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DOES DELETION OF FRENCH SCHWA LEAD TO NEUTRALIZATION OF LEXICAL DISTINCTIONS?

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ABSTRACT

This study explores the hypothesis that relatively invariant properties characterizing lexical items include non contrastive phonetic details such as the amount of linguopalatal contact, or aspects of inter-gestural timing. We show that, in French, a sequence of consonants resulting from the loss of schwa maintains some of the fine articulatory characteristics of the lexical form containing schwa. Such characteristics distinguish this sequence of consonants from an underlying cluster. Thus, we show that "d'r le" 'some role', with the apostrophe indicating schwa loss, remains articulatorily distinct from "dr le" 'funny'. A perception experiment shows that the two types of sequences (CC and C'C) are only marginally discriminable by French listeners. However, when the subjects identify correctly the two types of sequences, the distinct characteristics identified in production correlate with the listeners' judgments.

1. INTRODUCTION

In the phonological literature, it is generally assumed that the properties defining a lexical entry are limited to prosodic and featural attributes that are potentially contrastive. This study investigated a case of incomplete neutralization which suggests a different view. We examine the properties of certain consonant clusters generated by the deletion of schwa in French. For example, the sequence "de r le" [derol] ([e]=schwa) of role" can be produced as "d'r le" [drol], with a complete deletion of schwa, and in that case it is believed to become homophonous with "dr le" [drol] "funny". Our hypothesis, following [8], is that the neutralization between the schwa-less consonant sequence and its corresponding full form with schwa is incomplete: the consonants maintain some of the articulatory characteristics of the lexical form with schwa, and these characteristics differentiate them from underlying clusters. Our study is part of an increasing body of literature documenting incomplete neutralization of phonological contrasts (cf. [7] and [9] for review). A well known example of incomplete neutralization is the case of English stop epenthesis. In words like "dense", an intrusive stop can be produced making the word similar to "dents". [3] have shown that the duration of the silent gap between the [n] and the [s] is significantly shorter for the epenthetic stop compared to the underlying stop in "dents". The interest of the French data is that it documents incomplete neutralization as a consequence of segment loss. [5], [4], [6], and [2], among others, have shown that consonant clusters are characterized by specific inter-gestural timing patterns, marking the cohesion between the two consonants. Therefore, we can ask whether a sequence of consonants resulting from the loss of schwa does share the specific timing properties characterizing underlying CC clusters.

In this paper, we compare first in a production experiment, the articulatory and acoustic properties of consonant clusters to determine whether (1) the first

member of a C'C sequence maintains, after the loss of schwa, certain characteristic properties of its lexical CeC form; or whether (2) the first member of the C'C sequence becomes identical to its counterpart in underlying CC, thus neutralizing completely the C'C vs. CC distinction. In other words, we try to determine if the lexical distinction between the two apparently homophonous forms is maintained in production. Native French speakers, when asked informally, are not aware of either producing or perceiving a distinction between the C'C and CC sequences. Such strings may be ambiguous in French, as for example in "ils organisent un jeu [droll]", which can mean either "they organize a funny game (jeu dr le)" or "they organize an acting game (jeu de r le)". In a second experiment, we test whether listeners are able to discriminate between a consonant sequence resulting from the loss of schwa and an underlying cluster (d'r vs. dr). In this experiment, we try to determine whether the articulatory distinctions, if any, can be used by listeners to distinguish these forms.

2. METHOD

2.1. Production experiment:

The initial consonant (C1) of four types of consonant sequences were compared. Table I illustrates the four types for the sequence [dr]. The symbol # marks the location of the word boundary.

- 1- C1 is followed by schwa: (C1e #C2)
- 2- C1 is pre-consonantal due to the loss of schwa: (C1C2)
- 3- C1 is pre-consonantal in an underlying syllable onset: (#C1C2)
- 4- C1 is pre-consonantal and word final: (C1#C2)

1- Il n'a pas de r le, ...	he has no role, ...
2- Il n'a pas d'r le, ...	he has no role, ...
3- Il n'est pas dr le, ...	he is not funny, ...
4- Il voit l'jade rose, ...	he sees the pink jade, ...
c'moment ... en	now ...

