Accentual Phrase Boundaries and Lexical Access in 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

In French, a phonological phrase (PP) can either be isomorphic with an accentual phrase (AP, [1]) or else be produced as two separate APs, when possible. The PP has also been recently found to be directly involved in lexical access processing [2], in that a PP boundary might remove a temporary lexical ambiguity. In a set of two experiments, we show here that a temporary lexically ambiguous sequence can also be removed by the presence of an AP boundary. Specifically, reaction times for word monitoring were faster for ambiguous sequences when an AP boundary was present. These results suggest that tonal cues and other phonetic/phonological properties of the auditory stimuli have an impact on word recognition and must be considered for lexical access in French.

Index Terms: speech segmentation, lexical access, prosodic boundary, Phonological Phrase, Accentual Phrase, French.

1. Introduction

For many recognition models, the word recognition process consists of resolving a competition between several potential lexical candidates. Words that are phonologically consistent with the acoustic signal of the input are activated (see [3] for a review), and partial input is often consistent with several word interpretations. For instance the sequence [vi] in French is temporary ambiguous as being word initial in either *vipère* /vipɛʁ/ (‘*viper*’) and *virée* /viʁe/ (‘drive’).

However, the acoustic signal also contains cues deriving from the presence of potential prosodic boundaries. These boundaries can significantly alter the phonetic representation for the same lexical item. For instance, in French, the last syllable of a word, immediately preceding an accentual phrase boundary (AP), can be lengthened and appears to possess a great degree of prominence [1]. We know that listeners are capable of taking into account such cues in word segmentation. For example, Bagou et al. [4] showed that Swiss French listeners use lengthening of AP-final syllables and F0 rises to detect words in an artificial language. Spinelli et al. [5], [6] showed that tonal cues can help listeners find word beginnings in the speech stream. Thus the activation of a lexical candidate also depends on how well the phonetic realization matches input representation. Although the influence of prosodic boundaries on lexical competition between candidates has been shown (see for example [7]), word recognition models refer only to the phonemic overlap between the input and the potential lexical candidates.

Moreover, the domain within which segmentation strategies operate across languages is still unclear. Christophe et al. [2] proposed that segmentation strategies operate within a domain smaller than the utterance, yet larger than the lexical word in French, i.e. the phonological phrase (PP). As Christophe et al. showed, a phonological phrase boundary (as in le *chat grimpait* /ləʃa/$_{PP}$ /gʁɛ̃pe/$_{PP}$ ‘the cranky cat climbed up’) can remove a temporary lexical ambiguity with the word *chagrin* (‘sadness’) in French. This ambiguity would instead remain within a PP, even across prosodic word boundaries, as supported by reaction time data in a word monitoring task. According to Prosodic Phonology theories, such as that proposed by Selkirk [8], the right boundary of a phonological phrase can be aligned with the right edge of a major syntactic phrase boundary. A PP can have internal phonological properties, such as being the domain of sandhi phenomena. On the other hand, a tone unit such as the AP can either be isomorphic or non-isomorphic with a syntactically, edge-based PP grouping. In French [9], an AP is typically characterized by a final rise (LH*) and an optional initial rise (LHi). Generally, an AP has approximately the size of a PP, but AP (defined according to tonal cues) and PP (defined in syntactic terms) boundaries do not necessarily overlap. AP boundaries strictly depend on the number of final rises (LH*) actually produced by the speaker. For instance in the sentence *Je crois que Marie t'a parlé des pins somptueux de cette forêt* (‘I think that Mary told you about this forest's sumptuous pine trees’), the noun phrase (NP) *pins somptueux* (‘sumptuous pine trees’) can be pronounced as either one or two APs according to several factors such as speech rate [10] or speaking style (see Figure 1).

