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TITLE: Focus marking and prosodic boundary strength in French

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ABSTRACT

Background/Aims. In French, the size of a focus constituent is not reliably marked through pitch accent assignment as in many stress-accent languages. While it has been argued that the distribution of lower-level prosodic boundaries plays a role, this is at best a weak cue to focus, leaving open the question of whether other marking strategies are available. In this study, we assess whether the right edge of a contrastive focus constituent is marked by differences in prosodic boundary strength. *Methods.* We elicited utterances with target words in six combinations of focus and syntactic contexts using an interactive production task. *Results.* The results show that if a given location is realized as an Accentual Phrase boundary in an all-focus context, then it is realized as an Intermediate Phrase boundary when it coincides with the right edge of a narrow focus constituent. A location that is an Intermediate Phrase boundary in an all-focus context, however, remains unchanged under narrow focus. *Conclusion.* These findings suggest that focus constituents are constrained to align with a minimum prosodic domain size in French (i.e. the intermediate phrase), and that French does not rely on a general strategy of prosodic enhancement for marking focus.

1 Introduction

As speakers encode speech, they use prosody, together with other linguistic strategies such as word order variations (e.g., Kenesei, 1986, in Hungarian) or morphological markers (e.g., Rialland & Robert, 2001, in Wolof) to mark the difference between information that is part of a background (in a sense of being shared by interlocutors) and information that is part of a focus (in the sense of being presented by the speaker as new or contrastive; e.g. Krifka, 1992; Rooth, 1985, 1992). Previous studies have shown that different languages use different prosodic strategies in order to mark this difference. While stress-accent languages such as English signal focus through pitch accent type and location (Bolinger, 1961, 1986; Chafe, 1974; Cruttenden, 1986; Halliday, 1967; Pierrehumbert, 1980; Pierrehumbert & Hirschberg, 1990), the association between focus and prosodic features in French is less straightforward. Rather, it appears that French speakers use a variety of strategies to encode focus.

Studies on French intonation, for example, have shown that the focused element can be marked by a specific rising contour, which is both higher in pitch and aligned later than a typical final accent in non-contrastive contexts (cf. *accent d'insistance*, Di Cristo, 1996, or *focus accent*, Hf, Jun & Fougeron, 2000). Previous studies have also reported that the pre-focal region appears to be characterized by a reduced pitch range and amplitude of tonal movements and by a reduced number of phrase boundaries (Touati, 1987; Jun & Fougeron, 2000; Dohen & Loevenbruck, 2004), and that the post-focal region can be characterized by an absence of prominent pitch movements (Rossi, 1985; Touati, 1987; Di Cristo & Hirst, 1993; Clech-Darbon et al., 1999; Di Cristo, 1996; Jun & Fougeron, 2000; Féry, 2001; Dohen & Loevenbruck, 2004). More recent studies have also shown that the Initial Rise, which is an optional tonal LH unit associated to the left edge of the Accentual Phrase (or AP, the

smallest unit of phrasing in French), can be an informative cue to focus in that it is more likely to occur at the left edge of a contrastive focus domain (D'Imperio et al., 2012; German & D'Imperio, 2016).

Finally, the clearest consensus across studies on focus and prosodic features in French is that prosodic phrasing, i.e., the grouping of words into melodic/rhythmic phonological units of different sizes, is one of the main strategies employed by French speakers to mark the difference between given and contrastive elements. Specifically, a number of studies have reported a tendency for a narrow-focused constituent to be parsed in a separate AP (Féry, 2001; Dohen & Loevenbruck, 2004; Beyssade et al., 2009; Chen & Destruel, 2010; Michelas et al., 2014). In operational terms, if two elements would typically be grouped into a single AP in a non-focused context, then in case one of them is focused, a prosodic restructuring process isolates that element in a separate AP. However, since this phenomenon is only a probabilistic tendency, evidence for cases in which the distribution of AP boundaries reliably marks the span of focus constituents is limited. Consider that since prosodic boundaries usually respect the boundaries introduced by syntactic and/or phonological constraints, it is often the case that the focused element is already isolated as a single AP. This raises the question of whether the edges of focus constituents are marked through other means, such as through higher-level prosodic phrasing, or through relative phrase boundary strength.

Three different types of prosodic boundaries have been proposed for French (see Figure 1), corresponding to three levels of constituency in the prosodic hierarchy. From largest to smallest, these are the Intonational Phrase (IP), the Intermediate Phrase (ip), and the Accentual Phrase (AP). Most intonational models of French include an IP (Post, 2000; Jun & Fougeron, 2000, 2002; Delais-Roussarie et al. 2015), which is acoustically cued by a major tonal movement at its right edge. The IP is marked at its right edge by either a low

(L%) or high boundary tone (H%), and optionally followed by a silent pause. When an H% tone occurs, the final full syllable of the IP tends to exhibit higher fundamental frequency (f0) values than those associated with the first accentual peak of the utterance (Michelas, 2011; see 1st LH* vs. H% in Figure 1). In addition to this tonal marking, the IP has the highest degree of preboundary lengthening (Fougeron & Jun, 1998; Jun & Fougeron, 2000).

Studies also agree on a lower level of prosodic constituency, which can be identified by the presence of a typical final rise (LH*) associated with the last syllable of the phrase, and by the weakest degree of pre-boundary lengthening. This level is referred to as either the Accentual Phrase (Jun & Fougeron, 2000, 2002; Welby, 2006; Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014; Delais-Roussarie et al. 2015) or the Phonological Phrase (Delais-Roussarie, 1996; Féry, 2001; Post, 2000) depending on the particular approach.

Several studies also support a level of phrasing that is intermediate to the IP and AP (Jun & Fougeron, 2000; Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014). D'Imperio & Michelas (2014) showed that the ip is acoustically cued by an intermediate degree of pre-boundary lengthening, as well as an additional tonal unit at its right edge (the H- phrase accent). Crucially, in French, the H-phrase accent blocks downstep on the last H peak within the phrase, hence resetting the peak before the ip boundary (and not after as is the case in English). This leads to a complete pitch reset before the ip-right boundary, given that the preboundary peak is scaled at the same level as the first accentual peak in the ip. The result is that the first and last LH* rises in an ip are similar in height to each other (see the first LH* vs. the third LH* in Figure 1), and higher than those in medial positions (second LH* in Figure 1). This difference makes it possible to distinguish between AP and ip boundaries quantitatively.

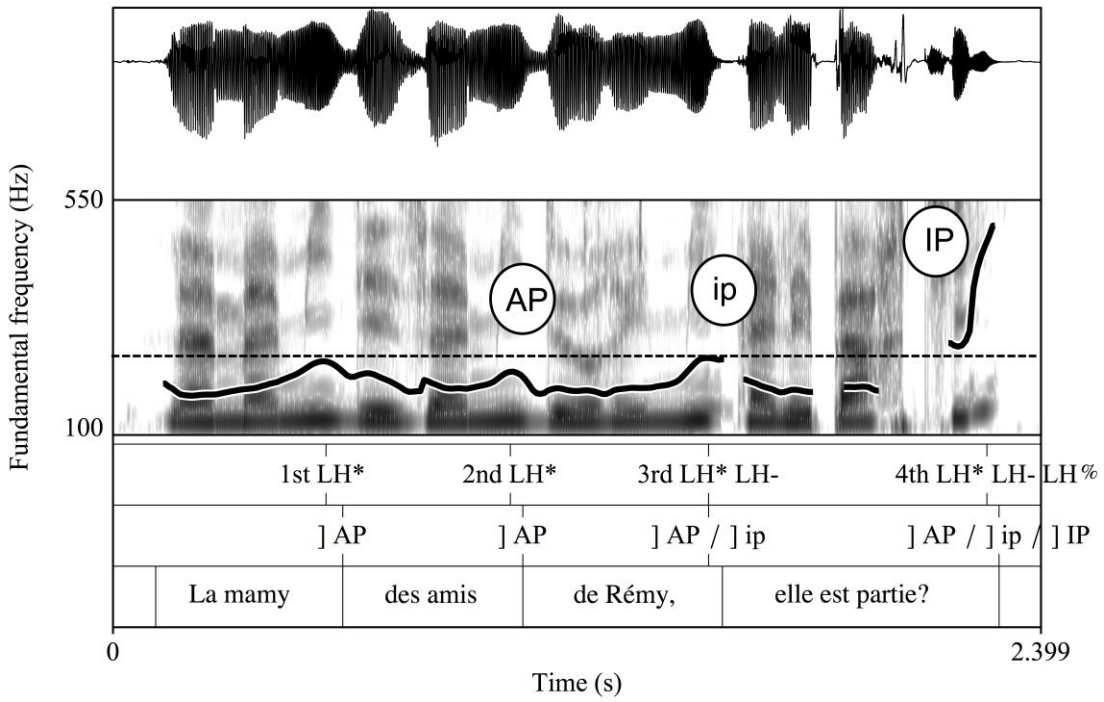

Figure 1. Waveform, spectrogram, and f0 contour for the sentence *La mamy des amis de Rémy, elle est partie* 'The granny of Remy's friends, has she left?' ending with three prosodic boundary levels (labeled circles). Dashed line indicates the register level set by the first accentual peak (LH*) of the utterance.

