The phonetic variation of German /r/*

Niels O. Schiller

It has already been acknowledged in the literature that German uvular /ɾ/ shows much articulatory variation (HALL 1993: 83; JESPERSEN 1920: 139, WIESE 1996: 170). Rhotics in general, not just in German, seem to have more articulatory variation than other phonemic targets (GÖSCHEL 1971, PILARSKY 1995). The aim of this paper is to give some phonetic and phonological reasons for the variation of rhotics. Special attention is paid to the reduction processes of German uvular /ɾ/. Phonetic data are reported which imply that the reduction of uvular /ɾ/ in German can pose problems for traditional approaches of description such as the sonority hierarchy. Instead, a more adequate theoretical approach to describe the different variants of uvular /ɾ/ in German is suggested, namely Articulatory Phonology (BROWMAN/GOLDSTEIN 1992a). It is shown that the articulatory relationship between the varying forms of reduction of uvular /ɾ/ is predicted by the framework of Articulatory Phonology.

0. Introduction

Rhotics (/ɾ/-sounds) and laterals (/l/-sounds) traditionally belong to the class of liquids, “[...] a term inherited from the grammarians of antiquity” (MÄMBERG 1963: 48). It is often assumed that this is because of phonetic and phonological features these sounds have in common. /ɾ/- and sonorant /l/-sounds have a similar distribution within the syllable and behave very similarly in sound change (BHAT 1974).¹ From a phonetic point of view, the relationship between rhotics and laterals is manifested in terms of articulation, acoustics and perception. Acoustically, the formant structure between /ɾ/- and /l/-sounds can be similar.² That is why the auditory-perceptual relationship between both kinds of sounds can be very close. [ɾ] and [l], for instance, can only be differentiated on the basis of the third formant (O’CONNOR et al. 1957: 28).³ Unfortunately, there is very little known about the similarities between rhotics and laterals in terms of articulation. Rhotics as a sound class show much diversity, and there is a lot of articulatory variability with respect to the realization of particular /ɾ/-variants.

The typological distribution of liquids is relatively widespread compared to the size of this sound class. According to MADDIESON (1984: 73) 95% of the 317 UPSID⁴

* The author would like to thank Ken Drozd (Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands) for proof-reading a first draft of the paper, Laura Walsh Dickey (University of Massachusetts/Amherst, USA, now at the Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands) for many useful remarks and comments on several draft versions, and Matthias Butt (Universität Potsdam, Germany) for carefully reviewing the paper.
languages have at least one liquid. /r/-sounds can be found in 76% of this language sample. The question arises which sounds were counted as rhotics. A scientific definition of ‘/r/-sound’ is not available so far. Sound classes can be defined by their extension, i.e., by means of enumeration of their members. MADDIESON (1984: 73) defines a set of core elements of the rhotics to which apical and uvular trills, taps and flaps belong. The extensive list of /r/-sounds given in LADEFOGED (1993: 169) also contains approximants and fricatives.

But in many languages, e.g., in German (see Section 1), reduced forms of the so-called core elements of /r/-sounds developed. These reduced forms also belong to the rhotics, at least from a phonological point of view, because they share their distribution with the original forms. Seen with the eyes – or rather, perceived by the ears – of a phonetician, the rhotics constitute quite a heterogeneous sound class (LINDAU 1980: 114, 1985: 158). Besides the trills (e.g., [ɾ], [ʁ], etc.) and the taps/flaps (e.g., [ɾ], [ɹ], etc.) there are fricatives (e.g., [ʋ], [ʃ], [ʒ], etc.), approximants (e.g., [l], [ɾ], [ʔ], etc.) and vocalized /r/-sounds (e.g., [əɾ], etc.) (LINDAU 1985: 158). Sometimes there is much variation even within the same dialect, as e.g., in the Portuguese dialects discussed by DICKEY (1995: 95). But as will be shown in this paper (see Section 3), even between these different /r/-sounds there are phonetic, i.e., articulatory similarities.

The reason for the great variation among the rhotics lies essentially in the fact that the core elements are rather unstable sounds. Trills, for example, are articulatorily marked by their complexity: the articulation of a trill requires the precise adjustment of primary and secondary articulator, a certain degree of stiffness in the primary articulator (for modeling see MCGOWAN 1992), and the satisfaction of aerodynamic conditions in order to evoke the Bernoulli effect (CATFORD 1977: 127). This later feature is responsible for the relatively high air consumption of the trills, a fact that also characterizes trills as very uneconomic sounds. The articulatory complexity and the uneconomic pronunciation of the trilled rhotics have a number of consequences: the late acquisition of trilled /r/-sounds (JAKOBSON 1969: 77), the rhotacism as a speech error (defective /r/), i.e., the non-standard pronunciation of trilled /r/ (especially of [ɾ]), is quite a widespread phenomenon (BÖHME 1980, BURROUGH/SMALL 1990, DALSTON 1991, LUHSINGER/ARNOLD 1970, MCNUTT 1979, STERN 1907, WÄNGLER/BAUMAN-WÄNGLER 1985a), and last but not least trilled rhotics are highly prone to sound changes.

1. Forms of /r/-reduction in German

The situation of the /r/-sounds in German appears to be highly complicated due to diachronic developments in the phonological system and because of a large set of reduction forms which developed in the more recent history of the German lan-
guage. Because the synchronic situation cannot be understood without some knowledge about the underlying diachronic processes, I will sketch the history of German /r/ before I describe the situation of /r/ in contemporary standard German.

1.1 The diachrony of German /r/

What is the true origin of the German velar uvular r? In all probability we shall never know.” (MOULTON 1952: 89)

In Proto-Indo-European (PIE), we already find a phoneme /r/ probably pronounced as an apico-alveolar trill, i.e., [r] (MALMBERG 1963: 46, STERN 1907: 14). According to LEHMANN (1951: 17) the distribution of /r/ was restricted to non-word-initial positions in PIE⁹ which might be a consequence of the chronologically late development of /r/ explained below (see also NIEKERKEN 1965).¹⁰

In Old High German (OHG) there was at least one /r/-sound ([r]) that had two diachronic sources (MUTSCHMANN 1908: 67, PAUL 1916: 354, PENZL 1961: 492). On the one hand, OHG [r] was inherited from IE and Germanic [r] (PAUL 1989: 143 for examples). On the other hand it developed via sound change (rhotacism) from Germanic [z] (e.g., Got. maiza → OHG méro). This sound change appears to be very natural when we consider the articulatory relatedness between the apico-alveolar fricative (i.e., [z]) and the apico-alveolar trill [r]. Both sounds differ only in manner, whereas place of articulation and organs of speech remain the same, i.e., both are voiced coronal continuants. In terms of articulation, the fricative does not completely reach its articulatory target but undershoots it (SOLE 1992: 261).¹¹ According to SOLE, the resulting approximant is reinterpreted as /r/ because only few languages have coronal frictionless continuant phonemes.¹² In fact, SOLE (1992: 263) provides some experimental evidence that shows that [z] can be interpreted as some kind of /r/-sound under certain distorted conditions. Sound changes such as [z] → [r] lead to the assumption that /r/ has been pronounced as an apico-alveolar trill in OHG. There are no facts that support a uvular pronunciation of /r/ in OHG, i.e., sound changes from /r/ to a uvular fricative or vice versa are – to the best of my knowledge – not known in OHG.

