R-coloring interactions in Element Theory

A Typological Survey

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Contents

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1 Introduction

This thesis contains a typological description and phonological analysis of rhotic-vowel interactions in various languages of the world with the aim to falsify the hypothesis that vowels will lower in terms of frequency distribution under the influence of rhotics. The introduction briefly covers the peculiarity of rhotics, the problems of fitting rhotics into early phonological frameworks and an introduction to the more recent generative phonological framework: Element Theory. Section 2 contains all the data from various languages of the world and includes an attempt of analysis of these data within a framework of Element Theory. Lastly, section 3 evaluates the success of this approach of Element Theory and tries to account for the found interactions within Element Theory more in-depth.

1.1 Rhotics

Rhotics are among the more peculiar sounds in the range of speech sounds in languages of the world for a number of reasons. Unlike other classes of phones like stops or fricatives, it is difficult to uniformly classify rhotics based on their articulatory or acoustic properties. In the International Phonetic Alphabet, there are a number of sounds that are classically classified as "rhotics" as they are represented by graphemes which are derived from latin <r> (Wiese, 2011).

	Alveolar	Retroflex	Uvular
Trill	r		ʀ
Tap or Flap	ɾ	ɽ	
Fricative			ʁ
Approximant	ɹ	ɻ	
Lateral Flap	ɺ		

Table 1: Sounds classically classified as rhotic in IPA (Wiese, 2011).

It becomes clear there is quite some phonetic variation after viewing Table 1. In the most basic classification of rhotics alone there are five different possible manners and three possible places of articulation. It can be immediately noted that the table is incomplete as there are sounds in the phonetic alphabet that share at least some articulatory feature with classical rhotics such as [ʙ] ("Handbook of the International Phonetic Association", 1999). Furthermore, there are languages where sounds not included in Table 1 may yet be classified as rhotics. Such is the case with [χ] in Armenian (Vaux, 1998). The observation that rhotics branch in many different realizations is especially interesting since it would seem languages with a rhotic phoneme are relatively common in the world. More than half of all languages seem to have at least one rhotic phoneme (Wiese, 2011). On the basis of this it has been suggested that an articulatory description encompassing all rhotics is simply impossible (Wiese, 2011).

There have been numerous studies in the past attempting to tie rhotics together in terms of acoustic characteristics (Ladefoged and Maddieson, 1996, Lindau, 1985). What has been found is a slightly lowered third formant for apical (alveolar/palatal) trills, uvular trills and rhotic approximants (at least approximants in American English) (Lindau, 1985). This is a powerful observation since these speech sounds are extremely commonly found as rhotics. However, there are also variants of rhotic sounds that have a relatively high third formant (Wiese, 2011). Although the early

study of Lindau (1985) notes that it is very difficult to define rhotics as a natural class in this way, it still reaches the conclusion that a lowered F3 is one of the phonetic correlates for rhotics in American English. Even within one phonological system with multiple interpretations of a rhotic phoneme, it can be difficult to group rhotics under one definition. In German (INDO-EUROPEAN) for example, it has been suggested that only a negative specification for the phoneme /r/ is possible in terms of acoustics (Kohler, 1995). This is to say that there are no specifying features that specifically denote rhotics. Rather, the defintion of rhotics is an enumeration of features that it does not possess. Ultimately, there is no single acoustic parameter that is able to define all rhotics.

1.1.1 Phonetic Variation exemplified: Dutch

Dutch (INDO-EUROPEAN) is language that is able to further illustrate the phonetic divergence of /r/. A corpus study revealed at least twenty different phonetic realizations of /r/ that can be observed in Dutch speakers across ten different urban dialects (Sebregts, 2015). Even in the same phonological system the interpretation of the phoneme can be extremely flexible: Generally, in Standard Dutch the interpretation may be any sound in the set {[r], [ʀ], [ɹ], [ʀχ], [χ], ∅}, but the precise variants are still disputed (Sebregts, 2015). In terms of acoustics, it is again seen that some rhotics in Dutch display a lowered third formant, but not all. All in all, the realizational divergence of /r/ in Dutch is immense and a prime example of the difficult to encompass variability of rhotics.