It is well-known that a large number of constraints of various types can condition the occurrence of the three levels of prosodic boundaries in French. Among these, syntax exerts a strong influence in determining the location as well as the strength of prosodic boundaries. In concrete terms, the right edge of a syntactic clause tends to align with the right edge of an IP (Delais-Roussarie et al. 2015). Specific syntactic structures such as tag-questions, vocatives and parenthetical constructions have also been found to induce IP breaks at both their left and right edges in a number of languages including French (for English see Selkirk, 1995; for French see Delais-Roussarie, 2005; Delais-Roussarie & Post, 2008; Avanzi, 2011). Concerning the ip-level, a syntactic constraint enforces the alignment of the right edge of a major syntactic break (i.e. the top node projection of the head, XP, such as the break

between an noun phrase (NP) and a verb phrase (VP)) with the right edge of an ip if the resulting phrase consists of at least two APs (Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014). Finally, AP boundaries occur at all other minor syntactic breaks within a maximal syntactic projection (e.g., NP/PP breaks within an NP; D'Imperio & Michelas, 2014).

There is already suggestive evidence that focus may be associated with prosodic boundaries higher than the AP in French. In a semi-spontaneous two-person dialogue task, German & D'Imperio (2010, 2016) found that the initial LH rise (IR) of the AP is more likely to occur when the left edge of the AP coincides with the left boundary of a contrastive focus constituent. While the IR is most closely linked to the AP, Astésano et al. (2007) show that it is more frequent at the left edge of an ip, perhaps serving as a marker of that domain. Putting these two sets of findings together, D'Imperio et al. (2012) propose that the ip may mediate the relationship between focus and the IR. In other words, given that the IR (weakly) marks the left edge of ip, the higher tendency for IRs at the left edge of focus constituents can be explained if focus constituents are constrained to be realized as a single ip. If true, it should be possible to find traces of ip-level phrasing at the *right* edge of a focus constituent as well. To date, however, no study has specifically tested whether a relationship exists between the right edge of a focus constituent and the occurrence of an ip boundary in French. In the present study, we therefore explore this hypothesis directly. Specifically, we test whether the right edge of a contrastive focus constituent is associated with a specific level of organization within the prosodic hierarchy, which we hypothesize is the ip-level. Formally, this can be stated as follows:

MINIMUM DOMAIN SIZE HYPOTHESIS (MDSH): The right edge of a focus constituent must coincide with the right edge of an ip boundary.

Strict Layering (Selkirk, 1986) is generally assumed to apply in French (Jun & Fougeron, 2000, 2002; Féry, 2001; Michelas & D'Imperio, 2012; though see Martin, 2009, for arguments against this view). The above hypothesis therefore predicts that the right edge of a focus must coincide with *at least* an ip boundary, and *possibly* an IP boundary, since the presence of the latter implies the former.

The MDSH implicitly assumes that the grammar directly encodes requirements on the alignment between focus and specific phrase boundaries. For at least some languages, however, the relationship between focus and prosodic structure appears to be more fluid, reflecting instead a general strategy whereby adjustments are made to prosodic structure in whatever way necessary to ensure that the focus constituent is afforded extra prominence. Gussenhoven (2004) suggests that such strategies reflect the Effort Code, whereby more extreme articulations (e.g., increased pitch excursions) or increased phonological complexity (e.g., a higher level prosodic boundary) are used to highlight the relatively higher 'significance' of the focused element. Gussenhoven points to Tokyo Japanese, for which the choice of prosodic boundary (accentual phrase or word boundary only) at the right edge of a focus constituent depends on the resulting *relative* prominence of the focal and post-focal regions. Specifically, if both the focal and post-focal constituents contain lexical pitch accents, then the preferred strategy is to phrase them together, since this causes deletion of the accent on the post-focal constituent, whereas phrasing them separately would prevent such deletion. However, if the focal constituent is lexically unaccented, then the preferred

strategy is to insert an accentual phrase boundary at its right edge, since this induces downstep on the following post-focal phrase.

The possibility of such a strategy for French is supported by the fact that focus marking in French appears to be somewhat more variable than in West Germanic languages. The tendency for postfocal deaccenting, for example, has been shown to be highly variable in French (Smith, 2002; Beyssade et al., 2009). Similarly, Beyssade et al. (2015) showed that an information focus may be marked with either an IR, a nuclear pitch accent, or both, though such marking is not obligatory. Finally, the association between the AP-initial rise and the left edge of focus constituents found by German & D'Imperio (2016) is only a probabilistic tendency, since the likelihood of an IR also depends on the length of the AP.

Together, these facts suggest an alternative to the MDSH, namely, that focus is marked at the right edge of a focus constituent by enhancing its prosodic prominence through whatever structural means are available. In French, H-marked boundaries at increasingly higher levels in the prosodic hierarchy are associated with increasingly higher peak F0 and greater final lengthening. One readily available strategy for conveying additional prominence, therefore, involves simply promoting the level of the boundary from its "default" level (i.e., what would normally occur in an all-focus context) to some higher level. In other words, if the right edge of the focus constituent would normally be realized with an AP boundary under all-focus, then it should be realized as an ip boundary or higher. If it would normally be realized as an ip boundary under all-focus (e.g., for syntactic reasons), then it should be realized as an IP boundary. This hypothesis can be formulated as follows:

BOUNDARY PROMOTION HYPOTHESIS (BPH): When a boundary coincides with the right edge of a focus constituent, it is raised to the next level up in the prosodic hierarchy (compared to what it would otherwise be under all-focus).

The BPH can be distinguished from the MDSH by examining what happens when the default boundary strength under all-focus is ip. According to the MDSH, the requirements of the grammar are already satisfied, so no changes to the structure are required. According to the BPH, however, leaving the boundary as ip does not contribute additional prominence, so speakers should realize it as an IP.

To test these two hypotheses, we collected speech samples in a controlled but interactive paradigm that enable us to characterize the strength of a particular boundary location in two different focus contexts (all-focus vs. narrow-focus). Since recent studies have demonstrated that the presence of an addressee and a common ground shared by two interactional partners can successfully constrain focus encoding (see for instance Michelas et al., 2012; German & D'Imperio, 2016; Michelas and Champagne-Lavau, 2018), we used an interactive task in which an interviewer (a naïve experimenter or confidant) was instructed to pose questions to an interviewee (the participant), who responded using a map. Because syntax can influence the strength of a boundary independently of focus, the syntactic structure at the target juncture was also manipulated. This not only served to provide a baseline for the phonetic differences between AP and ip, but it also allowed us to differentiate between the predictions of the MDSH and the BPH.

To characterize boundary strength across conditions, we measured two phonetic cues that are well-known to distinguish among AP, ip, and IP boundaries, namely f0 peak height and vowel duration. We first analyze the results for these two acoustic features separately

and then consider how the two features taken together support the presence of a perceptible categorical contrast across conditions. By establishing (i) whether boundary strength is systematically related to the presence or absence of the right edge of a focus constituent, and (ii) distinguishing between two possible mechanisms that explain the relationship, our study contributes to a better understanding of the inventory of possible focus marking strategies in French. Additionally, it extends the characterization of the functional role of the ip within the overall grammar, which is an issue that has received little attention.

2 Methods

2.1 Participants

21 speakers of French took part in the experiment as interviewees. All were native speakers of French from continental France, whose ages ranged from 23 to 48 years old, and all had university degrees. Most reported some competence in English, and five reported near-native proficiency in another language (three in English, one in German, and one in Spanish). For all subjects, however, French was the only language spoken during childhood. For all trials, the interviewer was a native French speaker, female, 26 years old, who crucially was naïve about the aims of the experiment.