Table I: corpus for [dr] sequences

Two types of consonant sequences were examined: [dr] and [kl]. The sequences were included in sentences where the immediate segmental context was controlled ([adro], [ikla]) and the meaning of the items in the minimal pairs was clearly elicited. Electropalatographic and acoustic data were collected with the Kay-Palatometer (96 electrodes) for two Parisian French speakers, one female (the first author, spk1F) and one male (spk2M). The sentences were presented to the speakers in a random order with fillers. 20 repetitions for the [dr] sentences and 10 repetitions for the [kl] sentences were collected. The initial consonants (C1) were compared in terms of amount of linguopalatal contact (%), lingual closure duration (from the onset to the offset of the linguopalatal seal), acoustic duration, and frequency of lenition (absence of full closure, as indicated by absence of at least one complete row of electrodes contacted). In the [kl] cluster, intergestural

timing was examined in terms of the latency between the back release for [k] and the appearance of front midsagittal contact for [l]. Consonant sequences were compared for these articulatory-acoustic properties through an ANOVA and a Fisher's PLSD post hoc test at 5% significance level.

2.2. Perception experiment:

A perception test was designed with stimuli produced in the production experiment. The 2 ambiguous sequences "pas dr le" ("dr" underlying cluster) and "pas d'r le" ("d'r" sequence resulting from the loss of schwa) were extracted from their context and presented to listeners in a random order. Listeners were asked to identify the stimulus they heard as part of the sentence "il n'a pas d'r le en c'moment" ("he has no role now") or "il n'est pas dr le en c'moment" ("he is not funny now") in a forced choice setting. For the 2 speakers, 15 out of the 20 repetitions of "dr" and "d'r" produced for the first experiment were used (for a total of 30 "dr" and 30 "d'r"). The speech was re-digitized in 8 bits on a Macintosh and presented to the subjects in a Hypercard stack. Stimuli from the same speaker were presented in groups of 5 and separated from each other by a pause of 3 seconds. Two trials of 5 stimuli from each speaker were used at the beginning of the test for practice. 17 French listeners (6 from the North of France and 11 from the South of France) participated in the experiment.

3. RESULTS

3.1. Production Results

The production data show that, despite the complete disappearance of schwa, the initial consonant in a C1'C2 sequence shares some of the characteristics of its underlying form with schwa. Figures 1 (a, b, c) show for each speaker that [d] in "d'r le" and in "de r le" has significantly greater linguopalatal contact, a longer lingual occlusion and is less subject to lenition than the [d] in "dr le" or "jade rose".

For the sequence [kl], no difference is found in the amount of linguopalatal contact of [k] or in its acoustic duration in the 4 sequences. However, comparison of the timing between [k] and [l] gestures shows that the latency between the release of the [k] and the appearance of contact in the midsagittal region for [l] is significantly longer for an underlying [kl] onset cluster than in a [k'l] sequence. This means that there is less overlap between the [k] and the [l] gesture in the underlying cluster as illustrated in Figure 2 for both speakers. Comparisons between the other sequences did not reveal consistent differences between speakers.

In sum, for the two speakers analyzed, the consonant sequences C1eC2 and C1'C2 share spatial, temporal and intergestural timing characteristics that distinguish them from an underlying C1C2 cluster and from a C1#C2 sequence.