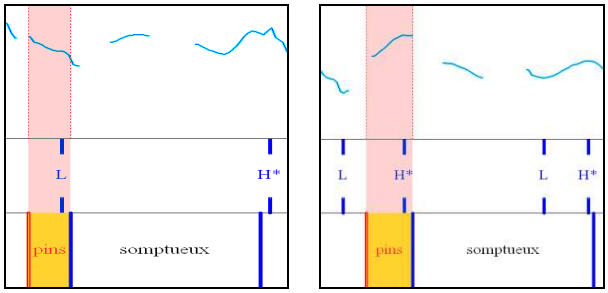

Figure 1 : *F0 curves of the noun phrase (NP) pins somptueux (‘sumptuous pine trees’) produced as either 1 APs (left) or 2 APs (right) excised from the utterance Je crois que Marie t'a parlé des pins somptueux de cette forêt.*

As mentioned above, tonal cues and other phonetic/phonological properties of the auditory stimuli do appear to have an impact on lexical access in French. Hence, we specifically predicted that the final F0 rise characterizing a LH* as well as the rhyme lengthening associated with an AP-final boundary in French would influence lexical access. We questioned whether PP and AP boundaries induce the same effect in removing temporary lexical ambiguity. Specifically we predicted that: 1. lexical access would be slower for items containing a local ambiguity at a prosodic word (PW) boundary than for items without lexical ambiguity; 2. as in Christophe et al. [2], PP boundaries would speed up the lexical decision task, and crucially that 3. AP boundaries would induce the same facilitatory effect.

2. Method

2.1. Corpus

In order to separately study the influence of PP and AP boundaries we employed potentially ambiguous sentences. We specifically predicted that, in a word monitoring task, participants will be slower in detecting the word *pins* ('pine trees') in items such as (1) than in items such as (2), because of the presence of a temporary lexical ambiguity (*pin* /pɛ̃/] can be temporarily ambiguous with the competitor *pinsons* ('finches') because of the following word *somptueux* /sɔ̃ptyø/.

(1) Je crois que Marie t'a parlé des pins somptueux de cette forêt.
'I think that Mary told you about this forest's sumptuous pine trees.'
Ambiguous: competitor *pinsons* /pɛ̃sɔ/

(2) *Je crois que Marie t'a parlé des pins luxuriants de cette forêt*
'I think that Mary told you about the somptuous pine trees of this forest.'
Non-ambiguous: no word starts in French with /pɛ̃ly/

We ran a set of two experiments using a similar experimental protocol to the one employed by Christophe et al. [2]. In Experiment 1, we focused on the temporary lexical ambiguity which occurs at two types of prosodic boundaries (i) at a PP boundary and (ii) at prosodic word boundary (PW). In Experiment 2, we studied the effect of lexical ambiguity associated with (i) a PW boundary vs. (ii) an AP boundary, neither of which overlapped with a phonological phrase (PP) boundary. The different prosodic conditions in each experiment are shown in Figure 2.

EXPERIMENT 1

	PW boundary	PP boundary
Ambiguous	…[sur ce **CHAT lé**gendaire]PP… **H***	…[son beau **CHAT**]PP [**lé**chait]PP… **H*** **H***
Non ambiguous	…[sur ce **chat fa***buleux]PP… **H***	…[son beau **CHAT**]PP [**mor***dait]PP… **H*** **H***

EXPERIMENT 2

	PW boundary	AP boundary within a PP
Ambiguous	…[des **PINS som**ptueux]PP… **H***	…[(des **PINS**)AP (**som**ptueux)AP]PP… **H*** **H***
Non ambiguous	…[des **PINS lu***xuriants]PP… **H***	…[(des **PINS**)AP (**lu***xuriants)]AP]PP… **H*** **H***

Figure 2: *Sample of corpus utterances, with prosodic condition crossed with ambiguity.*

For each experiment, 24 pairs of experimental sentences were constructed. In each pair one member contained a temporary lexical ambiguity. Target position within the sentence was kept constant. The sentences had a Subject Verb Object structure and were produced as all-focus utterances, all matched in number of syllables. The first part of the sentence was constructed in such a way that it did not semantically favor the activation of either the target word or its competitor (neutral preceding context). Ten native speakers of French judged the plausibility of the sentences on a scale from 0 (completely plausible) to 10 (highly plausible). Sentences containing competitors were all found to be plausible (mean rating: 6.2).