1.1.1 Trautmann’s hypothesis

But in contemporary standard German uvular trilled /r/, i.e., [r], can be found as a regular variant of /r/ – although it is already being superseded by new variants.¹³ There has been a long scientific controversy concerning the development of this uvular /r/ that still remains unsolved due to lack of historical documents. The diachronic source of uvular trilled [r] in German can only be guessed. Until the middle of this century the point of view first mentioned by TRAUTMANN (1880) was prevail-
ing. TRAUTMANN was of the opinion that [r] got into the German sound system via French during the 17th/18th century.

HADEN (1955: 507) explains the development of uvular trilled [r] in French with a phonologically induced sound change. When the phonemic contrast between /r/ and /z/ in intervocalic position was neutralized in French (/[r] → /[z]/), the trill was moved to another place of articulation in order to re-establish the phonemic contrast between /r/ and /z/ in all positions. Uvular trilled [r] then spread from intervocalic to all the other positions and clearly dominates in contemporary French over [r] (MALMBERG 1963: 46). HADEN (1955: 509) dates the development of [r] (in French) – in agreement with TRAUTMANN (1880) – in the 16th/17th century.

FALC’HUN (1972), however, argues on the basis of toponymic evidence that French /r/ has two different diachronic sources. On the one hand, Gaulish /n/ changed into French /r/, e.g. Ling(o)nes → Langres, Lund(i)num → Londres, on the other hand French /r/ continues a Gaulish velar spirant, e.g., conoch → Conore, (k)nech → Ners (all examples from FALC’HUN 1972). Based upon these facts, FALC’HUN (1972: 114-115) concludes that both the apical and the dorsal/velar variant of French /r/ are older than the French languages itself because they are inherited from a pre-roman language.

According to TRAUTMANN, the rapid spreading of [r] had sociological reasons: uvular trilled /r/ (r grassey’d) was especially known to be the specific pronunciation of /r/ of a certain higher-ranked group of the Parisian society known as the Précieuses. Due to the high prestige of this group, members from lower levels of the society tried to imitate the pronunciation of the Précieuses to affect a higher social status; this search for prestige speech is implicated in the quick spread of the uvular trill in French. When the French influence became greater in Germany during the 17th/18th century, there was also more language contact. [r] was imitated by German speakers because French style was the predominant fashion. In this way, uvular trilled /r/ became disseminated in the German sound system.

1.1.2 Counterevidence from Moulton and Penzl

In the middle of this century the first critical remarks were made on the hypothesis of TRAUTMANN (1880). MOULTON (1952: 86) provided evidence for the uvular pronunciation of /r/ in a Silesian dialect of German at the end of the 16th century, i.e., before the time of the French influence in Germany. This implies that in certain German dialects, [r] developed independently of French [r]. MOULTON (1952: 89) states that “[a]t the end of the 16th century, at least some German speaking areas showed instead a voiced velar spirant and/or uvular trill”. However, the fast spreading of [r] may still be due to sociological reasons brought by later French influence.
PENZL (1961) agrees with MOULTON's point of view. However, he dates the development of uvular /r/ in German even further back than MOULTON. PENZL (1961: 496) concludes that the diachronic facts imply the existence of both [r] and [R] since the late Middle High German (MHG) period.

But even if MOULTON (1952) and PENZL (1961) contribute important arguments that weaken the position held by TRAUTMANN (1880), still the question remains of why [r] developed at all.

1.1.3 Jespersen's hypothesis

JESPERSEN (1889) rejects TRAUTMANN's hypothesis because it is based on weak evidence. Instead, he gives a purely phonetic-articulatory explanation for the development of uvular /r/ in German. JESPERSEN accepts the view that German /r/ was originally the tongue tip trill [r] (see also JESPERSEN 1920: 137). But according to JESPERSEN, during the articulation of [r] not only the tip of the tongue is raised to achieve the trilling, but also the back of the tongue. JESPERSEN (1889) states that the raising of the tongue dorsum during the production of an apical trill is a consequence of the fact that individual articulators are not fully independent of each other. The raising of the tongue dorsum is especially pronounced when apical /r/ is produced without trilling, e.g., like the English [s], which is an approximant. The raising of the back of the tongue leads to an approximation between tongue dorsum and velum. This is in fact the basis for the transition from [r] via [s] to [R]. If the constriction between the tongue dorsum and the posterior part of the velum reaches a certain degree and the air stream exceeds a critical value, the trilling can easily be transferred to the uvula. This means that JESPERSEN assumes a continuous change from the apical trill via an alveolar approximant to the uvular trill. However, as far as I know, there is no evidence for such an intermediate state in German. Rather, it seems to be the case that the change from apical to uvular trill is actually discontinuous.

HAMMARSTRÖM (1953) gives a similar account for the change from alveolar to uvular trilled /r/ in Portuguese. According to him, it is the articulatory force in the production of [r] that caused the development of [R]. HAMMARSTRÖM (1953: 176) states that the muscular tension necessary to pronounce a trilled alveolar /r/ has the effect of setting the whole tongue in vibration and of raising the back of the tongue. That is how alveolar /r/ is transformed into uvular /r/. This explanation was later adapted by MORAIS-BARBOSA (1962). Because the development of uvular /r/ in Portuguese is quite a recent one (probably not starting before the end of the 19th century), French influence can be excluded. Instead, a purely phonetic explanation is given for the change from [r] to [R] in Portuguese.
1.1.4 Discussion of Trautmann's and Jespersen's hypotheses

Whether Trautmann is right in postulating sociological reasons for the development of uvular /r/ in German or whether its emergence can be fully explained by means of phonetic factors as suggested by Jespersen, cannot be decided. Both hypotheses have advantages and disadvantages. Trautmann's hypothesis can give an account for the alleged late development and fast spreading of uvular /r/ in German. However, there is some counterevidence by Moulton (1952) and Penzl (1961) suggesting that German uvular /r/ developed before the time of the French influence, possibly even independently of the French uvular /r/. And Trautmann (1880) does not give any explanation for the development of uvular /r/ in French.

Jespersen's hypothesis seems to be plausible in phonetic-articulatory terms because the change from [r] via the intermediate for [a] to [r] appears to be very natural. However, whether the tongue dorsum is really raised during the articulation of the tongue tip trill, has never been shown experimentally. The X-ray recording of the alveolar [r] in Wängler (1961, figure 13) does not show a marked raising of the tongue dorsum. Furthermore, Jespersen (1889) cannot account for the rapid spreading of uvular /r/ at a certain point during the development of the German language. Most importantly, however, a purely phonetic account cannot explain why uvular /r/ did not develop earlier, e.g., in OHG times or even in Germanic times.

I would like to take the view that both hypotheses are partly true. There must be a phonetic explanation for the change in place of articulation from the alveolar to the uvular area, but also, there must have been a certain impetus that was responsible for the emergence and rapid spreading of uvular /r/ in German.

