DANISH R AND ADJACENT SHORT STRESSED VOWELS[1]

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Abstract: This is a presentation of the main features of the distributional pattern of Danish r and of some formant measurements of r-combinations. The possibility of describing /ɛ, œ/ after /r/ as ultra-short diphthongs is discussed.

1. Introduction

There are, in modern Standard Danish, two types of r-sounds. One is generally described as a comparatively fricative, unrolled,[2] back r, which is said to occur both voiced and voiceless, the other as a comparatively vocalic r, a non-syllabic, low vocoid[3] (Andersen 1954; Fischer-Jørgensen 1962). In this paper, the two r-types will be rendered by [ɻ̞] and [e̯], respectively, and will be termed "contoid" and "vocoid" r.

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1) I thank Hans Basbøll, Lars Brink, Eli Fischer-Jørgensen, and Jørgen Rischel for valuable help and critical remarks in connection with the preparation of the manuscript. Lars Brink has further been of great help in plotting JR's vowels in Jones' cardinal vowel diagram. Janet Gunzenhauser has suggested many valuable improvements of my English style.

2) Lars Brink suggests (personal communication) that Danish contoid r should be regarded as a kind of vibrant, which, unlike ordinary vibrants, has rapid and irregular vibrations accompanied by friction.

3) The concepts "vocoid" and "contoid" are used as suggested by Hjelmslev 1954 (who uses them almost as Pike 1943). A vocoid is thus a voiced, non-lateral, non-nasal, frictionless, continuant sound, that may be syllabic or non-syllabic. A contoid is any other sound.

At an earlier period, there was only one type of r-sound, the contoid r. Vocoid r is the result of a weakening of the fricative r in postvocalic position. For details of this development, see Brink and Lund (1975) and section 3.1 below. In phonological descriptions, the two types of r-sounds are generally regarded as members of the same phoneme (e.g. Andersen 1954; Basbøll 1969). Lars Brink has argued, however, that contoid and vocoid r are, in fact, commutable, and that they should therefore be described as separate phonemes (personal communication). For arguments in favour of this opinion, see section 3.1 below.

The Danish vowel system has been strongly influenced by the existence of the r-sounds, partly because a number of vowels have been lowered/retracted before or after r (e.g., the vowels in words like tres, skrift, earlier pronounced [ɖʁes, sɡ̊ʁefɖ],[1] are now pronounced [ɖˢʁæs, sɡ̊ʁæfɖ] by young people); partly because earlier [ɑ] has been preserved after contoid r (e.g., raske [ʁɑsɡ̊ə]), while in other cases, it has developed into [a] before coronal (i.e., dental, alveolar, and alveolo-palatal) sounds and zero (e.g., aske [asɡ̊ə]); and, finally, because r in some cases has merged with the preceding vowel, which has resulted in the addition of two more vowel phonemes (/ɑ ɒ/) to the inventory, cf. ane [æ:nə] vs. Arne [ɑ:nə], and åle [ɔ:lə] vs. årle [ɒ:lə]. Formerly, a discrete r was pronounced after the vowel in words like Arne, årle, so that the vowels in word pairs like ane and Arne could be regarded as bound variants.

The purpose of the present paper is to contribute to the description of Danish r, both contoid and vocoid, and of the adjacent short stressed vowels. In section 3, the main distributional peculiarities concerning r and adjacent short vowels will be given. The consequences of the distributional pattern for the phonological description will be touched upon, but it is not my intention to go into a detailed discussion of Danish phonology. In section 4, some acoustic data about r and adjacent vowels taken from sonagrams will be given.

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1) For the values of the vowel signs, see below.

The kind of Danish described in this paper is approximately the same as that which Basbøll (1969) calls Advanced Standard Copenhagen. Thus, forms that are correlated with either relatively high age, relatively low socio-economic class, or some specific region in Denmark are excluded, which is not to say that everything that does lie within the chosen norm is treated exhaustively.

The phonetic notation used is that of IPA, except for the following modifications:

Primary stress is shown by acute accent (but not all cases of primary stress are indicated). A non-syllabic vowel is rendered by [̯] under the vowel sign, e.g., [e̯]. The following vowel signs have for practical reasons been redefined: [e, ø, o] = IPA [e˕, ø˕, o˕]; [ɛ, œ] = IPA [e˔, ø˔]; [æ, Œ] = IPA [ɛ, œ], [a] = IPA [ɛ˔]; [ɑ] = IPA [a-]; [ɔ] = IPA [ɔ+˕]; [ʌ] = IPA [a-ˀ] (thus [ʌ] is used as a sign for a (slightly) rounded vowel); [ɒ] = IPA [ɒ˕]. When diacritics are used, they refer to the above mentioned vowel values. Thus [Œ̞] = IPA [œ˔]. The signs [ä] and [Ö] are used as signs for the vowel segments in words like rem, træt and drøm, rønne respectively, without indicating any specific phonetic values; thus the sign [¨] does not in this paper have the traditional IPA-value "centralized". When the precise quality is not under discussion, the signs [i̯] and [o̯] are used for the second components in "i-" and "u-diphthongs" respectively, i.e., in words like vej, støj, and syv, hav (noun) [vɑi̯', sdʌi̯', syo̯', hɑo̯], disregarding the precise values. [ɪ] and [ʊ] are used for the corresponding syllabic sounds, i.e., for the last sound in words like veje, støje, løbe, have [vɑi̯ɪ, sdʌi̯ɪ, løo̯ʊ, hæo̯ʊ] (provided that they are not pronounced with [ə]). [ɪ] and [ɐ] are undefined with respect to lip position. As the "stød"-sign, ['] is used, as recommended by IPA; [?] has the usual value, "glottal stop".

2. Earlier descriptions of Danish r

2.1. Contoid r

Jespersen (1906, translations mine) describes Danish voiced contoid r as follows: "... the root of the tongue is retracted, so that a slit is formed between it and the uvula or (and) the pharyngeal wall. The velum is closed and blocks the nasal cavity, but the uvula, which is generally totally inactive, may now and then, especially in formal speech, start vibrating ... The vocal cords vibrate" (p. 79). He compares contoid r to [ɣ] and states: "thus r ... in ordinary Danish pronunciation only differs from [q][1] ... in being formed farther back in the mouth ..." (p. 37). About unvoiced r he says: "Our r is in most instances voiced, but it becomes voiceless ("pustet") [ʀ̥][2] ... after p, t, k, f, thus prise [pʀ̥i·sə][3] - [bri·sə] brise ..." (p. 57). These descriptions are not changed in the third edition, published in 1934.

Also Andersen (1954, translations mine) describes the place of articulation as uvular-pharyngeal and describes the articulation as follows: "While by the related slit-shaped velar approximant [ɣ] all of the back of the tongue is raised high towards the soft palate, the movement is in the case of [ʁ] restricted to the rear part of the tongue, which is but slightly raised, rather being pushed backwards towards the pharyngeal wall and the uvula, while at the same time the rear palatine arches are drawn together horizontally, so that the opening, as opposed to the flat slit in the case of [ɣ], here approaches the shape of the tube (groove)" (p. 349). As for the degree of constriction, he says: "the Danish [ʁ] is unrolled and very lax and open" (ibid.). Also Fischer-Jørgensen (1962) describes the place of articulation as uvular-

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1) = IPA [ɣ]

2) = IPA [ʁ]

3) More correct (in Jespersen's notation) would be [bʀ̥i·sə]. See below, section 3.1.

pharyngeal and mentions the contraction of the rear palatine arches, but in addition she says that contoid r has a lowering of the uvula and that this sound has a lower jaw position than [ɣ] (p. 75). Fig. 1 shows median profiles of contoid r.