All noun phrases (NP) were composed of preposition+(determiner)+ noun + adjective and were matched in number of syllables. In both experiments, the noun phrase of the Prosodic Word (PW) boundary condition was always produced as a single AP with a clear final rise (LH*) plus preboundary lengthening. In Experiment 1, PP boundary utterances always contained a LH* on the last syllable of the target word and another LH* associated to the last syllable of the following verb, so that PPs boundaries always overlapped with APs boundaries. In Experiment 2, within AP boundary utterances, the targets NPs were always produced as two APs within one PP so that PP boundaries never overlapped with AP boundaries.

The target word was always a monosyllabic word. The following word was necessarily different in the ambiguous and non-ambiguous conditions, although it was matched in number of syllables and frequency (ambiguous vs. non-ambiguous, for experiment 1, mean frequency: 8.3 vs. 7.6, $t(23)<1$; for experiment 7 vs. 7.7, $t(23)<1$). Frequencies were obtained from the database Lexique 2, [11]. We also obtained the frequencies of words following the target in both experiments to ensure that the following context would not influence participants' decisions in the two conditions (ambiguous vs. non-ambiguous; for Experiment 1, following word mean frequencies: 8.3 vs. 7.6, $t(23)<1$; for Experiment 2, 7 vs. 7.7 $t(23)<1$). Finally we also computed diphone statistics in order to verify whether the diphone spanning the word boundary (e.g. /al/ in *ch<u>at lé</u>gendaire*) was more likely to occur within a word or at a word boundary. For both experiments, we observed that, independently of the ambiguity, the diphones were more likely to occur at a word boundary than within a word (within a word vs. at a word boundary mean frequencies, for Experiment 1, 0.002 vs. 0.004 $t(47)=-5.7$, $p<0.0001$; for Experiment 2, $t(47)=-13$, $p<0.0001$). In both experiments 96 fillers were added to the 48 experimental sentences.

A 25-years old female, native speaker of French read all sentences 6 times at normal speech rate. We examined f_0 curves through Praat [12] in order to select utterances which best corresponded to our prosodic conditions. In this way we obtained 24 natural speech sentences for the PW condition of both experiments and 24 natural speech sentences with a clear LH* associated with the last syllable of the target word for the PP and AP conditions of Experiments 1 and 2.

The selected experimental sentences were interspersed with fillers in 4 blocks. These 4 blocks were built with the following constraints (i) each target word appeared only once in each block (ii) each block contained sentences of each level for each condition (ambiguity with two levels: ambiguous and non-ambiguous and prosodic boundary with two levels: PW and PP for Experiment 1 and PW and AP for Experiment 2). Within each block, order of presentation of the sentences was random and different for each subject. The blocks were presented to participants following a Latin square design. This process was intended in order to neutralize a potential list effect. In this way, participants heard only 12 experimental sentences (3 for each level of each condition) and each target word was heard only once.

2.2. Procedure

40 native speakers of French took part in each experiment. In both experiments, the task was a word-monitoring task. Participants were tested individually in the sound proof room of the *Laboratoire Parole et Langage (U. of Provence)*. Participants were seated in front of a computer. Items were presented over Sennheiser HD 212 Pro headphones at a comfortable listening level. Participants were instructed to click a button as soon as they heard the target word in the utterance. The target words were first visually presented and the sentences were played over the headphones at a comfortable sound level after one second while the computer

screen was left blank. Before the experiments began, participants listened to a few sentences to test the material and the procedure. Reaction times where recorded relative to target word onset.

3. Results

Out of 48 utterances used for each experiment, 46 were retained. Two items were excluded because participants systematically answered before the beginning of the target word onset. Incorrect responses (no response or response before the beginning of the target word) were removed (for Experiment 1:1.52%; for Experiment 2: 2.61%). Because of the intrinsic variability in word duration, RTs were corrected by subtracting the duration of each target word from the RT for the word. For each subject and experiment, both RTs longer than 1200 ms and those greater than 2.5 standard deviations above the participants' overall response time relative to target word offset were removed from the latency analyses (for Experiment 1:5.15%; for Experiment 2:7.59%). Results in each condition for the two experiments are presented in Figures 3 and 4.

