DETECTING GHOST PHONEME : THE "LIAISON ENCHAÎNEE" IN FRENCH

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ABSTRACT

This paper presents 2 experiments in which the detection of latent consonant of the "liaison enchaînée" in French is observed. Results suggest that the specific phonological nature of this segment impedes the subjects in locating word's boundaries. Apparently, they do not treat the words one by one in a strictly left-to-right parsing but rather use the phonological organisation of the speech stream to find word boundaries.

Key-words: Psycholinguistics, Speech Segmentation, Prosody.

1-SEGMENTATION AND "LIAISON ENCHAÎNEE" IN FRENCH.

"Understanding" spoken language is first of all a process of recognition of discrete words in continuous speech signal. This means that the hearer must locate the boundaries between words of each utterance that he hears. Now, contrary to a written text where words are isolated by blanks, speech signal does not comprise clear and systematic cues signalling the beginning and the end of a word. This is particularly true for French language in which the phonological phenomenon of "liaison enchaînée" (Encrevé, 1988) can remove the left boundary of word beginning with a vowel.

The "liaison enchaînée" consists of the following double phenomenon: when two vowels are in contact at a word boundary, a latent consonant appears at the boundary between the two words and it is resyllabicated at the attack of the second word: ie "bon ami" (good friend): "bon ami" when the words are produced separately, but "bon ami" when they appear together (Figure 1).

One can assume that this fact creates a difficulty for the segmentation process. How can a hearer locate the left boundary of a word when this word he has to access, has on the attack of the first syllable, a consonant that does not belong to its deep representation. In other words, how can the hearer treat this latent consonant on-line, how can he recover [b] and [ami] in the following utterance [bonami] which would be syllabificated as following: [b] [b] [ami]?

In the following experiments we observed how the hearers resolve these questions during their perception of continuous speech.

2-EXPERIMENTS

2-1: Experiment 1

Because of the actualisation of the latent consonant on the attack of the first syllable of the word "ami" in "bon ami", the hearer must recognize on-line the specificity of this latent consonant in order to avoid a wrong segmentation (ie "bō nanem"). In order to test if the hearer should show particular sensitivity with regard to this specific consonant, we used the Generalized Phoneme Detection (GPD) proposed by Fraunfelder & Segui (1989). This task consists in detecting target phonemes that might appear anywhere in an utterance. Thus, the subjects do not know where the target phoneme can appear. They cannot build a "expectation strategy" based on the place of the target in the word. The assumption was the following: if the subjects show a greater difficulty in detecting the phoneme (ie "n") in "un bon navire" [bō naniv] than in "un bon navire" [bō navir], this means that this segment must be treated specifically and must be distinguished from the initial consonant. Consequently, this means that this kind of boundary requires a specific process which permits to remove the ambiguity. On the contrary, if there is no difference of treatment between initial consonants and liaison consonants, this might suppose that the subjects are not sensitive to the specificity of this segment.

Materials

8 pairs of sentences were built: each comprising one item with /l/ as initial phoneme and one with /l/ as liaison phoneme (i.e. "un grand éléphant"/"un grand téléphone"). They were inserted in test sentences. Test sentences were inserted in two lists of 70 sentence fillers. Half of them contained the target either at the beginning of the word (tapis), or inside the word (tapi), or in the end of the word (Colette). Each sentence contains only a target phoneme /l/. There was also 20 practice items. Half of them contained liaison /l/.

Procedure

Sentences were read by a masculine speaker who did not know the aim of the experiment so that he should produce the liaison /l/ in a completely natural way. They were recorded on a REVOX 516 and digitized on Macintosh SII. On a second channel, inaudible for the subjects, clicks were placed on the burst of the stop consonant targets. These clicks triggered a clock, which was stopped by the subject's keypress response. The burst of the stop consonants were watched on a spectrogram.

Subjects

The subjects were 23 undergraduate students from the University of Paris V. They were French native speakers without any known hearing disabilities.

Results

For the analysis of the data, the reaction times below 100 milliseconds and those above 2,000 milliseconds were eliminated.

<table>
<thead>
<tr>
<th></th>
<th>RT</th>
<th>Init /l/</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>619</td>
<td>573</td>
<td>46</td>
</tr>
<tr>
<td>% miss</td>
<td>7.8%</td>
<td>4.6%</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Reaction times (RT) in milliseconds and missing percentage (% miss) in detection of the target /l/ in pairs like "un grand éléphant" (liaison /l/) and "un grand téléphone" (init /l/).

A Student test was performed taking the initial /l/ liaison condition as random factor. The t values are given for subjects (t) and for items (t'). The analysis shows a significant difference of reaction times between the initial condition and the liaison condition for items (t(1,8) = 2.87, p = 0.02) as for subjects (t(1,19) = 2.89, p = 0.0099).

Discussion

The results confirm the assumption that we have formulated above: the liaison consonants have been detected.
more slowly than the initial ones. The process of this kind of segments is apparently more complex than the monitoring of initial phonemes. In "un grand élaphe" [gratelefe], the resyllabification of the consonant induces some ambiguity with respect to the boundary. The subjects have a great difficulty to remove this ambiguity in order to be able to locate the left boundary and to access the word "éléphant" because of the realization of /l/ at the beginning of the word.