2.2 Materials

The materials consisted of controlled dialogues between two interlocutors who collaborated to report information about sightseeing monuments in Paris. The 'interviewer' (i.e., a confidant who was always the same person but who was naïve about the aims of the experiment) was instructed to pose questions to an interviewee (the experimental participant), who responded using a map. Each response included a target NP which

occurred in one of six conditions resulting from two different manipulations involving focus structure and syntax. 12 target NPs occurred in each of the six conditions for a total of 72 items.

For the first manipulation, the context was varied so as to elicit two different patterns of focus for a given sentence. This was achieved by varying both (i) the type of prompt used by the interviewer to elicit the interviewee's response and (ii) the specific type of contrast instantiated by the series of utterances in the interviewee's elicited response. In the NARROW FOCUS condition, the prompt was a wh-question which targeted a specific syntactic constituent within the response. The question in (1i), for example, targets a portion of the syntactic subject of the response in (1ii). In the ALL FOCUS condition, the prompt took the form of a request for general information about specific districts of Paris, as in (2i). Since no particular constituent in the response is targeted by such a request, the entire sentence is expected to be a single focus constituent, as in (2ii).

(1) Question prompt and target sentence (NARROW FOCUS)

i. *Quel palais de Paris fut édifié au 18ème siècle ?*

'Which palace was built in the 18th century?'

ii. *Le palais* **[** *de l'Elysée* **]**^{F} *de Paris fut édifié au 18ème siècle*

'The Elysée Palace of Paris was built in the 18th century.'

(2) Question prompt and target sentence (ALL FOCUS)

i. *Peux-tu me donner des renseignements sur trois curiosités du 8ème arrondissement ?*

'Can you give me some information about three attractions in the 8th district?'

ii. **[** *Le palais de l'Elysée de Paris fut édifié au 18ème siècle* **]**^{F}

'The Elysée Palace of Paris was built in the 18th century.'

To further reinforce specific focus patterns (i.e., over and above the reinforcement provided by the wh-questions), each target sentence occurred as the *second* in a series of three sentences. The three sentences in each series were identical *except* in terms of the constituent corresponding to the focus of the target sentence. Thus, the full response to the NARROW FOCUS prompt in (1i) was the series in (3), in which the target sentence (1ii) appears as the second element; the constituents that differ are indicated by underlining. Similarly, in the ALL FOCUS condition, the full response to (2i) was the series in (4), where the three sentences differ in their entirety.

(3) Response set – NARROW FOCUS

i. *Le palais <u>de justice</u> de Paris fut édifié au 18ème siècle.*

'The Courthouse of Paris was built in the 18th century.'

ii. *Le palais <u>de l'Elysée</u> de Paris fut édifié au 18ème siècle.*

'The Elysée Palace of Paris was built in the 18th century.'

iii. *Le palais <u>des congrès</u> de Paris fut édifié au 18ème siècle.*

'The Convention Palace of Paris was built in the 18th century.'

(4) Response set – ALL FOCUS

i. *Le boulevard Haussmann est classé monument historique.*

'Haussmann Boulevard is listed on the register of historical monuments.'

ii. *Le palais <u>de l'Elysée</u> de Paris fut édifié au 18ème siècle.*

'The Elysée Palace of Paris was built in the 18th century.'

iii. *La gare Saint Lazare a été construite avant la révolution.*

'The Saint Lazare train station was constructed before the revolution.'

Crucially, in the NARROW FOCUS condition the right edge of the target NP coincided with the right edge of the focus constituent, while in the ALL FOCUS condition, the right edge of the target NP was internal to the focus constituent.

The second manipulation was designed to control the type of prosodic boundary occurring at the right edge of the target NP in the ALL FOCUS condition by varying the syntactic structure of the sentence. As noted in Section 1, different types of prosodic boundaries are associated with different syntactic boundaries. In the SUBJECT-INTERNAL condition, the right edge of the target NP was internal to the syntactic subject (as in (1ii) and (2ii)). In the absence of narrow focus effects, this is expected to result in an AP boundary at that location (D'Imperio & Michelas, 2014). In the NP/VP BREAK condition, the right edge of the target NP was at the right edge of the syntactic subject, which in the absence of narrow focus effects is expected to in an ip boundary (Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014). In the PARENTHETICAL BREAK condition, the right edge of the target NP was at the boundary between the end of the syntactic subject and a following parenthetical structure – a position which has been found to be highly correlated with the presence of an IP boundary (Delais-Roussarie, 2005; Delais-Roussarie & Post, 2008; Avanzi, 2011). An example of the full 2 x 3 manipulation for one target NP is given in Table 1. The full list of target sentences is provided in Appendix A.

Table 1. Example of the 2 x 3 core manipulation (Focus x Syntax) for one target NP. The target juncture and expected prosodic boundary strength are indicated by '**|**'. The span of the focus constituent is indicated by '**[ ]**^{F}'.

	FOCUS	
SYNTAX	ALL FOCUS	NARROW FOCUS
SUBJECT-INTERNAL	**[***Le palais de l'Elysée* **|**$_{AP}$ *de Paris fut édifié…***]**^{F}	*Le palais* **[***de l'Elysée***]**^{F} **|**$_{?}$ *de Paris fut édifié…*
	'The Elysée Palace of Paris was built…'	
NP/VP BREAK	**[***Le palais de l'Elysée* **|**$_{ip}$ *fut édifié…***]**^{F}	*Le palais* **[***de l'Elysée***]**^{F} **|**$_{?}$ *fut édifié…*
	'The Elysée Palace was built…'	
PARENTH. BREAK	**[***Le palais de l'Elysée* **|**$_{IP}$*, dont on a parlé hier, fut édifié…***]**^{F}	*Le palais* **[***de l'Elysée***]**^{F} **|**$_{?}$ *dont on a parlé hier, fut édifié…*
	'The Elysée Palace, which we talked about yesterday, was built…'	

The segmental material preceding the target syllable was identical across all six items in each set. To achieve this, a textual label appeared next to each landmark on the map indicating its name, and participants were instructed to incorporate these labels verbatim into their responses. For all three levels in the syntactic manipulation, the labels corresponded to the content of the syntactic subject. For the parenthetical condition, these labels also included the associated parenthetical. Next to each landmark, a second textual label indicated a specific attribute, such as 'built in the 18th century', which could be used together with the name label to form a sentence. For target sentences, we carefully controlled the segmental composition of the subject (where acoustic measurements were made), though it was also necessary to control aspects of the verb phrase to ensure that the latter would not indirectly influence our acoustic measures. Consequently, the attribute label on maps always included the (main) verb. This was also the case for non-target sentences in NARROW FOCUS items (i.e., those occurring

either before or after the target in a sequence of three; e.g. (3i) and (3iii)), where it was important to maintain strict parallelism across the unfocused portions of the three sentences in a set. However, for most (83%) of the non-target sentences in ALL-FOCUS (e.g., (4i), (4iii)), as well as for the three training items, the attribute labels included no verb. For those items, the participant therefore had flexibility to choose a (main) verb in creating a sentence using the two labels (e.g., *Boulevard Haussmann* + *classé monument historique* in Figure 2 requires the insertion of *est* 'has been' or possibly *a été* 'was' to form a complete sentence). This step made it possible to reinforce the sentence-forming nature of the task (as opposed to reading) and to therefore encourage a more spontaneous and communicative style throughout the task.

Given the important role of length for phrasing choices, subject NPs were controlled so that they were always composed of 3-syllable APs. The number of APs within subject NPs depended on the type of prosodic boundary occurring at the right edge of the target NP (three APs in the Subject-internal condition, two APs for the NP/VP break condition). For the parenthetical break condition, the parenthetical structure was between 5 and 9 syllables long and always had the same syntactic structure. Possible microprosodic effects on subject NPs were minimized by ensuring that the target syllables were always open syllables with a voiced consonant in the onset.

The complete set of 72 responses was divided among six experiment lists, balanced for condition, such that each target NP appeared only once for each speaker. Interviewees' responses were therefore guided by one of 6 maps, an example of which is given in Figure 2.