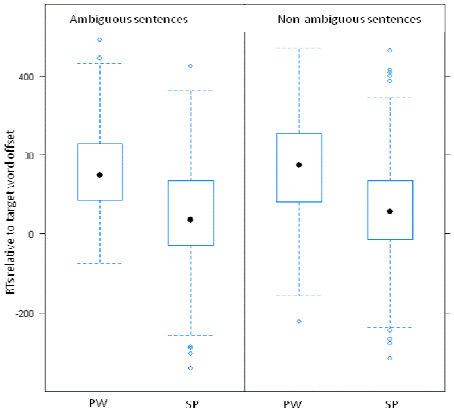

Figure 3: *Reaction times for Experiment 1. Interaction between the two fixed factors (Ambiguity and Prosodic boundary). PW = prosodic word; PP = phonological phrase.*

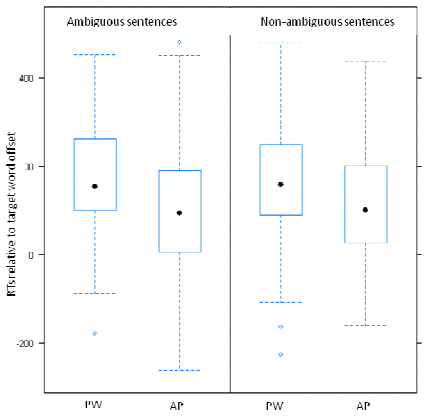

Figure 4: *Reaction times for Experiment 2. Interaction between the two fixed factors (Ambiguity and Prosodic boundary). PW = prosodic word; AP = accentual phrase.*

Mixed model analyses were conducted for both experiments with ambiguity (ambiguous/non-ambiguous) and prosodic condition (PW and PP for Experiment 1; PW and AP for Experiment 2) as fixed effects and participant and target word as random effects.

Mixed models showed that there is no significant effect of temporary lexical ambiguity (independent of prosodic condition) in neither experiment 1 nor 2 (for Experiment 1, t=-0.900, p=0.3687; for Experiment 2, t=-1.305, p=0.1926). However the reaction time analyses revealed a significant main effect of Prosodic boundary for both experiments (for experiment 1, t=-8.114, p<0.0001, effect size: 115ms; for experiment 2, t=-9.584, p<0.0001, effect size: 61ms). In experiment 1, participants responded earlier when a PP boundary was associated with the end of the target word, and the same effect was obtained for the AP boundary condition in experiment 2. In both experiments, the interaction between the two fixed effects was not significant (for experiment 1, t=1.374, p=0.172; for experiment 2, t=1.694, p=0.091). The data analyses showed that the percentage of responses given before the target word offset ("early responses") was preferentially matched with long target words and fit well with reaction times distribution. Thus early responses did not necessarily correspond to errors. The percentage of early responses for each experiment is shown in Figures 5 and 6.

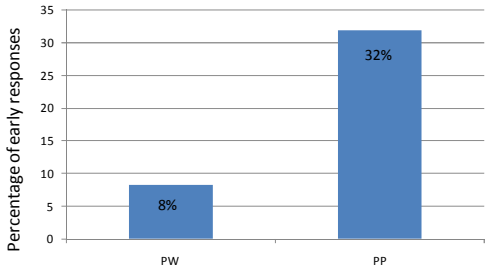

Figure 5: *Percentage of early responses for experiment 1 in PW and PP condition.*

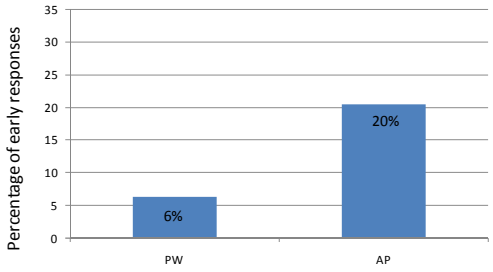

Figure 6: *Percentage of early responses for experiment 2 in PW an AP condition.*

4. Discussion

In the two experiments presented here, the effect of a temporary ambiguity on lexical access was not observed, which runs counter to the results of [2]. Specifically participants did not respond more slowly to the target word in context where the local ambiguity occurred at a PW boundary. Different from Christophe et al.'s study, these results suggest that the acoustic/prosodic cues at PW boundary may be sufficient in removing lexical ambiguity. However the absence of ambiguity could be partly explained by the fact that our fillers did not contain possible competitors to the target words (i.e. words in which the target would be embedded, such as *CHApeau* /ʃapo/ 'hat' if the target were *CHAT* /ʃa/ 'cat') therefore ambiguity was only potential and not explicitly reinforced by the experimental design. The absence of such

items could partly explain our fast reaction times (compared to [2]) and the absence of an ambiguity effect.