2.2. Vocoid r

Under the heading "Central Vowels", Jespersen (1906, p. 85) describes the vocoid r as "... a 'vocalic r' that is distinguished from the consonants by greater distance between the tongue and the pharyngeal wall and the velum and altogether by more lax muscle activity". Grove (1927) draws the logical conclusion from this and describes (monosyllabic) vowel plus vocoid r as a diphthong. According to Grove, the lip position is determined by the surrounding sounds; he describes the movement from vowel to vocoid r as a movement towards [ɒ] (after rounded vowel) or [ɑ] (after unrounded vowel). Also Diderichsen (1957), Basbøll (1973) and Heger (1975) describe the connections of short vowel plus vocoid r as diphthongs; Basbøll and Heger mention that the lip position is determined by the surrounding sounds. Basbøll describes the gliding as directed towards a low back vowel, while Heger and Brink and Lund (1975) describe the end point as a central vowel, except for the speech of older people. Andersen (1954) describes the vocoid r as "a pharyngeal vocoid, appr. = [ɒ]" (p. 349), but as he sometimes uses the sign [ʁ] for vocoid r, a sign that is undefined with respect to lip position, he probably does not consider vocoid r to have fixed lip rounding.

3. Distributional description

It was mentioned above that the two types of r-sounds are traditionally regarded as allophones of the same phoneme. It is not my intention to discuss the validity of such an analysis.

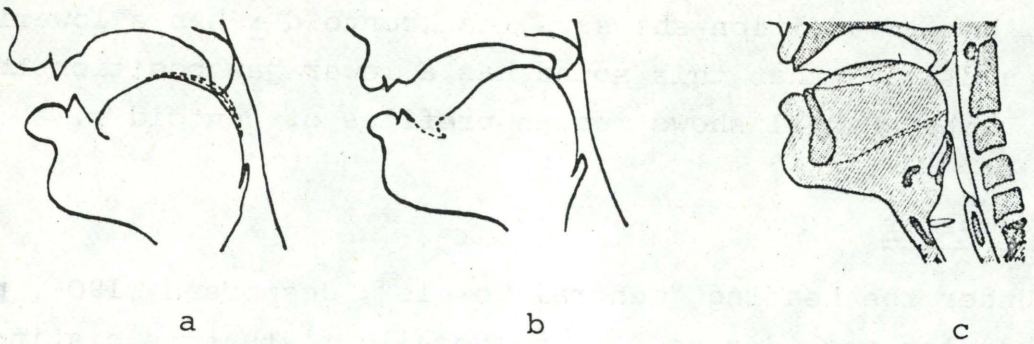

Figure 1

Contoid r; tracings from X-rays. a and b: contoid r as spoken between low back vowels by two different subjects (after Fischer-Jørgensen 1962). c: after Forchhammer 1942.

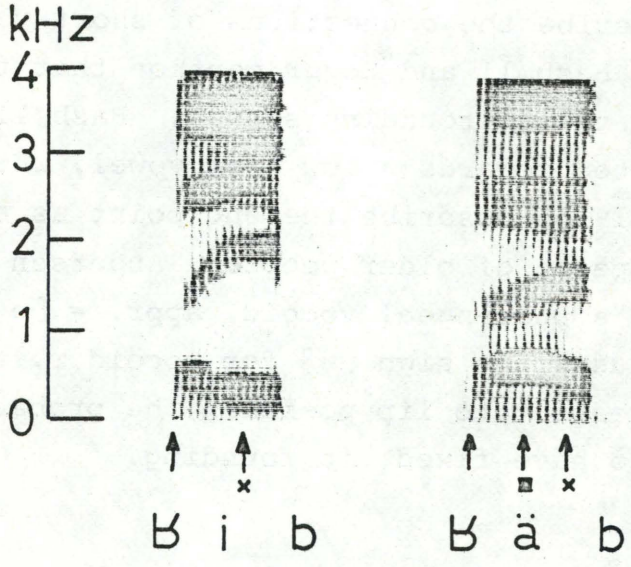

Figure 2

Examples of points of measurement in relation to the time scale in words with contoid r. Arrows: beginning of formant transitions from r to vowel ("contoid r"); crosses: F2-maximum; square: F1-maximum. The words are rippe and repsen (as spoken by the author).

I shall confine myself to a presentation of the main distributional properties of the two types of r-sounds, especially those which have consequences for the way in which the phonological analysis is carried out. Further, the (phonetically) short stressed vowels occurring adjacent to r-sounds will be enumerated. The rules given below all have the word as their "domain", i.e., they only concern utterances consisting of one word.

3.1. Distribution of the r-sounds

The most important limitations of the distribution of the two kinds of r-sounds are the following:

(i) contoid r only occurs immediately before a vowel
(ii) vocoid r only occurs immediately after a vowel.

A "vowel" is here to be understood as a syllabic vocoid. As [ðɐ] is a vocoid in Danish, [ðɐ̩] is included among the vowels.

The two r-types are further limited in their distribution with respect to the individual vowels and consonants. Concerning vowels, see section 3.2 below. Concerning consonants, the following limitations for contoid r can be mentioned:

(iii) when [ʁ] occurs in word-initial groups, it is always preceded by [ʦ, ʧ, ʧ̊] or [v], e.g. brise, dråbe, gris, vred;
(iv) [ʁ] only occurs after [ʦ, ʧˢ, ʧ̊] or [f], e.g. prise, tro, krat, fred;
(v) word-initially, [ʁ] does not occur in three-consonant groups.

The occurrence of initial contoid r can thus be summarized in the following formulae:

(a) ({(s){ʦ, ʧ, ʧ̊}, v}) ʁ [+syllabic]
(b) {ʦ, ʧˢ, ʧ̊, f} ʁ [+syllabic]

Note that [ʁ] and [ʁ̥] have overlapping distribution, as both occur after [b̥] and [g̊], and that they accordingly are commutable. Compare also minimal pairs like prise - brise, krigs - gris [b̥ʁ̥i:sə - b̥ʁi:sə, g̊ʁ̥i:'s - g̊ʁi:'s].[1] In most phonological descriptions, this difference between [ʁ̥] and [ʁ][2] is regarded as a manifestation of the difference between /p/ and /b/, /k/ and /g/ respectively (/pri:sə, bri:sə; kri:'s, gri:'s/).

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1) "Vowel with 'stød'" is written [V:'] where [V] stands for any vowel sign. This notation is to be understood as [VV̯'], thus [i:'] = [ii̯'].

2) Eli Fischer-Jørgensen points out (personal communication) that r may be voiceless after b, d, g; she prefers to describe the difference between pr and br etc. as one of aspiration. In this connection I should like to draw attention to the difference between what I shall tentatively call "breathed" sounds and voiceless sounds. Voiceless sounds are sounds without vibration of the vocal cords; e.g., [s], [g̊], and [h] are voiceless sounds. Breathed sounds are sounds with a comparatively large air flow through the glottis; the air flow must be greater than that of ordinary voiced sounds. Thus [s], [h], [ɦ], and the murmured (breathy) vowels are breathed sounds. As the properties of voicelessness and "breath" may be present or absent in a sound segment independently of each other, the following diagram may be set up:

	voiced	voiceless
nonbreathed	all voiced sounds except the murmured sounds.	voiceless stops; voiced, nonbreathed sounds during whisper; possibly some voiceless continuants, e.g. Danish r after b,d,g.
breathed	murmured vowels and the corresponding non-syllabic sounds ([ɦ]).	voiceless continuants that do not belong to the "pigeon-hole" above, e.g. [s], [h], Danish r after p,t,k.

Thus, what Eli Fischer-Jørgensen describes as an aspiration difference might also be described as a difference in the degree of air flow in the segment following the stop. Of course, the two r-sounds, the breathed and the nonbreathed r, are commutable anyway. Note that voiceless continuants are generally understood to be breathed. As there is no appropriate symbol for voiceless but nonbreathed sounds, [ʁ] will be used in this paper for nonbreathed contoid r, whether voiced or voiceless.

Traditionally, contoid and vocoid r are said to be in complementary distribution, so that contoid r occurs only in (syllable-)initial position, while vocoid r occurs in (syllable-) final position (e.g., Basbøll 1969). However, both [ʁ] and [ɐ̯] occur in intervocalic position, as appears indirectly from rules (i) and (ii) above, and they are, accordingly, not in complementary distribution.