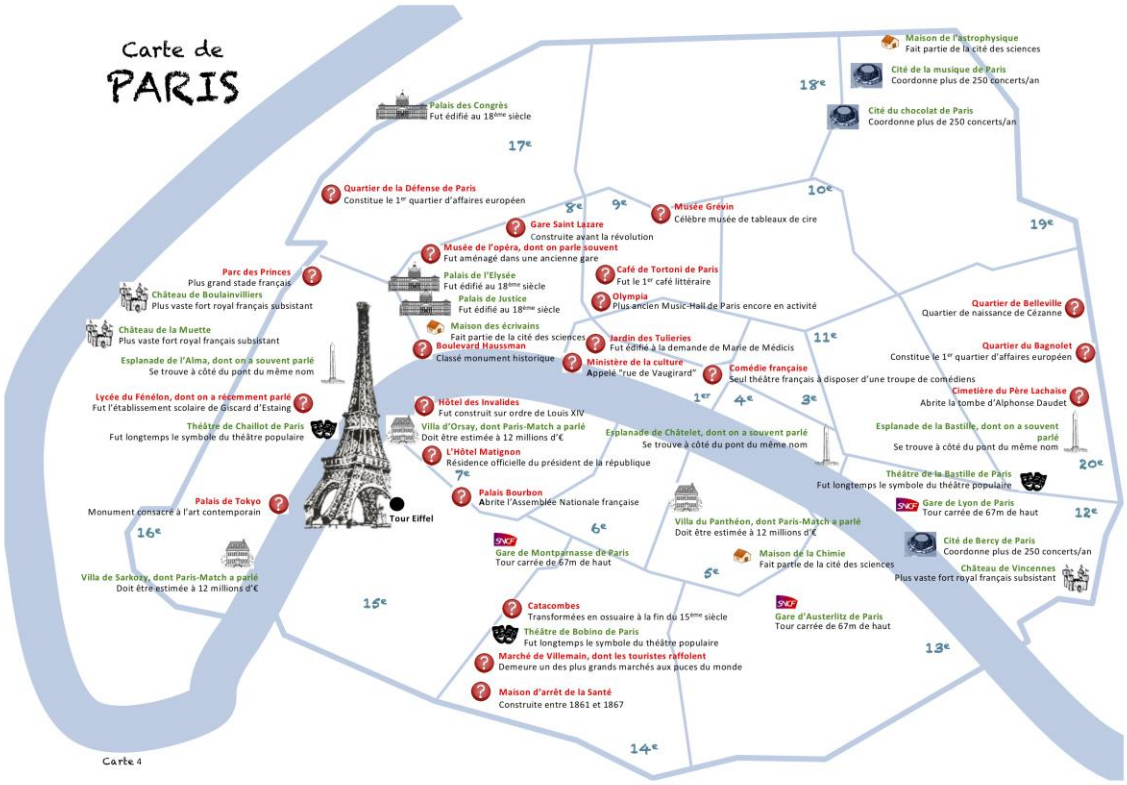

Figure 2. Example of a map used to guide response sets produced by the interviewee.

To facilitate participants' responses and guide their search on the map, questions designed to elicit NARROW FOCUS responses (all wh-questions) asked for details about specific monuments of Paris. These monuments were always represented on the map with symbols such as , and details about these monuments were written in green. By comparison, questions designed to elicit ALL FOCUS responses asked about general information, called "curiosities" (see 2i above), concerning specific districts of Paris. These "curiosities" were always represented on the map by the symbol and details about them were written in

red. Note that the map in Figure 2 corresponds to a single "list" (i.e., a particular allocation of target sentences to conditions).

2.3 Procedure

The interviewer and the interviewee were seated face-to-face in a sound-attenuated booth at the *Laboratoire Parole et Langage*. Dialogues were recorded digitally onto a computer using two Shure S10A head-mounted microphones on two separate channels. The interviewer had a list of questions while the interviewee had a map to guide his/her responses. For all conditions, the interviewer first asked a question from a list and then the interviewee was expected to produce the three *possible* answers (not necessarily correct; see below) for that question using his/her map. To ensure that speakers correctly produced the expected target NPs (landmark names) on which we conducted acoustic analyses, interviewees were instructed to produce full sentences which incorporated the names of the landmarks as they were written on the map, starting from the landmark closest to the Eiffel Tower.

For each set of three answers, only one was historically accurate. After the three possible answers had been enumerated, the interviewer and the interviewee were instructed to work together to identify the correct answer and then record it on a questionnaire. The correct answer was randomly distributed among the three possible responses. This task structure had at least two major advantages: First, for the NARROW FOCUS items, the production of three similar utterances in sequence reinforced the contrastive nature of the focus constituent (which was already enforced by the type of wh-question used). Second, by requiring cooperation, this helped to ensure engagement by the participants and to reinforce

the communicative and interactive aspects of the task. Before the experiment began, participants were given three training items.

Each map contained 45 landmarks of Paris corresponding to 12 experimental item sets plus 3 training sets. The former were counterbalanced for FOCUS and SYNTAX.

2.4 Analysis

Each utterance was phonetically segmented using EasyAlign (Goldman, 2011). Target vowels and syllables were then manually labelled after verifying segment boundaries through inspection of waveforms and spectrograms. The annotation schema is illustrated in Figure 3. To assess pre-boundary lengthening, the duration of the vowel in the final syllable of each target item was automatically extracted from the labels. Maximum f0 values within target syllables were automatically labelled and extracted using a PRAAT script (Boersma & Weenink, 2015). Since previous work has shown that tonal targets associated with boundaries in French are defined in relation to the first accentual peak of the phrase (refer to Section 1), the f0 height of target syllables was assessed in terms of the *ratio* of the f0 of the target peak (H) to the f0 of the first pitch accent in the utterance (H1).

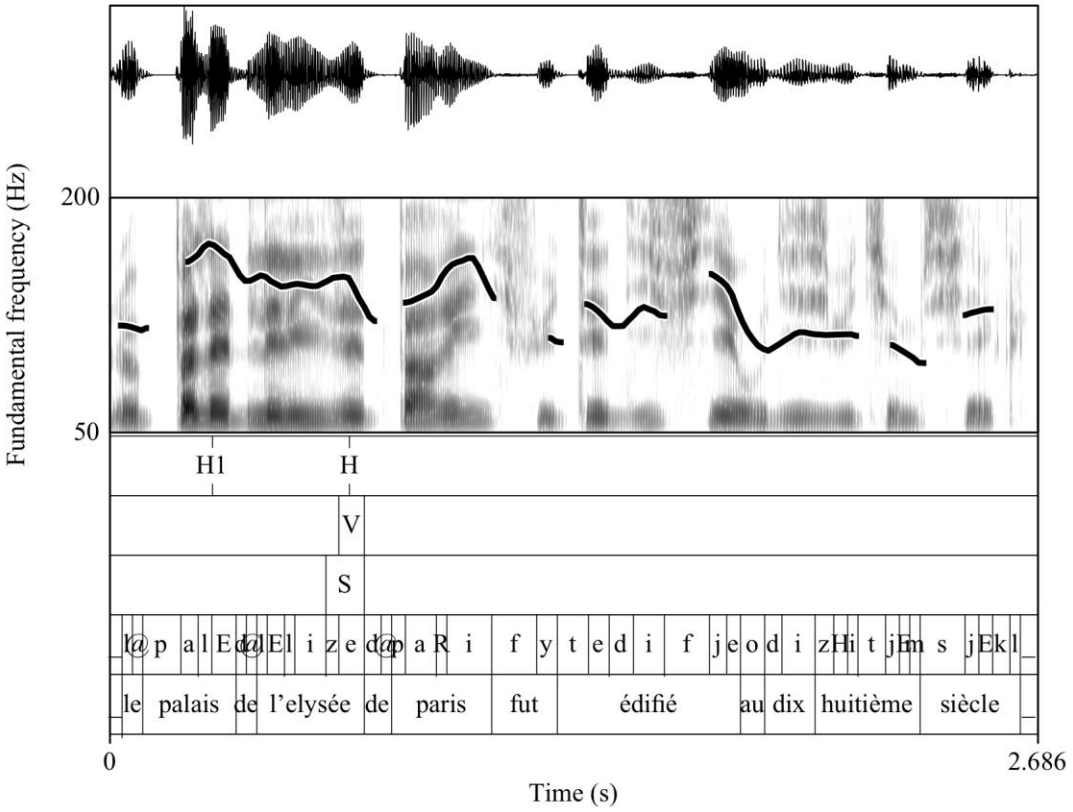

Figure 3. Waveform, spectrogram, f0 contour, and annotations of one target utterance by a male speaker for the sentence *Le palais de l'Élysée de Paris fut édifié au 18ème siècle* 'The palais de l'Élysée of Paris was built in the 18th century'. The target vowel and target syllable are labeled 'V' and 'S' respectively.

