

THE MANY COLORS OF PROMINENCE: A PILOT STUDY OF TOPIC PROSODIC UNITS

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Abstract: *This paper examines prominence from a pragmatic, phonological and acoustic-articulatory perspective. Based on results of a corpus-based analysis of Topic prosodic units in four languages (Italian, Brazilian and European Portuguese, and American English), three types of topic prosodic forms (TPFs) are described. Also are reviewed studies reporting phonological organization of English prominence patterns, as well as acoustic and articulatory characteristics of prominence, i.e., broad focus, narrow focus and emphasis, and specifically, how jaw lowering increases with increased prominence. Topic prominence has its scope on the whole prosodic unit, while narrow focus/emphasis prominence has its scope on one word. To examine the acoustic and articulatory characteristics of global prominence in a Topic prosodic unit compared with local prominence when the final topic word is emphasized, a pilot study of TPFs as spoken by an American English speaker was done. The results suggest that global Topic prominence differs from that of marking narrow focus/emphasis; narrow focus/emphasis prominence and Topic prominence are two different types of prominences both from the acoustic-articulatory and from the functional point of view. A new articulatory finding is that only for local prominence, i.e., when the topic word is emphasized, does the jaw show the largest amount of lowering in the phrase; for global prominence, the largest amount of jaw lowering occurs on another word within the phrase, not on the final topic word. Our findings, thus, suggest that there are different types of prominences whose functional values are reflected in the formal cues that implement them.*

Keywords: Topic; Prominence; Articulation; Pragmatics; Phonology.



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1 Introduction

This paper examines some of the “many colors of prominence”, starting from the perspectives of both a pragmatic description of information structure and from a phonetic/phonological description of speech building blocks in terms of their prosodic organization, i.e. how the phonological prominence patterns in an utterance are organized. The first approach focuses on functions of speech acts and one of their possible internal structures in different prosodic/informational units; the second approach analyzes the phonetic make-up of chunks of speech units, and their organization into larger chunks of speech units resulting in the rhythm and melody of speech.

With regard to the term “prosodic prominence”, each framework uses similar terms, but the scope of reference is different. This can lead to confusion when discussing linguistic prominence. The first part of this introduction will be a review of a pragmatic approach to prominence and prosodic segmentation inspired by the Language into Act Theory by (1) as described in (2)). The second part is a review of a phonological description of prosodic organization of prominence and segmentation, inspired by work by (3), as described in (4). The third part is a review of acoustic and articulatory characteristics of prominence, and the final section describes the Topic Information Unit per the Language into Act Theory.

1.1 Pragmatic approach per Language into Act Theory

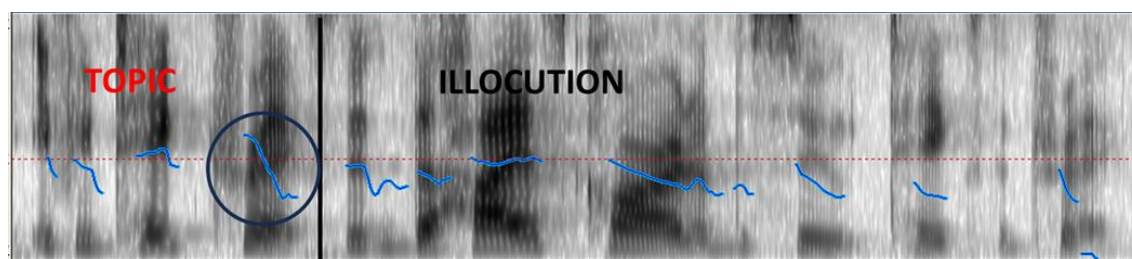
In pragmatic research, which looks at acoustic recordings of real speech events, the definition of a prosodic unit is what is in between two major perceptual boundaries, demarcated by different phonetic cues, such as pause, final lengthening, f0 shift and others (5), (6). The acoustic speech signal is segmented by two types of prosodic boundary units: ones that have a non-conclusive boundary, indicated by a single slash, and those with a conclusive boundary, indicated by a double slash. That is, speech is segmented by the boundaries; the prosodic unit is the result of the segmentation process. An utterance is defined as a speech string that has a conclusive boundary and that performs a speech act. It is the minimal stretch of speech that is pragmatically interpretable. In the transcription below, in addition to concluded and non-concluded prosodic units, there are interrupted utterances, indicated by the sign +, and interrupted words, indicated by the sign &. Table 1 shows examples illustrating prosodic units.

Table 1: Examples illustrating prosodic units

*DAN: what’s Hearts //
*JEN: hearts / it’s the card game //
*DAN: oh yeah // put it up there //
*JEN: wanna play hearts //
*DAN: let’s check that one out // neat // wait // play novice // I’ve never played hearts before in my life //
*JEN: you’ve never played hearts //
*DAN: no // I don’t know how to play it //
*JEN: oh // okay / I’ll teach you //
*DAN: passing disabled / that’s you //
*JEN: queen of &sp +
*JEN: &he first lead rotates // first / yeah // always pass left //

Each prosodic unit conveys an information function. The two main types of information units are the *illocution* and the *topic*. The illocution is the nucleus of a speech act, necessary to build an utterance, and functions to give pragmatic interpretability to the utterance, such as making an assertion, giving a warning, posing a question, etc. The topic is the prosodic unit that conveys the cognitive field of application of the illocution; it indicates the scope of focus of the illocution.

In some pragmatics frameworks, the prosodic unit is the formal counterpart of an information unit, that is, it conveys the information function and as such, its implementation is realized by the phonetic and phonological rules of organization of speech chunking. The information unit tells us how the prosodic unit contributes to the performance of an utterance. An utterance must have a prosodic unit that conveys an illocution (ILL) and may (but it is not mandatory) have other prosodic units with different functions (one of which can be a Topic function). A Topic unit plus an Illocution unit consists of two prosodic units. An example of a Topic-Illocution pattern is shown in Figure 1. The Topic prosodic unit (TPU), “If you take tricks”, is shown in bold red. The topic prominence is said to be on the final word (nucleus) of the TPU, “tricks”. The prosodic nucleus (prominence) of the TPU is circled. Note the difference here between prominence on a specific word and scope of prominence which is on the prosodic unit. The Illocution, “the highest card of the suite takes the tricks” is in bold black.



*JEN: **if you take tricks** / &th / **the highest card of the suite takes the trick** //

Figure 1: Example of Topic Unit plus Illocution.

As shown in Figure 1, the prominence is on “tricks”, i.e., “tricks” is the most prominent word in the topic unit, due to the fact it (i) occurs at the end of the topic phrase, and (ii) has the most salient F0 contour. The acoustic characteristics of topic prominence are discussed in more detail shortly. The important point to mention about this topic prominence is that this prominence conveys the function of topic for the whole content of the prosodic unit. This means that (due to an appropriate prominence on the right) the whole content “if you take tricks” is interpreted as a topic. Thus, the prominence is not “local” (it does not change the function of a specific word) but is “global” (it changes the function of the whole prosodic unit). So, the scope of the prominence is wider. Similarly, the nucleus of an illocutionary unit gives to the entire unit its actional specific function (assertion, question, order, calling, warning, etc.). This value is generally carried by one or very few syllables that characterize the functional value of the whole prosodic unit, and usually, but not always, is on the right edge of the utterance. Thus, for the illocution in Figure 1, which carries the function of an assertion, the nucleus is “trick”. The illocutionary nucleus is a prominence that has its scope over the whole unit, similar to what we see for the topic nucleus. The functions of the two prosodic units are different, but the scope is similar in that it refers to the whole prosodic unit.

Pragmatic prosodic units can consist of a single word or a series of words. The organization of the words within the prosodic units adheres to the phonetic/phonological rules of the language. We return to a discussion of topic units when describing the experimental design in Section 2.

1.2 Phonological Approach

In terms of phonology, descriptions of prominence are based on how syllables are organized into various sizes of “chunks” within an utterance: words, phrases, and utterances. The term utterance here roughly corresponds to the same definition as the pragmatic definition of utterance. The utterance in Figure 1, “If you take tricks, the highest card of the suite takes the trick”, can be further divided into two large phrases “If you take tricks” and “the highest card of the suite takes the trick.” The first phrase is often referred to as an intermediate phrase, and the two phrases together, as an intonational phrase, e.g., (7). Each phrase can be further broken down into smaller phrases, often corresponding to the syntax but subject to the speaker’s interpretation and production. Thus, the second phrase might be broken down into “the highest card of the suite” and “takes the trick”.

Prominence is used by the speaker to help organize the spoken utterance, so that each word is not produced separately, but grouped into larger units. These units are separated by breaks/pauses, and within each unit, one syllable is marked with more phonetic prominence than the others (as discussed in the next section). Word prominence in English is “lexical stress”, phrasal prominence is phrasal stress, and utterance prominence is nuclear stress.

However, an English speaker has relatively free choice about which word gets the most prominence in a phrase or an utterance. The default position of prominence for an utterance is often on the final content word (e.g., (8)) but the speaker has a choice where to stress/put prominence depending on his/her communicative intention (see (4) for a description to this approach to describing prominence). For example, in the utterance, “If you take tricks, the highest card of the suite takes the trick”, the default nuclear stress (syllable with the largest prominence) may be on the final word, “trick”; however, a speaker might choose to put the largest (nuclear) stress on “highest”, because it is felt that is the most salient word in the utterance. Regardless which word receives nuclear stress, the rule holds that within a unit (word, foot, phrase, utterance), one syllable will receive more prominence than the others.

In addition, to patterns of prominence as described above, prominence is also used by English speakers to communicate meaning to the listener; linguists use terms like narrow vs. broad focus and contrastive emphasis. Broad focus refers to the default nuclear stress, i.e., the word that receives the most prominence, when a statement (whatever the illocution it conveys) is made without previous reference to a word in the relatively immediate past context; narrow focus refers to putting increased prominence on a word that has been recently mentioned. In broad focus, the whole phrase is new and so the speaker has a choice where to put the nuclear stress. In narrow focus one (prosodic) word is the new information (the rest is given) and that is why this word gets the stress. Contrastive emphasis refers to more strongly contrasting/pointing out a difference in what has been previously said. Thus, depending on the situation, there are different types of prominences in speech. How these terms, specifically, nuclear stress and contrastive emphasis, are manifested in Topic units in English is a point of exploration in this paper.