1.1.5 Phonetic and phonological factors

What can be taken for granted is that uvular /r/ developed in French, German and many other languages. If we cannot definitely determine when and how uvular /r/ developed, we could at least try to find some reasons (beside the ones already discussed above) that were possibly advantageous for the spreading of uvular /r/. To my mind, two facts encouraged the development and extension of uvular /r/. Firstly, the articulation of [r] is claimed to be easier than the one of [r]. Especially in language acquisition it is argued on the basis of empirical data that this is the case. Haden (1955: 507) citing Gonçalves Vianna claims that Portuguese and Spanish learning children both have difficulties with the apical trill while they are able to trill the uvula. This is confirmed by Ruke-Dravina (1965: 66-67) who investigated language acquisition in Swedish and Czech learning children. She concludes that trilled uvular /r/ is easier to pronounce and acquired earlier than the apical trill because the uvular trill [r] is more simple to produce from an articulatory point of view. Curme (1891: 5) claims that it is very easy for children to acquire the uvular /r/, while it is
difficult to master for adults. The rapid spread of uvular /r/ can thus be explained by the alleged slighter effort\textsuperscript{21} required to produce it compared to [r]. It is to be noted, however, that the acquisition data just cited are off-line data, and that the assumed differences in articulatory complexity between [r] and [r] have not yet been proven on-line (experimentally).

But even if we assume for the moment that [r] is less complex than [r] from an articulatory point of view, the question arises why [r] did not develop in other Romance languages such as Spanish, Romanian, and most dialects of Italian. Beside possible sociological reasons there might be phonetic and phonological reasons as well. In terms of acoustic-perceptual features, [r] is very similar to [r] so it could work perfectly as a variant of /r/. But this is hardly ever the case. [r] is quite an areal phenomenon which is predominant in North- and West-Germanic languages (GÖSCHEL 1971, MADDIESON 1984, MALMBERG 1963: 46-47). Furthermore, uvular trills constitute less than 1% of all rhotics, whereas coronal trills make up almost half of all rhotics (DICEY 1995, MADDIESON 1984). From a phonological point of view, the uvular articulation constitutes the marked place of articulation in German, whereas the alveolar region is unmarked (WIESE 1996: 171). Therefore, we have to find additional reasons for the development of uvular trilled /r/ in these languages. The second reason I will give in this paper has to do with the reduction processes of /r/.

It has already been pointed out that the trilled variants of /r/ are not very stable. Often they are reduced to fricatives, approximants or vowels. But the extensive use of the alveolar-pre-palatal area of the oral cavity for the establishment of sound systems does not allow much reduction; otherwise, phonemic conflicts would arise. For instance, in German, a reduction of [r] to a homorganic fricative (i.e., [z]) is dispreferred because the distinction between [r] and [z] carries considerable functional load in German. Another example of a language where the reduction of [r] is blocked in certain positions is Spanish. In Spanish trilled [r] can be reduced to a tap (i.e., [ɾ]),\textsuperscript{22} except for word-initial position (LIPSKI 1990: 155).\textsuperscript{23} In rhyme position the trill is restricted to emphatic speech.\textsuperscript{24} In fact, the distribution of trilled and tapped /r/ is complementary. But in intervocalic position, tapped /r/ is in phonological opposition with trilled /r/,\textsuperscript{25} e.g., pero [pero] ("but") vs. perro [pero] ("dog"), and thus reduction of the type [ɾ] → [r] is blocked. In Puerto Rican Spanish, however, the alveolar trill [ɾ] changed via an pre-aspirated tap [ɾh] into an unvoiced velar or uvular fricative, i.e., [x] or [χ] (ZLOTCHEW 1974: 81-82). This fricative is probably comparable to a reduced uvular trill, such as in German (see Section 1.2). In Puerto Rican Spanish [x] can stand in phonological opposition to [ɾ] (intervocally) because the functional distinction is maintained in spite of the reduction of [ɾ]. In Portuguese where alveolar tap and trill were also phonologically distinctive in intervocalic position, the trill first changed its place of articulation (following the
phonetic account given by Hammarström 1953: 176) to \([r]\). This uvular trill was reduced to a dorsal fricative then and fronted afterwards (Morais-Barbosa 1962: 217-218, 222). Because \([r]\) first changed to \([r]\), the reduction of the trill did no harm to the phonological system. Intercorrelationally there is still a phonological opposition between two /t/-phonemes which are realized as \([x]\) and \([r]\), respectively. This is a good example for the claim to be made here that in the velar-uvular area there is much less exhaustion of the phonological space so that forms of /r/ reduction do not get into conflict with other phonemes, i.e., the production of uvular variants of /t/ does not demand the same degree of articulatory precision as for the coronal variants of /t/.

That is, there are probably several reasons that can be given for the change of apical to uvular /t/ in German. It is possibly true, though not proven experimentally so far, that the uvular trill is less complex in terms of articulation than the apical trill. Maybe the articulators have more degrees of freedom for achieving the goal of trilling the uvula than trilling the apex. This is at least suggested by the acquisition data. Furthermore, it seems to be the case that uvular trilled /t/ allows for more articulatory reduction than the apical trill. Therefore it better satisfies the speaker’s striving for articulatory economy (without doing harm to the necessary perceptual distinctivity) than apical /t/. Taken together, these arguments favor uvular /t/ over apical /t/. On the other hand, uvular articulations are marked, at least in north-west European languages. Nevertheless, uvular /t/ developed in any case in French and maybe independently also in German. The fast spreading of uvular /t/ and its contemporary dominance over apical /t/, however, seem to be due to non-linguistic factors.

Taking these arguments into account, why then, did /r/ develop before /r/ in German? To answer this question we have to consider the diachronic origin of the phoneme /t/. There are at least some facts that would suggest that /t/ has developed via phoneme split out of /l/. Niekerken (1965: 165) as well as Paul (1989: 144) emphasized the articulatory relatedness between /l/ and /r/. In Niekerken’s opinion, /l/ is articulatorily more simple than /r/, although he did not give any empirical evidence for this claim. But from a diachronic point of view, Niekerken’s proposal makes sense.

 Probably, /r/ developed out of /l/ first as an allophonic variant that became distinctive later on. This process would make the data provided by Lehmann (1951) plausible, namely the restricted distribution of /t/ in PIE. Possibly, the phonological development of /t/ was still not completely finished in PIE times. That is why /t/ could not appear in all positions then. Another point that is still observable is the similar distribution of /l/ and /t/ which might be the result of a phoneme split. If /t/ actually developed out of /l/, then it is only natural that it was pronounced as an apical sound. Taken together, it seems probable that /r/ preceded /r/. The apical trill
was the dominant (and maybe the only) /r/-variant until [r] developed. But then [r] was forced back by the uvular trill more and more.

1.2 Forms of /r/-reduction in contemporary New High German (NHG)

Although [R] is likely to have arisen by late MHG, standard NHG pronunciation – in the normative sense of the term – requires an apical trilled pronunciation of /r/. In Siebs’ reference work entitled Deutsche Bühnenaussprache it says, for example:

Es ist in allen Fällen durchaus gerolltes Zungenspitzen-r zu fordern; nur dadurch kann der schon sehr stark eingebürgerten Mode begegnet werden, die die spirantischen oder vokalischen Reduktionen des r […] duldet.  

(SIEBS 1898: 51)

In more recent editions of Siebs’ dictionary this rather conservative point of view has been slightly modified. Uvular trilled pronunciation is now allowed for /r/, too (SIEBS 1961), although [r] is still preferred.