As we have seen, the "liaison enchainée" implies a phonetic alteration of the speech signal but that is bound by phonological constraints. As a matter of fact, the actualization and the resyllabification of the liaison segment does not occur anywhere in the speech stream. The frequency and the distribution of the liaisons are bound by the nature of the phonological domain in which they appear (De Jong 1990). Thus, the liaison is considered obligatory in the clitic group (i.e. "un ami") and quasi-obligatory in the phonological phrase ("un bon ami"). De Jong has shown that it is actualized by 99% of speakers in CG and by 75% of speakers in PP. The more syllactically cohesive the group, the more obligatory the liaison. One can assume that this phonological production constraint also comes into play during the perception. In order to examine if this phonological constraint is a factor of the perceptual process of liaison phoneme, we replicated the first experiment but with liaisons in clitic groups.

2.2 Experiment 2
Materials and procedure
Materials was built in strictly identical way except for the nature of the domain in which the liaison appears. In this experiment, the target phoneme was /n/ as initial phoneme as liaison phoneme (i.e. "un navire" a ship [navir] "un avion" a plane [navajo]). The procedure was strictly the same. The subjects were 37 undergraduate students from the University of Paris V.

Results
Subjects have had many difficulties in performing the task. In spite of the increase of the number of subjects, the number of detected liaison target phonemes was insufficient to perform a statistic analysis. Then, the missing detections had been systematically analyzed.

<table>
<thead>
<tr>
<th></th>
<th>Liais /n/</th>
<th>Init /n/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miss</td>
<td>40%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Table 2: missing detections (% miss) for detection of the target /n/ in pairs like "un avion (liais /n/)" and "un navire" (init /n/)

A Student test was performed taking the initial / liaison condition as random factor. The t values are given for subjects (t1) and for items (t2). The analysis shows a significant difference of percentage of detection between the initial condition and the liaison condition for items (t1 = 4.22 p = 0.0039) as for subjects (t1 = 1.36 p = 5.75 p = 0.0002). Although, the subjects had been explicitly asked to detect also the liaison consonants, they missed many target phonemes. They didn't seem to perceive this kind of segment, as if they were deaf in regard to these liaison consonants. Although the results of experiment 1 (RT) cannot be directly compared with those of experiment 2 (% of missing responses), in both cases the subjects have shown many difficulties to detect liaison consonants, but most characteristically in clitic groups. This detection seems quite impossible as if the more obligatory the liaison, the more difficult the target detection.

3-DISCUSSION
This difficulty can be interpreted in two ways. One can first make the hypothesis that initial consonants and liaison consonants do not have the same acoustic realization. In that case, the differences between liaison condition and initial condition could be assigned to a subject's sensitivity to this kind of information. Thus, this would mean that they have used low-level acoustic information to locate the words' boundaries and process the segmentation of the speech stream.

Acoustic hypothesis
It is traditionally and generally admitted in phonological literature that the realization of initial consonant, and liaison consonant, are acoustically identical (Encrévé, 1988). However, a few results (Durand, 1953; Bradley & Dejean, 1990; Bresson & Grosjean, 1994) showed that the initial consonant in PP was significantly longer than the liaison consonant. More particularly, Dejean has shown that VOT and occlusion's duration are shorter in the case of liaison consonants.

We made the same measurements of our materials. The measurements were made on spectrograms in Unice (table 2).

<table>
<thead>
<tr>
<th>Voix</th>
<th>Init</th>
<th>Li</th>
<th>Diff</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOT</td>
<td>49</td>
<td>43.5</td>
<td>5.5</td>
<td>1.14</td>
<td>0.29</td>
</tr>
<tr>
<td>Occl</td>
<td>69.7</td>
<td>49.7</td>
<td>20</td>
<td>3.42</td>
<td>0.01</td>
</tr>
<tr>
<td>Dur</td>
<td>120</td>
<td>95</td>
<td>25</td>
<td>4.14</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Table 3: VOT, occlusion's duration (occl) and consonant's duration (dur) of /n/ in pairs like "un grand élaphe" / "un grand téléphone"

Our results confirm the inferences made by Dejean : the initial phonemes are longer than liaison consonants. One can think that this difference of duration explains the difference of RT. However, we have calculated a correlation between the results of the experiment 1 (RT) and the durations that we have measured (VOT, occl, dur), and, we have found no significant correlation between the RT and the durations of the consonants. Moreover we have also compared acoustic realizations of initial /n/ and liaison /n/ and we have found no significant difference (table 4).

<table>
<thead>
<tr>
<th>Voix</th>
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<th>Li</th>
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<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dur</td>
<td>61</td>
<td>57.8</td>
<td>3.2</td>
<td>1.15</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Table 4: duration (dur) of /n/ in pairs like "un navire" / "un avion"

This would mean that this kind of acoustic information is not preferentially used by the hearers to resolve the ambiguity created by a liaison on a word's boundary.

One can also make the hypothesis that the phonological specificity of the liaison consonant is what the subjects have to consider.

Phonological hypothesis
In these experiments, the results have shown that the subjects have many difficulties in performing the phoneme-monitoring task for the liaison phonemes as if they could not isolate them as 'phonemes'. Moreover, the cohesion of the phonological domain in which the liaison appears seems to be a factor of the subjects incapacity to isolate the target from the group and to recognize it. This would mean that this kind of process is performed as a single unit and not split in two or three words (ie article, adjective, noun) that are isolated and successively accessed. Besides, this kind of free lexems could be lexicalized in French (ie un bon homme (a good man) > un bonhomme (a fellow).

Thus those results suggest that the segmentation of French, as it has been proposed by Christophe (1993) could be processed by phonological units larger than the words in which the lexical access could occur.

REFERENCES