In addition to linguistic types of prominence, there are other types of “prominences” which are not linguistically “meaningful”. For example, clear speech is produced when one is speaking to a person hard of hearing or someone whose first language is not English. This is often referred to as hyperarticulated speech. Lombard speech, speech that is spoken in a noisy environment, might also be called hyperarticulated speech.

1.3 Acoustic /Articulatory Phonetic Approach

Turning now to the term “prominence” within the framework of phonetics, a syllable/word which stands out is more prominent than the other syllables/words. A speaker achieves this by increasing

(or decreasing) fundamental frequency, increasing duration, increasing intensity (e.g. (9)). Some prominent syllables also have “pitch accents”, i.e., increased or decreased F0 on a prominent (stressed) syllable), but not all prominent syllables have pitch accents (Gussenhoven, pc). Most syllables with pitch accents have increased duration and/or increased intensity but note that Japanese pitch accents involve only F0 changes (e.g., (10), (11)). Studies of differences between broad and narrow focus report that greater intensity, longer duration, and higher mean and maximum F0 occur for narrow focus compared to broad focus, e.g. (12).

In terms of articulation, a more prominent syllable is produced by increased acceleration/magnitude of displacement of both the initial consonant articulators and the syllable articulator, i.e., the mandible/jaw (e.g. (13), (14)). With regard to the jaw, numerous studies have reported increased mandible lowering for increased prominence. For emphasis or narrow focus, see e.g., (15), (17), (18), (19), (20), (21).

As the mandible lowers more for producing prominent syllables, the tongue also moves more forward or back depending on whether the vowel is a high or low vowel; consequently, the vowel formants change, often showing increased F1 (e.g. Erickson 2002). Thus, increased F1 is an acoustic characteristic of increased syllable prominence, as are changes in F2, depending on the specific vowel (e.g. (17), (22)).

Work by e.g., (3) and ((4) purport that prominence makes a syllable bigger relative to other syllables in the phonological grouping (e.g. word, foot, phrase, utterance). In their work, “bigness” (i.e., syllable magnitude) is related to, among other things, mandible lowering: the mandible has a lower vertical position for a prominent syllable, the amount of mandible lowering below the occlusal plane is commensurate with the prominence/stress level of the syllable. As the mandible lowers more, F1 raises, especially for low vowels, but also for other vowels (17 Erickson 2002). Recent work has shown that the different types of communicative prominences have different articulatory characteristics, e.g., words with increased prominence (e.g., contrastive focus, emphasis, narrow focus) have more mandible lowering than broad focus words. This is shown in figure 2 below from (16) (23), (13), (14). (24) and (25) reported how words with contrastive emphasis have more jaw lowering than words with broad focus/nuclear stress. To the best of our knowledge no comparative jaw lowering study of broad vs narrow focus has been done or narrow focus vs contrastive emphasis; however, in terms of phonetic implementation, it is thought that contrastive emphasis is quantitatively “larger” than narrow focus, i.e., more increased F0, duration, intensity, and jaw lowering than narrow focus; and narrow focus has more increased F0, duration, intensity and jaw lowering than broad focus.

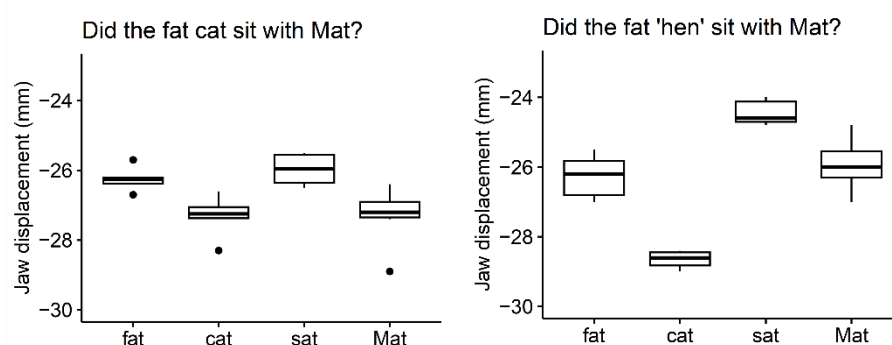


Figure 2: Jaw displacement (i. e., amount of jaw lowering) for each word in the reply utterance for broad focus, *Yes, the fat cat sat with Mat* (left graph) vs for contrastive emphasis, *No, the fat CAT sat with Mat* (right graph). The questions presented to the speaker are shown above each graph. Notice how much lower the jaw is for contrastive emphasis than broad focus (adapted from (24)).

As mentioned above, contrastively emphasized words are produced with more lowered mandible than are broad focus/nuclear stress words, e.g., (4), (25), (26). This is shown in Figure 3. Note that here the terms broad focus and nuclear stress are used interchangeably.

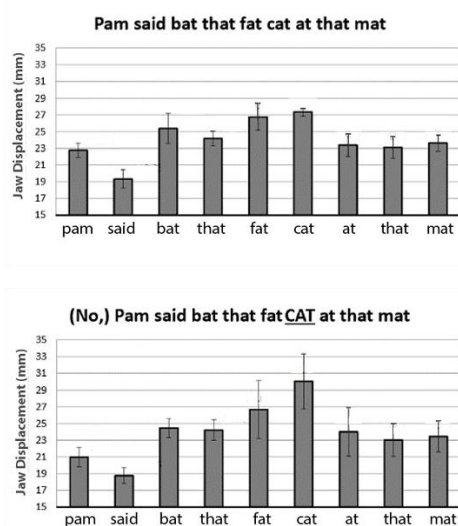


Figure 3: Amount of jaw lowering (mm) as measured from the occlusal bite plane for each word in the sentence, *Pam said bat that fat cat at that mat*. The bottom graph shows increased jaw lowering on the emphasized word *cat*, the top figure shows a tendency for increased jaw lowering on the nuclear stress word *cat*. (adapted from (4), (31)).

Contrastively emphasized speech involves independent tongue body and mandible lowering (Erickson 2002), whereas clear hyperarticulated speech is produced with synchronized lowering of tongue body and mandible (27), (4 figure 2. 26). In their pilot study, the authors report that for hyperarticulated /a/, the jaw and tongue dorsum show a positive regression of 0.69, whereas for contrastively emphasized /a/, there is a negative regression of 0.52. (28) reported similar findings for hyperarticulated syllables spoken in noisy environments. See also (29) for differences in articulation depending on the linguistic task.

As concerns nuclear stress, work by (30) report increased jaw. Moreover, (31) report a significant correlation between increased jaw lowering and perceived prominence, suggesting that increased jaw lowering is a marker of syllable prominence, with the largest jaw lowering marking utterance nuclear stress. The concept of degrees of jaw lowering as an articulatory marker of degrees of prominence is based on work by (3), and further illustrated by work by (4).

English speakers can choose where in the utterance to place nuclear stress, as mentioned above. That the amount of jaw displacement marks nuclear stress was discussed by e.g. (30). For the utterance, *I saw five bright highlights in the sky tonight*, American English speakers produced the greatest jaw displacement on *sky* (never on the final word ((to)night), sometimes on *high*(lights), and even sometimes on *five*. Thus, the hypothesis is that the jaw is used to help organize groups of syllables/words into stress units, i.e. word/lexical stress, foot stress, phrasal stress, utterance stress, with the most jaw lowering on nuclear stress, and progressively, the least, on word/lexical stress.

1.4 Summary of Introduction to Prominence

Prominence comes in different colors: in terms of quantitative phonetic measures, prominence can be bigger or smaller; prominence is manifested in variations of f0, duration, intensity, formants, jaw-tongue-lip movement. In terms of qualitative differences, within a pragmatic

framework, the term prominence can refer to the scope or location of prominence whereas within a phonological framework, it can refer to rhythmic grouping.

A question we investigate is what are the acoustic and articulatory characteristics of prominence when (a) the scope of prominence is on the prosodic topic unit vs. (b) the scope of prominence is on single word? Is there a qualitative difference also in terms of acoustic/articulatory features between prominences that mark the function of the whole prosodic unit that hosts them vs. prominences that mark a word within the prosodic unit?

Now we turn back to elaborating on the topic information unit, and our specific research question for this paper.

1.5 The topic Information Unit

The topic information unit features a prominence which is phonetically manifested on a word, but has its scope over the whole prosodic unit, thus being responsible for the informational value of the unit ((1), (2)). Two kinds of prominences are of this type: illocutionary prominence (32), (33), (34) and topic prominence. In fact, the nucleus of an illocutionary unit gives to the entire unit its actional specific function (assertion, question, order, calling, warning, etc.). This value is generally carried by one or very few syllables that characterize the functional value of the whole prosodic unit. The same happens with the topic, where a specific prominence generally over two syllables conveys the function.

We define the topic function in a pragmatic way, differently from the semantic definition (that depends on the context) of the formal tradition of Krifka (35). In our view, the topic has the function of establishing the field of application of the illocution ((1), (2)). The topic provides the cognitive framework to which the illocution refers. This framework must be referential, this means it must provide an identification domain (a person, a place, a time, a circumstance), but has no morphosyntactic restrictions. It can be a noun phrase (NP), a verb phrase (VP) (both a principal or a subordinated clause), a prepositional phrase (PP), an adverbial phrase (AdvP), an adjective phrase (AP) or a pronoun (PRO), or even a function word if cited ((36). Distributionally, the topic unit occurs always at the left of the illocutionary unit. The referential content of topic can be given or new. It is a choice of the speaker to bring in the topic unit the cognitive domain of the illocution whenever he thinks it is useful for the discourse goal.