But in fact, in contemporary NHG, neither [r] nor [R] seems to have survived. Instead of the trills, reduced forms predominate in standard German. These reduced forms are widely accepted by the language community (RICHTER 1979). A trilled pronunciation of /r/ is very unusual except in the few dialects in which trills have survived (e.g., in southern dialects such as Bavarian and in northern dialects such as North Saxon, see also APPEL in this volume). HILDEBRANDT/HILDEBRANDT (1965) have observed that reduction of [R] is dependent on the position in the syllable as shown in Tab. 1 (see also KOHLER 1977). Even in syllable initial position, however, /r/ is hardly ever trilled (SCHILLER/ MOOSHAMMER 1995).

<table>
<thead>
<tr>
<th>vowel</th>
<th>long</th>
<th>short</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>stressed</td>
<td>unstressed</td>
</tr>
<tr>
<td>Onset /RV.../</td>
<td>r/₃</td>
<td>r/₃</td>
</tr>
<tr>
<td>Onset cluster /CR.../</td>
<td>₃</td>
<td>₃ (R)</td>
</tr>
<tr>
<td>Coda /...VR/</td>
<td>ₐ (r/₃)</td>
<td>ₐ/₃/₀</td>
</tr>
<tr>
<td>Coda cluster /...VRC/</td>
<td>ₐ (r/₃)</td>
<td>ₐ/₃/₀</td>
</tr>
</tbody>
</table>

Tab. 1: Phonetic realizations of uvular /r/ in German across different syllable positions (based on HILDEBRANDT/HILDEBRANDT 1965)

Initially, [R] is usually pronounced as a trill or – what is even more common nowadays – as a fricative or as an approximant. In initial C-clusters, the fricative seems to be predominant. After a long (stressed) vowel, [R] is vocalized most often, whereas after short, stressed vowels it can also be realized as a fricative. Generally, the tendency to vocalize [R] seems to be strongest when the rhotic is the only segment in the
coda. After unstressed short vowels, [r] is usually articulated in the form of a fricative as well. The fricativized forms of uvular /r/ surface either as voiced or as voiceless velar/uvular fricatives—depending on the phonemic context (BETHGE 1954: 396). According to RICHTER (1979: 155) and GRIFIN (1982: 310), velar fricatives predominate over uvular fricatives which are judged to be “clearly regional” (RICHTER 1979: 155). However, these authors do not provide any empirical evidence (e.g. articulatory/acoustic data) for their claims. From a purely articulatory point of view, however, it seems more plausible that fricativized uvular /r/ surfaces as a uvular fricative. SCHILLER/MOOSHAMMER (1995) give some empirical evidence for this argument.

The realization of uvular /r/ after short stressed vowels seems to be particularly interesting because the sound is pronounced very differently in different dialects of German. Beside a vocalized form of /r/, which is prevailing in contemporary NHG (which for its part is strongly influenced by northern German pronunciation), there are fricativized forms of uvular /r/, e.g., in the Franconian dialects. So in a word like Erdbeere ("strawberry"), the first /r/ is pronounced as a vowel in contemporary NHG, i.e., [ɛr.t.be.ʁɛ], whereas it is a fricative in Franconian, i.e., [ɛr.t.be.ʁə]. In some word forms this pronunciation can lead to phonetic forms which violate the sonority hierarchy, e.g., when words like Turm ("tower") are realized as [tɔʁm], as e.g., in some Lower Rhine dialects. When /r/ becomes a fricative in this context, it does not conform to the sonority sequencing principle (SELKIRK 1984): [tɔʁm] is a monosyllabic word with two sonority peaks. To provide some empirical evidence for the realization of uvular /r/ as a fricative in this condition, some acoustic measurements have been carried out in a small empirical investigation. From the obtained data it can be shown that the sonority hierarchy cannot adequately describe all sequences of sounds with an underlying /r/.

2. Empirical investigation

To investigate cases of a uvular (fricative) rhotic followed by a sonorant consonant in a coda in more detail, the pronunciation of /r/ by two speakers from the Lower Rhine was studied. If /r/ is actually pronounced as a fricative in word forms like German Turm ("tower"), Korn ("grain"), etc., then this would strongly suggest that the sonority hierarchy is in fact not able to account for certain kinds of /r/ reductions such as [r] → [ɾ]/_ [+sonorant, +consonant].

2.1 Participants

Participants were two male native speakers from the area of Düren who spoke standard German with Lower Rhinian influences. At the time when the empirical investigation was carried out, both participants were undergraduate students at the
University of Trier. They volunteered for the experiment. Both participants were linguistically naive and not informed about the goal of the investigation.

2.2 Material

The material consisted of eight target words which were embedded in full sentences (see list of the sentences in the Appendix). The target words/morphemes all had the same phonological structure: /C₁VRC₂/ where C₁ represents an obstruent, V a short stressed vowel, R a uvular variant of /r/ and C₂ a nasal or a lateral. This structure is in accord with the sonority sequencing principle because rhotics are ranked higher than nasals and laterals on the sonority hierarchy for German (Jespersen 1920, Vennemann 1988)³³. This allows rhotics to occur more closely to the syllable nucleus than laterals or nasals.

2.3 Procedure

Both participants were asked to read the sentences two times from a sheet of paper in a speech tempo that was considered comfortable by each of the participants. Their speech productions were recorded by means of a Sony ECM-959DT microphone and a Sony TCD-D10 DAT recorder. The recordings were digitized at a sampling rate of 16 kHz and analyzed on a SiliconGraphics Iris Indigo work station using the waves/ESPS signal analysis software. The target words were spliced out of the spoken utterances and saved separately. Then the target words were analyzed auditorily and acoustically.

2.4 Results

The acoustic analyses revealed that some of the target words contained aperiodic parts in their waveforms where we would not expect them if the produced word forms respected the constraints imposed by the sonority hierarchy. In particular, it can be seen (see Fig. 1 and 2) that the transition phase from the vowel to the nasal or lateral (between the cursors) is not strictly periodic in nature. A periodic transition would be expected if the /r/-sound between vowel and nasal/lateral was either a trill or a vocalized variant. Instead, aperiodic parts appear in the waveform that are due to aerodynamic turbulences at the constriction location. This supports the auditory judgement in which a fricativized variant of /r/ was perceived.³⁴ The aperiodic part of the waveform is rather short and not very strong because the fricativized articulation of the /r/-sound is weak which might be an effect of syllable position. The syllable coda is the typical environment for the appearance of weak forms (Kenstowicz 1994). Furthermore, the /r/-sound is masked by coarticulatory effects of the vowel and the following sound (nasal/lateral). From articulatory experiments it is known that German /r/-sounds are likely to show large coarticulatory effects (Schiller/Mooshammer 1995). In some of the spectrograms friction noise could be detected
between the glottal impulses shortly before vowel offset. This friction noise is possibly due to the fricativized production of /t/.

Fig. 1: Waveform of test item 'Turm' ([tuvml]) from speaker 1

Fig. 2: Waveform of test item 'Zwirn' ([tsvkn]) from speaker 2

2.5 Discussion

The results of the small empirical investigation showed that German uvular /t/ is pronounced as a fricative in certain areas of the central Franconian dialect (Lower Rhinian) although this runs counter to the sonority hierarchy for German (Jespersen 1920: 192, Sievers 1901, Vennemann 1988: 9), i.e., the sonority hierarchy does not predict this phenomenon.\(^{35}\) The sonority hierarchy fails in describing this particular reduction of uvular /t/.\(^{36}\) But there are some more reasons why the sonority hierarchy should not be used to explain the sound structure of a language.
2.5.1 Sonority hierarchies and circularity

Sonority hierarchies are based on the concept of ‘sonority’. BUTT (1992: 45) characterizes sonority as "[...] a multi-valued feature, ordering segments or segment classes on a one-dimensional scale". Phonetically, sonority is based on intensity, resonance, voicedness, perceptibility, degree of aperture, etc. But most of these features are impressionistic rather than based on phonetic definitions. Some of them are hardly even objectivizable (e.g., perceptibility). Furthermore, the proportion of each of the acoustic correlates of sonority is not known. All this leads to the conclusion that sonority is at most a pre-scientific term that does not provide a quantifiable measure because it is defined in a way that can not be verified empirically.

