

# Brain waves and syllabic stress clash

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## Abstract

The resolution process for stress clash condition, where two consecutive syllables are both (morphologically) stressed, has been well documented for lexically stressed languages such as English or Italian. However, non-lexically stressed languages such as Korean or French present more variations in their mechanism of stress clash resolution. Acoustic analysis examples taken from the spontaneous speech corpus Orfeo show that there is no stress shift of the first stressed syllable when the gap between the phonologically stressed vowels exceeds some 250 ms. This gap depends on the speech rate, a slow rate leading to maintain the morphologically stressed syllable in place, whereas a fast speech rate would reduce the gap between the stressed vowels below 250 ms and will lead to a stress shift. This 250 ms gap value is linked to the minimum interval required by delta brain oscillations to synchronize the perception of stressed syllables.

Keywords: Syllabic stress, stress clash, French, Delta brain oscillations.

## Introduction

Non-emphatic syllabic stress in lexically stressed languages such as English or Italian is assumed to be located on some syllable of lexical words (verbs, nouns, adjectives and adverbs), categories opposed to grammatical words (pronouns, conjunctions, etc.). However, non-lexically stressed languages (e.g., French, Korean) place syllabic stress on some word final syllable according to a rhythmic rule separating consecutive stressed syllables by an interval between 250 ms and 1250-1350 ms (Martin, 2018).

This property of stress in French leads to the definition of an accent phrase as a sequence of words, the last of which is stressed on its final syllable. As lexical words do not have to be necessarily stressed as in English or Italian, an accent phrase can contain more than one lexical word, as in *la ville de Strasbourg* or *l'air du temps*, etc.

## Stress clash

The so-called stress clash condition has been analyzed for some time, whether for lexically stressed languages like English (Lieberman and Prince, 1997), or for non-lexically, rhythmic, stressed language like French. (Garde, 1968). In both cases, the question pertains to a stress shift when two consecutive stressed syllables occur.

Two often-cited examples include an oxytonic first word, such as *thirteen* and *kangaroo* leading to realizations such as *thirteen men* and *kangaroo saddle*.

In contemporary French, the word stress is oxyton, and paroxyton if the last pronounced syllable includes the vowel [ə]. A stress clash configuration can therefore only occur if the second word involved is monosyllabic, such as *noir* or *verte* in *soulier noir* or *la ceinture verte*, with both words belonging to the same syntactic unit.

Most of the recent (Jun and Fougeron, 2002) or old (Dell, 1984) analyses either propose rules accounting for these stress shifts, or describe them as possible but not obligatory while remaining undecided on their conditions of realization. We propose here a unique explanatory principle based on the temporal properties of sequences of stressed syllable.

### Stress and brain waves

Electroencephalographic (EEG) analysis, exploring the relationship between brain waves and the perception of syllables, has shown that theta brain waves, varying in the range 4 Hz to 10 Hz, i.e., between 100 ms and 250 ms, synchronize syllabic perception in listeners (Ghitza, 2013). Without this synchronization, syllabic perception becomes less efficient, since it is triggered by unorganized theta waves on the temporal axis.

On the other hand, delta brain waves, whose periods vary between approximately 250 ms and 1250-1350 ms, have been shown to be synchronized by speech stressed syllables (Martin, 2015). They also trigger the perception of syllable as stressed even in the lack of relevant acoustic parameters of stress. In the absence of speech, the delta waves oscillate freely in their frequency range, but the occurrence of effectively stressed syllables provoke their temporal alignment. Therefore, stressed syllables ensure the regulation of accent phrases linguistic processing, necessarily taking place in the range of delta waves variation, i.e., between 250 ms and 1250-1350 ms. To satisfy this condition, the intervals between consecutive stressed syllables must therefore fall within this interval.

