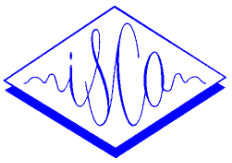

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A STUDY OF PALATAL SEGMENTS' PRODUCTION BY DANISH SPEAKERS.

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ABSTRACT

Most acoustical researches consider palatality through languages dominated by the palatalization process, like Russian. In this paper, we propose to apply acoustical analysis, adapted to the dynamical character of the palatal sounds to the Danish language, which is exempt from any palatalization process and has no palatal phonemes, except [j].

In all cases, we can observe the setting up of a transitionality marking the acoustical signal in one or several of its attributes. The realizations of the sequences associating the palatal segment with a nasal one offered very interesting results: some particular reorganizations of the time function, which do not exist in Russian, can be observed

1. INTRODUCTION

The analysis of the literature shows that few acoustical research on palatality have been conducted (Bruyninckx, 1995, Bruyninckx & Harmegnies, 1996a). Most focus on palatality through languages dominated by the palatalization process, like Russian (Bruyninckx & Harmegnies, 1995) but they never do so through languages in which palatality has no prevailing status in the phonological system. Therefore, palatal quality has been mainly described as it appears under the effect of phonological processes, but rarely studied when it derives from the existence of a simple trait of the phonological system. In order to fill this gap, we propose to apply acoustical analyzis processes, adapted to the dynamical character of these sounds (Bruyninckx & Harmegnies, 1996b, 1997a), in Danish. As a matter of fact, Danish is exempt from any palatalization process and has no other palatal phonemes, than [j] that always appears in pre- and/or in post-vocalic position (Spore, 1965).

2. CORPUS

This paper is a part of a larger, extensive research aimed at describing the acoustical characteristics of the palatal unit productions in context and this, for different languages (Bruyninckx & Harmegnies, 1997a, 1997b, 1998). Therefore, we needed to explore all the sequences that can be created by the variations of S in a S_1 *P* S_2 structure, where *P* is the palatal segment, S_1, the previous segment and S_2, the following segment. Four categories of acoustical events were taken into account in order to establish the context of the palatal segment: complex periodic sounds (CPS), aperiodic sounds (AS), nasal sounds (NS) and silence or "null context" (Ø) (see table 1).

For the complex periodic sounds, we selected [i], [a] and [u] because of the universality of their extremal character in the vocalic systems. Two types of aperiodic sounds were considered: impulsed and continuous in relation with the occlusive and fricative articulatory modes. For each of these two categories of sounds, we selected the units presenting the greatest distance between their articulatory point and the hard palate area; that is to say: ahead the vocal tract ([p], [f]) and behind the vocal tract ([k], [ʃ]). We decided to keep only unvoiced sounds in order to preserve their strictly aperiodic character.

Concerning the nasal sounds, [n] was selected because of its relatively high frequency of possible combinations with the palatal segment [j] and moreover, because this choice allowed us to study acoustically close palatal sounds such [ɲ].

This paper summarize the results found when applying this general set up to Danish.

	ʊ	**AS$_2$**	**NS$_2$**	**CPS$_2$**
ʊ	✗	✗	✗	[ji][ja][ju]
AS$_1$	✗	✗	✗	[pji][pja][pju] [kji][kja][kju] [fji][fja][fju]
NS$_1$	✗	✗	✗	[nji][nja][nju]
CPS$_1$	[aj]	[ajp][ajk][ajf]	[ajn]	-

Table 1: selection of the target structures on the basis of exclusion criterions (✗) and on the basis of inclusion

criterions.