3.2. Perception Results

Our subjects have indicated that the task of identifying the sequence [padrol] as belonging to the "d'r" or "dr" types of stimuli was very difficult. In general, while the [padrol] stimuli are correctly identified above chance level ($\chi^2(1)=33$ p<.0001, N=1019), the probability of having a correct identification is fairly poor (p(c)=.58). Closer examination of the results show that the ability to identify the stimuli holds only for the speech of the speaker 2M ($\chi^2(1)=33$, p<.0001, N=509), while for the

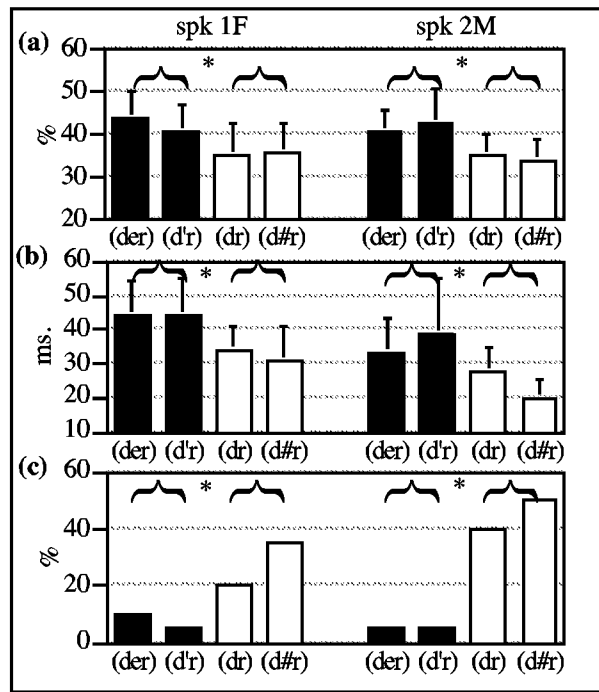


Figure 1: (a) Amount of linguopalatal contact in [d]; (b) Duration of the lingual occlusion gesture of [d]; (c) Frequency of lenition of [d] in the 4 types of sequences: "de r le" (der) ([e] = schwa), "d'r le" (d'r), "dr le" (dr), and "jade rose" (d#r).

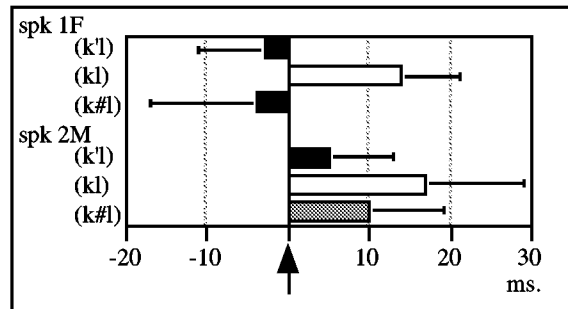


Figure 2: Latency between back release for [k] (at arrow) and appearance of front midsagittal contact for [l] in the 3 types of consonant sequences. For each speaker, bars of different shading are significantly different.

speech of speaker 1F the responses do not depend on the nature ("dr" or "d'r") of the stimuli ($\chi^2(1)=.9$, p=.3, N=510).

To understand the speaker-dependent character of the identification results, we examine some of the acoustic-articulatory characteristics in the sequence [padrol] that could be used by the listeners to discriminate the two types of stimuli. For the two speakers the [d]s in the "d'r" stimuli have a greater amount of linguopalatal contact and a longer acoustic duration. The "d'r" stimuli are also distinguished by a shorter vowel [a]. For both speakers, the two types of stimuli do not differ in terms of the duration of the vowel-like transition between the [d] and the [r], nor in terms of the duration of the [r]. In the speech of speaker 2M, an additional correlate was found to distinguish the two stimuli: in the "dr" stimuli, the [o] ([drol]) is significantly shorter and more coarticulated (lower F1 and F3) than in the "d'r" stimuli. In the speech of speaker 1F, the total duration of the

[padrol] sequence was significantly longer for the "d'r" stimuli. In order to correlate the acoustic-articulatory characteristics of the stimuli with their identification scores, we divided the stimuli into two categories: (1) stimuli that were correctly identified by at least 60% of the listeners (CI), (2) stimuli that were misidentified as belonging to the other category by at least 60% of the listeners (MI). Performance on all other stimuli was assumed to be at chance level: consequently these other stimuli were not further analyzed.