1.1.2 Phonological Unity of Rhotics

Despite the considerable phonetic variation of rhotics both language-internally and cross-linguistic, it is still possible to define rhotics as a natural class. The evidence for rhotics as a natural class is based on their phonological behaviour and phonotactics. Wiese (2011) lists the following phenomena that evidence the connection of the interpretation of rhotics:

(1) a. The phonotactic unity of rhotics.
b. Their place in syllable structure.
c. The influence of rhotics on neighbouring vowels.

It is established that r-phonemes within a language phonologically behave like sonorant liquids regardless of their phonetic realization (Sebregts, 2015). An example of a language where this phonotactic unity is displayed is Malakmalak (ISOLATE), where the phonemes /r/ and /ɾ/ may never appear word-initially (Wiese, 2011). This rule targets the class of rhotics in Malakmalak as a whole rather than a single phoneme. As for their place in syllable structure, it can be typologically observed that in languages with complex onset or coda clusters rhotics generally appear immediately adjacent to the nucleus of the syllable (Wiese, 2011). This means that syllables with a rhotic and both a complex onset and a complex coda will generally take the form of $CrVrC$.

The main focus of this thesis will lie in the interactions rhotics display with neighbouring vowels. This topic will be extensively discussed in section 1.1.3.

1.1.3 Rhotic-vowel interactions

One of the more puzzling phenomena in which rhotics uniformly play a big role is that of consonant-vowel interactions. It has been observed that, if a language allows syllabic consonants, rhotics are

most often included in the set of grammatical syllable nuclei (Pouplier and Benus, 2011). Additionally, rhotics are very frequently involved in diachronic consonant-vowel metathesis (Blevins and Garrett, 1998). The focus of this thesis will be on a third type of consonant-vowel interaction, namely the process whereby vowel quality is altered under the influence of neighbouring rhotics.

It is often the case that the phonetic values of vowels are altered based on their adjacency to a rhotic consonant (Lindau, 1985, Hall, 1997, Wiese, 2011, Spreafico and Vietti, 2013). An example of this is seen in British English (INDO-EUROPEAN). In rhotic variants of English, only lax vowels such as /ɪ, ɛ, ɑ, ʊ, ɔ/ may occur before a rhotic approximant. All other vowels are neutralized to the central vowel [ɜ] in a pre-r position (Wiese, 2011). In addition to this, surface representations of rhotic variants of English frequently contain [ə˞]. This rhoticized schwa is a result from an underlying rhotic in coda position (Harris, 1996). In (2) this rhoticization is exemplified and contrasted with Scottish English, a variant of English that is non-rhotic.

(2)

WORD	RHOTIC ENGLISHES	SCOTTISH ENGLISH
Skirt	[skə˞t]	[skɪrt]
Pert	[pʰə˞t]	[pʰɛrt]
Hurt	[hə˞t]	[hʌrt]

(Harris, 1996)

These type of interactions have also been dubbed under the name of *"r-coloring"*. Many more of these type of interactions where vowel quality is altered under the influence of rhotics can be observed in languages of the world ranging from very diverse language families. These languages include Berber, Dutch, Japanese, Kumiai and more. In section 2 of this thesis these vowel-interactions will be described extensively. What is intriguing about these quality-alterations is that the phonological motivation for this phenomenon is not transparent, yet cross-linguistically observable. The motivation cannot be phonetic: for most of these interactions occur uniformly across all rhotics in a language. Yet again, Dutch can be used to illustrate this fact. The altering of vowels in the neighbourhood of rhotics has already been noted in Gussenhoven (1993). Tense vowels /i, y, u/ are lengthened before /r/. This is demonstrated in (3). Also note that the interpretation of /r/ in these cases is /ɹ/. It is a known observation that, especially in western dialects of Dutch, syllable-final rhotics are interpreted as approximants (Sebregts, 2015).