The target structures have been selected on the basis of exclusion criterions (non-sense situations) and on the basis of inclusion criterions: namely, the patent existence in this very language of a corresponding phonemes sequence or of a phonological combination empowering the production of the nearest realization (selection based on Bang, 1976, Brink et al., 1991, Blinkenberg & Hoybye, 1991 dictionaries). For example, we selected the nearest Danish realization of [p] and [k] in a palatal context, that is to say [b̟] and [g̟] . All the occlusive sounds in Danish are characterized by a devoiced realization, nevertheless lightly different from true non voiced sounds like [p] or [k] (Fisher-Jorgensen, 1968; Spore, 1965; De Steman, 1963) but it is clear however that their occlusive character correlated with their unvoiced character brings them nearer the [p t k] series than the [b d g] one. The realization of the sequence with [f] as AS_1 does not pose any problem. An univocal relation between production and writing does not exist for the sound [ʃ]. The analyze of the literature shows a great variety of realizations, dominated by many individual variants (Basbøll, 1975). Consequently, we decided to exclude [ʃ] from our corpus. The vocalic sounds allow two different quantitative realizations: they can be produced in a short or in a long form. Nevertheless, whatever their duration is, the vocalic sounds must be pronounced as monophtonges, that is to say without any timbre modification during their emission (Fisher-Jorgensen, 1972a). At the end of a word, the vocalic sounds are produced in their short form only if they are followed by a *stød* (De Stemann, 1963; Basbøll, 1972). This typical Danish phonetic event, characterized by a kind of glottal closure (Bredsdorff, 1958), is described by Fisher-Jorgensen (1989) as a phonation type related to creaky voice, associated with variations of pitch and intensity. In consequence, we decided to use only the long form of the vocalic sounds in final position, that allowed us to avoid analyze problems that could be generated by the presence of the *stød*.

Target Structures	Non-sense words Inserted in bearing sentences
/ji/	**Ji** er et kinesisk ord.
/j :/	**Jar** ligner et hollandsk ord.
/ju/	**Ju** er et engelsk ord.
/b̟ji/	**Lupji** er et russisk verbum.
/b̟j̟ˑ/	**Tapjar** er en spansk maler.
/b̟ju/	**Pipju** er en lille fugl.
/g̟ji/	**Nokji** er et japansk firma.
/g̟j̟ˑ/	**Pakjar** er en indisk by.
/g̟ju/	**Lokju** er mærket på en lås.
/fji/	**Tafji** er en indisk kaffe.
/fj :/	**Kefjar** er en blomst.
/fju/	**Røfju** er et oliemærke.
/nji/	**Linji** er et berømt slægtsnavn.
/nj :/	**Barnjar** er et provencalsk ord.
/nju/	**Barnju** ligger i Spanien.
/ j/	**Markaj** er en afrikansk stamme
/j̟b̟/	**Unitajp** er et skrivemaskinemærke
/j̟g̟/	Jeg dyrker jiu-jitsu, judo og **tajk**.
/ jf/	**Zajf** er et thailandsk efternavn.
/ jn/	Hver morgen rider **Zajn** til Jaffa.

Table 2: target structures placed in **non-sense words**, inserted in bearing sentences.

The target structures have been placed in non-sense words, inserted in bearing sentences (see table 2). They were presented to the subjects in an orthographic form (based on Hansen, 1990), enabling unambiguous production of the expected unit(s). For example, in order to make the pronunciation of [:] firm in final position, it has been necessary to add the letter "r", which is not pronounced in Danish, but associates the sound [:] to the letter "a", which otherwise would have been pronounced [ɐ].

3. SUBJECTS

Five Danish native male subjects, all from the Copenhagen area and living since very little of time at the SHAPE military base in Maisières (Belgium) were selected. They were all officers, 30-year old on average and did not suffer from any recent or ancient speech pathology.

4. RECORDINGS

All the recordings were performed in a sound proof room at the Phonetics Laboratory of the University of Mons, by means of a Neumann U87 P 48 microphone, connected to a Sony 501 ES PCM coder. The digitized sounds were stocked on a Panasonic VHS video recorder.

5. ANALYZES

The utterances of the corpus have been analyzed by means

of sonagrams and time-normalized LPC formants tracks. When needed, pitch analyzes and FFT-based spectrogram were applied.

6. RESULTS

In all cases, we can observe the setting up of a transitionality marking the acoustical signal in one or several of its attributes.

When the palatal segment is produced in a strictly vocalic environment, the dominant strategy of the Danish speakers results in establishing a formantic transition, from the preceding sound frequencies to those of the following one. The sound [j] has then the acoustical nature of a vowel.

When the sequence [ji] is produced, a non-transitional formantic structure is associated with a decrease of energy and a very light increase of the pitch on the palatal segment. Our hypothesis is that this process would contribute to reduce the perceptual salience of some spectral zones and so, contribute to the setting up of a transitionality of the perceived timbre.

Target	Formants	Beginning	End
/ji/	F_1	240	240
	F_2	2280	2280
/j :/	F_1	240	800
	F_2	2160	1360
/ju/	F_1	280	280
	F_2	2160	800
/ j/	F_1	880	480
	F_2	1400	2040

Table 3: averaged formantic values (F_1 and F_2) -in Hertz extracted from the target structures' productions in a strictly vocalic environment.