As a result, stressed syllables must imperatively be spaced apart by a minimum of 250 ms and a maximum of 1250-1350 ms, whether in production or in perception, even in silent reading, and independently of their linguistic function. Experimental data from spontaneous speech recordings in French presented below do support clearly this hypothesis, showing that consecutive stressed syllables remain in place while separated by a gap of more than some 250 ms.

### Experimental data

The analyzed experimental data presenting potentially stress clash conditions were extracted from the ORFEO corpus, which brings together various corpora of spontaneous speech in French. Examples were easily located thanks

to the integrated concordancer of the WinPitch software (2022). This software automatically displays the speech sound corresponding to the selected concordancer text, together with its acoustic analysis, spectrogram and melodic and intensity curves. In the examples given below, the numbers between potentially stress clashed words give the measured gap in ms, taken from the peak of the stressed syllable vowels. Parentheses indicate the syntactic group involved, and the speech rate is given in number of syllables per second.

### Gap < 250 ms

#### 1.1 First word of the sequence with 1 syllable

*et je crois que ce qu'il a voulu d- expliquer à ce moment-là c'est que c'était pas du tout du tout **noir** (et tout 200 **blanc**) mais que au contraire par exemple justement il y avait des des druides qui étaient pythagoriens 5.29 syl/s (13madmc110913)*

*il a commis l'erreur de venir me chercher une **veille** (de bac 163 **blanc**) 8.2 syl/s (07madmc110912)*

#### 1.2 First word of the sequence with 2 syllables or more with stress shift

*il y a deux ampoules blanches et une ampoule bleue ms donc (les **ampoules** 195 **blanches**) sont là pour apporter de la lumière et euh faire ressortir la couleur des euh des poissons 3.27 syl/s (bres\_m1\_08) **recul***

*mais elles prédisent toujours (**L'avenir** 229 **noir**) 6.42 syl/s (ago\_ram\_07)*

#### 1.3 First word of the sequence with 2 syllables or more unstressed

*la reine prend le linge elle le plonge dans l'eau et à peine l'a-t-elle plongé dans l'eau que le **linge** (devient 163 **blanc**) 5.04 syl/s (nataf\_041-3\_le\_roi\_des\_corbeaux)*

*parce qu'il y a un **gros** (machin 226 **noir**) qui est passé c'est un corbeau 4.84 syl/s (alg\_jac\_06)*

### Gap > 250 ms

*regarde-le si tu aimes (l'**humour** 250 **noir**) regarde-le 8.62 syl/s (04gicl110912)*

*et une (**ampoule** 261 **bleue**) 4.83 syl/s (bres\_m1\_08)*

*et tu as ton premier (**cheveu** 280 **blanc**) là 280 ms 5.5 syl/s (03\_mv\_cd\_100222)*

*il y a deux (**ampoules** 306 **blanches**) et une ampoule bleue ms donc les ampoules blanches sont là pour apporter de la lumière et euh faire ressortir la couleur des euh des poissons 3.27 syl/s (bres\_m1\_08)*

*genre le vieux bâti**ment** 316 **noir** 5,36 syl/s (unine08a03m)*

These data show clearly that the stress clash condition does not involve a first stress shift when the gap between stressed vowels is greater than 250 ms.

Moreover, the complexity of the consonant clusters potentially present between consecutive stressed syllables does by itself avoid a stress shift when the distance between the two syllables is below 250 ms.

We also note, at least on these samples of spontaneous speech, that stress drop in the event of a collision is not at all the rule when the first word is not monosyllabic (cases 1.2). Moreover, when a stress shift occurs, the first stress is not necessarily located on the first syllable of the first polysyllabic word (when it exists), but could be on the final syllable of a preceding word (cases 1.3). Whether by this mechanism or by shifting the stress, the speaker creates stress groups of longer duration, so as to ensure eurythmy between successive stress groups (Martin, 2018).

## Conclusion

The minimum and maximum gap between two successive stressed syllables, linked to the range of delta brain waves periods, is the key which gives a proper account of stress clash resolution in French, and potentially for other non-tonal languages as well.

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