(3)

WORD	DUTCH
Beer	[biːɹ]
Beet	[bit]
Feed	[vuːɹ]
Joint	[vuχ]
Fire	[vyːɹ]
Cubic meter	[kypˤ]

Sebregts (2015) adds that this r-coloring happens under the influence of not just /ɹ/ but also other variants of rhotics in Dutch.

The phenomenon of r-coloring has been well documented, but is generally not phonologically well understood. There have been multiple attempts at making sense of r-coloring within numerous phonological frameworks. These will be discussed in section 1.2.

1.2 Rhotics in previous phonological accounts

1.2.1 SPE

In the traditional rule-based derivational framework of phonology called SPE (**S**ound **P**attern of **E**nglish) pioneered by Chomsky and Halle, 1968, rhotics prove to be a difficult class of sounds to capture. As this framework grounds phonological representation in distinctive articulatory and phonetic features, the trouble rhotics give SPE is somewhat expected. This is because as I have discussed in section 1.1, the phonetic variation of rhotics is immense. However, there has been an attempt at formulating a full specification of /r/ in terms of features. This is represented in (4).

(4) [+cons,+son,+appr,+cont,+voice,-nas,-lat,-asp, COR] (Booij, 1995)

There are many languages that oppose this specification. For example Alyawarra (PAMA-NGYUAN), which has two rhotic phonemes (/r/ and /ɹ/) that behave as a class in certain phonological processes (Colin, 1977) or Dutch which, as Sebregts (2015) has shown, exhibits variation so wide such that almost all of the features in (4) may be specified in the opposite direction for at least one of the surface variants of Dutch. Booij (1995) accounts for this by suggesting that Dutch surface variations are all allophones of /r/. This is however demonstrably not the case as for some speakers /r/ may be entirely absent from speech and is completely substituted by /ʀ/ (Sebregts, 2015).

The difficulties of incorporating rhotics within purely traditional SPE have been recognized. There have been proposals to account for rhotics in SPE with slight modifications to the original theory. Most notable of these proposals is Hall (1997) who proposes a feature without phonetic content ([rhotic]) that denotes all rhotic sounds in a language. Hall (1997) correctly observes the phonetic and allophonic variation of rhotics in languages of the world and that despite this rhotics behave as a natural class within a phonological system. In his proposal he also admits the difficulty of using traditional features to describe rhotics as a natural class. For these reasons it was deemed necessary to postulate [rhotic] as an existing feature within SPE. This proposal has been subject to heavy criticism. Sebregts (2015) notes that the proposal of this feature is an ad-hoc solution as it does not serve to constrain the rhotic class and is unnecessary for any other phoneme. Another problem is of how the phonetic exponents of /r/ could be associated with the feature [rhotic] in language acquisition (Gsiorowski, 2006). It would also seem that [rhotic] is a privative feature. That is to say that there is no reason to assume the absence of rhoticity ([-rhotic]) to be of any phonological relevance. The proposal has been ultimately deemed a circular explanation or "a restatement of the problem rather than a solution" (Wiese, 2001: 344).

1.2.2 Other accounts

Wiese (2001) attempts to encapture rhotics as a class not through shared distinctive features, but by their place in the sonority hierarchy. Based on what is known about the distributional phonotactic properties of /r/ cross-linguistically (namely, rhotics tend to occur adjacent to nuclei and co-occur frequently with laterals and glides in German for example), Wiese (2001) postulates rhotics as inhabiting a place in the sonority scale in between laterals and glides. This proposal encounters the same circularity problems as the proposal made by Hall. The sonority scale is supposed to be a measure from which we can derive the phonotactics of phonemes, but in this case it is the phonotactic distribution of rhotics that dictates the place in the sonority hierarchy (Sebregts, 2015). This sort of reasoning is theoretically very costly for the concept of the sonority

hierarchy. The learnability of rhotics as a place on the sonority scale is again problematic if it is assumed for languages where vowels may be interpreted as rhotics. Gsiorowski (2006) also notes that Polish (INDO-EUROPEAN) has glide rhotic onset clusters which would clash with the suggested interpretation of the sonority scale by Wiese (2001). Lastly, the sonority scale as a whole is a dubious construction as it is unclear how certain aspects such as voicing may play a role in the determination of sonority (Harris, 2006, Ohala, 1992).