Out of 30 stimuli per speaker, 24 stimuli in the speech of speaker 2M (14 "d'r", 10 "d'r") and 17 stimuli in the speech of speaker 1F (8 "d'r", 9 "d'r") were correctly identified. For these stimuli, we examined the 3 acoustic-articulatory properties found in both speakers speech to distinguish the two types of sequences, namely amount of linguopalatal contact, acoustic duration of [d] and [a]. Figure 3 shows, for each properties, the characteristics of the CI stimuli (black columns) compared to the other stimuli (both MI or identified at chance level) (gray columns). Looking at the amount of linguopalatal contact (3a) and the acoustic duration of the [d]s (3b), it can be seen that the correctly identified stimuli have the characteristics that distinguish their category as a group. In that sense CI stimuli are prototypical in each category. For example, correctly identified tokens of "d'r" have a [d] with a relatively large amount of contact and a relatively long duration, while correctly identified "d'r" stimuli have shorter and less contacted [d]s. Compared to the amount of linguopalatal contact and the duration of the [d], the duration of the vowel [a] (3c) does not seem to have an effect on the identification of the stimuli, since CI stimuli have similar [a] duration to the other stimuli. This holds for the speech of the 2 speakers, although only data for speaker 2M is presented here.

Let us consider now the properties of misidentified stimuli (MI). For speaker 2M, most of the MI stimuli are [d'r] stimuli, while for speaker 1F the same number of "d'r" and "d'r" were misidentified. MI stimuli can be divided into two types. First, MI stimuli that share some of the properties defining the group they are misidentified with. This is the case of all the "d'r" stimuli of speaker 2M and half of the MI stimuli of speaker 1F. While most of the characteristics of these stimuli are typical for their category, or at least do not overlap with the ones of the other category, the "d'r" cases that are misidentified as "d'r" stimuli have the same amount of linguopalatal contact and the same acoustic duration as "d'r" stimuli.

In Figure 4, it can be seen that these stimuli (black circles) effectively look like "d'r" stimuli. The same holds for half of the "d'r" stimuli of speaker 1F that are misidentified as "d'r" (black squares): they have the same amount of contact and duration of [d] as "d'r" stimuli. The other type of MI stimuli (the only "d'r" MI stimulus of speaker 2M and half of the MI stimuli of speaker 1F) do not share properties characterizing the category they are identified for. Judging from their linguopalatal contact or duration, as seen in Figure 4 (gray symbols), these are either extreme or typical stimuli for their category. In these cases, we cannot offer an explanation for the perception results.

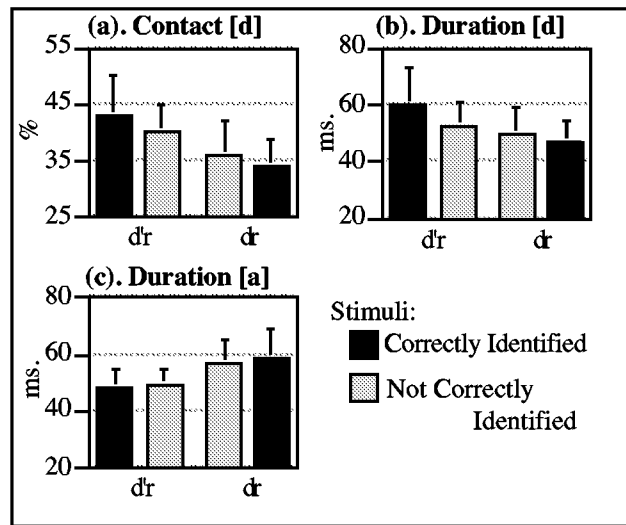


Figure 3: (a) Amount of linguopalatal contact in [d]; (b) Acoustic duration of [d]; (c) Acoustic duration of [a] (spk2M), in the stimuli "d'r" and "d'r" depending on their identification score.