We founded our research on topic on spontaneous speech corpora prosodically annotated to study information structure: C-ORAL-ROM ((37) for Italian and European Portuguese, C-ORAL-BRASIL (38) for Brazilian Portuguese, and the Santa Barbara Corpus of Spoken American English ((39). For the analysis of topic forms, three 20 texts and 30,000 words comparable subcorpora were used. The number of topics analyzed varies among the three subcorpora: 111 topics for Italian (proportionally extracted from all the texts), 227 topics from the BP subcorpus; and all the 403 topics present in the American English subcorpus. A sample of 79 European Portuguese topics was analyzed too (40), (41), (42), (43), (44).

We found the same three prosodic forms for Topic units in all four languages, but with different proportions (Raso et al. 2017). These forms were then modeled using the F-PCA technique (Cavalcante 2020, Cavalcante et al. 2023) that confirmed the previous description, showing that all the Topics pertain to one of the three phonetic forms.

Figure 4 shows a case of the pattern topic-illocution in Brazilian Portuguese. The content of the utterance is: *a orientadora !=TOP= ela não quer fazer o papel da coordenadora //* (the supervisor / she doesn't want to play the role of the coordinator). In this example, the Topic form (TOP) is of type 1. The vertical bar separates the topic from the illocution. In the topic, the prominence that conveys the function is circled. It is this prominence that gives the function to the whole unit. If one cuts off the first part of the unit and leaves only the prominent syllables,

one can perceive that the left part (*dora*, that sounds like a proper name in BP) maintains the function of topic. Therefore, the syllables of the topic unit that do not pertain to the nucleus are superfluous from the informational point of view and play a role only from the semantic point of view, being just a preparation of the prosodic and functional syllables that carry the information function.

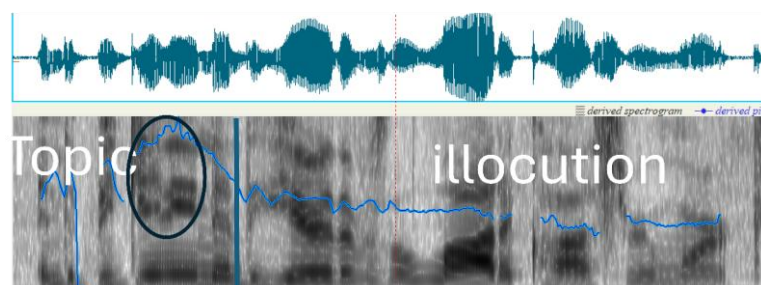


Figure 4: Example of Topic-illocution pattern in Brazilian Portuguese.

1.5.1 The three topic forms (TPF)

TPF1 is the most frequent in Italian, in which the study on topic forms began ((40). Its nucleus, at the right side of the unit, is lengthened and more intense, and features a rising-falling f_0 movement, on the last stressed syllable and the possible post-stressed ones. If there is no syllable after the stressed one, the whole rising-falling movement is performed on the stressed syllable. Figure 5 shows a stylization of this form.

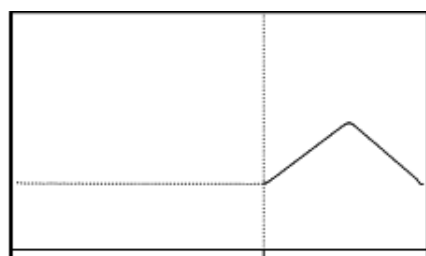


Figure 5: Stylized f_0 curve of TPF1. To the left of the dotted vertical line is “preparation”; to the right is the “nucleus.”

TPF2 is the most common in BP (41). Also, in this case we have a preparation and a lengthened and more intense nucleus in the last stressed syllable and possible post-stressed, but the f_0 movement is only rising. Figure 6 shows the stylized TPF2.

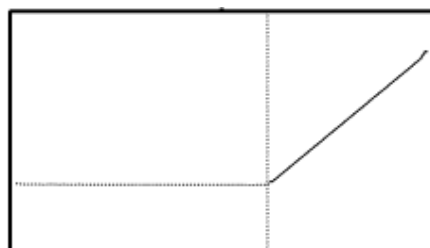


Figure 6: Stylization of the f_0 curve of TPF2. To the left of the dotted vertical line is “preparation”; to the right is the “nucleus.”

TPF3, which is the most common in European Portuguese (EP) (43) and especially in American English (AE) ((42), (45), (46), is more complex. In fact, it features two, often discontinuous semi-nuclei, one on the left side and the second on the right side of the unit. The possible preparation stays in between, linking the two semi-nuclei. Both semi-nuclei are lengthened and more intense, but the second one is longer and more intense than the first. As for the f0 contours, the first semi-nucleus can reach a very high level, while there is no mandatory f0 contour in the second semi-nucleus, which can be flat and low, as shown in the stylized figure 7, or, it can be slightly falling or rising. In any case, a possible final rising contour in this form is not sufficient to convey the topic function if not supported by the first semi-nucleus. Figure 7 shows the stylized F0 form.

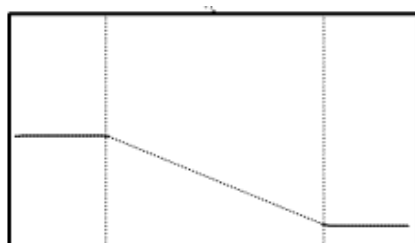


Figure 7: Stylization of the f0 curve of TPF3. To the left of the first dotted vertical line is the first semi-nucleus, the middle section between the two dotted vertical lines is the linking preparation, and the final section is the second semi-nucleus.

These three forms can have a few syllables after the right nucleus, but this happens almost only in AE and in TPF3.

Figure 8 shows the frequency of each form in the three languages systematically analyzed. European Portuguese (EP), for which we have only sampling data, seems to prefer TPF3, but not as much as AE. So, TPF1 is the preferred form in the Italian corpus, TPF2 the preferred one in the Brazilian corpus, and TPF3, by far the preferred one in the American corpus.

The three forms do not seem to convey different sub-functions or depend on the topic phrase's syntactic structure.

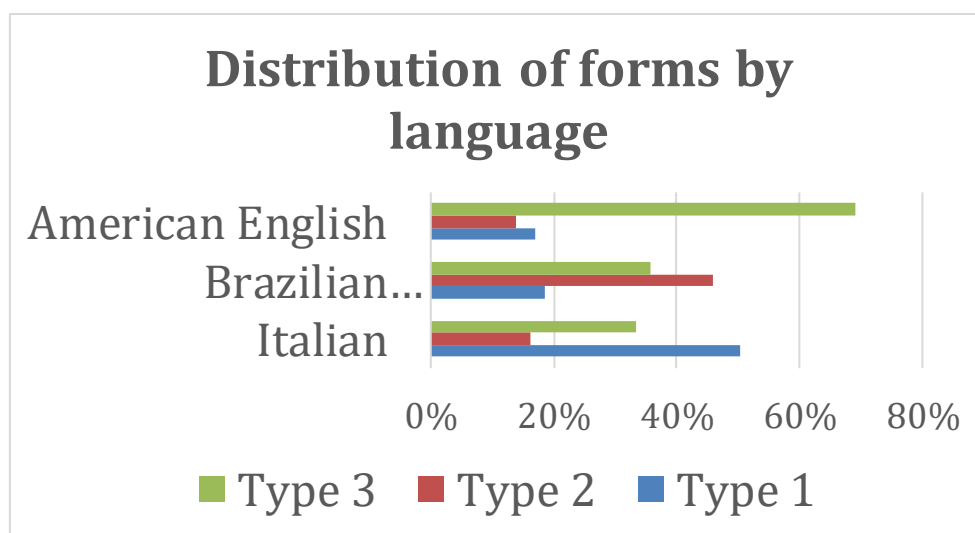


Figure 8: TPF distribution in AE, BP and Italian

To summarize, topic information units are based on the (i) function, (ii) distribution and (iii) prosodic form, where the topic (TOP) function is conveyed by a nucleus at the right edge of the unit. As summarized above, the nucleus is reported to be associated with increased duration and intensity and well-defined F0 contours; specifically, for TPF1, the F0 contour on the topic word is a rise and fall (HL), for TPF2, it is a rise (LH). TPF3 is more complex and is associated with both a high initial F0 at the beginning of the TPF and often a low F0 on the nucleus at the right edge of the TPF—but the final F0 can also be a gentle fall or gentle rise. However, as stated above, no study has been done about mandible movement patterns for TPFs.

In order to investigate some of the colors of prominence, we conducted a small pilot study based on experimental data. Some questions we ask in this pilot study are whether the jaw also lowers more for the nucleus at the right edge of the unit, and, also, what are the prosodic characteristics, including the jaw movement patterns, for the entire topic phrase. In addition, what happens when the topic word is emphasized, i.e. when the scope of prominence is both on the whole unit and on a single word? In other words, what happens when we have at the same time topic prominence and narrow focus/emphasis on the word that carries the topic nucleus?

Here we don't attempt to describe all the phonetic differences— just to point out a few to show some of the different colors of prominence in terms of acoustic and articulatory qualitative characteristics. For this pilot study, we examine the prosodic characteristics for only TPF1 and TPF2. The reason we chose TPF1 and TPF2 is that these two TPFs have just one (final) nucleus, whereas TPF3 has two nuclei, an initial and final semi-nucleus.

This paper explores the phonetic markings of the nucleus of the TPFs. In terms of pragmatics, the nucleus of the TPF1 and TPF2 topic phrases is the final content word and has been reported to be marked phonetically with increased duration, intensity and unique F0 movements (41). A question is about the articulation of the nucleus of the topic unit. Since in an English utterance, nuclear stress is marked with increased jaw lowering (30), will we see increased jaw lowering for the TPF nucleus? That is, in terms of scope, does the nucleus in a topic informational unit behave similarly to nuclear stress in an utterance? Also, how does emphasis on the nucleus affect the prosodic measurements of duration, intensity, formants and jaw lowering? Another question concerns whether the nuclei of TPF1 and TPF2 vary in terms of other phonetic characteristics in addition to the final F0 movements. Finally, with regard to the entire topic phrase, what prosodic patterns do we see?