1.2.3 Rhotic-vowel interactions

With regards to the quality-altering vowel interactions (as introduced in section 1.1.3), numerous problems arise when attempting to explain these phonological processes in SPE. First of all, consonants and vowels in SPE share no primitive features. Therefore (if it possible at all to encompass rhotics in distinctive features) it is not possible to assume that some feature belonging to a rhotic is able to spread to an adjacent vowel. Consequently, any rule that is construed within SPE blurs the functional purpose of the phonological process. After all, why would a process like rhotic-vowel interaction even exist if there are no shared primitives between rhotics and vowels? SPE predicts that rhotics and vowels behave independently, but this is demonstrably not the case. It is clear that a different framework that can deal with rhotics as a class and their phonological behaviour is necessary. In section 1.3 the framework of Element Theory and its relation to rhotics is discussed.

1.3 Element Theory

Element Theory (or "ET") is a framework of generative phonology that diverges from SPE in quite a few ways. The immediate difference is that Element Theory is not grounded in speech production and movements of the articulatory organs, but rather in acoustic targets for speech sounds (Backley, 2011). Central to ET, the speech signal is shared by both speakers and listeners. Element Theory works on the observation that humans can recognize and distinguish acoustic patterns. If this is the case, it would make less sense to derive properties of phonology based on purely articulatory (from the speaker's perspective) or purely perceptual (from the listener's perspective) features (Backley, 2011). It is the task of a speaker to produce certain acoustic events such that they can be decoded and interpreted by a hearer. Thus in the framework of Element Theory, speech needs to be derived from primitives that describe these acoustic patterns which are relevant to both speakers and listeners. These primitives in Element Theory are referred to as *elements*.

Secondly, elements are monovalent. This is to say that the primitives of Element Theory are present or not and the absence of a primitive does not necessarily have phonological consequences (Backley, 2011). Feature-based theories encounter some problems stemming from the fact that their primitives are bivalent (meaning either + or −). SPE, for example, makes incorrect predictions regarding the phonology of languages of the world. SPE correctly states that [+nasal] sounds act as a class and participate as such in phonological processes, but it incorrectly predicts that the same is the case for [-nasal] (Backley, 2011).

Thirdly, since Element Theory relies on acoustic targets, consonants and vowels are described using the same elements. Consonant-vowel unity is a fundamental concept in Element Theory. If this unity is not assumed, it becomes difficult for any generative theory of phonology to account for any interaction between the two types of speech sounds. It follows from this that elements are able to be interpreted autonomously, meaning that a singular element may be sufficient to describe a particular segment.

In the following section I will briefly summarize the main structure and arguments of Element Theory. Additionally I will provide some examples and evidence for the claims Element Theory makes.[1]

1.3.1 Elements of vowels

In total there are six distinct elements. Three for vowels and three for consonants. The vowel primitives are respectively |I|, |U| and |A| and they correspond to what are classically interpreted as the *cardinal vowels* [i, u, a]. These are noted as cardinal vowels, because almost all known phonological systems in the world contain at least an interpretation of [i, u, a] (Backley, 2011). Even if the cardinal vowels of a given vowel system do not exactly match [i, u, a] (like Quechua which has [ɪ, ʊ, ɐ] (Backley, 2011)) we can still interpret their phonological content as |I|, |U| and |A| respectively. The elements are abstract representations of acoustic targets, therefore phonetic variation in the interpretation of these abstractions is to be expected. The acoustic characteristics of these basic vowel elements are found in the distribution of spectral energy. Vowels corresponding to |I| are characterized by having two frequency peaks in its spectral pattern: one around 500 Hz and one around 2.5 kHz. Element |U| has a concentration of spectral energy in the lower end of the frequency range (0-1 kHz). Element |A| has a large concentration of energy in the middle section of the frequency range (around 1 kHz) (Backley, 2011). The spectral patterns are roughly visualized in Figure 1.