Firstly, the two r-sounds occur in intervocalic position conditioned by word conjunction, either in utterances with more than one word, or in compounds. Consider, for example, utterances like de råber 'They call (out)' and han giver ål 'He treats to eel' [ɡiʁɔ̝:'ɓʌ, haŋ̊giɐ̯ɔ̝:'ɪ], or compounds like iturevet and urafstemning [iɡ^{sh}ûʁæɷ'ð̩ɐ^{1}, ûɐ̯ɑ̯sɡɛm'neŋ]. Accordingly, it will be possible to form minimal (utterance) pairs that show the commutation [ʁ] - [ɐ̯], for instance, Så giv rivalen fred 'Then give the rival a little peace' - Så giver I hvalen fred 'Now you give the whale a little peace' [sʌ̊giʁivæ̝:'ˌnfɓæ̝ð̩ - sʌ̊giɐ̯ivæ̝:'ˌnfɓæ̝ð̩]. (On the other hand, the position of the word boundary, if any, will be indicated by the kind of r-sound that occurs, because the word boundary, according to rules (i) and (ii), must go immediately before an intervocalic [ʁ] and immediately after an intervocalic [ɐ̯].) Thus it is clear that the difference between vocoid and contoid r may be the only difference between two semantically different utterances, or that [ʁ] and [ɐ̯] are commutable. Of course, the fact that there may be a glottal stop between vocoid r and the following vowel in such cases does not contradict this conclusion.

Secondly, the two r-sounds occur in intervocalic position in simplex words (including derivatives). In most of these cases, the two r-sounds alternate freely, with contoid r being favoured by:

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1) Note that other phoneticians use the sign [æ] for the vowel in words like tremme, strække, which in this paper is rendered by [ä].

1) strong stress on the following vowel
2) articulate speech
3) a rare word
4) conservative language,

whereas vocoid r is favoured by:

5) weak stress on the following vowel
6) slurred speech
7) a frequent word
8) speech of the younger generation
9) the fact that the following sound is, or has developed from, [ə]
10) occurrence after a short stressed vowel.

The quality of adjacent vowels may also play a role. Note that, in some cases, [ʁ] alternates with other sounds than [ɐ̯], compare, e.g., fyrig [fy:ʁi, fy:ʌɻ], hare [hɑ:ʁə, hɑ:ɑ].

However, some simplex words always have vocoid r, even if all the factors favouring contoid r are present. This is the case in derivatives with the endings -agtig ('-like' or '-ish') or -inde ('-ess'). That words like majorinde and storagtig, (derived from major, stor) [maɻoɐ̯énə, sɡoɐ̯ɑ̊ɡɡi] always have vocoid r (while words like rigoristisk and professorat (derived from professor) [ʁiɡ̊oʁɪ̈sɡisɡ̊, ɓʁofɛsoʁɑ̈:'ɡ], generally have contoid r) cannot be predicted on the basis of the phonetic properties of the words in question.

Since the two r-sounds, in the cases where they have the same distribution, are not in free variation, each of them constitutes a (pre)phoneme. Therefore, any phonological description that wants to get by with only one /r/-phoneme must account in some other way for the words that have [ɐ̯] in spite of rules 1-4 above. (Probably this would be done most expediently by having a commutable syllable boundary (which we can render by /$/), which, in this connection, only occurs in words that, in spite of the above mentioned rules 1-4, always have vocoid r. It would, in

addition, require the manifestation rule: "/r/ is always manifested as vocoid r before /$/".)

3.2. The short vowels occurring adjacent to r-sounds

3.2.1. Short vowels after contoid r

	front		central		back
	unrounded	rounded	unrounded	rounded	rounded
high	[i] Brit	[y] brynje			[u] brud
					[o] rod
	[æ] bredt	[œ] grynt			[ɔ] gråd
low	[ä] bræt	[Œ̈] grønt	[ɑ] brat	[ʌ] front	[ɒ] rov

The above table displays in order of phonetic value the (phonetically) short vowels occurring after contoid r, including an example of each possible combination of contoid r plus vowel. The combinations [ɹæ, ɹœ, ɹä, ɹŒ̈], i.e., contoid r followed by non-high front vowel, have developed gradually from earlier [ɹe, ɹø, ɹɛ, ɹœ] respectively. Therefore, qualities closer to the earlier pronunciations can also be found, mostly with older speakers (Brink and Lund 1975). In the other cases, vowel quality and vowel length are not conditioned by the r.

3.2.2. Short vowels before vocoid r

	front		back
	unrounded	rounded	rounded
high	[i] svir	[y] styr	[u] turban
	[e] klaver	[ø] dør (verb)	[o] sort (adj.)
	[ɛ] hver	[œ] dør (noun)	([ɔ] åerne)
low	[a̟] forvær	[Œ̟] forstør	

In words like forvær, qualities between [æ] and [a] occur. Similarly words like forstør have [Œ̞] or lower qualities. In the case of many younger speakers, there is no [ɛ] before vocoid r; instead, they have [æ̞]. Also [œ] before [ɐ̯] is rare with younger speakers, who thus frequently only have 3 commutable vowels in each of the front series, i.e., [i, e, æ̞] and [y, ø, Œ̞]. The occurrence of short [e, ɛ, ø, œ, ɔ] before [ɐ̯] is conditioned by the fact that earlier long [e:, ɛ:, ø:, œ:, ɔ:] (including the corresponding "stød"-vowels) have been shortened as a part of the general shortening of vowels before vocoid r (and the corresponding syllabic sound [ʌ]). This shortening, which is not obligatory except for the younger speakers (and even then not in all types), is much less widespread in the case of [ɔ(:)], compare [ɔ:'ʌnə] åerne without shortening vs. [ɔɐ̯'ʌnə]. (For a discussion of the words spirrevip and spiritus, see section 4 below.)

It thus appears that, for speakers who have both [ɛ] and [æ̞] and [œ] and [Œ̞] before [ɐ̯], there are eight commutable short front vowels and therefore eight (pre)-phonemes. As for the back series, there are three commutable vowels, but [ɔ] occurs somewhat more infrequently than the other vowels.

3.2.3. Short vowel both before and after r-sound

	front		back
	unrounded	rounded	rounded
high	[i] rir	[y] gryr	[u] Ruhr
			[o] ror
		[œ] strør	([ɔ] råerne)
	[æ] ræ̞r		
low		[Œ̞] rør	

The combination contoid r plus [œɐ̯] only occurs when [ɐ̯] is an inflexional suffix, cf. infinitive strø [sɡʁœ:'], present tense

strør [sɡʁœ:'ʁ, sɡʁœʁ'], the last form with shortening of the vowel. As for [ɔ], see section 3.2.2 above.

4. Acoustic description

In this section, some acoustic data will be presented concerning the two types of r-sounds in Danish and their adjacent short vowels, compared with short vowels not adjacent to r. The data are based on a sonagraphic investigation of two speakers of Standard Danish. The two subjects, JR and MBL, read the following word lists (MBL did not read list no. 3):

List no. 1:	List no. 2:	List no. 3:	
hippie [hiɻi]	rippe [ʁiɻə]	hirse [hiʁsə]	/i/
yppe [yɻə]	krybbe [k̊ɡʁyɻə]	hyrde [hyʁɡə]	/y/
gubbe [g̊uɻə]	gruppe [g̊ʁuɻə]	urter [uʁɡʌ]	/u/
sippet [seɻð̩ᵀ][1]	ribset [ʁæɻsð̩ᵀ]		/e/
høflig [høfli]	røffel [ʁœf̩l]		/ø/
humle [hɔmlə]	rumme [ʁɔmə]		/o/
heppe [hɛɻə]	repsen [ʁäɻsn̩]	herse [hæʁsə]	/ɛ/
ømme [œmə]	rømme [ʁŒmə]	ørken [Œʁɡŋ̊]	/œ/
oppe [ʌɻə]	rubber [ʁʌɻʌ]		/ɔ/
haste [hasɡə]	raste [ʁɑsɡə]		/a/
hapse [hɑɻsə]	rapse [ʁɑɻsə]		

The phonetic transcription above is not a reproduction of the way the two speakers read the lists, but rather a kind of "standard transcription". List no. 3 only contains words whose short vowels are not short due to the above-mentioned shortening before vocoid r. The three word lists were read three times by JR, who was born in 1934 and speaks standard Danish (somewhat conservatively for his age). Lists no. 1 and 2 were read twice by MBL, who was

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1) Some people pronounce this word with an [i] which, however, was not the case for these two subjects.

born in 1930 and also speaks standard Danish. Both subjects are males (and phoneticians). The recordings took place at the Institute of Phonetics, University of Copenhagen, with professional equipment. Sonagrams, both narrow and wide, were taken of all the words.