2.5 Predictions

By crossing the FOCUS manipulation with the SYNTAX manipulation, our design allowed us to assess how the presence or absence of the right edge of a focus constituent influences what would otherwise be an AP, an ip, or an IP boundary. According to the MINIMUM DOMAIN SIZE HYPOTHESIS, target junctures realized as AP boundaries in ALL FOCUS (as predicted for the Subject-internal condition) should be realized as ip in NARROW FOCUS, while targets realized as ip or IP in ALL FOCUS should be unchanged in NARROW FOCUS. If this is the case, we expect shorter vowel durations and lower f0 ratios in the ALL

FOCUS+SUBJECT-INTERNAL condition (where AP boundaries are predicted) compared to all five other conditions (where boundaries higher than AP are predicted). By contrast, we expect similar durations and f0 ratios in the NARROW FOCUS+SUBJECT-INTERNAL condition compared to the ALL FOCUS+NP/VP BREAK condition (since ip-boundaries are expected in both cases). According to the BOUNDARY PROMOTION HYPOTHESIS, the predictions for SUBJECT-INTERNAL conditions are the same: these should be realized as AP in ALL FOCUS and as ip in NARROW FOCUS. For locations that are realized as ip in ALL FOCUS, however, the BPH predicts that these should be realized as IP in NARROW FOCUS. Since IP is the highest possible level of phrasing for French, locations that are IP in ALL FOCUS are expected to remain IP in NARROW FOCUS under both hypotheses. The predictions for both the MDSH and the BPH are summarized in Table 2.

Table 2. Expected prosodic boundary strength by condition and hypothesis.

		ALL FOCUS	**NARROW FOCUS**	
			MDSH	**BPH**
SYNTAX	SUBJECT-INTERNAL	AP	ip	ip
	NP/VP BREAK	ip	ip	IP
	PARENTH. BREAK	IP	IP	IP

3 Results

A total of 252 target utterances were collected. Those containing disfluencies, hesitations, naming errors, or an unexpected syntactic structure were excluded, leaving 243 utterances that were used for analysis.

3.1 Vowel duration

Mean vowel durations by FOCUS and SYNTAX are shown in Table 3. Overall, vowel duration increases across the three levels of SYNTAX according to expected boundary strength, though the size of this effect appears to depend on the focus context. For SUBJECT-INTERNAL items, mean vowel duration was longer for NARROW FOCUS than for ALL FOCUS. In addition, mean vowel duration was shorter in the SUBJECT-INTERNAL+ALL FOCUS condition compared to all five other conditions as predicted by both hypotheses.

Table 3. Mean and standard deviation of vowel duration in milliseconds by condition.

		SYNTAX		
		SUBJECT-INTERNAL	NP/VP BREAK	PARENTHETICAL BREAK
FOCUS	ALL FOCUS	91 (42)	146 (49)	168 (63)
	NARROW FOCUS	126 (42)	143 (40)	150 (43)

Since the logarithm of vowel duration was more normally distributed than the untransformed values, the former were used for statistical comparisons. The distributions of the log transformed values are shown in Figure 4. Linear mixed effects comparisons were carried out using the *lmerTest* package (Kuznetsova et al., 2017) implemented in R (R Core Team, 2017). SYNTAX, FOCUS, and their interaction were introduced as fixed factors. Random effects in the model included random intercepts for participants and items, and random slopes for participants (see Appendix B.1). By-item random slopes for the two fixed factors were not included because these resulted in a model that did not converge. Residuals larger than 2.5 times the standard deviation were considered outliers and removed (3 items, 1% of the data). Significance was assessed using the two following criteria: t-values for the

estimate greater than 1.96, and p-values (based on Satterthwaite's approximations) less than or equal to 0.05.

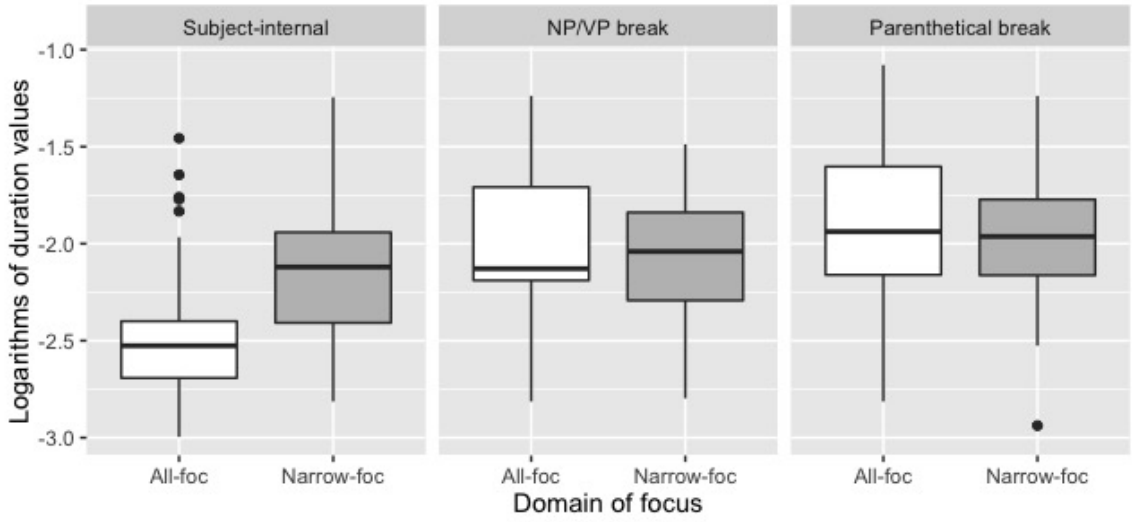

Figure 4. Boxplots of the logarithm of target vowel duration by condition.

This analysis revealed a significant main effect of SYNTAX (F=26.90, p<0.0001) as well as a significant FOCUS x SYNTAX interaction (F=7.96, p<0.0001). To interpret this interaction, the 2 x 3 factor design was converted into a 1 x 6 factor design including the maximum random structure (Appendix B.2). The contrasts of interest were obtained using the *glht* function of the *multcomp* package (Hothorn et al., 2008) and p-values were adjusted using Tukey corrections. The results reveal that the SYNTAX x FOCUS interaction was due to shorter vowel durations in ALL FOCUS+SUBJECT-INTERNAL compared to all other contrasts (p<0.05) except the contrast of ALL FOCUS+PARENTHETICAL BREAK versus NARROW FOCUS+SUBJECT-INTERNAL (z=3.24, p<0.05). Consistent with the predictions of both the MDSH and the BPH, for SUBJECT-INTERNAL items, vowels were longer for NARROW FOCUS than for ALL FOCUS (z=3.92, p<0.01), while the difference between NARROW FOCUS+SUBJECT-INTERNAL and ALL FOCUS+NP/VP BREAK was not significant (z=2.10,

p>0.20). Also consistent with the MDSH, but contrary to the BPH, there was no significant difference between ALL FOCUS+NP/VP BREAK and NARROW FOCUS+NP/VP BREAK (z=-0.83, p>0.20). In other words, FOCUS had no effect on vowel duration when the default boundary strength was predicted to be ip.

3.2 f0 ratio

Mean f0 ratios of H to H1 are shown in Table 4 by SYNTAX and FOCUS. In all but one condition, f0 ratios were within the range expected for an ip boundary based on previous findings (Michelas, 2011). For ALL FOCUS+SUBJECT-INTERNAL items, the mean f0 ratio closely approximates values previously found for AP boundaries. F0 ratios in the two PARENTHETICAL BREAK conditions were at or below 1.0, suggesting that the syntactic manipulation did not induce IP boundaries in those conditions.

Table 4. Mean and standard deviation of f0 ratio by condition.

		SYNTAX		
		SUBJECT-INTERNAL	NP/VP BREAK	PARENTHETICAL BREAK
FOCUS	ALL FOCUS	0.86 (0.06)	1.04 (0.18)	0.98 (0.19)
	NARROW FOCUS	0.98 (0.14)	1.01 (0.23)	1.00 (0.20)

Since the logarithm of f0 peak ratio was more normally distributed than the untransformed values, the former were used for statistical comparisons. The distributions of the log transformed values are shown in Figure 5. A linear mixed effects model included the log of H1/H as the dependent variable and SYNTAX, FOCUS, and their interaction as fixed factors. The model also included random intercepts for participants and items and random

slopes for participants. By-item random slopes for the two fixed factors were not included because these resulted in a model that did not converge. Residuals larger than 2.5 times the standard deviation were considered outliers and removed (13 items, 5% of the data).