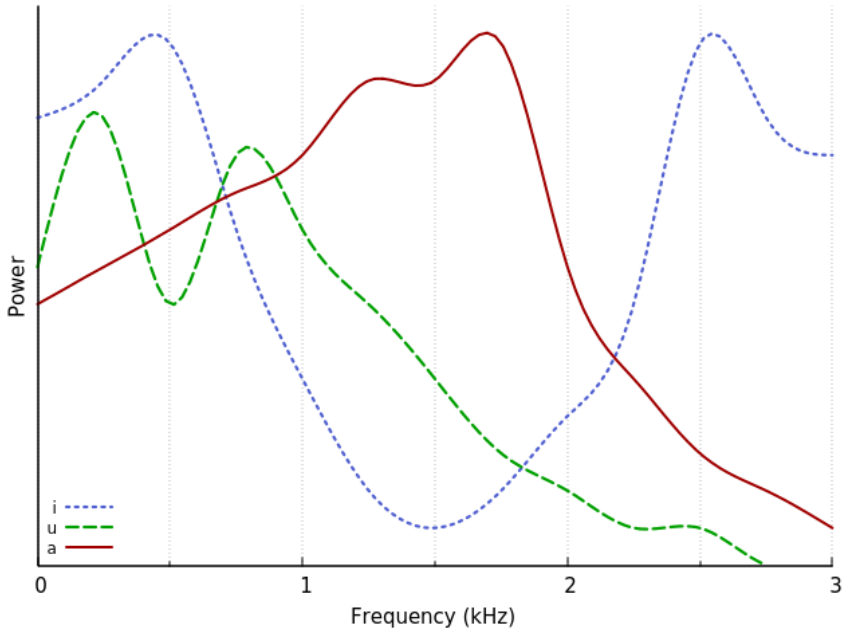


Figure 1: Rough spectral patterns of the vowels i, u and a.

Of course there can be more than just the three cardinal vowels present in a language. Most other vowels are derived by combining the three basic vowel elements together. Many languages

[1]Element Theory is a vast framework and very thorough in its definitions. Because the scope of this thesis is limited I will provide as many details and examples as possible, however for a complete description of Element Theory (and any speech sounds that I may not discuss in this thesis) I refer the reader to Backley (2011).

have a 5-vowel system consisting of the sounds [i, u, a, e, o]. The vowels [i, u, a] can be represented by the three basic elements. The vowels [e] and [o] can be analyzed as compound segments (i.e. they consist of more than one element). The phonological content of [e] is |I, A| and that of [o] is |U, A|. Combining all three elements may result in a sound such as [ø]. Phonetically, compound elements share characteristics of their individual components (such as roundness from |U| in the case of [ø]) (Backley, 2011). Phonological evidence comes from various languages. For example, in multiple varieties of African English the diphthongs [aɪ] and [aʊ] are realized as [ɛ] and [ɔ] respectively (Backley, 2011).

Some languages have even more vowels than the systems described above. An example of this is again English, which has a phonological contrast between [ɛ] and [æ] (Harris, 1996). In many other branches of linguistics such as syntax and semantics, but also in prosodic phonology, asymmetrical relations are observed between heads and dependents. Element Theory adopts this notion of headedness to account for further variation in phoneme inventories. The vowel distinction in English can then be explained by assuming [æ] has the elemental makeup of |I, A|, rather than |I, A| (which is the phonological makeup of [ɛ]) (Backley, 2011). In this representation underlined elements are headed and any segment may have more than one headed element. Phonetically this is justified, as [æ] shares more acoustic properties with [a] than [ɛ] does.

Finally there are some special cases that Element Theory needs to account for, namely central vowels like [ə] and [ɨ]. In the framework of ET, these central vowels are analyzed as empty segments (Backley, 2011). Recall that the three basic vowel elements all have distinct and unique distributions of spectral energy. This is not the case for central vowels like [ə] and [ɨ], whose spectral patterns are indistinct (Backley, 2011). In to Element Theory, these central vowels serve as a baseline for additional phonetic and phonological structure. Phonologically, central vowels are rarely stressed and are frequent in weak syllables. They are additionally almost exclusively the epenthetic vowels in svarabhakti processes (Backley, 2011).