2 Experiment Methods

Acoustic and articulatory (mandible) recordings were made using the Carstens AG501 Electromagnetic Articulograph at the Lund University Humanities Laboratory.¹ For recording the mandible, a sensor was glued to the gum line below the lower front incisors. Five American English speakers, four of whom were currently living in the Lund, Sweden area and one, a trained phonetician, Midwest dialect, recorded four to five (randomized) repetitions each of five different sentences with topic phrases. Since jaw lowering is affected by vowel height (47), all words within a topic phrase contained the same vowel (/ɑ/, /ε, or /ɪ/). The topic phrases written in italics, along with the complete sentences, are shown in Table 2.

Table 2: Corpus

Sentence 1	Emphasis Condition of Topic word	Sentences that appeared on ppt to be read by subjects
TPF1 (rise-fall F0 on topic word)	No emphasis	Hmmm ... <i>John's hot pots of chops</i> , everybody likes.
	Emphasis	John's fries? Hmmm... <i>John's hot pots of CHOPS</i> , everybody likes.
TPF2 (rising F0 on final topic word)	No emphasis	John's hot pots of chops, everybody likes.
	Emphasis	John's fries? John's hot pots of CHOPS, everybody likes.
Sentence 2		
TPF1 (rise-fall F0 on topic word)	No emphasis	Hmmm...When Pen set the pet at the bed, I started laughing
	Emphasis	Pen set the pet at the couch? Hmmm....When Pen set the pet at the BED, I started laughing.
TPF2 (rising F0 on final topic word)	No emphasis	When Pen set the pet at the bed, I started laughing.
	Emphasis	Pen set the pet at the couch? When Pen set the pet at the BED, I started laughing.
Sentence 3		
TPF1 (rise-fall F0 on topic word)	No emphasis	Hmmm ...For John to go to Osborn, something bad must have happened.
	Emphasis	John went to Washington? Hmmm ...For John to go to OSBORN, something bad must have happened.
TPF2 (rising F0 on final topic word)	No emphasis	For John to go to Osborn, something bad must have happened.
	Emphasis	John went to Washington? For John to go to OSBORN, something bad must have happened.
Sentence 4		
TPF1 (rise-fall F0 on topic word)	No emphasis	Hmmm... If Jean really feels mean, she'll start yelling.
	Emphasis	Jean feeling kind? Hmmm... If Jean really feels MEAN, she'll start yelling.
TPF2 (rising F0 on final topic word)	No emphasis	If Jean really feels mean, she'll start yelling.
	Emphasis	Jean feeling kind? If Jean really feels MEAN, she'll start yelling.
Sentence 5		
TPF1 (rise-fall F0 on topic word)	No emphasis	Hmmm... Bill's thick big lips, I never saw before.
	Emphasis	Bills nose? Hmmm... Bill's thick big LIPS, I never saw before.
TPF2 (rising F0 on final topic word)	No emphasis	Bill's thick big lips, I never saw before.
	Emphasis	Bills nose? Bill's thick big LIPS, I never saw before.

The speakers were asked to produce two types of TPFs (TPF1 with the rising-falling final F0 contour and TPF2 with the rising F0 contour) and two emphasis conditions: emphasis on the nucleus vs. no emphasis on the nucleus. The speakers seemed to easily grasp the concept of topic

phrases and were instructed how to produce specific F0 contours appropriate for TPF1 and TPF2. Specifically, they were shown the stylized figures of TPF1 and TPF2, as shown in section 1, and asked to produce TPF1 with a final rising-falling contour and a final rising contour for TPF2. They were also asked to keep the first part of the contour flat. The speakers were asked to read the sentences from a powerpoint display. To help elicit the emphasis condition, an introductory phrase was presented before the topic phrase. For example, for sentence 1, the speakers were asked to read the phrase *John's fries*, and also to “put emphasis” on the word **CHOPS** written in capital bold letters. As mentioned above, the speakers easily understood the concept of topic phrases, but had difficulty producing the desired F0 patterns characterizing the TPF1 and TPF2 prosodic units. Thus, for this pilot study, we report on one speaker (a trained phonetician and first author of the paper) who before the recordings trained with the second authors extensively to produce a topic phrase with a specific F0 movement on the nucleus, i.e., to keep the first part of the TPF low and flat and the final topic word, either with a rise-fall F0 pattern (TPF1) or a rise F0 pattern (TPF2). Moreover, only one of the topic phrases, *John's hot pots of chops* (in Sentence 1) containing the low /a/ was analyzed. In addition, only two recordings of TPF2 with emphasis were able to be recorded, due to technical difficulties of recording. Table 3 shows the pilot corpus examined in this study.

Table 3: Number of TPFs examined in this pilot study of Topic Prosodic Units

	No Emphasis	Emphasis
TPF1	4	5
TPF2	4	2

Using the PipeLine tool developed by Sylvain Coulange ((48) <https://gricad-gitlab.univ-grenoble-alpes.fr/lidilem/plspp>), for each of the /a/ vowels in the four content word in the topic phrase (*John's*, *hot*, *pots*, *chops*), the following measurements were made for the each of the repetitions of the utterance: mean F0 (Hz), mean intensity (dB), mean duration (s), mean F1(Hz) and F2 (Hz), and mean lowest jaw position (mm).

3 Results: *John's hot pots of chops*

Focusing on the prosodic phrase, *John's hot pots of chops*, we report on the acoustic and articulatory characteristics of TPF1 and TPF2. First, we compare the two types of topic units in the no-emphasis condition (section 3.1), and then in the emphasis condition (section 3.2), focusing on the topic nucleus *chops*. Finally, 3.3 compares the prosodic measurements of all content words in the two topic phrases for the two conditions of emphasis.

3.1 Topic units in no emphasis condition: Comparison of nuclei of TPF1 and TPF2.

Figures 9 and 10 show jaw, F0, and acoustic signal data for *John's hot pots of chops* produced with TPF1 and TPF2, respectively, with no emphasis on the topic nucleus. The figures show the topic unit along with the subsequent illocutionary unit, even though, in this pilot study, only the phonetic characteristics of the TPFs are examined. Looking at the F0 pattern (middle panel) for the Topic unit, we see that the speaker was able to keep F0 low for the first part of the phrase, and then on the nucleus, F0 shows either a rise-fall pattern for TPF1 or a rise pattern for TPF2.

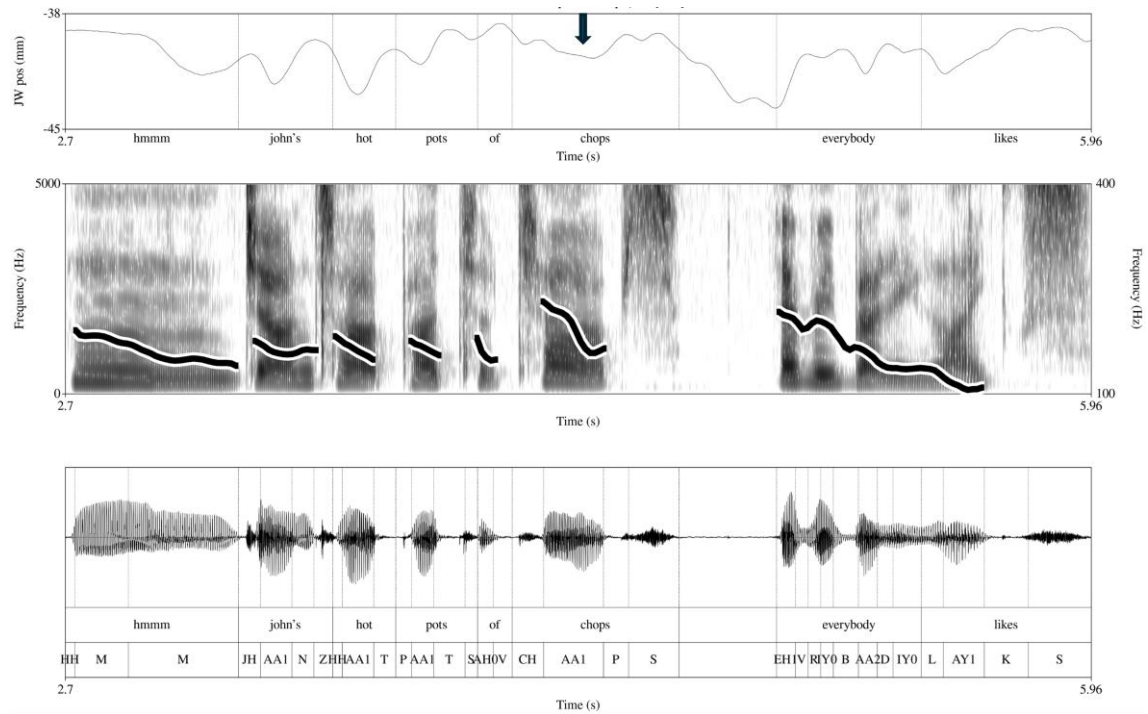


Figure 9: TPF1 no emphasis. *hmmm. John's hot pots of chops, everybody likes*. Top panel shows jaw lowering patterns (with arrow pointing to *chops*), middle panel, spectrogram, with F0 contours, and bottom panel, acoustic wave form.