When the palatal segment is produced in a heterogeneous environment (*AS_1 P CPS_2* or *CPS_1 P AS_2*) , the dominant strategy of the Danish speakers also results in establishing a formantic transition, from the preceding sound frequencies to those of the following one. The sound [j] also has, in this case, the acoustical nature of a vowel. Nevertheless, in the case of the *CPS_1 P AS_2* or *CPS_1 P NS_2* sequences, we can observe a general transfer towards bottom of the second formant and a translation towards the upper parts of the first formant. This can be explained by the Danish orthoepy , which tends to the production of a long [:] in final and the production of a short [ ] when followed by [j]. Similar frequential differences have been observed by Fisher-J rgensen (1972) when analyzing long and short realizations of this vocalic sound.

When the sequences [b ji], [g ji] and [fji] are produced, a non-transitional formantic setting is paired with a decrease of energy on the palatal segment.

Target structures	Formants	Beginning	End
/b ji /	F_1	280	280
	F_2	2120	2120
/b j /	F_1	240	640
	F_2	2080	1400
/b ju /	F_1	280	280
	F_2	2080	1040
/g ji /	F_1	280	280
	F_2	2200	2200
/g j:/	F_1	320	880
	F_2	2040	1480
/g ju /	F_1	320	320
	F_2	2040	880
/fji/	F_1	300	300
	F_2	2240	2240
/fj :/	F_1	280	720
	F_2	2240	1600
/fju/	F_1	320	320
	F_2	2120	960
/ jb /	F_1	720	320
	F_2	1280	2080
/ jg /	F_1	720	320
	F_2	1400	2360
/ jf/	F_1	720	320
	F_2	1280	2080

Table 4: averaged formantic values (F_1 and F_2) –in Hertz- extracted from the target structures' productions in a heterogeneous environment

The realizations of the sequences associating the palatal segment with a nasal one offer very interesting results. As a matter of fact,
some particular reorganizations of the time function, which do not
exist in Russian, can be observed (see table 6).

Seg	Formants		S_1	S_2	S_3	S_4	S_5
[n]	**F_1**	**Beg**	293	207	362	293	224
		Mid	224	207	276	293	224
		End	291	207	241	293	224
	F_2	**Beg**	1175	1054	1106	1400	1054
		mid	1261	1054	1106	1400	1088
		End	1261	1054	1106	1400	1054
	F_3	**Beg**	1365	1330	1918	2074	2212

		mid	1505	1728	2333	2224	2212
		End	2005	2298	2350	2316	2212
[ji]	**F_1**	**Beg**	241	190	276	207	224
		Mid	241	190	362	295	224
		End	241	190	501	345	224
	F_2	**Beg**	2005	2298	2350	2316	2212
		Mid	2350	2350	2005	2254	2229
		End	2212	2405	1693	2195	2229
	F_3	**Beg**	2921	3339	2852	3370	3215
		Mid	2817	3094	2558	2955	3105
		End	2419	2938	2419	2731	2903

Table 5: averaged formantic values (F_1, F_2 and F_3) -in Hertz- extracted from the [n] and the [ji] segments' productions.

It can be observed in table 6 that the duration of the [n] segment varies from 83 to 167 ms, with an average value of 122 ms. The duration of [ji] is always greater (224 ms vs. 122ms). Besides, a stable formantic structure appears, for three subjects (1, 2 & 5), before the end of the nasal segment (see table 5). The establishment of the [i] sound is, during 102 ms on average, concomitant with the production of the nasal timbre. In this case, the timbre move from a dark quality (the nasal segment quality) to a clear one ([i]) through a transitional state, obtained via a specific management of the time function. The other two subjects (3 & 4), are characterized by a more transitional structure where the two segments are contiguous.

Subjects	**1**	**2**	**3**	**4**	**5**
[n] duration	88	158	83	116	167
[ji] duration	172	303	173	246	228
[nji] duration	260	461	256	362	395
beg. of [ji]	25	74	83	116	67

Table 6: Averaged duration (ms) of the [n] and [ji] segments; averaged total duration ([nji]); delay between beginning and emergence of the segment associated to [ji].