According to traditional phoneme analysis, Danish has 10 short vowel phonemes, of which /e, ø, ɛ, œ/, and /a/ before coronals and zero, have clearly different allophones after contoid r, while the other phonemes have practically the same vowel quality after contoid r as in other positions. The word list above indicates which vowels are generally regarded to be allophones of the same phoneme. Earlier, the allophones after contoid r had the same quality as in other positions, so that the present-day difference between the qualities of /e, ø, ɛ œ/, and /a/ before coronals, in the position after contoid r and their qualities in other positions is caused by the contoid r. The influence of contoid r has resulted in a lower and/or more retracted quality after r than in other positions. Similarly, vocoid r has caused a lowering of earlier [ɛ, œ] to the present-day [æ̝, ɶ̝] in words like herse, ørken. On the other hand, earlier [e, ø] before vocoid r, e.g., in hirse, hyrde, has been raised to modern [i, y]. (The words spirrevip and spiritus may, however, retain [e], probably for reasons of vowel harmony.) Vowels whose quality is relatively low and/or retracted due to the presence of an r-sound will hereinafter be termed "r-coloured vowels".

It will be seen that the word lists permit the following kinds of comparisons:

1) r-sounds occurring after/before different adjacent vowels may be compared (e.g., [ʁ] in rippe (/ri../) and [ʁ] in ribset (/re../) or [ɐ̯] in hirse and [ɐ̯] in herse);

2) A vowel adjacent to r may be compared with the "same" vowel in other positions (e.g., [ɪ] in rippe and [i] in hippie or [ɪ] in hirse and [i] in hippie);

3) r-coloured vowels may be compared to the corresponding "un-coloured" vowels (e.g., [æ] in ribset and [e] in sippet or [æ̝] in herse and [ɛ] in heppe).

The sonagrams were measured in order to determine the formant frequencies. The intention was to measure the formant frequencies at the points that corresponded to the articulatory target position of the vowels and the r-sounds. In words from list no. 1, the vowel was measured at the beginning of the vowel segment (except in gubbe and sippet). The points of measurement in words with contoid r are examplified in fig. 2, where a dot denotes a point of measurement. It was not possible to measure the target position in the case of contoid r because there was not sufficient energy present; instead measurement was made at the beginning of the transition to the vowel. (In the cases where F3 begins later than F1 and F2, it was not measured at all.) The vowel after contoid r was measured at the F2-maximum, on the assumption that the target position in these cases could neither be earlier in the vowel segment if F2 was still rising, because a rising F2 is generally regarded as an indication that the tongue is being advanced (disregarding an opening at the lips, which cannot take place in these cases), nor later in the vowel segment, because the only factor that could cause a lowering of F2 is the on-glide to the following labial sound. The possibility that a simultaneous advancing of the tongue and closing at the lips might cause the F2-maximum to occur too early in the segment and/or to be too low in relation to the articulatory target position of the tongue exists, but it is only likely in the cases where the target position of the vowel is far away from that of contoid r, i.e., when r is followed by high front vowels, and in these cases the F2-maximum actually occurs comparatively

late in the vowel segment (compare fig. 2). It was in order to ensure that there was an F2-maximum that the words in list no. 2 were chosen with a labial consonant after the vowel.

In words like ribset, røffel, repsen, rømme, i.e., in cases of non-high front vowel after contoid r, the transitions from r to F2-maximum do not consist of concurrent movements of F1 and F2, since F1 rises from r to a maximum that is attained earlier than the maximum of F2 (see fig. 2). In these cases, measurements for JR were also made at the F1-maximum.

In words from list no. 3, the vowel was measured at the beginning of the vowel segment, while vocoid r was measured at the F1-maximum.

4.1. The results

The numerical results appear from table 1 (JR) and table 2 (MBL). In both cases, the tables contain the average values. The standard deviations have not been calculated, but the dispersion for JR was about 25-75 Hz (except for one instance, where it was 175 Hz). For MBL, the dispersion was of a similar extent. In fig. 3, the values for JR, lists no. 1 and 2, have been plotted in the usual F1-F2 diagram. In these and the following F1-F2 diagrams, a dot indicates the values for the measurements in list no. 1; a cross indicates the values measured at the F2-maximum in words from list no. 2, a square values measured at the F1-maximum; the values measured at the beginning of the vowel transitions in words from list no. 2 (i.e., the beginning of the transitions from contoid r) are connected with the other values by an unbroken line; "r" is thus indicated by the right-hand end-point of this line. The measurements in the words hapse and rapse, i.e., /a/ before [b̥], have been omitted from the diagram. Note that, in fig. 3, all F1-values connected with /a/ have been increased (arbitrarily) by 50 Hz in order to avoid a crossover of lines.

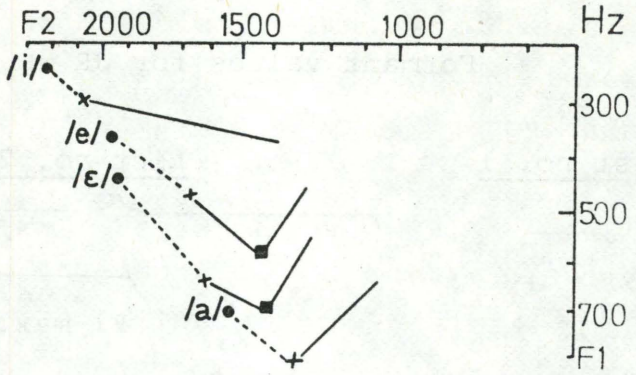
TABLE 1

Formant values for JR

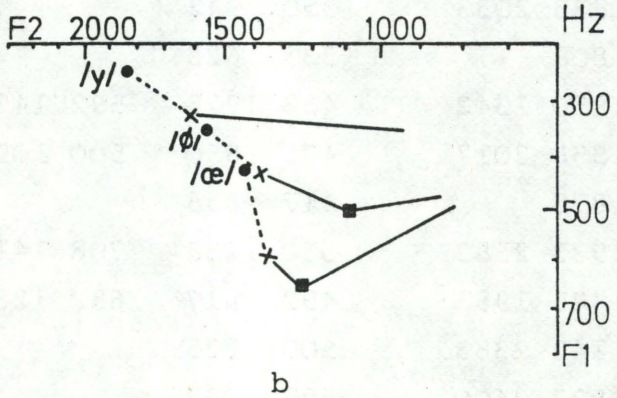
	List no. 1			List no. 2					
				"[ɣ̞]"		vowel			
						F1-max.		F2-max.	
	F1	F2	F3	F1	F2	F1	F2	F1	F2	F3
/i/	242	2208	3008	375	1375			300	2075	2633
/y/	250	1833	2033	350	942			325	1608	2075
/u/	275	808		333	625			325	642	
/e/	367	1950	2542	458	1275	592	1433	475	1675	2358
/ø/	350	1558	2017	475	850	500	1092	433	1375	2067
/o/	458	875		417	658			450	792	
/ɛ/	442	1933	2583	550	1258	708	1417	642	1617	2383
/œ/	425	1425	1983	492	817	652	1233	592	1350	2158
/ɔ/	675	1142	2383	500	825			633	950	
/a(s)/	658	1533	2400	592	1067			767	1325	2483
/a(b)/	725	1392	2467	575	1125			725	1142	2475