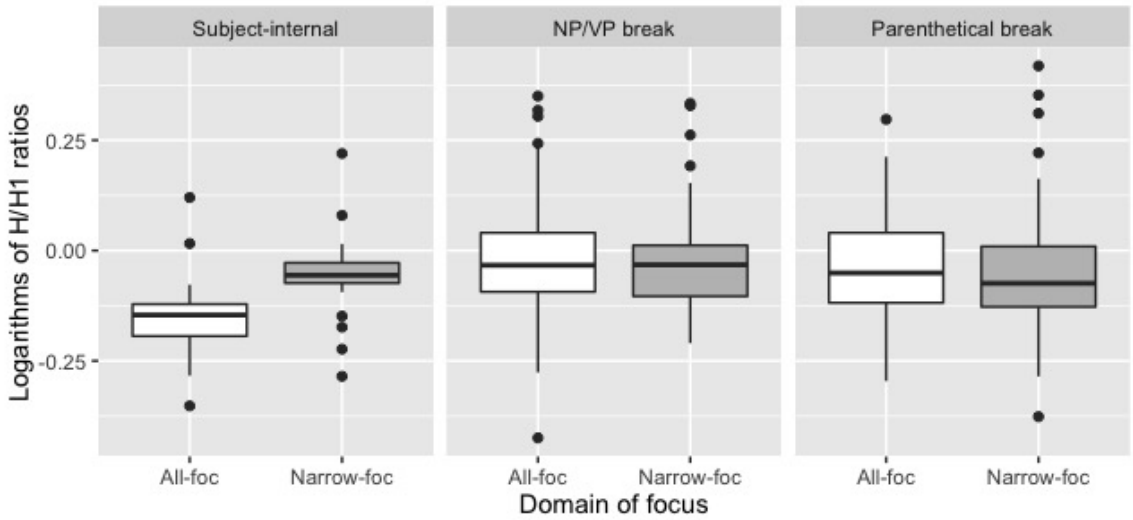

Figure 5. Boxplot of the logarithm of H/H1 ratio by condition.

The analysis revealed a significant main effect of SYNTAX ($F=19.37$, $p<0.05$), a significant main effect of FOCUS ($F=7.31$, $p<0.01$), and a significant SYNTAX x FOCUS interaction ($F=6.54$, $p<0.01$). To interpret this interaction, the same post-hoc procedure was used as for duration. As with the duration analysis, the SYNTAX x FOCUS interaction was due to lower ratios in ALL FOCUS+SUBJECT-INTERNAL compared to all other contrasts ($p<0.01$). Consistent with the predictions of both the MDSH and the BPH, for Subject-internal items, ratios were higher for NARROW FOCUS compared to ALL FOCUS ($z=3.89$, $p<0.01$), and the difference between NARROW FOCUS+SUBJECT-INTERNAL and ALL FOCUS+NP/VP BREAK was not significant ($z=1.52$, $p<0.20$). Consistent with the MDSH and contra the BPH, there was no effect of Focus for NP/VP BREAK items ($z=-0.37$, $p>0.20$). The ALL

FOCUS+PARENTHETICAL BREAK and NARROW FOCUS+PARENTHETICAL BREAK conditions did not differ from any other conditions ($p>0.20$) except ALL FOCUS+SUBJECT-INTERNAL ($z=3.97$, $p<0.001$ and $z=4.43$, $p<0.001$ respectively). This corroborates the findings for vowel duration that these items were likely realized with ip rather than IP boundaries.

3.3 Discriminant analysis

In the two sets of analyses above, the same pattern of results emerged: for SUBJECT-INTERNAL items, vowels were longer and f0 was higher in NARROW FOCUS than in ALL FOCUS. According to both the MDSH and the BPH, we expect this distinction to reflect two different levels of phrasing in the prosodic hierarchy, namely the AP and the ip. Categorical distinctions in boundary strength generally manifest through a combination of parameters (e.g., Streeter, 1978; Price et al., 1991). If the two sets of observations indeed reflect two different categories, then we expect them to be well-separated in a space defined by a combination of their phonetic correlates. To test this, we applied linear discriminant analysis to the vowel durations and f0 ratios of SUBJECT-INTERNAL tokens, using the two levels of Focus as the dependent variable. This method estimates how reliably group membership (i.e., (i.e., ALL FOCUS versus NARROW FOCUS) can be predicted on the basis of a strict separation by a linear (or planar) threshold in a space defined by one or more continuous parameters (i.e., vowel duration and f0 ratio). A score of 100% indicates that predictive accuracy is perfect – in other words, the groups have no overlap and can be perfectly separated by a line – while a lower score indicates that there is some overlap in their distributions. This makes it possible to assess whether the two groups could *in principle* be distinguished perceptually on the basis of the tested phonetic parameters alone. Additionally, by comparing the predictive accuracy of the full model (both parameters) against simplified

models (single parameter), it is also possible to assess the relative contribution of the individual parameters to overall group separation.

To adjust for large inter-speaker differences, speaker-standardized z-scores were used. Figure 6 shows the tokens from our corpus in a two-dimensional plane defined by z-score of duration values and z-scores of H/H1 ratios. Predictive accuracy was assessed using leave-one-out cross-validation, in which a single datapoint is used as a test set and the remainder of the data is used as the training set (Hastie et al., 2009). When both duration and f0 were included in the model, the posterior predictive accuracy of the resulting linear discriminant was 87.2%, indicating that the separation between the groups is robust. A binomial test confirmed that this rate is significantly different from chance ($p<0.0001$). The dashed line in Figure 6 represents the eigenvector of the linear discriminant, which means that the two groups had the best separation when projected normally onto a line having a slope of 4.62. Figure 7 shows the degree of overlap in the distributions of the two groups after each data point has been projected onto the eigenvector of the discriminant (dashed line in Figure 6). The distribution for the NARROW FOCUS items appears slightly bimodal, with a weak mode coinciding near the center of the distribution for ALL FOCUS ITEMS. This pattern suggests that a small number of NARROW FOCUS items were produced with the durational and F0 characteristics of an AP.

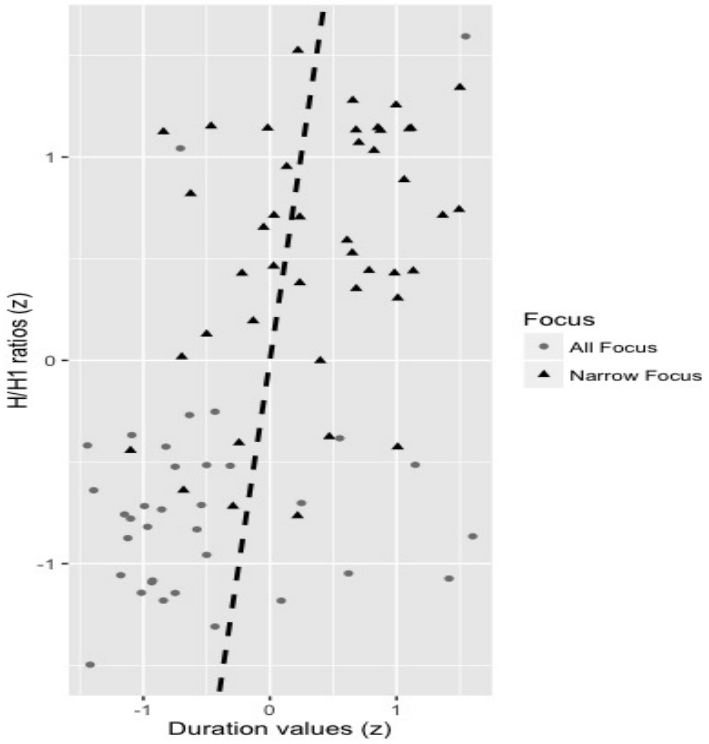

Figure 6. Scatterplot of target vowel duration and H/H1 ratios by boundary type. All values are standardized by speaker (z-score) and the dashed line represents the eigenvector of the linear discriminant.

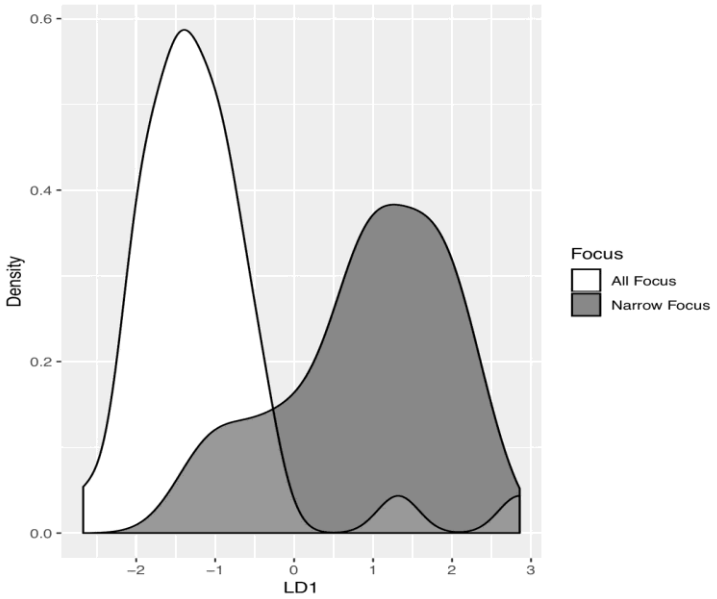

Figure 7. Density plot of the orthogonal projection of the data points in Figure 6 onto the eigenvector of the linear discriminant.