In fact, sonority hierarchies are not established on the basis of the concept of sonority but on the basis of distributional criteria concerning the occurrence of individual segments in the syllable. Otherwise, the ordering of /t/ relative to /l/ could not be accounted for. But even the difference between plosives and fricatives is not straightforward in terms of sonority. BUTT (1992: 50), for instance, warns that an assumed sonority contrast between stops and fricatives cannot be justified until the phonetic nature of sonority is clarified. In phonology, however, sonority hierarchies are often used to explain syllable structures, although this entails a circularity because the sonority hierarchy is in fact derived from syllable structure.

Instead of sonority hierarchies, OHALA (1990: 327) argues that the modulations of certain phonetic parameters in the trajectories of successive segments are important for the sequencing of sounds. According to him, speech sound sequences should be ranked according to the degree to which they create acoustic modulations. To summarize, OHALA (1990: 334) argues strictly against sonority:

'Sonority' and its cousin 'strength' do not exist and should be abandoned for the sake of explaining universal sequential constraints.

3. A gestural approach to the reduction of uvular /r/

If we take the uvular trill [ʁ] as the basic form of uvular /r/ in German, then all the other variants of uvular /r/ can be considered as reduced forms, e.g., uvular fricatives ([ʁ], [χ]), velar fricatives ([v], [ʃ]), a velar/uvular approximant ([ʋ]/[v]), and the vocalized form of uvular /r/, namely [v]. These reduced forms seem to be quite heterogeneous from the point of view of a phonological taxonomy because they belong to different sound classes. But from an articulatory (gestural) point of view, all variants of German uvular /r/ possibly differ only in one parameter. The framework of articulatory phonology can provide a simple description for the reduction process of German uvular /r/.
3.1 The model of articulatory phonology


Browman and Goldstein distinguish between articulatory gestures, vocal tract variables and model articulators. Articulatory gestures are "[...] characterizations of discrete, physically real events that unfold during the speech production process" (BROWMAN/GOLDSTEIN 1992a: 156). Gestures are the basic units of phonological contrast, and at the same time they characterize articulatory events in an abstract way. These articulatory events consist of formations and releases of constrictions in the vocal tract (i.e.: 156). The dimensions of these constrictions are specified by the non-dynamic tract variables, e.g., lip protrusion, tongue dorsum constrict location, velic aperture, etc. The targets of the vocal tract variables are to be achieved by the model articulators, e.g., upper and lower lips, tongue body, velum, etc. (see figure in BROWMAN/GOLDSTEIN 1990: 310). In the case of German uvular /r/, the tract variable under consideration is the tongue dorsum constriction location. The articulatory target is a certain degree of constriction — depending on the variant of /r/, e.g., trill, fricative, approximant or vowel — which is to be achieved by the post-dorsal part of the tongue.

The model articulators are located on different articulatory tiers. These articulators are not inherently dynamic. The dynamics of the process of articulation arise when the equations for the articulator movements are specified. These equations are dynamically characterized and contain information about the target, the stiffness, and the damping of the model articulators.

A gesture is specified by a set of tract variables. Gestures are physical events, i.e., they have a certain spatial and temporal extension. The sequential production of gestures in connected speech requires coordination. According to Fowler/Saltzman (1993: 172) there are coordinative structures that implement phonetic gestures by establishing dependencies among different articulators. The function of these dependencies is to reduce the degrees of freedom of the articulators. We are able to move every individual articulator in many different manners and directions. But when we produce speech, it is important to coordinate different articulators in order to achieve certain well-defined phonetic goals, the phonetic gestures. To achieve this goal we have to make sure that the individual articulators work together in a coordinated fashion, i.e., we have to reduce the degrees of freedom of the articulators. The before-mentioned dependencies reduce the degrees of freedom by restricting the
articulators to a subset of possible movements that will serve for the achievement of a phonetic gesture.

Since individual gestures have an internal duration and a spatial extension, they can overlap in time and space. In BROWMAN/GOLDSTEIN (1987) two different kinds of overlap are distinguished: 'hiding' and 'blending'. 'Hiding' is defined as "[...] gestural overlap between gestures on separate oral tiers" whereas 'blending' means "[...] partial overlap of gestures on the same tier [...]" (l.c.: 17-18). If coarticulation affects articulators on different tiers, the spatial extension (movement) of the involved articulators simply co-occurs. They do not influence each other because they operate on different tiers. But the articulation on one tier may hide the acoustic output of another tier. Articulation is still there but the acoustic effect is no longer audible, i.e., the gesture is hidden. In the case of German uvular /r/ there is a lot of blending with adjacent vowels because the primary articulator for vowels is also the tongue dorsum. A consequence of this fact is that the place of articulation of uvular /r/ in intervocalic position is difficult to determine (SCHILLER/MOOSHAMMER 1995).

The sequential organization of gestures ('gestural phasing') in the model of articulatory phonology is coordinated in a 'gestural score'. A gestural score specifies the duration of individual gestures as well as the overlap among the gestures. The gestural score is two-dimensional in nature: one dimension specifies the articulatory tiers, the other conveys the temporal information (BROWMAN/GOLDSTEIN 1989: 75).

According to articulatory phonology the process of articulation is characterized by the coordinated execution of articulatory gestures. The gestural score specifies the coordination of individual gestures, e.g., the amount of blending and hiding. In connected speech these patterns of gestural overlap may vary as a function of speech rate (lento vs allegro), stress pattern (unstressed vs. stressed), and speech style (formal vs. casual) and syllable position (onset vs. coda). It is important to note that not the gestures themselves but just their temporal and/or spatial relations are changed. In the case of the different forms of reduction of uvular /r/ in German SCHILLER/MOOSHAMMER (1995) showed that the variable 'syllable position' plays an important role for the articulation.

3.2 The change of German uvular /r/ as a gestural modification

In order to show the gestural connection between the different variants of uvular /r/ in German, an articulatory description of the uvular trill [ʁ] must be given first. Unfortunately, very little is known about the articulatory processes that take place during the pronunciation of the uvular trill. According to LADEFOGED (1982: 285) a trill in general is characterized by "[a]n articulation in which one articulator is held loosely near another so that the flow of air between them sets them in motion, alter-
natively sucking them together and blowing them apart”. In other words, the trilling articulator is held in motion by means of the Bernoulli effect (CATFORD 1977: 32-33). According to CATFORD (1977: 128) a “[t]rill can be thought of as a kind of loosely formed stop in which the closure is intermittent, and repeated at least two or three times. [...] Trill is itself a maintained posture, providing for an aerodynamically generated, periodic flapping”. This is true for all kinds of trills, i.e., uvular, apical and labial trills. In fact, there seems to be a great similarity in terms of the rate of vibration between trills made at different places of articulation, which might be perceptually motivated.39 It is hypothesized that the reason why all these trills have almost the same rate of vibration lies in the control of tension of the corresponding articulators involved in the trill (LADEFOGED/COCHRAN/DISNER 1977: 52, TARNÓCZY 1948: 76). However, this has not been investigated experimentally.

