distinctions, on the other hand, differentiate among the different focus types characterizing the accented positions. An alternative interpretation is that each focus type that is phonetically marked in a given language corresponds to a distinct level in that language's hierarchy of prominence. This interpretation could be supported by establishing that each focus type is marked by a specific, language-dependent, type of pitch accent. To conclude, in order to evaluate the categorical vs. gradient status of prominence marking, we need to complement the examination of the durational dimension with an analysis of meaning of intonation across prosodically different languages. We will also need to corroborate production data with perceptual assessments. Regardless of which account prevails, it is safe to assume that, although languages may differ in where they set the boundaries between prominence levels, these cover a wide range between absence of stress and contrastive focus.

In terms of interactions of accentual lengthening with the prosodic dimensions of word length and position of lexical stress, we did not find any effects on the amount of accentual lengthening. However, it is yet to be determined whether these factors affect the scope of the effect, i.e., the stretch of speech affected (cf. [11, 12, 32, 33]).

## 5. Conclusions

Prominence-related lengthening encodes four degrees of phrasal prominence in American English. These are from higher to lower degrees of prominence: contrastive focus, narrow focus, broad focus, and absence of focus/accents. Given that American English also distinguishes between stressed and unstressed syllables via lengthening, we propose five degrees of prominence in American English. Further examination of intonational meaning could assist establishing whether these degrees correspond to categorical levels in the hierarchy of prominence in that language.

## 6. Acknowledgements

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## 7. References

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