These results could be explained by the necessity for the Russian speakers of respecting the accentual system rules that do not allow a free manipulation of the time function (Bruyninckx & Harmegnies, 1998), which is not the case in Danish. Inversely, the modulation of pitch, which can be unrestrainedly used by Russian speakers, is slightly present in Danish only as an alternative or complementary process in extreme situations.

7. CONCLUSION

Our results show that the timbre transitionality is an essential marker of the palatal quality. It is generally obtained by a formantic transition when the environment allows it (e.g., strictly vocalic environment or heterogeneous environment). Other behavioral modalities can compensate when it is difficult for the speaker to use this kind of process. In these cases, the speaker can use a specific management of some parameters such the time function, the intensity or the pitch but always respecting the language system rules.

8. REFERENCES

Concerning letters Æ(æ), Ø(ø) or Ö(ö) et Å(å), these references respect the usual alphabetical order of the Scandinavian dictionaries in positioning of these letters immediately after the traditional Roman alphabet.

1. Bang, J., *Gyldendals leksikon*, Gyldendal, Copenhagen, 1976.

2. Basbøll, H., *Some conditioning phonological factors for the pronunciation of short vowels in Danish with special reference to syllabification*, Annual Report of the Institute of Phonetics, University of Copenhagen, *6*, 1972, pp. 185-210.

3. Basbøll, H., Is Danish 'sj' one or two sounds?, *Annual Report of the Institute of Phonetics*, University of Copenhagen, *2 (reprinting)*, 1975, pp. 157-160.

4. Blinkenberg A. and Høybye P., *Dansk-Fransk ordborg, Ny nordisk forlag,* Arnold Busck, Copenhagen, 1991.

5. Bredsdorff, E., *Danish. An elementary grammar and reader*, Cambridge University Press, Cambridge, 1958.

6. Brink, L., Lund, J., Heger, S., and Normann Jørgensen, J., *Den store Danske udtaleordbog, Munksgaards ordbøger*, Copenhagen, 1991.

7. Bruyninckx, M., Les spécificités de la qualité palatale, *Revue de Phonétique Appliquée, 114*, 1995, pp. 65-80.

8. Bruyninckx, M. and Harmegnies, B., La palatalité au crible de la phonétique, *Revue de Phonétique Appliquée, 118-119*, 1996a, pp.31-42.

9. Bruyninckx M. and Harmegnies B., La qualité palatale: prémices d'une description phonétique, *Cahiers de l'Institut de Linguistique de Louvain, 23 (1-2),* 1996b, pp. 419-427.

10. Bruyninckx M. and Harmegnies B., An approach of

the Catalan palatals discrimination based on durational patterns of spectral evolution, *Proceedings of the 5th European Conference on Speech Communication and Technology (Eurospeech 97), 2,* 1997, pp. 947-950.

11. Bruyninckx M. and Harmegnies B., Une approche inter-linguistique de la réalisation conjointe des qualités nasale et palatale, *Proceedings of the 16th International Congress of Linguists*, Pergamon, Oxford, *paper 0156,* 1997, 5 pages.

12. Bruyninckx M. and Harmegnies B., Spécificités acoustiques des segments palataux produits par des russophones, *Slavica Occitania, 6,* 1998, pp.143-172.

13. De Stemann, I., *Manuel de langue danoise*, Klincksieck, Paris, 1963.

14. Fisher-J ?rgensen, *Almen fonetik*, Gylendals, Copenhagen, 1962.

15. Fisher-J ?rgensen, E., Voicing, tenseness and aspiration in stop consonants, with special reference to French and Danish, *Annual Report of the Institute of Phonetics*, University of Copenhagen, *3,* 1968, pp. 63-114.

16. Fisher-J ?rgensen, E., Formant frequencies of long and short Danish vowels, *Annual Report of the Institute of Phonetics*, University of Copenhagen, *6,* 1972, pp. 49-57.

17. Fisher-J ?rgensen, E., Perceptual studies of Danish stop consonants, *Annual Report of the Institute of Phonetics*, University of Copenhagen, *6,* 1972, pp. 75-176.

18. Fisher-J ?rgensen, E., Phonetic analysis of the stød in standard Danish, *Phonetica, 46,* 1989 pp. 1-59.

19. Hansen, M., P., *Dansk Udtale,* Gyldendal r ?de ordb ?ger, Gyldendals, Copenhagen, 1990.

20. Spore, P., *La langue danoise*, Akademisk Forlag, Copenhagen, 1965.