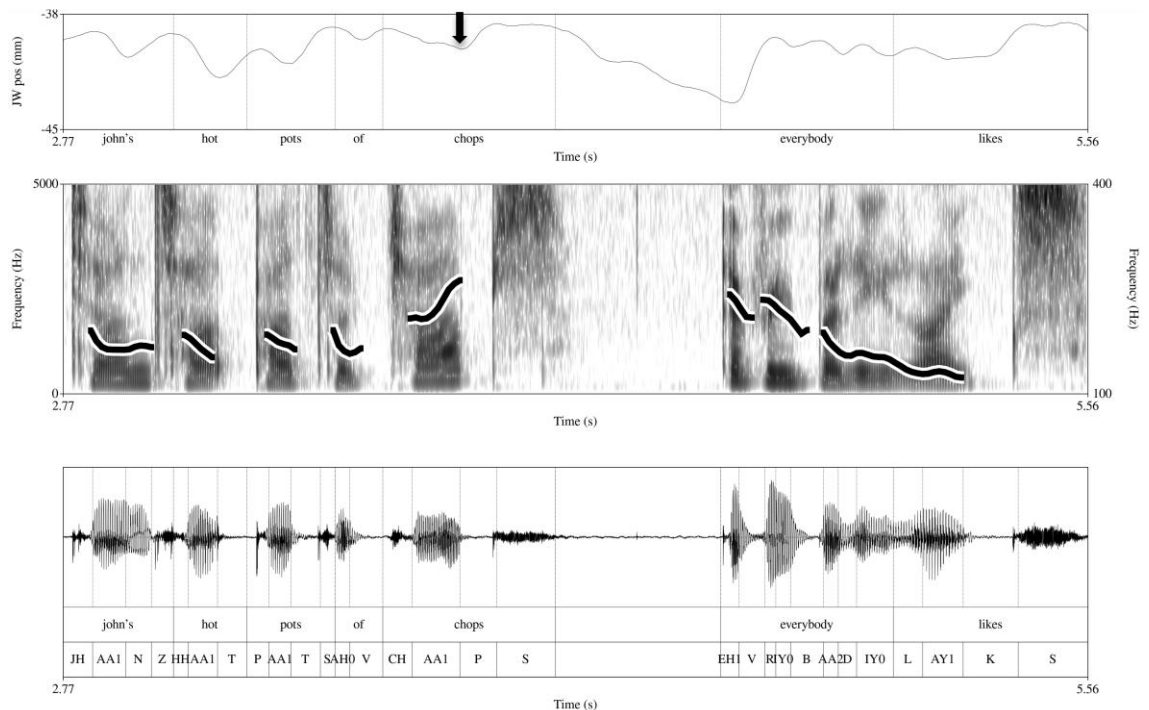


Figure 10: TPF2 no emphasis. *John's hot pots of chops, everybody likes*. Top panel shows jaw lowering patterns (with arrow pointing to *chops*), middle panel, spectrogram, with F0 contours, and bottom panel, acoustic wave form.

3.1.1 Topic phrase nucleus *chops*: Comparison of TPF1 and TPF2

As shown in Figures 9 and 10, the nucleus of TPF1 has a rising-falling F0 contour, and that of TPF2, a rising F0 contour, thus confirming that the speaker successfully produced the typical F0

movements associated with these TPFs. However, what are some other phonetic differences between the nuclei of these two TPFs? Table 4 shows the mean and standard deviation for each of the six measurements (F0 (Hz), intensity (dB), duration (sec), F1 (Hz), F2 (Hz), and lowest jaw position (mm)) of four repetitions of the /a/ vowel in the nucleus of each of the TPFs produced without emphasis. The last two columns of Table 4 show the results of the Mann-Whitney U Test, with p-values in bold indicating significant differences. The table shows that the nucleus of the TPF2 (rising contour) compared to that of TPF1 (rising-falling contour) has a significantly higher mean F0, higher mean F1 than TPF1, but significantly shorter mean duration and significantly less low jaw position than that of TPF1. As far as we know, no previous study has reported differences other than F0 movement for TPF1 and TPF2 nuclei. Given the small data sampling size, these results need to be confirmed by more data.

Table 4: Mann-Whitney U Test for comparison of prosodic measurements for /a/ vowel in topic nucleus for TPF1 vs TPF2 (no emphasis condition). Significant differences are shown in bold p-values.

Chops						
Variable	TPFS	N	Mean	Standard Deviation	Chi-Square	p-Value
F0	1	4	185.7	8.31	5.333	0.021
	2	4	232.5	10.95		
INT	1	4	51.54	1.68	0.75	0.386
	2	4	50.53	1.25		
DUR	1	4	0.185	0.01	5.463	0.019
	2	4	0.125	0.01		
F1	1	4	694.8	83.85	4.083	0.043
	2	4	824.5	56.27		
F2	1	4	1267.1	93.85	1.333	0.248
	2	4	1398.2	87.99		
JAWMAX LOW	1	4	40.582	0.28	4.083	0.043
	2	4	40.149	0.22		

3.2 Topic units when nucleus is emphasized.

Figures 11 and 12 show a sample recording of jaw displacement, F0 contours, and acoustic signal of the speaker producing emphasis on the nucleus of the topic phrase in the utterance: *John's fries? Hmmm....John's hot pots of chops, everybody likes.* The topic phrase can be seen in the middle of the figure, with an arrow pointing to the large jaw lowering in the nucleus, *chops*. Figure 11 shows TPF1 (F0 rise-fall on the nucleus) and Figure 12 shows TPF2 (F0 rise on the nucleus). Looking at the F0 pattern, we see that the speaker maintained a low F0 for the first part of the phrase, and then on the nucleus, F0 shows either a rise-fall pattern for TPF1 or a rise pattern for TPF2. Notice that for the emphasized nucleus, F0 is higher compared to when it is not emphasized (Figures 9 and 10) and moreover, the jaw also lowers more for emphasis.

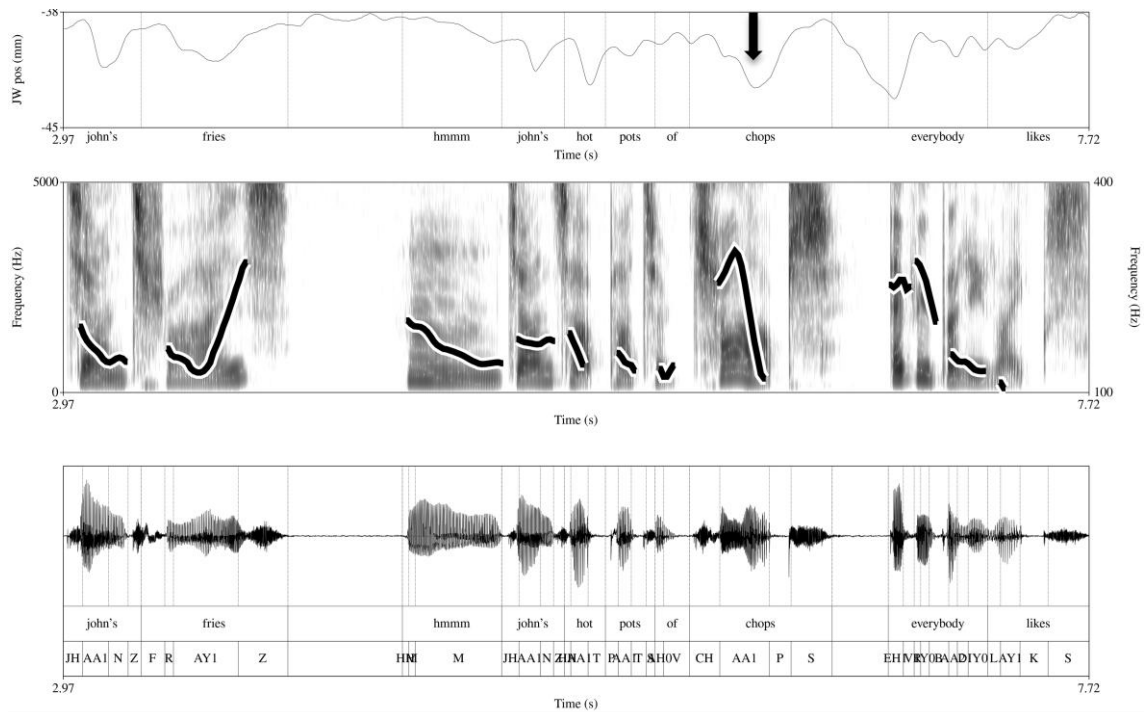


Figure 11: TPF1 with emphasis on the nucleus, *chops*. *John's fries? hmmm. John's hot pots of chops, everybody likes*. Top panel shows jaw lowering patterns (with arrow pointing to *chops*), next panel, spectrogram, with F0 contours, and bottom panel, acoustic wave form.

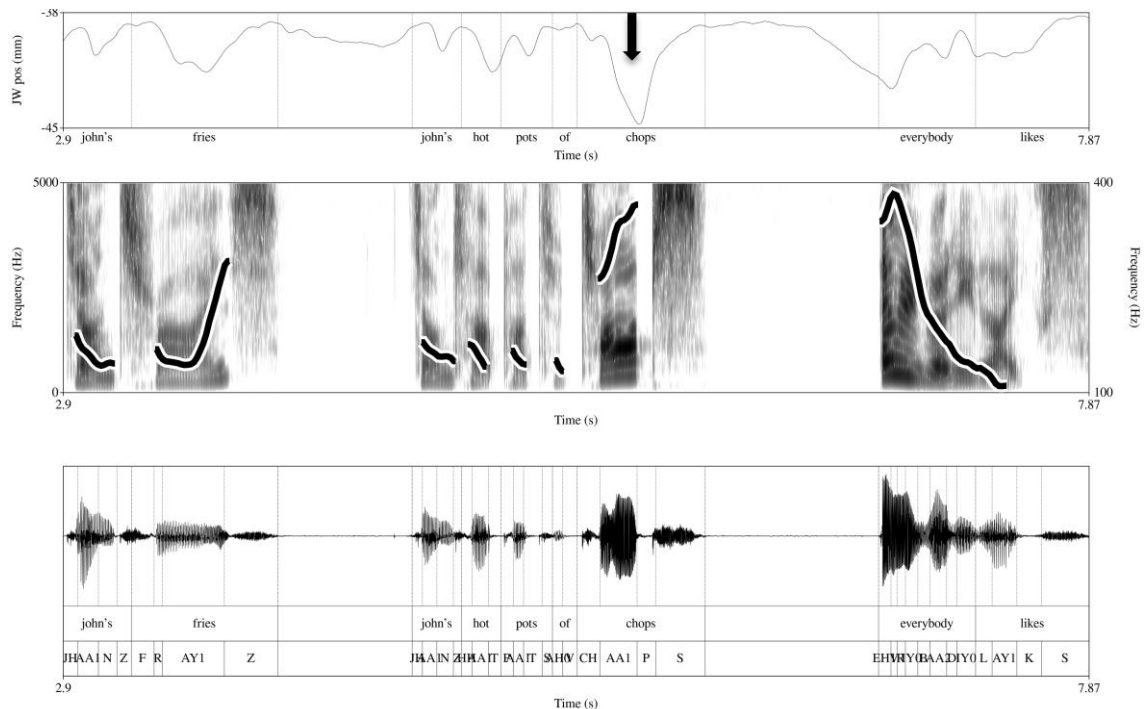


Figure 12: TPF2 with emphasis on the final topic word, *chops*. *John's fries? John's hot pots of chops, everybody likes*. Top panel shows jaw lowering patterns (with arrow pointing to *chops*), next panel, spectrogram, with F0 contours, and bottom panel, acoustic wave form.