Perceptually, the most salient feature of trills is the trilling of the articulator involved. According to LADEFOGED/COCHRAN/DISNER (1977: 52) the similarity in trilling rate among the individual trills “[...] leads to a certain degree of auditory similarity among all the trill sounds”. It is probably due to this similarity that different trills can coexist as variants of the same phoneme, as it is with the German trilled rhotics [r] and [ɾ]. The opposite might possibly also be true. Because [r] and [ɾ] belong to the same class of sounds they are controlled for a similar frequency of vibration.

For the uvular trill the post-dorsal part of the tongue body is slightly elevated in order to approximate the uvula. According to some authors, the tongue body forms a longitudinal groove, in which the uvula vibrates (CATFORD 1988: 99, CURME 1891: 5, KRÄMER 1979: 66, STERN 1907: 9, ULBRICH 1972: 47). This has never been proven experimentally, either. If the uvula has a certain stiffness, the air stream reaches a certain value and the constriction between the post-dorsal part of the tongue and the uvula reaches a certain degree, then the uvula is passively set into motion by the Bernoulli effect.

If the articulatory channel is slightly widened, i.e., the cross-sectional area between the back of the tongue and the uvula becomes bigger, the Bernoulli effect comes to a standstill. The reason for that lies in the fact that the Bernoulli effect indirectly depends on the cross-sectional area of the channel through which the flow of air is taking place (CATFORD 1977: 34). But if the cross-sectional area of the channel is not big enough to allow a laminal flow of air, the streamlines of air intercross and mix, evoking turbulences of the air stream (CATFORD 1977: 37) and the resulting sound is a velar/uvular fricative ([v], [ɣ]). Further widening of the articulatory channel has the effect of converting the turbulent into laminal air flow. The uvular fricative becomes a uvular approximant (CATFORD 1988: 99). This is supported by Catford (1977: 119) stating “[...] a voiced approximant has non-turbulent air flow
through a channel slightly larger than that of a fricative”. If the constriction degree between the back of the tongue and the uvula is further enlarged, i.e., the cross-sectional function of the articulatory channel becomes bigger by lowering the post-dorsal part of the tongue body, a resonant sound arises. This resonant is the vocalized variant of uvular /ɾ/ (i.e., [ɾ]). Resonants are distinguished from approximants by the manner of articulation. While approximants contain turbulent air flow when they are voiceless, resonants are “[...] entirely generated at the glottis, and the articulatory structure has merely the function of shaping the resonance chamber of the mouth” (Catford 1977: 121).

In terms of articulatory phonology all these variants of German uvular /ɾ/ can be described by modifying only one gesture, namely a post-dorsal constriction gesture of the tongue. The only thing that differs between the variants is the tract variable ‘tongue dorsum constriction degree’. Actually, the constriction degree of the tongue body decreases from stop, via trill, fricative and approximant to vowel (resonant). Schiller/Mooshammer (1995) show in an articulatory study using EMA that the tongue body position for uvular /ɾ/ is generally higher in syllable-initial position when uvular /ɾ/ is pronounced as a uvular voiced fricative. In syllable-final position, when uvular /ɾ/ is reduced to a vowel, the position of the tongue body is in general lower. This seems to be at least some evidence for the gestural similarity between the different variants of uvular /ɾ/ in German. Furthermore, the results of the acoustic analysis of the experiment reported above (see Section 2) imply that gestural adjustments are not constrained by concepts like the sonority hierarchy. The gestural score, which controls for the coordinated articulation of successive sounds, does not have to respect the restrictions of the sonority hierarchy.

4. Conclusion

Rhotics represent a class of sounds that is characterized by the diversity of its members. The diversity of /ɾ/-sounds is demonstrated for the case of German. It was argued that the reason for the development of the uvular trilled /ɾ/ may have both phonetic and phonological reasons, i.e., [ɾ] possibly requires less articulatory control than [ɾ], and it allows for more reduction than [ɾ] because the phonemic space is less crowded in the velar/uvular area of the oral cavity.

It is shown that uvular /ɾ/ has indeed a large set of reduced variants in German. Empirical data for fricativized variants is provided which are not predicted by traditional concepts such as the sonority hierarchy. It is therefore suggested that we must be more suspicious against pre-scientific notions such as ‘sonority’. Instead, relatively recent concepts, e.g., the model of Articulatory Phonology, seem to be able to account for the different forms of /ɾ/-reductions in German very easily. Possibly all variants of uvular /ɾ/ can be described just by adjusting the vocal tract variable that
controls the post-dorsal constriction gesture of the tongue. A first attempt to provide articulatory evidence for this is presented in SCHILLER/MOOSHAMMER (1995). In this paper the attempt was made to combine phonological (functional) arguments with empirical (acoustic and articulatory) data in order to shed some more light on the development and variation of uvular /r/ in German.

Notes

1 Rhotics often alternate with liquids both diachronically and synchronically. The sound change of [l] → [r] (e.g., Lat. rivellus → Fr. rivière) can be observed as well as the reverse change of [r] → [l] (e.g., Lat. marmor → Span. marmol; Gr.-Lat. papyrus → Span. papel, but Fr. papier, Engl. paper, Germ. Papier, MALKIEL 1980: 278-279). The alternation of [r] and [l] is made clear by means of the dissimilation of the Latin suffix for adjectives -alis to -alis after preceding [l] (e.g., navis - navalis vs. miles - militaris, KENSTOWICZ 1994 for a discussion of this dissimilation from the point of view of phonological underspecification theory). DICKEY (1995: 103-104) gives some examples for the /l/-/l/-alternation in non-European languages. In intervocalic position both [r] and [l] show a tendency to be lost (e.g., Basq. efirle, Basq. ada/rla, HAASE 1993: 27; Lat. volare → Gal.-Port. voar, BALDINGER (1958): "La position du gascon entre la Galloromanie et l'Ibéromanie." Revue de linguistique romane 22; 241-292 [cited in HAASE 1993]).

2 According to TARNÓCZY (1948: 75) the apical-alveolar trill [r] (F1 550 Hz, F2 1400 Hz, F3 2000 Hz) has the greatest similarity with [l]. This point of view is essentially confirmed by the data of MEYER-EPPLER (1959).

3 Another indication for the auditory-perceptual similarity of /r/ and /l/ is the fact that in some languages both /l/- and /r/-sounds are allophones of the same phonemic category, e.g., in Japanese (see YAMADA 1991).

4 UPSID = UCLA Phonological Segment Inventory Database.

5 TRASK (1996: 310) tries to define rhotics in the following way: "Any member of a particular group of phonetically heterogeneous segments which for various phonological reasons are conveniently treated as a class - informally, the class of 'r-sounds'."

6 Taps and flaps are often mixed up although there is a clear and important distinction between both types of sounds (PIKE 1943: 124-125). Both have "a single short closure" (LADEFOGED/MADDIESON 1996: 230) but flaps involve the retraction of the tongue. According to LADEFOGED (1993: 168-169) the fact that flaps are retroflex sounds is the main difference between these two types of sounds.