List no. 3

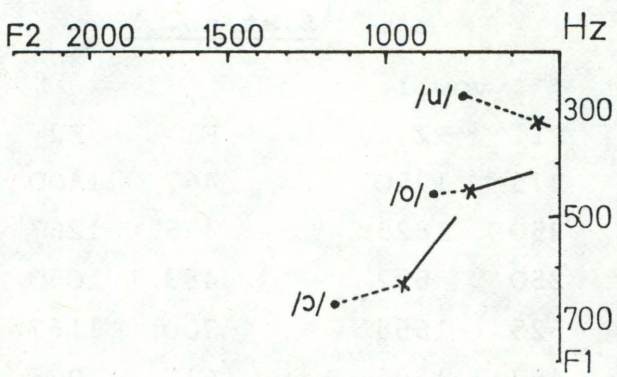
	vowel		[ɐ̞]		
	F1	F2	F1	F2	F3
/i/	275	1950	467	1400	2267
/y/	250	1825	475	1267	2117
/u/	250	692	483	1050	2158
/ɛ/	525	1658	700	1167	2233
/œ/	467	1392	617	975	2067



a



b



c

Figure 3

(Text, see opposite page)

Figure 3 (opposite page)

F1-F2 diagrams showing the beginning of vowel transitions from contoid r, as well as vowels after contoid r compared to vowels not adjacent to r. Right-hand end-point of solid lines: beginning of transitions from contoid r; squares: F1-maximum (if any) in the vowel segment following contoid r; crosses: F2-maximum in the vowel segment following contoid r; dots: vowels not adjacent to r, i.e., vowels in words from list no. 1. The values from the words hapse and rapse are omitted from the diagrams. Note that all F1-values found in words with /a/ are increased by 50 Hz in order to avoid a cross-over of lines. Subject: JR.

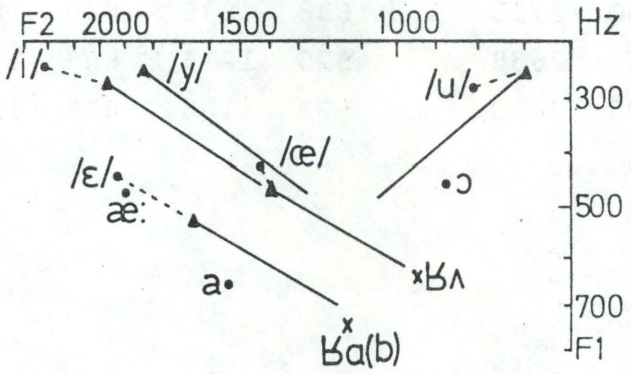


Figure 4

F1-F2 diagram showing vowels before vocoid r compared to vowels not adjacent to r, as well as vocoid r. Triangles: vowels in words with vocoid r; dots: vowels in words from list no. 1, i.e., vowels not adjacent to r; lower end-point of solid lines: vocoid r. In order to facilitate a comparison, some other vowel qualities are plotted, namely the quality of long [æ:] (as in hale) and the qualities in haste, rapse, rubber and humle. Subject: JR.

TABLE 2

Formant values for MBL

	List no. 1			List no. 2				
	vowel			"[ɣ̞]"		vowel (F2-max)		
	F1	F2	F3	F1	F2	F1	F2	F3
/i/	263	2375	3013	425	1238	375	2063	2663
/y/	238	1975	2213	375	1000	313	1613	2288
/u/	250	875		363	675	288	700	
/e/	300	2200	2813	525	1288	400	1963	2450
/ø/	300	1650	2213	475	838	375	1425	2313
/o/	338	900		350	650	438	825	
/ɛ/	363	2250	2863	663	1225	725	1863	2463
/œ/	325	1638	2300	538	775	688	1500	2438
/ɔ/	663	1250	2725	638	875	688	1088	2625
/a(s)/	700	1663	2638	575	1213	663	1325	2075
/a(b)/	775	1525	2400	538	1188	675	1275	2088

4.1.1. Contoid r

As appears from tables 1 and 2 and from fig. 3, F1 begins in the area 325-675 Hz. In the case of the three high vowels [i, y, u], F1 begins with a higher frequency than that of the following vowel, i.e., F1 falls from r to the vowel, while, in the case of the non-high vowels, it begins relatively low and then rises. This is also true for MBL. (Also in the case of MBL's contoid r plus /e/ and /ø/ there are examples of an F1-maximum before the F2-maximum, although they do not appear from table 2.) In all cases, F2 begins with a lower frequency than that of the following vowel. It was often difficult to measure F3 because of lack of intensity, particularly in the back vowels. Before [i, æ, ä], F3 begins in the area 2100-2475 Hz, depending on the F3-value of the vowel; before [y, œ], F3 begins at about 2250 Hz.

4.1.2. Vowels after contoid r

In fig. 3, a solid line connects values found in words with contoid r, while a dotted line connects a vowel from list no. 2 (after r) with the corresponding vowel from list no. 1 (after other consonants). This is justified by the fact that those vowels connected by dotted lines are traditionally regarded as having (almost) the same vowel quality (which is the case for /i, y, u, o, ɔ/), or that they at an earlier time had the same quality, but have been changed under the influence of contoid r (which is the case of /e, ø, ɛ, œ/, and /a/ before coronal and zero). It will be seen that the vowel occurring after r (marked by a cross) in all cases is different from the corresponding vowel from list no. 1 (marked by a dot), including those vowels which are traditionally regarded as having the same quality. In the case of rounded back vowels and the high vowels (/i, y, u, o, ɔ/), the difference is simply that the vowel after r is closer to r. In the case of the other vowels, the difference is that

the vowels after r (the r-coloured vowels) have a higher F1 and a lower F2, a difference that generally corresponds to a lower and/or more retracted tongue position. In the case of /e, ɛ, œ/, the higher F1 cannot be explained on the basis of the formant values for r, since r's F1-value in these three cases is lower, cf. fig.s 3a and 3b. For all four non-high front vowels, the difference can, however, be explained as an influence from the F1-maximum (marked by a square), occurring in the vowel segments in question.

It still remains to be explained why the F1-maximum has such a high value for /e, ɛ, œ/. This may be an automatic and unavoidable effect of the movement of the tongue from the r-position to the vowel, even when this movement is the shortest possible and/or most direct one, or it may be caused by a diphthongal movement of the tongue from the r-position through an (audibly) lower vowel position than necessary. Since the concept "diphthong" denotes a perceptual phenomenon (as do many other phonetic concepts), the possibility of a diphthongal interpretation of the formant movements in question cannot be discussed without referring to the auditory impression of one or more persons.[1] A few Danish phoneticians, including the present

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1) It seems indisputable that the above-mentioned complex formant movements from r to the target values of the following vowel may be caused by a corresponding diphthongal movement of the tongue. On the other hand, it is also possible that such complex formant movements might arise as a consequence of a non-diphthongal tongue movement; but I am not at present in a position to determine whether the complex formant movements in the present material could be caused by a non-diphthongal tongue movement (Fant 1960, which contains information relevant to the discussion, does not allow for any specific conclusions concerning this issue). In any case, even if it could be shown that the complex formant movements might be caused by a non-diphthongal tongue movement, only perceptual evidence would be decisive in order to settle the discussion about the appropriate analysis of the pronunciations in question, i.e., whether they contain diphthongs or not.

Note, incidentally, that Delattre 1971 has found in a number of languages with consonants related to Danish contoid r, instances of a complex tongue movement between vowel and consonant.

writer, perceive the vowel segments in [ʁ(ᵒ)ä]- and [ʁ(ᵒ)Œ̈]-combinations as diphthongal and closely related to the Danish diphthongs [ɑɛ̯] and [ʌœ̯] (as, e.g., in the words rejse, trøjer), but differing from these in that, in [ä] and [Œ̈], the second component is closer to the first, i.e., approximately [ɑa̯] and [ʌŒ̯] respectively.

However, in this connection we can mention an auditory test carried out by Peter Molbæk Hansen and Bent Møller in order to examine whether the words strække and strejke have merged in the sociolect of the lower socio-economic classes in Copenhagen.[1] When not merged, the two words are pronounced with [ʁäg̊] and [ʁɑɛ̯g̊] respectively. The two words are perceptually very close to each other, but speakers of Standard Danish have a clear commutation in spontaneous speech. A speaker who was assumed to pronounce the two words alike recorded them. They were then played back in random order in the presence of various audiences, among other a group of phoneticians (including the author), who were asked to identify the test words as either strække or strejke. It turned out that the test words could not be identified correctly with more than random accuracy: a test word was identified now as strække, now as strejke, regardless of whether it was a pronunciation of strække or of strejke. Of course, this indicates that there was no difference in pronunciation between the two words. But in our connection, it is interesting to note that as many pronunciations of the word strejke were identified as strække as the other way around. It is tempting to regard this as an indication that strække is also pronounced with a diphthong, for how could a word containing a diphthong regularly be heard as a word not containing a diphthong?