In order to illustrate how ET analyses and derivations work, I have exemplified a simplified analysis of vowel harmony in Turkish (TURKIC) below. Turkish is known for having vowel harmony. That is to say some morphemes show variations in their phonetic interpretation based on preceding vowels.

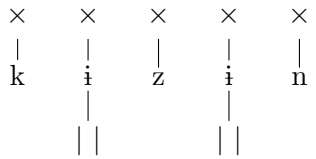
(5)

NOMINATIVE SINGULAR	GENITIVE SINGULAR	NOMINATIVE PLURAL	
kɨz	kɨz-ɨn	kɨz-lar	*Girl*
ip	ip-in	ip-ler	*Rope*

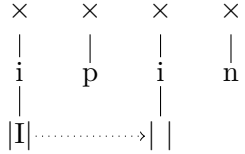
(Backley, 2011)

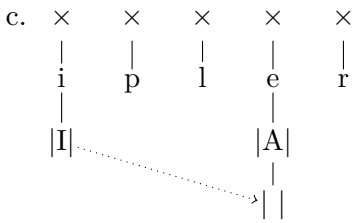
(6)

a.



b.





1.3.2 Elements of consonants

There are three manner elements that primarily belong to consonants, namely |H|, |L| and |ʔ|. However, as stated earlier, consonant-vowel unity is an important concept in Element Theory. Therefore the vocalic elements may also be used to describe consonants to some extent. Phonologically, consonants and vowels interact frequently with each other. Additionally, vocalic elements are elements that describe resonance and it is not the case that consonants do not have resonance. For these reasons it is important to be able to apply vocalic elements to consonants.

Palatal consonants and some coronal consonants have |I| resonance, velar and labial sounds have |U| resonance and guttural and some coronal consonants have |A| resonance (Backley, 2011). There is ample phonological evidence for each of these claims. Palatalization often happens under the influence of front vowels. Velars and bilabials often interact with each other and rounded vowel. Lastly, gutturals share the spectral patterns of |A| (Backley, 2011). In (7) these phenomena are (in simplified form) exemplified respectively.

(7)

LANGUAGE	TRANSCRIPTION	TRANSLATION	PHENOMENON
Ngyiambaa	[miri-ɟul]	*'dog'*	Palatalization
	[mura-d̪ul]	*'spear'*	
Mapila Malayalam	[pal-ɨ]	*'milk'*	Rounding
	[japp-u]	*'pound'*	
Tiberian Hebrew	[ruːħiː]	*'my spirit'*	Vowel lowering
	[ruaħ]	*'spirit'*	

(Backley, 2011)

In some languages palatals and coronals form a natural class, if this is the case it is possible to postulate a framework in which both palatals and coronals have the resonance element |I| (Backley, 2011).[2] This is the case for Korean (KOREANIC) and Lahu (SINO-TIBETAN). For these languages palatals are |I̲| and most coronals (like dentals) are |I|. There is also some phonetic evidence that some coronals share acoustic cues with [i] (Backley, 2011). This classification does not work for all coronals however. Retroflex and some alveolar sounds cross-linguistically do not pattern with either palatals or [i]. It is however the case that these sounds share more commonalities with |A|. In Element Theory, retroflex sounds are denoted by |A̲| and alveolar sounds by |A| (Backley, 2011).

Aside from the resonance elements in consonants there are the manner elements |H|, |L| and |ʔ|. The |ʔ| element (also known as the occlusion element) represents a sudden reduction in spectral energy, much like what is observed in ordinary stops. Stops are classified as sounds with a complete obstruction in the mouth and a drop in spectral energy followed by a release of this built-up energy.

[2]Note that the term "coronals" is a cover term for segments articulated at the alveolum. This is not of any relevance in the analysis of Element Theory, but the term is used for convenience.

It comes to no surprise as stops are analyzed as having |ʔ| in their phonological structure (Backley, 2011).

