Uncovering the role of the intermediate phrase in the syntactic parsing of French

Amandine Michelas[*], *Mariapaola D'Imperio*[*]

[*] Université Aix-Marseille I et Laboratoire Parole et langage, CNRS, Aix-en-Provence, France
michelas@lpl-aix.fr, mariapaola.dimperio@lpl-aix.fr

ABSTRACT

This study tested whether an Intermediate Phrase (ip) right boundary is interpreted by French listeners as cueing a major syntactic break (e.g. NounPhrase/Verb Phrase break) or also a weaker syntactic break (e.g. Noun Phrase internal boundary). Pairs of Noun Phrases, whose segmental structure was identical up to the sixth syllable, but differing in the potential placement of either an Accentual Phrase (AP) or an ip boundary at their right edge, were employed. In a two-forced choice completion task (Verb Phrase choice or Prepositional Phrase choice) participants gave more Verb Phrase responses (significantly different from chance) when an ip boundary was present in the stimulus relative to when only an AP boundary was present. This is taken as evidence that prosodic boundary level can influence the syntactic parsing early in the utterance. The authors discuss the implication of these results both for models of French prosodic structure and models of speech processing.

Keywords: Prosodic phrasing, speech processing, Intermediate Phrase, French Intonation

1. INTRODUCTION

Models of French intonation generally include two levels of prosodic phrasing i.e. the Intonational Phrase (IP) and a smaller constituent defined differently according to theories (*i.e.* syntactically defined: the Phonological Phrase [8], or tonally defined: the Accentual Phrase [4]). In fact, the last syllable of a word, immediately preceding an AP boundary is usually lengthened and appears to possess a great degree of prominence [3], [4], [9]. Recent studies [1] have shown evidence for an additional level of phrasing, i.e. the Intermediate Phrase, or ip, ranked between the AP and the IP. The ip right boundary appears to be cued through a phrase accent (H-) which is responsible for blocking downstep of subsequent pitch accents within the ip, as well as by greater preboundary

lengthening relative to AP-final syllables. As Figure 1a shows, the second pitch accent in the utterance is downstepped relative to the first, while when an ip boundary is present this is not the case (1b).
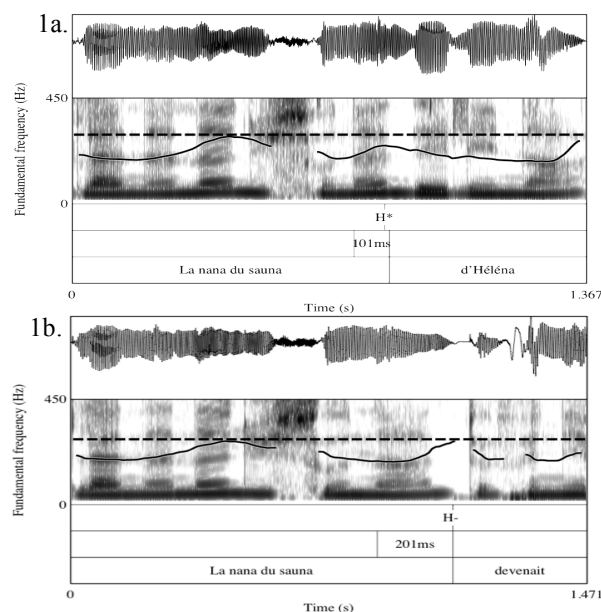

Figure 1. *f0* contour for two Noun Phrases extracted either from the sentence *La nana du sauna d'Héléna devenait insupportable* "The girl who managed Helena's sauna became really nasty" (upper, with an AP boundary) or (lower, with ip boundary); extracted from the sentence *La nana du sauna devenait insupportable* "The girl who managed the sauna became really nasty".