3.2.1 Comparison of TPF1 nucleus *chops* spoken with and without emphasis

Table 5 compares the mean and standard deviation for each of the six measurements (F0 (Hz), intensity (dB), duration (sec), F1 (Hz), F2 (Hz), and lowest jaw position (mm) of the /a/ vowel in

the nucleus, *chops*, of TPF1 produced without emphasis vs produced with emphasis. The last two columns of Table 4 show the results of the Mann-Whitney U Test, with p-values in bold indicating significant differences. The table shows that the nucleus of the TPF1 (rising-falling contour) has a significantly higher mean F0, louder intensity and lower jaw position when the nucleus of the TPF is emphasized vs when it is not. That we find the emphasized nucleus has significantly higher F0 and louder intensity than the non-emphasized nucleus is to be expected, given previous reports, e.g., (12). Also, the finding of more jaw lowering for emphasis compared to non-emphasis one is consistent with previous reports of increased jaw lowering with emphasis (e.g. (15), (17), (18), (19), (20), (21).

Table 5: Mann-Whitney U Test for comparison of prosodic measurements for /a/ vowel in topic nucleus “chops” in TPF1. Emphasis vs No Emphasis. Significant differences are shown in bold p-values.

chops						
Variable	EMP H	N	Mean	Standard Deviation	Chi- Square	p- Value
F0	0	4	185.7	8.31	6	0.01
	1	5	223.4	9.08		
INT	0	4	51.54	1.68	6	0.014
	1	5	58.81	2.57		
DUR	0	4	0.185	0.01	2.16	0.142
	1	5	0.214	0.07		
F1	0	4	694.8	83.85	2.94	0.086
	1	5	795.5	79.55		
F2	0	4	1267.1	93.85	0.24	0.624
	1	5	1300.4	120.53		
JAWMAXLOW	0	4	40.582	0.28	6	0.014
	1	5	42.848	0.81		

The phonetic measurements for the emphasis and non-emphasis conditions for TPF2 are like those for TPF1 (Table 6), but statistical tests cannot be done due to the limited number of repetitions for the emphasis condition (N=2).

Table 6: Prosodic measurements for /a/ vowel in topic nucleus *chops* in TPF2. Emphasis vs No Emphasis. Notice that the emphasized vowels (in bold) all have higher values than the non-emphasized ones.

chops				
Variable	EMPH	N	Mean	Standard Deviation
F0	0	4	232.5	10.947
	1	2	301.5	21.253
INT	0	4	50.53	1.245
	1	2	61.5	0.185
DUR	0	4	0.125	0.006
	1	2	0.185	0.007
F1	0	4	824.5	56.271
	1	2	903.3	32.463
F2	0	4	1398.2	87.989
	1	2	1255.8	56.1
JAWMAXLOW	0	4	40.149	0.223
	1	2	43.581	1.669

3.3 Comparison of prosodic measurements of all content words in the topic units

Tables 7 a and b show comparisons of the mean prosodic measurements of all the /a/ vowels in the content words in TPF1 and TPF2 in the condition of no emphasis on the nucleus word (*chops*). For both TPF1 and TPF2, the vowels in the nucleus, compared with the vowels in the other three words, have the highest mean F0, the longest duration, and the lowest mean F2. Note that the nucleus in a TPF with no emphasis does not have the most jaw lowering in the topic phrase. Instead, the word with the largest amount of jaw lowering in the TPF is *hot*. Also, note that in contrast to previous reports (41), the nucleus is not louder than the other words, in fact, the initial word is the loudest.

As for TPFs with the nucleus emphasized (Table 7c and 7d), we see a very different pattern: compared to the other three words in the topic phrase, the vowel in the nucleus has the highest mean F0, largest mean intensity, longest mean duration, highest mean F1, lowest mean F2 and also the lowest mean jaw position. The acoustic findings of increased F0, intensity and duration are compatible with other findings for emphasis (e.g., (4), (18)). Lowest jaw position, as well as highest F1 and lowest F2, also is to be expected, given previous prosodic findings for emphasis, (e.g. (18)).

Table 7: Prosodic measurements of vowels in content words in the TPFs *Johns hot pots of chops* with and without emphasis on the topic word, *chops*.

a. TPF1. no emphasis (N=4)					b. TPF2. no emphasis (N=4)				
	johns	hot	pots	chops		johns	hot	pots	Chops
F0	152.8 Hz	148.8 Hz	152.4 Hz	185.7 Hz	F0	143. 4 Hz	145.2 Hz	191.9 Hz	232.5 Hz
intensity	53.3 dB	51.8 dB	50.5 dB	51.5 dB	intensity	51.2 dB	51.9 dB	50.1 dB	50.5 dB
duration	1.1 s	.8 s	.6 s	1.9 s	duration	.9 s	.9 s	.5 s	1.3 s
F1	641.0 Hz	719.4 Hz	759.2 Hz	694.8 Hz	F1	659. 7 Hz	789.7 Hz	874.3 Hz	824.5 Hz
F2	1527. 7 Hz	1306. 8 Hz	1438. 3 Hz	1267. 1 Hz	F2	1503 .6 Hz	1412. 1 Hz	1453. 6 Hz	1398. 2 Hz
Jaw max low	40.9 mm	41.6 mm	40.9 mm	40.6 mm	Jaw max low	40.8 mm	41.7 mm	40.6 mm	40.2 mm
c. TPF1. Emphasis (N=5)					d. TPF2. Emphasis (N=2)				
	johns	hot	pots	chops		johns	hot	pots	Chops
F0	169.3	168.4 Hz	190.8 Hz	223.4 Hz	F0	175. 3 Hz	141.3 Hz	160.1 Hz	301.5 Hz
intensity	56.1	58.0 dB	54.0 dB	58.8 dB	intensity	58.5 dB	58.1 dB	55.2 dB	61.5 dB
duration	1.0 s	.9 s	1.2 s	2.1 s	duration	1.0 s	.9 s	.6 s	1.9 s
F1	643.6 Hz	747.0 Hz	728.2 Hz	795.5 Hz	F1	750. 2 Hz	837.6 Hz	867.5 Hz	903.3 Hz
F2	1595. 5 Hz	1410. 8 Hz	1353. 7 Hz	1300. 4 Hz	F2	1415 .2 Hz	1404. 5 Hz	1347. 5 Hz	1255. 8 Hz
Jaw max low	41	41.4 mm	40.7 mm	42.8 mm	Jaw max low	40.4 mm	41.5 mm	41.4 mm	43.6 mm

Looking again at the F0 pattern for TPF1 and TPF2, respectively, with no emphasis on the final word (Figures 11 and 12), we see that the F0 is low for the first part of the phrase, and then on the final word, F0 shows either a rise-fall pattern for TPF1 or a rise pattern for TPF2. Notice that the jaw does not lower the most on the final topic word.

Figures 13 and 14 show comparison of the jaw lowering pattern in the topic units when there is no emphasis and when there is emphasis, respectively.

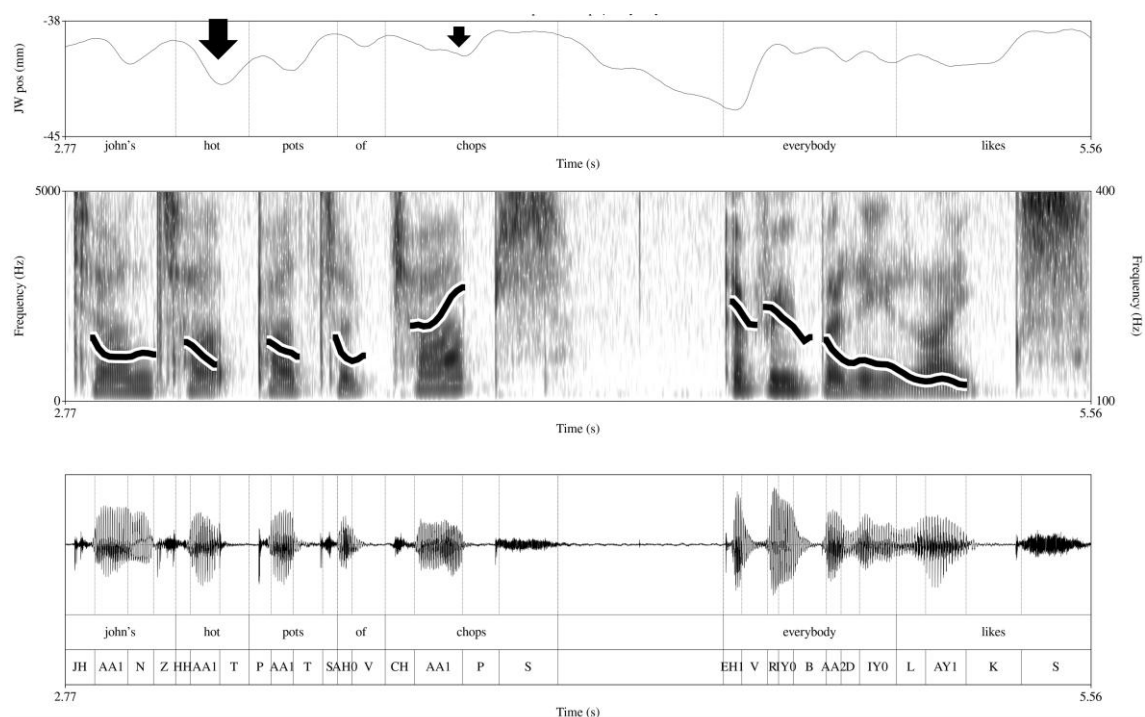


Figure 13: Comparison of jaw lowering patterns for TPF1(top) and TPF2 (bottom) with no emphasis on the final topic word. Large arrows indicate lowest jaw position for *hot*; small arrows indicate next lowest jaw position for topic word, *chops*.