7 A practical definition of /l/-sound is given by KRESHECK et al. (1972: 301): "The term 'r phone' is used [...] to refer to any minimal identifiable segment of an utterance occurring in a word in a position where /r/ would be expected (corresponding to orthographic r in that word, according to the phonology of this dialect).

8 "There is no symbol to distinguish between uvular fricatives and approximants. Both sounds are symbolized by [r]" (LADEFOGED 1993: 170).

9 Cross-linguistically, there are a number of languages which rule out rhotics word-initially (DICKEY 1995: 117-119).
10 According to Niekerken (1965: 165) the articulatory similarity between [r] and [l], namely
the obstruction of the airflow at the alveoles or at the palate is — in addition to the similar distri-
bution both sounds share — good evidence for the assumption that /r/ developed via phoneme
split out of /l/.

11 For the notion of articulatory 'undershoot' see Lindblom (1963).

12 This argumentation is also supported by Dressler (1980: 109) who states: "M.E. dürfte das
natürliche Ergebnis eines Lautwandel's z → r kein Vibrant, sondern ein Approximant (dem
amerikanischen [l] vergleichbar) sein. [...] Da ein r-Approximant gewöhnlich das direkte oder
indirekte Schwächungsprodukt eines Vibranten ist, können wir annehmen, daß über kurz oder
lang ein aus /z/ entstandener r-Approximant mit einem daneben vorhandenen Vibrantenpho-
nen identifiziert wird [...]" ("In my opinion, the natural result of a sound change z → r should
not be a trill but an approximant (similar to American [l]). [...] Because an r-approximant is
generally the direct or indirect reduction form of a trill, we can assume that an r-approximant
that resulted from a /z/ will sooner or later be identified as the also existing trill phoneme [...]",
translation/transliteration by the author).

13 Note that [r] and [ɾ] are not allophones in German, i.e., they do not constitute positional vari-
ants of the same phoneme /t/. Instead, they are free (ideolectal, dialectal) variants of /t/ (Dickey, p. c.).

14 This process — called assimilation of /t/ — is the contrary phenomenon to rhotacization.
Although Sole (1992) argues that rhotacization is basically a unidirectional process, assimila-
tion of /t/ occurs occasionally, too (see the examples given in Sole 1992: 260, 266; Haden
1955). This demonstrates the potential interchangeability of /t/ and /ɾ/.

15 In the Massif Central the change from [ɾ] to [ɾ] is still in progress. According to Nauton
(1972) the distribution of the two alternatives of /t/ is dependent on the speakers' age. In fact,
the oldest generation tended to use only [ɾ] whereas the youngest generation stuck almost
exclusively to [ɾ]. The generation in between, i.e., speakers aging from 25 to 40 used both vari-
ants. This specific example might show how the process of sound change from [ɾ] to [ɾ] gener-
ally proceeded in French.

16 "[...] on admet par là même que deux façons d'articuler l'r français, l'une apicale at l'autre dor-
sale (ou velaire), sont plus anciennes en France que la langue française elle-même, puisqu'elles
seraient l'héritage d'une langue pré-romane" (Falc'hun 1972: 114-115).

17 Basilius (1942) and Lancaster (1934) agree with Trautmann, but they modify his
hypothesis in the following respects. According to Lancaster (1934: 243-244), Traut-
mann's evidence for the existence of French uvular /ɾ/ in the seventeenth century is much too
weak because the expression 'parler gras' — as mentioned by Chapel in Relation d'un Voyage de
France, Trautmann's primary source — does not necessarily have to mean "producing uvular
/ɾ/". Instead, Lancaster (1934: 247) considers Raymond Poisson's play L'Après-Soupe des
Auberges (1665) as the attempt to record the use of uvular /ɾ/ in French. According to Lan-
caster, the uvular /ɾ/-sound began to be used at the French court in the middle of the 17th
century and was probably not a trilled but a reduced sound. Court influence is therefore the
reason for the introduction of uvular /ɾ/ (Lancaster 1934: 248). Basilius (1942) gives a
more precise account for the spreading of French uvular /ɾ/ in Germany. He locates the start-
ing-point of German uvular /ɾ/ in Berlin where many French Huguenots settled at the end of
the 17th century and became teachers there. Basilius (1942: 454) concludes: "It seems reason-
able to assume that the Huguenot influx into Germany, specifically into Brandenburg and Ber-
lin, in the second half of the 17th century, particularly after the revocation of the Edict of
Nantes, was the social impulse that brought [n] to Germany, and that this fact is the missing link needed to lend complete credence to Trautmann's theory of the German origin of [r]."

18 In the writings of Jacob Böhme (1575-1624) MOULTON (1952) found an articulatory description of a graphemic \( \langle \text{r} \rangle \) which hints at a uvular pronunciation.

19 It is not clear whether HAMMARSTRÖM (1953) arrived at his explanation independently of JESPERSSEN (1889). It is true that he does not refer to Jespersen's work but Jespersen published his idea clearly before Hammarström.

20 He literally states: "Même sans recourir à la méthode instrumentale, il nous semble légitime de supposer que la tension nécessaire à la prononciation d'un r alvéolaire très fort a pour effet de faire vibrer à peu près toute la langue et de relever, du fait que la langue est tendue, sa partie postérieure" (HAMMARSTRÖM 1953: 176).

21 With the term \textit{effort} I do not mean 'physical effort' but rather the 'articulatory motor skill' that is necessary to produce a certain sound. Whether the physical effort is different for the production of [s] and [r], e.g., because of differences in mass and/or stiffness of the articulators involved, i.e., uvula and tongue tip, respectively, is yet to be determined.

22 As Laura Walsh Dickey pointed out to me, the reduction from a trill to a tap can also be observed in several African and Australian languages. See also LINDAU (1980: 118) and THELWAL (1980).

23 It is important to note that the tapped apical /\textipa{t}/ is not equivalent to a trilled apical /\textipa{t}/ with only a single tap of the tongue. RECASENS (1991) carried out one of the few articulatory studies addressing the production of /\textipa{t}/. The results of his coarticulatory study show that alveolar taps and trills "[...] show contrasting degrees of resistance to coarticulation from the adjacent vowels" (l.c.: 279). The tap is more influenced by the vowel in V-to-C transitions than the trill. According to RECASENS the production of the tap may require less articulatory control whereas the production of the trill is more constrained. In fact, he suggested that apical taps and trills are executed by means of two different articulatory gestures (l.c.: 279).

24 This confirms the statements made by LINDAU (1985: 158) ("Rhotics often alternate with other rhotics") and BHAT (1974: 84) ("A trill is found to occur in stressed position, to denote emphasis, or in slow speech. As against this, a flap (or tap) occurs in an unstressed position, and in non-emphatic speech").

25 According to DELATTRE (1971), this phonological opposition in Spanish is a purely durational one (i.e., \textipa{\text{\v{c}}}r\textipa{\text{\v{c}}}) is more than three times as long as \textipa{\text{\v{c}}}r\textipa{\text{\v{c}}}), i.e., Delattre differentiates only between a single and a multiple tapped alveolar /\textipa{t}/. Although his X-ray recordings reveal some differences in manner of articulation between the two variants, DELATTRE (1971) does not consider them to be important in distinguishing [r] from [r]. According to MORAIS-BARBOSA (1962: 221), the intervocalic opposition between [r] and [r] in Portuguese is also marked by duration only (but see RECASENS 1991).