We also know that listeners are capable of taking into account preboundary cues in parsing processes. Prosodic boundaries cues are used to segment words [2], [5], [12] but also to perform syntactic analyses of spoken utterances [6], [7]. Specifically, adults appear to exploit major intonation boundary such as IP boundaries to resolve syntactic ambiguities [10], [11]. Recent studies have also shown that prosodic cues of lower level boundaries (i.e. Phonological Phrase boundaries) seem to be used in order to resolve syntactic ambiguities in French [6], [7], where

such prosodic units are defined according to syntactic algorithms. In a subsequent study, [5] it has been shown that the predictions of Prosodic Phonology [8] are not always met in the actual tonal structuring rendered by the speakers, since in French a single Phonological Phrase can be produced as either one or two APs. Moreover, it was crucially observed that when an AP break coincided with a major syntactic break (such as a Noun Phrase/Verb Phrase break) and when the phrase is sufficiently long (minimally two APs) the boundary is associated to a higher level of structure in the prosodic hierarchy (i.e. an Intermediate Phrase) cued by a greater amount of final lengthening and blocking of downstep between subsequent APs within the ip.

In this experiment we tested whether listeners would interpret an ip right boundary as cueing a major syntactic break (a Noun-Phrase/Verb-Phrase break). On the other hand, we expected than AP right boundary would only cue a weaker syntactic break (i.e., a Noun Phrase-internal boundary).

2. METHOD

Pairs of utterances, whose segmental structure was identical up to the sixth syllable, but differing in the potential placement of either an AP or an ip boundary at their right edge, were presented to listeners. Consider the following French utterances:

1a. **La nana]AP du sauna]AP** d'Héléna devenait vraiment méchante. "The girl who managed Helena's sauna became really nasty".

1b. **La nana]AP du sauna]AP/ip** devenait vraiment méchante. "The girl who managed Helena's sauna became really nasty".

If only the segmental material is taken into account, the two sequences are identical up to *sauna* 'sauna'. However, the prosodic characteristics of the second AP are different between the two utterances: (i) the last syllable of the 2nd AP shows a greater degree of preboundary lengthening in 1b than in 1a and (ii) the second AP is lowered in pitch relative to the first one in sentence 1a while this is not the case in sentence 1b because of the presence of an ip boundary (Fig1).

Participants listened to target sequences and were instructed to complete them in a two-forced choice task (Prepositional Phrase choice or Verb Phrase choice). We expected more VP-responses,

hence stronger syntactic break parsing, when an ip boundary was present in the stimulus relative to when only an AP boundary was present. In other words, we expected that listeners inferred the depth of the syntactic beaks in the grammatical structure (major syntactic break or minor syntactic break) depending on prosodic boundary cues they heard (AP vs. ip boundary cues).).

2.1. Speech material

20 pairs of utterances were constructed. In each pair, the target Noun-Phrase could either be associated with an AP boundary or an ip boundary. Noun phrases of each pair were segmentally identical up to the sixth syllable. The only difference between them was the prosodic characteristics of the second AP. Target Noun Phrases were always composed of two three-syllabic APs in Subject position.

Target syllables were always CV syllables. In the A-condition, target Noun Phrases were always followed by a Prepositional Phrase beginning with the preposition *de* "of". In the ip-condition, target Noun Phrases were always followed by a Verb Phrase beginning with the consonant /d/ (e.g. *d'Héléna* for the AP condition, *demandait* for the ip condition).

We also checked whether both completions (VP or PP) were plausible within the sentences. To do so, a group of 10 French participants read all experimental sentences and judged their overall plausibility on a 0 (completely implausible) to 7 (highly plausible) scale. Prepositional Phrase completions obtained the same result as Verb Phrase completions (mean of 6.1 for PP completions, 6.2 for VP completions).

A native speaker of French produced the utterances employed for the perception stimuli. The speaker was asked to read aloud the list of utterances at a self-selected normal rate. For each utterance the two authors checked if the speaker produced the expected prosodic parsing. We also measured duration and pitch of target syllables associated to AP and ip boundaries.

Duration analyses revealed that target lengthening was significantly longer in the ip condition than in the AP condition, $t(33) = 8.8$, $p < 0.0001$. The *f0* analyses revealed that the target syllable was produced with significant lower *f0* values when it was non-final within the ip (AP-condition) than it was (ip-condition), $t(31) = 8.7$, $p < 0.0001$.

On the basis of the utterances thus produced, two lists of sentences were constructed so that each member of a pair appeared in a different list. Half of the participants heard list 1 and the other half heard list 2. In each list, 40 distractor sentences, randomly cut at a word boundary, were added to the 20 experimental sentences.