When vowel duration alone is included, the predictive accuracy of the resulting discriminant model is 76.9%, which is significantly different from the accuracy of the two-parameter model (i.e., 87.2% when both duration and f0 are included) according to a chi-square test ($\chi^2 = 4.87$, $p<0.05$). When f0 alone is included, the predictive accuracy is 88.5%, which is not significantly different from the accuracy of the two-parameter model ($\chi^2 = 0.21$, $p>0.20$). This result suggests that f0 ratio is responsible for most of the separation between the groups. Given that the groups are well-separated when the two phonetic parameters are combined as well as when f0 alone is included, these results support (i) the presence of two phonetically distinct boundary categories in the NARROW FOCUS+SUBJECT-INTERNAL versus the ALL FOCUS+SUBJECT-INTERNAL conditions, and (ii) the fact that f0 cues play a dominant role in distinguishing between these two categories.

4 Discussion

The first goal of our study was to test whether prosodic boundary strength is related to the right edge of focus constituents in a systematic way, and our results clearly confirm that this is the case. Specifically, we found that when a particular syntactic juncture is realized as an AP boundary under all-focus, that same position is generally realized as an ip boundary when it coincides with the right edge of a narrow focus constituent. This was supported by results for two different measures of boundary strength, namely vowel duration and f0 ratio. Furthermore, a linear discriminant analysis involving both measures suggests that these differences reflect the presence of two phonetically distinct categories.

The linear discriminant analysis showed that the dominant pattern for SUBJECT-INTERNAL+NARROW FOCUS items included an ip boundary at the right edge of the focus constituent. Nevertheless, Figure 7 suggests that a portion of these items were produced

with an AP boundary. While such instances do not strictly conform to our hypotheses, we suggest that they can be explained by the fact that participants may not have always been fully attentive or responsive to the intended focus pattern set up by the context. In other words, it is possible that they simply failed to mark narrow focus because they did not recognize it, and therefore produced the "default" ALL FOCUS pattern which involved only an AP boundary. This explanation amounts to a common type of experimental error which is to be expected, especially in a study like ours which seeks a reasonable compromise between ecological validity and control.

Given that a relationship exists between focus and boundary strength, a second goal of the study was to distinguish between two possible underlying mechanisms for that relationship. For NP/VP BREAK items, the MDSH predicts that the target juncture should be realized as an ip boundary, regardless of whether a focus edge is present, while the BPH predicts that the target juncture should be realized as ip in ALL FOCUS and as IP in NARROW FOCUS. Our results show no effect of focus condition for these items, and therefore favor the MDSH over the BPH. On that basis, we propose the generalized alignment (McCarthy & Prince, 1993) constraint in (5) which requires that the right edge of a focus constituent is aligned to the right edge of an ip. Since we assume Strict Layering, our constraint might also be paraphrased as "align the right edge of a focus constituent with a phrase boundary that is at least as strong as ip."

(5) ALIGN(FOC_R, ip_R): Align the right edge of a focus constituent with the right edge of an intermediate phrase.

We expected PARENTHETICAL BREAK items to be realized as IP boundaries. We know from Michelas (2011) that IP boundaries marked by H% are realized with H/H1 ratios

greater than one, and instead those items were realized with f0 ratios less than or equal to one. On that basis, it is clear that our speakers produced ip and not IP breaks for the Parenthetical Break targets, regardless of the focus context. This is surprising given previous findings of a strong correlation between parenthetical boundaries and IP boundaries in French (Michelas 2011; Michelas & D'Imperio, 2012; Avanzi, 2011). There are at least two possible reasons for this result. First, some previous studies (Michelas, 2011; Michelas & D'Imperio, 2012) used a standard reading task, whereas our study used a controlled but interactive task. This difference likely resulted in a less formal speaking style and/or a faster speech rate, both of which are associated with a reduced number of IP boundaries (Fougeron & Jun, 1998). Second, there is some evidence that parentheticals tend to include IP boundaries at their right, but not necessarily their left edge (Avanzi, 2011). Future studies are needed to better understand the specific conditions that give rise to IP boundaries in utterance non-final positions. Nevertheless, our results show that the presence of the right edge of a focus constituent is not one of those conditions.

Our findings rule out the BPH as a mechanism for marking the right edge of a focus. This suggests that general prosodic enhancement (c.f., Gussenhoven, 2004) is not an available strategy for marking focus in French, at least not in all contexts. This finding also has implications for the reliability with which focus can be signaled in situated communication in French. Under a BPH-type mechanism, the presence or absence of the right edge of the focus constituent is predicted to be marked more or less reliably by a phonological contrast in every case except when the default boundary strength is IP, a feature which was not supported by our findings. In such a situation, listeners would be able to recover the location of the edge of the focus constituent reliably for a relatively wide range of contexts. Under the MDSH, however, a contrast is available only in case the default

boundary strength is AP or lower. It is only in such a case, therefore, that the listener can reliably use boundary strength to identify the right edge of the focus. These findings are therefore in line with previous proposals that focus is marked in French through a combination of relatively weak or probabilistic cues (D'Imperio et al., 2012; Beyssade et al., 2015; German & D'Imperio, 2016).

At the same time, our study only considers one type of variability in phonological structure, namely prosodic boundary strength. Speakers and listeners, however, may have a variety of available strategies for communicating about the location and span of focus constituents, and only some of these may be necessary on any given occasion. In many cases, the preceding discourse context may even over-determine the focus structure of an utterance, to the extent that marking of focus through the introduction of additional structural complexity is not only unnecessary, but actually dispreferred (German et al., 2011). Additional studies are needed to assess the extent to which multiple 'weak' marking strategies are used in concert to ensure that the speaker-intended focus structure is reliably communicated to the listener.

Our findings also have implications for the phonological model of intonation in French. As mentioned in Section 1, the number and definition of phonological units in the prosodic system of French is still under debate. While the AP and IP levels have long remained quite uncontroversial, the ip-level has only more recently been put forward (Jun & Fougeron, 2000; Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014). In the present study, we conducted linear discriminant analyses to assess the goodness of separation between two groups of items, ALL FOCUS+SUBJECT-INTERNAL and NARROW FOCUS+SUBJECT-INTERNAL, which were predicted to be realized with AP and ip boundaries, respectively. The results showed that these two groups are phonetically very well-separated, providing strong

support for the presence of two phonologically distinct categories. Importantly, the NARROW FOCUS+SUBJECT-INTERNAL items were realized with acoustic properties that previous studies have shown correspond to the ip-level (Michelas & D'Imperio, 2012; D'Imperio & Michelas, 2014), in that H/H1 ratios were not greater than one. In that sense, our findings both corroborate the necessity of including an intermediate phonological unit in the prosodic hierarchy of French, and also contribute to the growing body of findings concerning the factors that contribute to the distribution of ips (esp., Delais-Roussarie et al., 2015).

Finally, it is worth noting that the discriminant analyses presented in Section 3.3 provide insight into the relative weighting of different acoustic cues in the marking of prosodic units. The predictive accuracy of the linear discriminant model was highly comparable whether f0 was used alone or both parameters were used together. Since we expected the distinction between the ALL FOCUS+SUBJECT-INTERNAL and NARROW FOCUS+SUBJECT-INTERNAL conditions to be manifest through a combination of both f0 and duration, this result is somewhat surprising. Nevertheless, this supports a recent proposal by Michelas & D'Imperio (2015) that "the relative weight of each type of cue depends on the level of the prosodic constituent in the hierarchy" (p. 142). In two perception experiments, the authors of that study asked participants to complete noun-phrases (e.g., *La nana du sauna* 'The girl who manages the sauna') which ended with either an AP or an ip boundary. The participants were then asked to choose whether the noun-phrases were likely to be followed by a prepositional phrase (e.g., *d'Héléna*'of Héléna') or instead by a verb phrase (e.g., *déconseille* 'advises against'). While duration cues were sufficient for participants to correctly complete a sentence fragment ending with an AP boundary, both duration and tonal cues were necessary to perceive and exploit the presence of an ip boundary. In line with this result, the

present research confirms that f0 cues are particularly important to the ip-level. Specifically, ip boundaries appear to be mainly defined by the relationship that LH* accentual peaks have within the phrase and provide information about the way in which APs are linked together.