The |H| elements represents friction or a concentration of high frequency noise. This is the type of noise that is encountered in voiceless fricatives. Rather than having periodic energy, the spectral energy encountered in elements with |H| is aperiodic and concentrated in the upper part of the spectrum (2-4kHz). It is indeed the case that in ET voiceless fricatives have |H|. However so do voiceless stops. What differentiates the two classes is that fricatives do not have |ʔ| and stops do (Backley, 2011). The |H| element is also loosely associated with high tone in tonal languages (Backley, 2011).

Contrary to |H|, the |L| element represents a concentration of low-frequency energy. This element is active in nasals as they exhibit this particular concentration of spectral energy (Backley, 2011). In ET the |L| element is responsible for the common phenomenon of nasal assimilation by which segments (especially) are 'infected' with nasality from neighbouring sounds. The |L| segment is also active in languages where the phonemic inventory has voice distinction. This means that voiced stops/fricatives may contain (headed) |L| in order to signify voicing[3] (Backley, 2011). It has also been noted that |L| may be active in assigning low tone to some tone bearing units (Backley, 2011).

1.3.3 Rhotics in Element Theory

In Element Theory, glides and liquids (meaning rhotics and laterals) are analyzed similarly. The glides /j/ and /w/ are interpreted with regards to their resonance properties. This means that the phonological content of /j/ and /w/ is |I| and |U| respectively (Backley, 2011). The phonological content of these glides is identical to their vowel counterparts. Element Theory states that vowels are able to form glides in order to fill a non-nuclear position[4] (Backley, 2011). It is expected that the |A| element may find a similar solution to fill non-nuclear positions. This is where Element Theory analyses /r/ and /r/-like segments as having only |A| (Backley, 2011). This vowel-glide pair is much less transparent than /i/-/j/ and /u/-/w/ as are not as much phonetic similarities between the two segments.

Consequently the evidence is based in phonological distribution rather than in phonetic similarities (Backley, 2011). Both diachronically and synchronically /r/ is often reinterpreted as /a/. Such is the case in German where /r/ was reinterpreted as [ɐ]. The /r/ has been fossilized in modern German spelling as <r> (Kohler, 1990).

(8)

ORTHOGRAPHY	TRANSCRIPTION	TRANSLATION
Pferd	[pfeːɐt]	*'Horse'*
Vier	[fiːɐ]	*'Four'*
Wir	[ʋiɐ]	*'We'*

(Backley, 2011)

Another piece of evidence comes again from British English, where in normal paced conversation so-called "linking elements" may be inserted in between words to facilitate speech (Backley, 2011). In the data for these linking elements a three-way contrast that aligns with the vowel elements of

[3]It is not the case that all languages have transparent voice distinction (English for example). It is then not as simple as assigning |L| to voiced segments and |H| to voiceless segments. Voicing is a complex concept in Element Theory and for a proper analysis of voicing I refer the reader to Backley (2011) and Honeybone (2005).

[4]As stated in 1.1.3, some languages do allow /r/ in a nuclear position.

ET becomes apparent. [r] is only inserted as linking element if the preceding vowel contains |A| in its representation.

(9)

	Linking /I/	*Linking /U/*	*Linking /A/*
Preceding vowel	{iː, ɪ, eɪ, aɪ, ɔɪ}	{uː, ʊ, əʊ, aʊ}	{ɛː, ɑː, ɔː, ə, ɪə, eə, ʊə}
Resulting glide	[j]	[w]	[ɹ]
Example (Backley, 2011)	*fly* [j]*away*	*go* [w]*away*	*far* [ɹ]*away*

Backley (2011) notes however that the |A| glide formation is cross-linguistically less common than the |I| and |U| equivalents. It is also the case that the phonological evidence for /r/ being just |A| is sparse. It has been observed that rhotics occur most often adjacent to nuclear positions. If this observation is taken into account and if an Element Theory analysis of /r/ is assumed (namely, rhotics are |A|), the prediction surfaces that /r/ affects adjacent vowels systematically. More specifically, vowels adjacent to /r/ are expected to lower in spectral quality (towards |A| in a vowel trapezium).