2.2.   Participants and procedure

36 native speakers of French took part in the experiment, 18 in each block. Each participant was tested individually in a quiet room. Participants were seated on a computer screen with headphones. Instructions written on the screen informed them that they had to listen to a sentence beginning and had to complete it by choosing one of two possible sentence segments written on the screen.

Listeners were aware that both choices were plausible but were forced to choose the most appropriate response depending on the way the heard sequence was uttered. A trial began with the auditory presentation of a sequence and 2 seconds after the two completions appeared on the screen. Participants had to press either the right or the left button to indicate their choice. Before the experiment began, participants performed a 9-items training.

3.   RESULTS

Figure 2 presents the percentage of PP-responses and VP-responses in both AP and ip conditions.
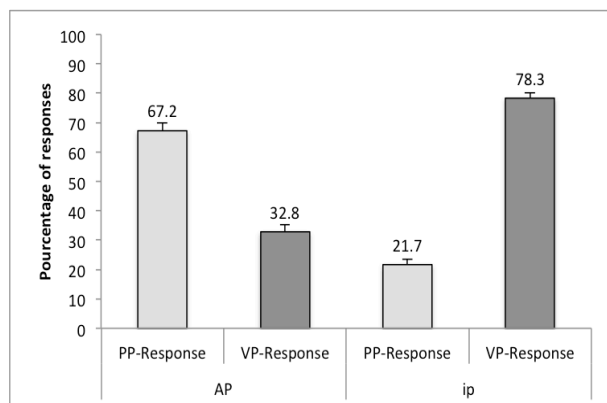

Figure 2. *Percentages of PP-responses and VP-responses for AP and ip conditions. Errors bars represent the standard error of the mean.*

Two analyses of variance (ANOVAs) were conducted on the percentage of responses, one with participants and one with sequence as random factors. The by-subjects ANOVA included two within-subject factors: prosodic boundary type (AP vs. ip) and responses type (PP-responses vs. VP-responses). The by-items ANOVA included two within-sequence factors: prosodic boundary type (AP vs. ip) and responses type (PP-responses vs. VP-responses).

The analysis showed a significant main effect of response type, since participants responded with more VP completions independent of boundary type $(F_1(1,35) = 6.6, p < 0.02; F_2(1,17) = 8.98, p < 0.008)$. Crucially though, the interaction between prosodic boundary type and response type was also significant, reflecting the fact that participants gave more PP responses for the AP boundary condition $(F_1(1,35) = 16.3, p < 0.0002; F_2(1,17) = 27.35, p < 0.0001)$ and more VP responses for the ip boundary condition $F(1,35) = 91.12, p < 0.0001$: $F_2(1,17) = 104.05, p < 0.0001)$.

4. DISCUSSION

The present experiment showed that French adults exploit prosodic boundary type (ip vs. AP boundaries) to infer depth of syntactic embedding. Listeners gave more VP-responses when an ip boundary was present in the stimulus relative to when only an AP boundary was present. This is taken as evidence that ip right boundaries were interpreted by listeners as cueing major syntactic breaks (such as Noun Phrase/Verb Phrase breaks) while AP right boundaries cue minor breaks (such as NP-internal breaks). These results have implications both for French intonation models and studies of speech processing.

Models of French Intonation generally include two levels of prosodic structure: a major prosodic level *i.e.* the Intonational Phrase and a lower level i.e. the Accentual Phrase while a recent production study [1] shows evidence for an additional level of phrasing (the Intermediate Phrase, ip) ranked between the AP and IP. This level of phrasing appears to be sensitive to syntax/prosody alignment constraints. If we postulate that only an AP right boundary would be present at the end of the utterance segment employed in our study, we would not be able to explain why participants were able to provide significantly different completions. Note that we obtained more VP-completions (78.3% of responses) than PP-completions (21.7% of responses) when an ip boundary was present in the stimulus relative to when only an AP boundary was present. This is taken as evidence that

prosodic boundary level (AP vs. ip) can influence the syntactic parsing of utterances and support the existence of an intermediate level of structure in the French prosodic hierarchy.