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1) For a brief, general presentation of Molbæk's and Møller's investigation, see their paper in this volume of ARIPUC (the problem of strække - strejke is not included in that paper).

4.1.3. Vocoid r

The numerical results for vocoid r appear from tables 1 and 2 and fig. 4, where a triangle indicates vowel values in words from list no. 1, and values for vocoid r are unmarked but connected with the values for the corresponding vowels by an unbroken line. As in fig. 3, a dotted line connects values for vowels from list no. 1 with values for vowels from list no. 3, with the justification either that the connected vowels traditionally are regarded as having (practically) the same vowel quality (which is the case of /i, y, u/)[1], or that this was earlier the case (/ɛ, œ/).

After the high vowels, vocoid r seems to be something like a non-syllabic neutral vocoid, [ɚ̯], while, after /ɛ/ and /œ/, it is, rather, a central low non-syllabic vocoid. The F3-values for vocoid r lie between those of the unrounded and rounded vowels, which indicates that vocoid r has no specific lip position, but that this may vary, depending on the lip position of the surrounding sounds.

4.1.4. Short vowel before vocoid r

In one case, there is no difference between the values for a vowel from list no. 1 and the values for the corresponding vowel from list no. 3, namely in the case of /y/. In the other cases, the vowel before r is closer to r, except /u/, where the vowel before r is farther away.

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1) As mentioned above (section 4), [iɚ̯] and [yɚ̯] have gradually developed from earlier [eɚ̯] and [øɚ̯] respectively; accordingly, there also occur intermediate qualities. Words with modern [uɚ̯] have also had a lower quality, [oɚ̯], at an earlier date. Of course, [i, y, u] before [ɚ̯] may also have developed from earlier long vowels, cf. section 3.2.2 above.

4.2. The acoustic data compared with an auditory description

In order to give the reader an idea of the more exact phonetic quality of the vowels that are described acoustically above, the vowels from JR's first reading of the lists have been plotted in Daniel Jones' cardinal vowel diagram, using two tape recorders so that Jones' and JR's vowels could be compared directly and immediately. Two different plottings were carried out by the Danish phonetician Lars Brink and the author; they were done independently of each other, and there was no later correction. They are seen in figs. 5 (Lars Brink) and 6 (Steffen Heger). The same symbols are used as in the previous figures. Thus, a dot denotes a vowel from list no. 1, a cross a vowel from list no. 2, and a triangle a vowel from list no. 3. Two crosses connected by a solid line indicate that a glide from the low to the high quality (i.e., a closing diphthong) was heard. Note that diphthongs were not heard in every case of non-concurrent formant movements, and that LB and SH differ in their descriptions of the vowel in ribset. In figs. 7a and 7b, the corresponding F1-F2 values are given.

4.3. Intervocalic contoid r

In order to make it possible to measure the F1-F2-values corresponding to the target position of [ʁ], a series of nonsense syllables consisting of vowels and intervocalic [ʁ] was spoken by the author. [ʁ] was spoken between a number of Danish vowel qualities, without any attempt to pronounce structurally possible combinations. Instead, it was attempted to attain the same vowel quality before and after r. The results appear from fig. 8 , where the left-hand end-point of each line indicates the F1-F2 values for the vowel, while the right-hand end-point indicates the F1-F2 values for the corresponding r-sound.

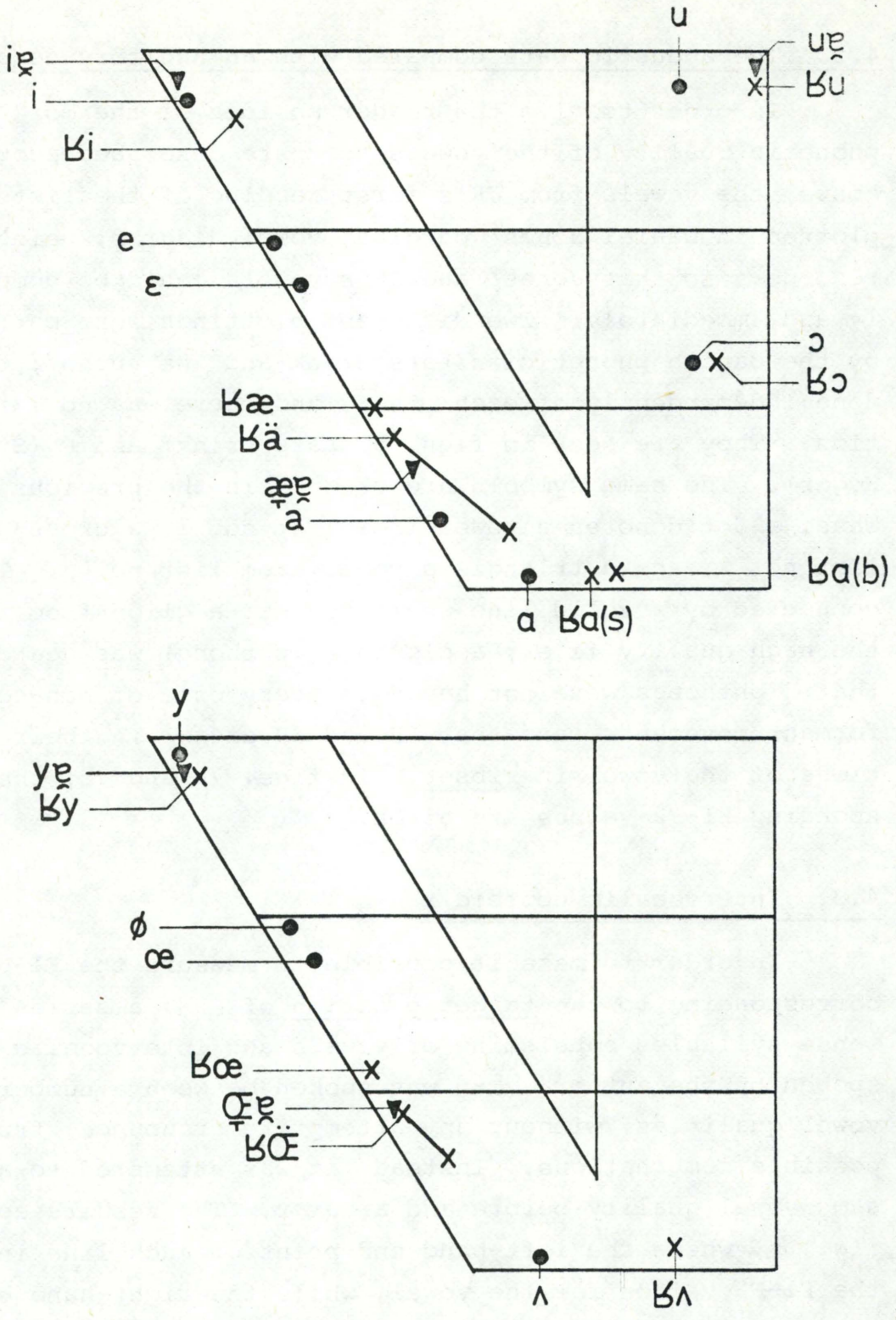

Figure 5

JR's vowels, 1st recording, plotted by Lars Brink. Note that the phonetic transcription in figs. 5-7 is the same as that of the word lists in section 4 and thus only serves the purpose of identifying the plots with the words in the word list. i e̯ means [i] before [e̯], ʁi means [i] after [ʁ], etc. In figs. 5-6 a glide in vowel quality is expressed by two crosses connected by a line.