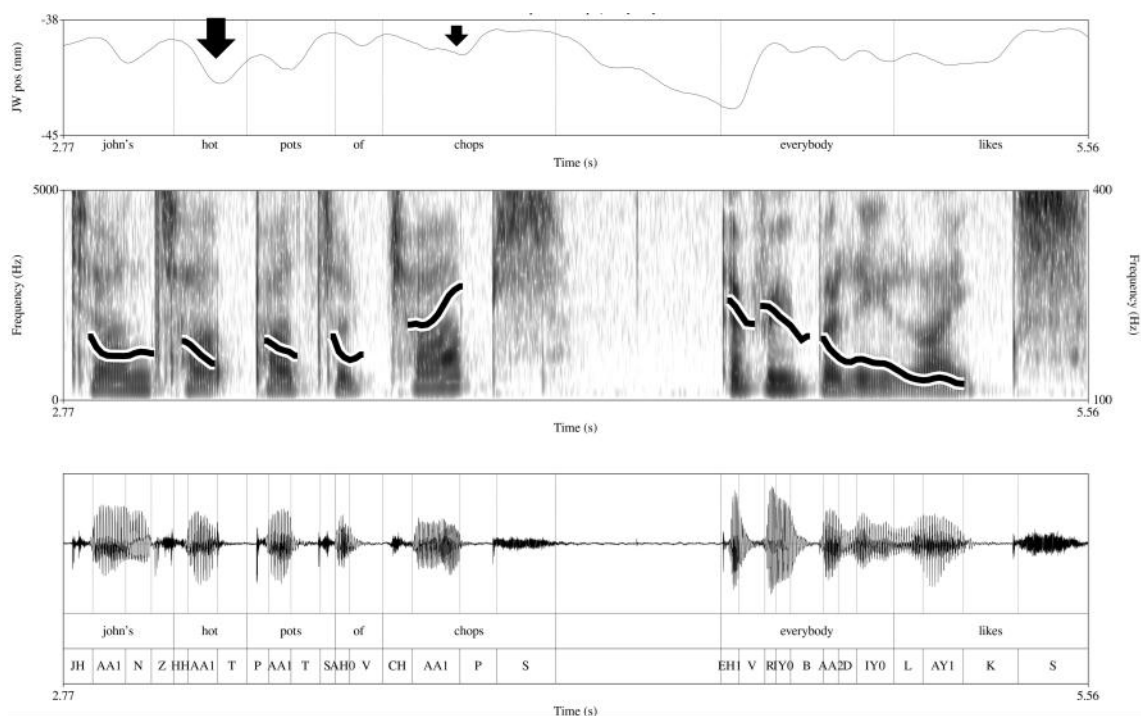


Figure 14: Comparison of jaw lowering patterns for TPF1 (top) and TPF2 (bottom) with emphasis on the final topic word. Large arrows indicate lowest jaw position for emphasized topic word *chops*; small arrows indicate next lowest jaw position for *hot*.

As shown in Figure 13 for TPFs with no emphasis on the nucleus, the jaw does not show the most lowering; the word with the most jaw lowering is *hot* (see large and small arrows on *hot* and *chops*, respectively). For TPFs with emphasis on the nucleus, the topic word *chops* has the most jaw lowering, while *hot* has the second largest jaw lowering (see small and large arrows on *chops* and *hot*, respectively).

4 Discussion

This pilot experiment investigated acoustic and articulatory characteristics of TPFs. The speaker was asked to produce two types of TPFs, one with a rising-falling contour on the nucleus and one with a rising contour on the nucleus. The speaker successfully performed these final F0 movements. In addition to F0 differences, the vowel of the nucleus of the TPF2 (rising contour) compared to that of TPF1 (rising-falling contour) was produced with a significantly higher mean F0 and higher mean F1, but significantly shorter mean duration together with significantly higher jaw position than that of TPF1. That the nucleus of TPF1, with the rise-fall contour has a longer duration than that of TPF2 with a rise, is consistent with findings by (49) who report that complex (i.e., rise-fall) contours in Spanish and Catalan are longer than simple contours (i.e., rise or fall). Given the small data sampling size, the results from our pilot study on TPFs need to be confirmed by more data.

The results of our pilot study also show that in the case of emphasis compared to no emphasis, the speaker produced the vowel of the nucleus of TPF1 with significantly increased F0, intensity, and jaw lowering yet no significant differences in duration. The findings of increased F0, intensity and jaw lowering are consistent with previous reports about acoustic and articulatory characteristics of emphasis (e.g., (4)); the lack of finding increased duration for emphasis is consistent with previous reports, (e.g. (50), (51) Kochanski et al. 2005, Watson 2010) who report that increased duration is not always an acoustic correlate of emphasis. As for the phonetic markings for emphasis on the nucleus of TPF2, they were similar to those of TPF1 (as shown in Table 6), but small data size did not permit statistical comparisons.

With regard to the entire TPF unit, a question posed in the introduction was whether the topic nucleus has the largest amount of jaw lowering in the TPF. Since in an English utterance, nuclear stress is marked with the largest amount of jaw lowering in the utterance (e.g. (4), (30)), does the nucleus of the TPF also show the largest amount of jaw lowering in the topic unit? The jaw tracings in Figures 13 and 14, along with the measurements of Table 7, indicate that the TPF nucleus does not have the lowest amount of jaw lowering in the TPF; rather the word *hot* shows the lowest amount of jaw lowering. This suggests, as discussed in the introduction, that for English, one member of a phrasal unit, must have more jaw lowering than the others. Thus, for these TPFs in order to maintain the pragmatic function of the TPF and still follow the phonological and phonetic rules of English, the speaker produced the largest amount of jaw lowering on another word in the TPF, *hot*. To further explore acoustic and articulatory markings of prominence in TPFs, we need to examine a variety of topic units, e.g. TPFs with more or fewer prosodic words, as well as polysyllabic nuclei. We also need to be able to normalize across vowel types.

An additional question arises about Topic units of other languages—how do speakers of other languages produce the nuclei of non-emphasized TPFs? One reason we ask this is, as discussed in the introduction, for English speakers nuclear stress does not always occur on the final stressed syllable. However, speakers of French, Japanese, Mandarin Chinese and Brazilian Portuguese, produce phrasal stress always on the phonological phrase final full syllable (see e.g. (52)), which is articulatorily evidenced by increased jaw lowering ((4), (26), (53)). For these

speakers, would the non-emphasized nuclei be articulated with the largest amount of jaw lowering in the TPF? This is a question for future ongoing research.

These tentative findings suggest different articulatory strategies for topic vs. local prominence. That is, as discussed in the introduction, the Topic word, i.e., nucleus, in a topic prosodic unit indicates that the whole unit acquires a determinate function. But when the topic word is emphasized, the phonetic features change, resulting in local prominence superimposed on the topic prominence.

Future work will examine the prosodic characteristics of more TPFs (including TPF3) for more speakers of English. Also, the plan is to compare prosodic measurements of TPFs cross-linguistically. Given that languages vary in terms of prosodic organization, does this influence speakers' preferences as to which type of TPF they prefer? The tentative findings of this pilot study open doors to examining the various ways "prominence" works in spoken languages. These ideas need to be explored more as we examine additional speakers and different Topic phrases. The study of TPFs here opens a window into thinking along these lines

To summarize, it appears that prominence is not only a matter of degree/quantity. In addition, prominence is also a matter of quality/category. Topic prominence, where the scope of prominence is on the entire unit is qualitatively different from local prominence where one member/word is prominent. Moreover, the results about topic informational units (TPFs) suggest that quantitatively speaking, the phonetic parameters are different for local prominence than those for a wider scope. The findings reported in this pilot study encourage exploring the different colors of prominence resulting from the interplay of phonetics, phonology and pragmatics.