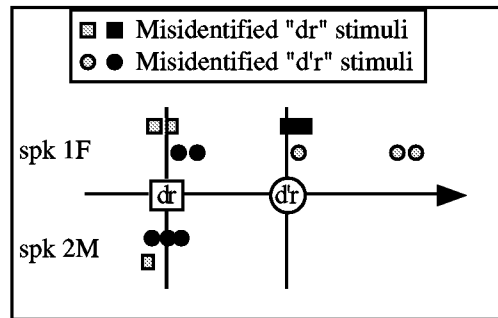


Figure 4: Amount of linguopalatal contact for the MI stimuli compared to the average value of the "d'r" (white square) and "d'r" (white circle) categories. Black symbols are stimuli sharing the properties of the category they are misidentified with. The graph representing lingual closure duration of MI stimuli shows similar relations.

Our study does not allow us to conclude that the amount of contact or the duration of [d] are the only or even the principal cues used by the listeners to distinguish "d'r" from "d'r" stimuli. We have not systematically studied the properties of [r], other than its duration, in [d'r] vs. [d'r] sequences. It is possible, following [8]'s results, that [r] quality is either an ambiguous property in the MI stimuli or else that it is as misleading as the properties of [d]. It is also the case that the properties we have isolated are the temporal and spatial magnitude of the [d] closure. These properties are probably correlated (although not obligatorily), so that one or the other, or both, are of importance in the perception judgments. However, our perception results indicate that the presence, absence, or false value for these spatial and temporal characteristics of [d] closure do correlate with the correct identification of the stimuli.

4. DISCUSSION and CONCLUSION

Our study has confirmed earlier findings by [5] and [2], who observe that word affiliation has systematic consequences for the articulatory realization of consonant clusters. These findings are echoed in our work by the observation that latency of [k] release and [l] closure in [kl] clusters differs in French depending on whether [kl] is a word-internal cluster or a [k^l] sequence belonging to distinct words. The differences between the articulatory realization of [d'r] vs. [#dr] could also be due to a basic difference in interconsonantal timing, correlated in the same way to word affiliation. However, our study adds a new element to this class of investigations: the word affiliation effect is not sufficient to explain the [dr] data, since the [d'r] tokens are realized not only as distinct from [#dr] but also as distinct from [d#r]. Moreover, the [d'r] tokens are very similar, in duration and amount of linguo-palatal contact, to the lexically related [de r] sequences. We suggest the following interpretation for the production results for [dr]: when occurring directly before [r], [d] has a shorter closure duration which may result in reduced or incomplete lingual contact (lenition). This tendency towards articulatory reduction in pre-consonantal [d] is however overridden in the case of [d'r] sequences by the fact that this token of [d] corresponds, in careful speech, to a prevocalic [de]. We suggest that the motor control program of [d] in "de" is maintained, despite loss of schwa, even in the truncated [d'] realizations of this morpheme.

Note now that the articulatory properties distinguishing [d] in [d'r] and [de#r], from [d] in [#dr] and [d#r] - temporal and spatial magnitude of the [d] closure - are non-contrastive at the underlying level in French as well as in all other languages we are aware of. Their poor perceptibility can explain that. What is noteworthy is the relative invariance of these non-contrastive properties identifying [d] in [d'r] as a token of the [de] morpheme. This invariant character of the duration and spatial magnitude of the [d] closure in [de]/[d'] suggests to us that these are properties present in the lexical entry of [de], despite their non-contrastive character. Thus we conjecture that non-contrastive properties - that is properties which by themselves cannot support a phonemic contrast - may nonetheless be present in lexical entries [1, 9].

Finally we note that the perceptual counterpart of the articulatory distinctions documented here is still to be securely established: our study shows that listeners can identify [d'r] as distinct from [#dr], but that this identification is far from consistent.

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