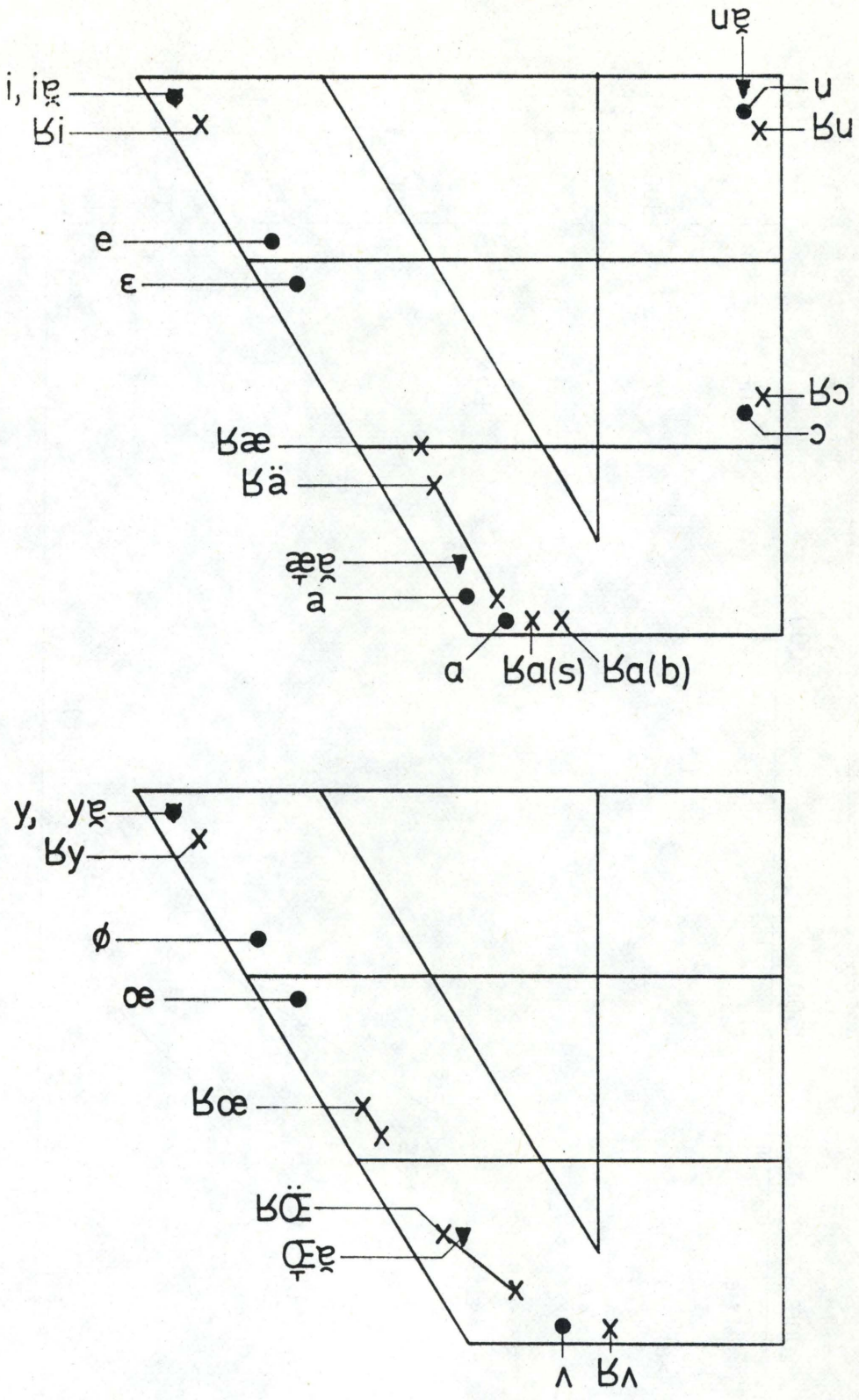

Figure 6

JR's vowels, 1st recording, plotted by Steffen Heger.

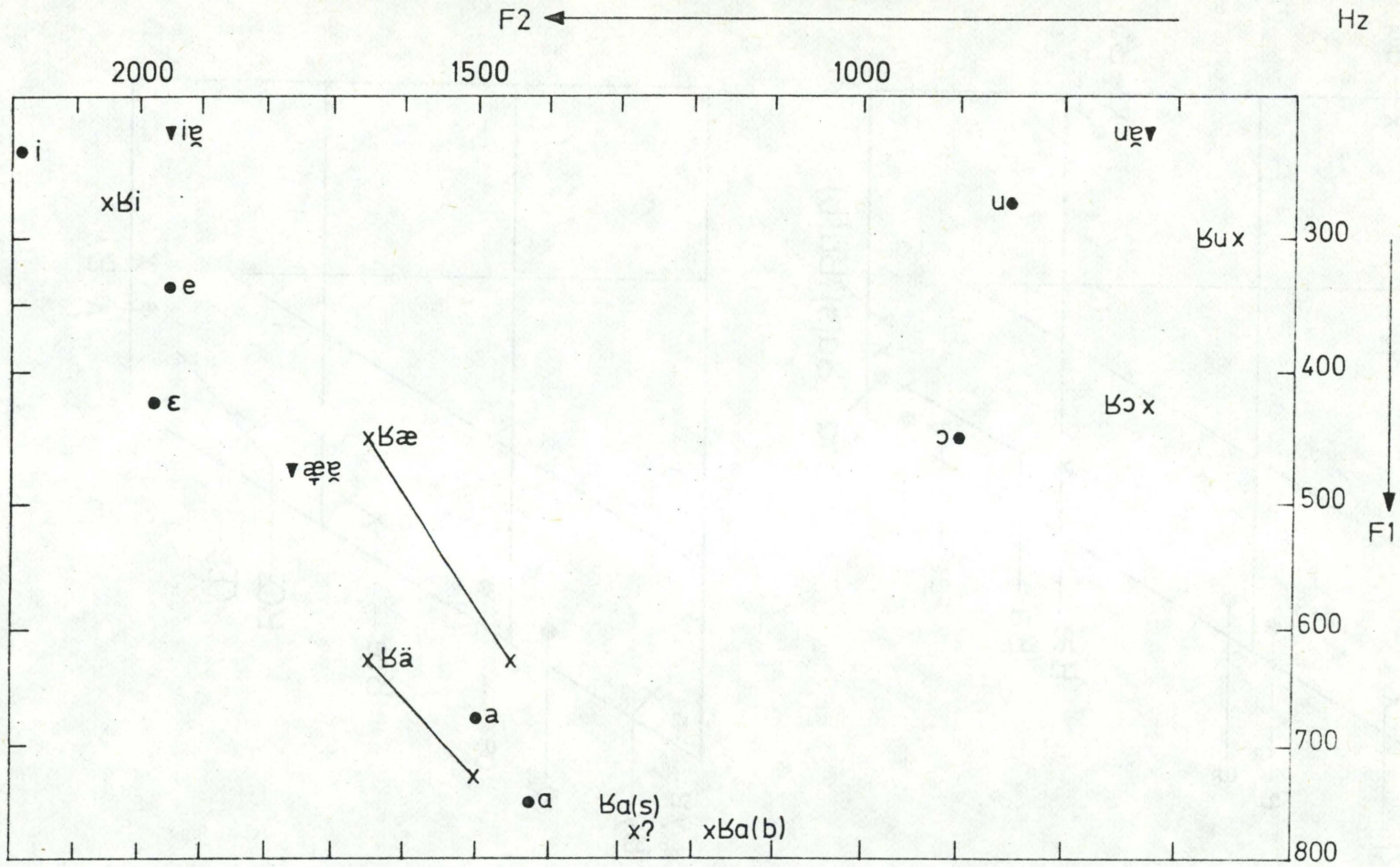

Figure 7a

JR's vowels, 1st recording, F1-F2 diagram.