5 Conclusion

The main question investigated in this study was whether in French the presence or absence of the right edge of a contrastive focus constituent is associated with differences in prosodic boundary strength. Our results show that this is clearly the case, though only for cases where an AP boundary normally occurs in all-focus contexts. Given that prosodic boundary strength is not sensitive to focus in other cases, this association does not represent a fully reliable strategy for marking focus. In line with other findings, this suggests that if focus marking is reliably communicated in French, it must involve a probabilistic integration of a variety of partially reliable cues.

STATEMENT OF ETHICS:

All participants gave written informed consent in accordance with the Declaration of Helsinki. The data were collected from the February 1, 2012 to the February 15, 2012 in the *Laboratoire Parole et Langage* in Aix-en-Provence, France. The study was approved by the local research institute committee: the experiment was classified as purely behavioral, and the testing involved no discomfort or distress to the participants.

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DISCLOSURE STATEMENT:

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS:

A.M. and J.S.G contributed to the design of the study, the analyses, the interpretation of the data and to the final manuscript. A.M. was responsible for all data collection.

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Appendix A. Experimental target sentences. Target NPs are underlined.

Key:
a. SUBJECT-INTERNAL
b. NP/VP BREAK
c. PARENTHETICAL BREAK

(1) a. Le jardin des Tuileries de Paris fut édifié à la demande de Marie de Médicis.
b. Le jardin des Tuileries fut édifié à la demande de Marie de Médicis.
c. Le jardin des Tuileries, dont on parle peu, fut édifié à la demande de Marie de Médicis.

(2) a. Le palais de l'Elysée de Paris fut édifié au 18ème siècle.
b. Le palais de l'Elysée fut édifié au 18ème siècle.
c. Le palais de l'Elysée, dont on a parlé hier, fut édifié au 18ème siècle.

(3) a. Le lycée du Fénélon de Paris fut l'établissement scolaire de Giscard d'Estaing.
b. Le lycée du Fénélon fut l'établissement scolaire de Giscard d'Estaing.
c. Le lycée du Fénélon, dont on a récemment parlé, fut l'établissement scolaire de Giscard d'Estaing.

(4) a. La cité du chocolat de Paris, coordonne plus de 250 concerts par an.
b. La cité du chocolat coordonne plus de 250 concerts par an.
c. La cité du chocolat, dont on a parlé à la télé, coordonne plus de 250 concerts par an.

(5) a. Le musée de l'opéra de Paris fut aménagé dans une ancienne gare.
b. Le musée de l'opéra fut aménagé dans une ancienne gare.
c. Le musée de l'opéra, dont on parle souvent, fut aménagé dans une ancienne gare.

(6) a. L'esplanade de Châtelet de Paris se trouve à côté du pont du même nom.
b. L'esplanade de Châtelet se trouve à côté du pont du même nom.
c. L'esplanade de Châtelet, dont on a souvent parlé, se trouve à côté du pont du même nom.

(7) a. Le quartier du Bagnolet de Paris, constitue le premier quartier d'affaire européen.
b. Le quartier du Bagnolet constitue le premier quartier d'affaire européen.
c. Le quartier du Bagnolet, dont il est souvent question, constitue le premier quartier d'affaire européen.

(8) a. La maison des écrivains de Paris, fait partie de la cité des sciences.
b. La maison des écrivains fait partie de la cité des sciences.
c. La maison des écrivains, dont les journaux parlent souvent, fait partie de la cité des sciences.

(9) a. Le café de Tortoni de Paris, fut le premier café littéraire.
b. Le café de Tortoni fut le premier café littéraire.
c. Le café de Tortoni, dont parlent les critiques, fut le premier café littéraire.

(10) a. Le théâtre de Bobino de Paris, fut longtemps le symbole du théâtre populaire.
b. Le théâtre de Bobino fut longtemps le symbole du théâtre populaire.
c. Le théâtre de Bobino, dont le programme a été refait, fut longtemps le symbole du théâtre populaire.

(11) a. Le marché de Villemain de Paris demeure un des plus grands marchés aux puces du monde.
b. Le marché de Villemain demeure un des plus grands marchés aux puces du monde.
c. Le marché de Villemain, dont les touristes raffolent, demeure un des plus grands marchés aux puces du monde.

(12) a. La villa de Sarkozy de Paris doit être estimée à 12 millions d'euros.
b. La villa de Sarkozy doit être estimée à 12 millions d'euros.
c. La villa de Sarkozy, dont Paris Match a parlé, doit être estimée à 12 millions d'euros.

Appendix B. Details of statistical analyses.

(1) Full linear mixed effects model for vowel duration:
lmer(logDuration ~ Syntax*Focus + (0 + Syntax | Speaker) + (0 + Focus | Speaker) + (1 | Speaker) + (1 | Item)

(2) Post-hoc linear mixed effects model for vowel duration:
lmer(formula = logDuration ~ Condition + (0 + Condition | Speaker) + (1 | Speaker) + (1 | Item)

Table B1. Post-hoc comparisons for the log of vowel duration.

Comparison	**z-value**	**p-value**
Subject-internal narrow-foc vs. subject-internal all-foc	3.92	<0.01
NP/VP break all-foc vs. subject-internal all-foc	6.10	<0.001
NP/VP break narrow-foc vs. subject-internal all-foc	5.34	<0.001
Parenthetical break all-foc vs. subject-internal all-foc	7.16	<0.001
Parenthetical break narrow-foc vs. subject-internal all-foc	6.79	<0.001
NP/VP break all-foc vs. subject-internal narrow-foc	2.10	0.28
NP/VP break narrow-foc vs. subject-internal narrow-foc	1.46	0.69
Parenthetical break all-foc vs. subject-internal narrow-foc	3.24	0.01
Parenthetical break narrow-foc vs. subject-internal narrow-foc	2.73	0.07
NP/VP break narrow-foc vs. NP/VP break all-foc	-0.83	0.96
Parenthetical break all-foc vs. NP/VP break all-foc	1.10	0.88
Parenthetical break narrow-foc vs. NP/VP break all-foc	0.49	1.00
Parenthetical break all-foc vs. NP/VP break narrow-foc	1.90	0.40
Parenthetical break narrow-foc vs. NP/VP break narrow-foc	1.28	0.79
Parenthetical break narrow-foc vs. parenthetical break all-foc	-0.61	0.99

(3) Full linear mixed effects model for f0 peak ratio:
lmer(logRatio ~ Syntax * Focus + (0 + Syntax | Speaker) + (0 + Focus | Speaker) + (1 | Speaker) + (1 | Item)

(4) Post-hoc linear mixed effects model for f0 peak ratio:
lmer(logRatio ~ Condition + (0 + Condition | Speaker) + (1 | Speaker) + (1 | Item)

Table B2. Post-hoc comparisons for the log of f0 ratio.

Comparison	z-value	p-value
Subject-internal narrow-foc vs. subject-internal all-foc	3.89	<0.01
NP/VP break all-foc vs. subject-internal all-foc	5.30	<0.001
NP/VP break narrow-foc vs. subject-internal all-foc	4.72	<0.001
Parenthetical break all-foc vs. subject-internal all-foc	3.97	<0.001
Parenthetical break narrow-foc vs. subject-internal all-foc	4.43	<0.001
NP/VP break all-foc vs. subject-internal narrow-foc	1.52	0.65
NP/VP break narrow-foc vs. subject-internal narrow-foc	1.09	0.89
Parenthetical break all-foc vs. subject-internal narrow-foc	0.19	1.00
Parenthetical break narrow-foc vs. subject-internal narrow-foc	0.63	0.99
NP/VP break narrow-foc vs. NP/VP break all-foc	-0.37	1.00
Parenthetical break all-foc vs. NP/VP break all-foc	-1.31	0.78
Parenthetical break narrow-foc vs. NP/VP break all-foc	-0.89	0.95
Parenthetical break all-foc vs. NP/VP break narrow-foc	-0.89	0.95
Parenthetical break narrow-foc vs. NP/VP break narrow-foc	-0.47	1.00
Parenthetical break narrow-foc vs. parenthetical break all-foc	0.43	1.00