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REFERENCES

1. Cresti E. *Corpus di Italiano Parlato*. Firenze: Accademia della Crusca, 2000
2. Moneglia M, Raso T. Appendix: Notes on the Language into Act Theory. In: Raso T, Mello H, editors, *Corpora and Linguistic Studies*. Amsterdam: John Benjamins, 2014. p. 468-493. <https://doi.org/10.1075/sci.61.15mon>
3. Fujimura O. The C/D model and prosodic control of articulatory behavior. *Phonetica* 2000; 57:128-138.
4. Erickson D, Niebuhr O. Articulation of prosody and rhythm: Some possible applications to language teaching, *Studies in Laboratory Phonology*. Language Science Press (langsci-press.org) 2023:1-45. DOI: 10.2478/9788366675728-001.202
5. Izre'el S, Mello H, Panunzi A, Raso T. In search of a basic unit of spoken language: Segmenting speech. In: Izre'el S, Mello H, Panunzi A, Raso T. editors. *In Search of Basic Units of Spoken Language: A corpus-driven approach*, Amsterdam: John Benjamins, 2020, p. 1-32. <https://doi.org/10.1075/sci.94>
6. Barth-Weingarten D. *Intonation Units Revised: Cesuras in talk-in-interaction*. Philadelphia: John Benjamins Publishing Company, 2016.
7. Beckman M, Hirschberg J, Shattuck-Hufnagel, S. The original ToBI system and the evolution of the ToBI framework. In: Jun S-A, editor. *Prosodic Typology – The Phonology of Intonation and Phrasing* Oxford: Oxford University Press. 2005. p. 9-54.
8. Cole J, Hualde J, Smith CL, Eager C, Mahrt T, de Souza RN. Sound, structure and meaning: The bases of prominence ratings in English, French and Spanish, *Journal of Phonetics* 2019; 75:113–147.
9. Lehiste I. *Suprasegmentals*. Cambridge: MIT Press. 1970.
10. Kubozono H. Japanese Pitch Accent in a Typological Perspective. *The International Symposium on Tonal Aspects of Languages (TAL-2014)* Nijmegen, The Netherlands May 13-16 2014, p. 195-198.

11. Kubozono H. Accent in Japanese Phonology. *Oxford Research Encyclopedia of Linguistics*. March 29, 2017.
<https://oxfordre.com/linguistics/view/10.1093/acrefore/9780199384655.001.0001/acrefore-9780199384655-e-279>.
12. Breen M, Fedorenko EG, Wagner M, Gibson E. Acoustic Correlates of Information Structure. *Language, Cognition and Neuroscience* 2010; 25(7):1044-1098. DOI: 10.1080/01690965.2010.504378.
13. Svensson Lundmark M, Erickson D. Segmental and syllabic articulations: a descriptive approach. *J. Speech Language and Hearing Res.*, 2024a. https://doi.org/10.1044/2024_JSLHR-23-00092.
14. Svensson Lundmark M, Erickson D. Jaw complex: openness, prominence and dynamics. *Fonetik, Stockholm, Sweden*. 2024b.
15. Beckman ME, Edwards J. Articulatory evidence for differentiating stress categories. In: Keating P, editor, *Papers in Laboratory Phonology*, vol. III, Cambridge: Cambridge University Press, 1994, p. 7–33.
16. de Jong K. The supraglottal articulation of prominence in English: linguistic stress as localized hyperarticulation. *J. acoust. Soc. Am.* 1995; 97: 491–504.
17. Erickson D. Effects of contrastive emphasis on jaw opening. *Phonetica* 1998; 55: 147-169.
18. Erickson D. Articulation of extreme formant patterns for emphasized vowels. *Phonetica* 2002:134-149.
19. Harrington J, Fletcher J, Beckman ME. Manner and place conflicts in the articulation of Australian English. In: Broe J, Pierrehumbert JB, editors, *Papers in Laboratory Phonology* (5). Cambridge: Cambridge University Press 2000. p. 40–51.
20. Menezes, C. Rhythmic pattern of American English: Articulatory and acoustic study. PhD diss. Ohio State University, USA. 2003.
21. Stone M. Evidence for a rhythm pattern in speech production: observations of jaw movement. *J. of Phonetics* 1981; 9:109–120.
22. Mo Y, Cole J, Hasegawa-Johnson M. Prosodic effects on vowel production: evidence from formant structure. *Interspeech* 2009:668.
23. Svensson Lundmark M, Erickson D, Niebuhr O, Tiede M, Chen W-R. A new articulatory tool: Comparison of EMA and MARRYS. *PaPE* 2023: 33-34.
24. Erickson D. (2004) On phrasal organization and jaw opening. *Proceedings From Sound to Sense*, June 13, MIT, CDRom publication. 2004:24
25. Svensson Lundmark M, Erickson D, Niebuhr O, Tiede M, Chen W-R. A new articulatory tool: Comparison of EMA and MARRYS. *PaPE* 2023: 33-34.
26. Erickson D, Barbosa P, Silveira G. The interplay between acoustics and syllable articulation organized by Mandible movement. *International Seminar on Speech Production*, Autrans, France. 2024.
27. Erickson D, Iskarous K, Whalen D. Production of hyperarticulated vs. contrastively emphasized vowels. In *Proceedings of Un siècle to Phonetique experimentale: historie et developpement*, de Theodore Rosset a John Ohala. 2005, p. 41.
28. Šimko J, Beňuš S, Vainio, M. Hyperarticulation in Lombard speech: Global coordination of the jaw, lips and the tongue. *The Journal of the Acoustical Society of America*, 139, 2016:151.
29. Mefferd AS. Tongue- and Jaw-Specific Contributions to Acoustic Vowel Contrast Changes in the Diphthong /ai/ in Response to Slow, Loud, and Clear Speech. *J Speech Lang Res.*, 2017; 60(11): 3144-3158.
30. Erickson D, Suemitsu A, Shibuya Y, Tiede M. Metrical structure and production of English rhythm. *Phonetica* 2012; 69:180–190.
31. Erickson D., Kim J, Kawahara S, Wilson I, Menezes C, Suemitsu A, and Moore, J. Bridging articulation and perception: The C/D model and contrastive emphasis. *International Congress of Phonetic Sciences* 2015.
32. Moneglia M. Spoken Corpora and Pragmatics. In: *Revista Brasileira de Linguística Aplicada* (2), 2011: 479-519
33. Cresti E. The Definition of Focus in Language into Act Theory (L-AcT). In: Mello H, Panunzi A, Raso T. *Pragmatics and Prosody*. Firenze: Firenze University Press, 2011, p. 39-82.
34. Raso T, Rocha B. Illocution and attitude: on the complex interaction between prosody and pragmatic parameters. *Journal of Speech Science*, 2016; 5: 5-27.
35. Krifka M, Musan R. Information structure: overview and linguistic issues. In: Krifka M, Musan R. editors, *The Expression of Information Structure*. Berlin/Boston: De Gruyter Mouton, 2012, p. 1-49.
36. Signorini S. *Topic e soggetto in corpora di italiano parlato spontaneo*. Phd. Dissertation, Università di Firenze, 2005.

37. Cresti E, Moneglia M. editors. *C-ORAL-ROM. Integrated reference corpora for spoken Romance languages*. Amsterdam: John Benjamins, 2005.
38. Raso T, Mello H. editors. *C-ORAL-BRASIL I: corpus de referência de português brasileiro falado informal*. Belo Horizonte: UFMG, 2012 : 473-497.
39. Du Bois, JW, Chafe, WL, Meyer Ch, Thompson SA, Englebretson R, Martey N. *Santa Barbara corpus of spoken American English, Parts 1-4*. Philadelphia: Linguistic Data Consortium, 2000-2005.
40. Firenzuoli V, Signorini S. L'unità informativa di topic: correlati intonativi. In: Marotta G editor, *La coarticolazione*. Atti delle XIII giornate di studio del Gruppo di Fonetica Sperimentale. Pisa: ETS, 2003. p. 177-184.
41. Raso T, Cavalcante F, Mittmann M. Prosodic forms of the Topic information unit in a cross-linguistic perspective: a first survey. In: de Meo, A, F. M. Dovetto, FM, editors, *La comunicazione parlata/Spoken Communication*. Rome: Aracne, 2017, p. 473-498
42. Cavalcante FA. *The topic unit in spontaneous American English: a corpus-based study*. M.A. Thesis. Belo Horizonte: UFMG, 2016.
43. Rocha B. Características prosódicas do tópico em PE e o uso do pronome lembrete. Belo Horizonte: UFMG, MA Thesis. 2012.
44. Mittmann, M. *O C-ORAL-BRASIL e o estudo da fala informal: um novo olhar sobre o Tópico no Português Brasileiro*. Belo Horizonte: UFMG, Ph Dissertation.
45. Cavalcante, FA. *The information unit of Topic: a crosslinguistic, statistical study based on spontaneous speech corpora*. PhD Dissertation. Belo Horizonte: UFMG, 2020.
46. Cavalcante, F, Raso, T, Barbosa, P. The Topic information unit: modeling prosodic forms in a crosslinguistic perspective. In: Castagneto M, Ravetto M, editors. *La comunicazione parlata/ Spoken Communication*. Roma: Aracne 2023. p. 427-460.
47. Menezes C, Erickson D. Intrinsic variations in jaw deviation in English vowels. *Proc. of International Congress of Acoustics. Proceedings of Meetings on Acoustics*, 2013; 19: 060253.
48. Coulange S., Kato T., Rossato R., Masperi M. Enhancing Language Learners' Comprehensibility through Automated Analysis of Pause Positions and Syllable Prominence. *Languages*, 9 (3) 2024: 78. <https://doi.org/10.3390/languages9030078>.
49. Prieto P, Ortega-Llebaria M. Do complex pitch gestures induce syllable lengthening in Catalan and Spanish, In: Vigario M, Frota S, João M, editors, *Phonetics and Phonology: Interactions and interrelations*, Amsterdam: John Benjamins Publishing Company, Chapter 3. 2009. [10.1075/cilt.306.03pri](https://doi.org/10.1075/cilt.306.03pri).
50. Kochanski G, Grabe E, Coleman J, Rosner B. Loudness predicts prominence: fundamental frequency lends little, *The Journal of the Acoustical Society of America*, 2005: 118:1038.
51. Watson DG. 2010. Chapter 4 - The Many Roads to Prominence: Understanding Emphasis in Conversation. *Psychology of Learning and Motivation* 2010; 52:163-183.
52. Jun, SA. Prosodic typology: By prominence type, word prosody, and macrorhythm. In: Jun S-A, editor, *Prosodic typology II. The phonology of intonation and phrasing*. Oxford: Oxford University Press. 2014. p. 520-539.
53. Erickson, D., Rilliard, A., Svensson Lundmark, M., Rebollo Couto, L., Silva, A., de Moraes, J., Niebuhr, O. Collecting Mandible Movement in Brazilian Portuguese. *Proceedings of Interspeech*. 2024.