Moreover, in line with recent studies [6], [7], our results indicate that prosodic cues inform the first stage of syntactic processes by guiding the generation of syntactic parsing. The question of when prosodic information intervenes within the syntactic process is still unclear in the literature. One of the primary methodologies used to address the question of syntactic analysis of spoken utterances is to study the processing of sentences containing syntactic ambiguities. When participants are faced with ambiguous sentences that allow multiple structures to be built, the parsers encounter problems in assigning syntactic structure. The prosodic cues must be activated in the first stage of speech treatment or at a later stage when the syntactic parser detects the ambiguity to resolve. In our study, the data did not contain a clear ambiguity. When participants heard a sequence, which is cut after the sixth syllable and could be associated either to an AP or an ip boundary, they were capable to build expectations about the syntactic category of incoming sequences (a Verb Phrase vs. a Prepositional Phrase). This shows that prosodic boundaries cues are generally employed to guide the first steps of syntactic analyses. In other words prosodic cues are not only used when the syntactic parser faces an ambiguity. Rather listeners interpret those cues as soon as they hear them in order to guide syntactic parsing.

In addition, in previous studies [6], [7], prosodic units were defined according to the predictions of Prosodic Phonology. However, we know that these predictions are not always met in the actual tonal structuring rendered by speakers. In this experiment we tested the effect of phonetic and phonological properties of Accentual Phrases and Intermediate Phrases defined through both temporal and tonal structure. Our results suggest that acoustic cues associated to different boundary levels (AP vs. ip) influence in a different way the syntactic analysis of utterances at early stages of the treatment. The next step will be to investigate the role of each acoustic cue (duration or tonal cues) independently of each other, by using resynthesized speech. This will allow us to precisely determine which acoustic cues are relevant in the perception of an ip boundary, relative to either AP or IP boundaries.

5. CONCLUSION

Results from a sentence completion study show that in French prosodic cues related to either an ip or an AP boundary can facilitate syntactic processing. Major syntactic boundaries are more frequently parsed when an ip boundary is present in the stimulus heard that when a lower (AP) boundary is present. This result is taken as additional evidence for the existence of an intermediate level of phrasing in French (the ip) as well as for the active role of prosodic cues in early stages of syntactic parsing.

6. REFERENCES

[1] D'Imperio, M., Michelas, A. 2010. Embedded register levels and prosodic phrasing in French. *Proceedings of the V Speech Prosody Conference*, Chicago, USA.

[2] Christophe, A., Peperkamp, S., Pallier, C., Block, E., Mehler, J. 2004. Phonological phrase boundaries constrain lexical access: I. Adult data. *Journal of Memory and Language*, 51, 523-547.

[3] Hirst, D., Di Cristo, A. 1984. French intonation: a prametric approach. *Die Neuren Sprach*, 83(5), 554-569.

[4] Jun, S.A., Fougeron, C. 2000. A phonological model of French intonation. In A. Botinis (Eds.), Intonation: Analysis, modelling and technology. Kluwer Academic Publishers: Boston, MA, 209-242.

[5] Michelas, A., D'Imperio, M. 2010. Accentual Phrase boundaries and lexical access in French. *Proceedings of the V Speech Prosody Conference*. Chicago, USA.

[6] Millotte, S., René, A., Wales, R., Christophe, A. 2008. Phonological phrase boundaries constrain the on-line syntactic analysis of spoken sentences. *Journal of Experimental Psychology: Learning Memory and Cognition*, 34, 874-885.

[7] Millotte, S., Wales, R., Christophe, A. 2007. Phrasal prosody disambiguates syntax. *Language and Cognitive Processes*, 22, 898-909.

[8] Nespor, M., Vogel, I. 1986. *Prosodic Phonology*.Dordrecht: Foris.

[9] Pasdeloup, V. 1990. *Modèle de règles rythmiques du français appliqué à la synthèse de la parole*, Doctoral Dissertation, Université de Provence.

[10] Schepman, A., Rodway, P. 2000. Prosody and parsing in coordination structures. *The Quarterly Journal of Experimental Psychology*, 53A(2), 377-396.

[11] Schafer, A. J., Speer, S. R., Warren, P., White, S. D. 2000. Intonational disambiguation in sentence production and comprehension. *Journal of Psycholinguistics Research*, 29(2), 169-182

[12] Spinelli, E., Nicolas, G., Meunier, F. and Welby, P. (2010). , "An Intonational Cue to Word Segmentation in Phonemically Identical Sequences". Attention, Perception and Psychophysics, 72(3).