26 "There has to be trilled tongue-tip-r in all cases; only in this way the fashion of a spirantized or vocalized reduction of r can be prevented" (Translation/transliteration by the author).

27 The declining use of apical trilled /\textipa{t}/ has provoked some remarks that are unjustified from a scientific point of view. STERN (1907: 15), for instance, wrote: "Da das Zungen-R, wie kein anderes R, unserer Sprache Markigkeit, Kraft und Deutlichkeit verleiht, so ist es um so mehr zu beklagen, daß sein Gebrauch zurücktritt" ("Because the tongue-R, like no other R, gives bombast, power, and clarity to our language, it is the more lamentable that its use goes down", translation/transliteration by the author). SIEBS (1961: 61) argued: "Doch ist die Zungen-
spitzenform des r vorzuziehen, weil sie die Bildung der Vokale nach vorn verlegt, und darum stimmhygienisch den Vorzug verdient" ("But the tongue tip form of r has to be preferred because it moves the production of the vowels forward and therefore it has an advantage from the point of view of voice hygiene", translation/transliteration by the author). See WANGLER (1983: 156) for criticism. The most pathetic complaint about the decline of the apical trill can be found in VISCHER's note entitled Leiden des armen Buchstaben R auf seiner Wanderung durch Deutschland ("Sufferings of the poor letter R on his trip through Germany") (1882). Interestingly, descriptions of non-natives about German /t/ are much more to the point and unbiased (e.g., CURME 1891). MÜTSCHMANN (1908: 68) considers uvular /t/ even as "the 'received sound' of educated speech". The reduction of the uvular trill to a voiced velar/uvular fricative or approximant or even to a vowel is already mentioned by both CURME (1891: 5) and MÜTSCHMANN (1908: 68-69).

28 After long vowels, /t/ seems to be especially weak. In OHG times, /t/ was lost after long vowels (BEHAGHEL 1916: 232, PAUL 1916: 355). German vocalized /t/ is perceptually similar to the vowel [a]. This is confirmed by DELATTRE (1971: 106), showing that the formants of the vocalized variant of German /t/ shift very close to [a]. WIESE (1996: 254) argues "[...] that [v] should be identified in its phonological features with the vowel [a]."

29 This is in accordance with DELATTRE (1971: 104) stating that German /t/ is generally stronger after short than after long vowels. Whether uvular /t/ is realized as a fricative or as a vowel seems at least in part to be dependent on the quality of the preceding vowel (HARDEN 1981: 97). By far the most frequent consonantal realizations of /t/ were found after /l/ and /ol/, whereas after /al/ and /ul/ this proportion is much lower.

30 The picture drawn by WIESE (1996: 253) is much simpler because he argues that "[ ... ] /t/ in Modern Standard German can best be described as an approximant [...]", a view that is a bit oversimplistic to my mind. According to WIESE uvular /t/ is consonantal in onsets and vocalic elsewhere, with the exception of the consonantal realization after short vowels. However, he gives a plausible phonological reason for the exceptional status of /t/ after short vowels. In intervocalic position, /t/ following a short vowel becomes ambisyllabic, e.g., in Sperre /spa:ra/ ("closure"). Therefore it can never become vocalized in that position, i.e., /t/-vocalization is blocked by the double linking constraint.

31 In North Saxon, however, the vocalization of /t/ is a function of the /t/-variant spoken by the particular speaker. In some empirical data, the author was able to observe differences in the postvocalic vocalization behaviour between apical and uvular /t/.

32 "In any syllable, there is a segment constituting a sonority peak that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values" (SELKIRK 1984: 116).

33 The so-called 'consonantal strength hierarchy' in VENNEMANN (1988: 9) is identical to JEPSEN's (1920: 198) sonority hierarchy except for the fact that consonantal strength is in inverse proportion to sonority.

34 According to HARDEN (1981: 97), a following nasal encourages the pronunciation of German uvular /t/ as a fricative. In the dialect of the 'Ruhrgebiet' he observed uvular /t/ more often as a fricative in words like Dirne /dir.na/ or Zwirn /tsvirn/ than in Wirt /vitr/ or wirken /vitr.kon/ where vocalized pronunciation of uvular /t/ prevailed.

35 More complicated sonority hierarchies such as the two dimensional model proposed in DRESSLER (1980: 109) may describe more phonological phenomena but they do not provide the simplicity which makes the traditional sonority hierarchy so appealing to many phonolo-
gists. In DRESSLER’s model, for instance, the sonority relations between voiced fricatives and trills, flaps, and taps do not become clear. We cannot, therefore, determine whether DRESSLER’s model can account for the data any more than another sonority hierarchy.

36 In fact, this has already been shown for other cases in German, too, e.g., in onset clusters consisting of /sl/+ plosive as in Stimme (“voice”) /ʃtmə/ or in coda clusters of the form plosive+ /sl/+ plosive as in Herbst (“autumn”) /hɛɐbst/. In these cases, however, it can be argued that the segments not obeying the sonority constraints are syllabic affixes (appendices). In the current examples, the sequences are word-internal and cannot be explained away by syllable affixes.

37 This point has also been mentioned by BUTT (1992: 56) who states: “It is very likely that the sonority ranking between nasals and glides [...] cannot be approved for all liquids. Furthermore, many sounds described as liquids are subject to context-dependent or free variation such that the actual pronunciation is often that of a vowel, a glide or a fricative”.

38 KRÄMER (1979: 46) distinguished different classes of vocalized /t/ (e.g., [v]) dependent on the quality of the preceding vowel, i.e. the ‘Kopfvokal’.

39 LADEFOGED/COCHRAN/DISNER (1977: 52) observed average values of 29.3 Hz for the rate of vibration of bilabial trills, 28.6 Hz for lingual (apico-alveolar) trills and 26.2 Hz for uvular trills. LINDNER (1958) provided similar results: 19-23.5 Hz for the uvular trill (‘Zäpfchen-R’) and 23.5-37.5 Hz for the apical trill (‘Zungen-R’). LINDAU (1985) provides mean values of several different languages. For apical trills the mean rate of vibration is 25 Hz, slightly lower if they are voiceless (22.5 Hz). The mean rate of vibration for uvular trills is 30.5 Hz (LINDAU 1985: 160-161). SCHÖNLE et al. (1983: 266) who measured the articulation of the apical trill by means of EMA (Electro-Magnetic Articulography) obtained a frequency of vibration of 24 Hz on the average.

40 The similarities in position of articulation have already been noticed implicitly by GRIFFEN (1982: 304) who stated that German uvular /t/ “[...] is always produced with the back part of the dorsum (the postdorsum) raised and slightly back”.

References


Trautmann, Moritz (1880): Besprechung einiger schulbücher nebst bemerkungen über die r-lauten. *Anglia* 3; 201-222.


Appendix

Test utterances

(1) *Der Bauer hat eine Menge Korn geerntet.*

(2) *Der Stoff ist aus gutem Zwirn gefertigt.*

(3) *Das Boot wäre im Sturm fast gekentert.*

(4) *Der Berggipfel ist mit Firn bedeckt.*

(5) *Sein Bruder ist ein netter Kerl gewesen.*

(6) *Die Hose ist mit festem Garn genäht.*

(7) *Er hat den hohen Turm schon von weitem gesehen.*

(8) *Die Fabrik stößt aus dem Schornstein weißen Rauch aus.*