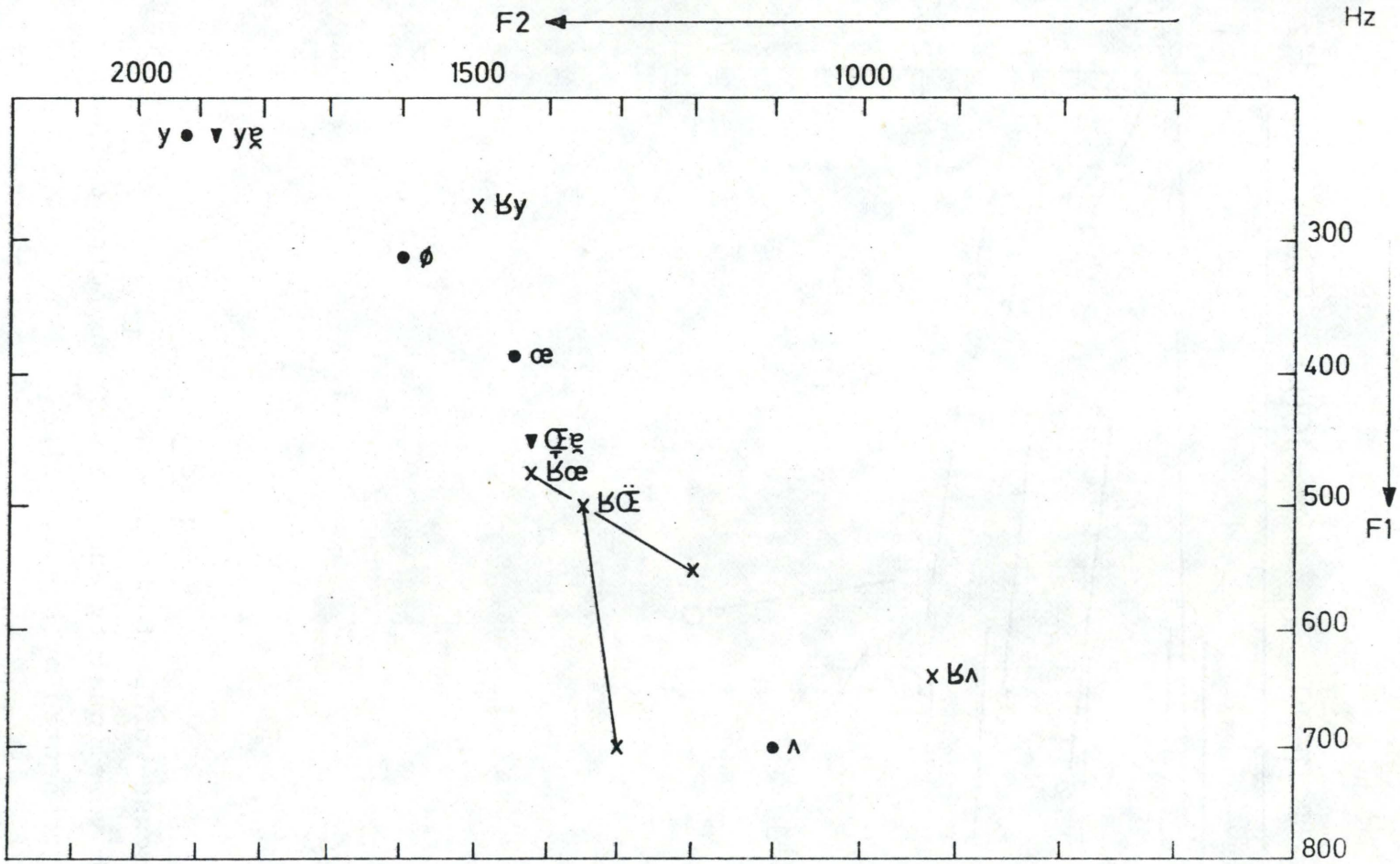

Figure 7b

JR's vowels, 1st recording, F1-F2 diagram.
Note that there is no one-to-one correspondence between vowel segments with an F1-maximum and vowel segments heard as containing a change in vowel quality (compare figs. 5 and 6).

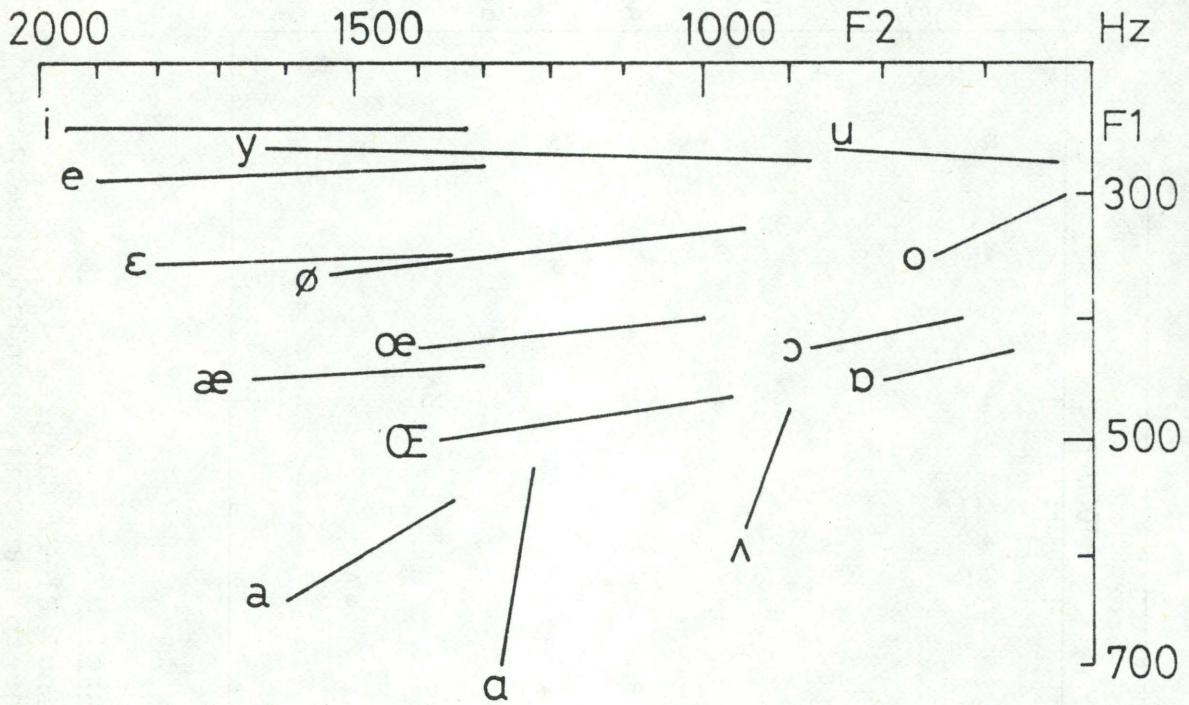

Figure 8

Nonsense-words of the type V_1+ʁ+V_1, F1-F2 diagram. Each vowel quality and the corresponding contoid r are connected by a solid line.

4.4. Additional material

Other spectrograms confirm that /e, ø, ɛ, œ/ after contoid r may show the above-mentioned non-concurrent formant movements, where both F1 and F2 rise from r and then F1 falls while F2 continues to rise (whereafter the formants move towards the "locus" of the following consonant). Thus Eli Fischer-Jørgensen has sonagrams produced by 7 male subjects who have spoken a number of words with contoid r followed by short vowel that in many cases (perhaps all; it is often difficult to determine the formant movements of the sonagrams in question) display the non-concurrent formant movements of contoid r plus /e, ø, ɛ, œ/. Recordings of final [ʁä] (in the utterance: "Jeg sagde trefod, ikke træ-") also display examples of the complex formant movements, which shows that they are not caused by the following consonant. Finally, in Molbæk Hansen and Møller's material (see their paper in this volume), with six subjects, there are four whose sonagrams display the complex formant movements before labial and alveolar (that not all six subjects have them is unsurprising, since some of their subjects were chosen because they were expected to have /ra/ instead of /rɛ/ except before velar: the investigation was done in order to cast light on the merger of /rɛ/ and /ra/, where both kinds of words are pronounced with [ʁɑ]).

5. Concluding remarks

The purpose of the present paper has been to present various phonetic data concerning r-combinations in Danish, as part of the prerequisites for phonetic and phonological analyses of the r-combinations.

There is one problem in particular which stands out as unsolved after the present investigation, viz. the question whether the vowel segments corresponding to the phonemes /ɛ, œ/

after contoid r should be described as monophthongs or diphthongs. I have given some acoustic data, but in my opinion the issue is ultimately a perceptual one.

Obviously, X-ray data on these r-combinations in Danish, as well as a deeper understanding of the relationship between perceived changes in vowel quality and formant movements, will also contribute to the solution of this problem.

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