Nevertheless, irrelevant of ambiguity, results show that participants respond earlier than in PW condition when the target word is followed by either a PP (Experiment 1) or an AP boundary (Experiment 2). These results suggest that participants exploited prosodic boundary cues in order to segment speech as already proposed in the literature for several languages (see [13] for French). This is in line with Christophe et al's main findings suggesting that prosodic structure might influence lexical activation online. Crucially, AP boundaries appear to behave similarly to PP boundaries in speeding up lexical activation, independent of the presence of a syntactic constituent boundary. These results showed that the AP-final rise (LH*) plus preboundary lengthening associated with an AP-right boundary [1] can influence lexical decision.

These results have implications both for the linguistic definition of prosodic units and for models of lexical access. First, our results show that tonal and duration cues have to be taken into account in the definition of prosodic units, which are not entirely dependent on syntactic phrasing. Although the results of Christophe et al. [2] suggested that the PP (defined in syntactic terms according to prosodic phonology) constrains lexical access, our results indicate that the AP boundary (defined taking into account both prosodic cues and syntactic constrains) speeded participant responses in a cross-modal monitoring task. Analyses of percentage of responses given before the offset of the target word confirmed this AP boundary effect.

The comparison between the early responses obtained in Experiments 1 and 2 seemed to indicate that the effect of AP boundary is reinforced when the syntactic structure is aligned with the prosodic structure. Specifically we predicted that when an AP boundary is aligned with a major syntactic break, such as the boundary between an NP subject and a VP (as it was the case in PP condition of Experiment 1) the effect of the boundary would be reinforced. This hypothesis is in line with recent studies on the prosodic hierarchy in French, which support the existence of an intermediate level of phrasing between the AP and the Intonation Phrase (IP) [14], [15], i.e; an intermediate phrase (ip). In fact, an ip can occur within all focus utterances when the right edge of a prosodic boundary is aligned with the right edge of a major syntactic break [15].

Second, our results also have an impact on models of lexical access. The domain within which segmentation strategies operate is still unclear. Christophe et al. have proposed that segmentation strategies might operate within the Phonological Phrase domain in French. Since we did not find an ambiguity effect, we cannot distinguish between domain hypotheses at this point. However, our results offer new insight about how and when prosodic information intervenes within the lexical access process. Two possible roles of prosodic information in the lexical process have been proposed: (i) prosodic cues are called upon to help in removing ambiguities when segmental cues are not sufficient to recognize a word (ii) prosodic cues are activated in parallel with the other cues (segmental/acoustic/semantic/syntactic etc…) during lexical activation process.

Our results, in line with Christophe et al. findings support the idea that prosodic boundaries are among the cues that contribute, in parallel with other cues, to the activation of lexical candidate since prosodic boundaries speed up participant responses even if there is no ambiguity in the utterance. While our results suggest that prosodic boundaries cues are computed at the same time as lexical activation and can influence it, additional studies are necessary to examine whether the prosodic information is computed simultaneously with a segmental analysis or if they are encoded in the lexical representations themselves.

5. Conclusion

In this study we have shown that AP boundaries can induce the same facilitation on lexical retrieval as PP boundaries. AP boundaries appear to speed participants' responses in a cross-modal word monitoring task. This suggests that both duration and tonal cues to prosody need to be controlled separately from syntactic structure in order to assess the role of phrasing in lexical access strategies. The results also support the hypothesis of an active role of fine phonetic detail in candidate activation mediated by rich lexical representations. Finally, since the PP boundary was accompanied by specific tonal and duration cues that might differ from mere AP boundary cues, the study indirectly supports the existence of the ip in French.

6. References

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