This thesis tests whether this prediction is borne out cross-linguistically under the assumption that Element Theory has correctly analyzed /r/. Section 2 contains an analysis of multiple languages which display interesting behaviour with regards to their rhotics and vowels. These behaviours will be analyzed using an Element Theory approach. In section 3 the success of analyzing rhotics using Element Theory will be evaluated and any remaining issues will be discussed.

2 Data

This section contains an analysis of various cross-linguistic phenomena that seem to be relevant to the lowering-hypothesis presented in Section 1. The phenomena are analyzed based on data from reference grammars where possible or from own observation (in the case of Dutch).

2.1 Synchronic Phenomena

2.1.1 Berber

Berber (AFRO-ASIATIC) is a cover term for the (related) languages spoken in certain areas of Morocco and Algeria (Chtatou, 1982, Kossmann, 2016).[5] Berber has three distinct instances of rhotics: r, rr and ř (interpreted as [ɾ], [rː] and [r] respectively) (Kossmann, 2016). Furthermore Berber has a classic vowel system comprising of {/i/, /a/, /u/}, but other vowels are also attested in modern day speech namely {[e], [ɑ], [o], /ɑ̣/, /o̞/}[6] (Chtatou, 1982).

Diachronically, a similar vocalization to the one which German exhibits is also observed in Berber. The segments /rr/ and /r/ affect a preceding vowel and become vocalized. The interaction is exemplified in (10).

(10)

∗ur	[oă]
∗ir	[eă]
∗ar, ər	[a]
∗urr	[oăɾ]
∗irr	[eăɾ]
∗ar, ərr	[aɾ]

(Kossmann, 2016)

Chtatou (1982) goes as far to say that all non-classic vowels are derived from Vr constructions in some varieties of Berber. According to Chtatou (1982) this is evidenced by suffixes that create clashing nuclei (two vowels next to each other). As a result of these clashing nuclei a linking element is inserted. For some words this linking element is *'y'* [j] and for other words this is *'r'* [r]. The alterations are demonstrated in (11) and (12).

(11)

SINGULAR NOUN	ADDED SUFFIX	SURFACE FORM	GLOSS
ðini	ðini+a	ðiniya	*"these dates"*
ðara	ðara+a	ðaraya	*"this water spring"*
furu	furu+a	furuya	*"this string"*

(Chtatou, 1982)

(12)

SINGULAR NOUN	ADDED SUFFIX	SURFACE FORM	GLOSS
aʃbe	aʃbe+a	aʃbira	*"this robe"*
mɑ	mɑ+a	mara	*"this beard"*
ayo	ayo+a	ayura	*"this moon"*
ifiɣɑ̣	ifiɣɑ̣+a	ifiɣaṛa	*"this snake"*
aḥbo̞	aḥbo̞+a	aḥbuṛa	*"this hole in the ground"*

(Chtatou, 1982)

[5] For the purposes of this thesis it will be assumed that most varieties of Berber have the same underlying phonology. Any possibly relevant distinctions will be discussed.

[6] The segments /ɑ̣/ and /o̞/ are pronouced [æ̞ˤ] and [ɔ̞ˤ] respectively.

It would be very costly for an analysis to argue for a different linking element in on the one hand the data in (11) and on the other hand the data in (12) because of the discrepancies between preceding vowels. It is however the case, according to Chtatou, 1982, that /r/ is part of the underlying form for the data in (12). The immediate implication is that /r/ in these data is not actually a linking element, but is required to remain in the surface form to avoid a vowel clash. Under this analysis it no longer becomes necessary to account for both /r/ and /y/ as linking elements.

However, under this assumption that /r/ is part of the underlying form, it now becomes necessary to somehow derive the vowels {[e], [ɑ], [o], /ɑ̣/, /o̞/} from an underlying form containing /r/. Chtatou (1982) makes an attempt at such a derivation in an SPE-like fashion. The derivation for the forms [aʃbe], [ayo] and [mɑ] is exemplified in (13).

(13)

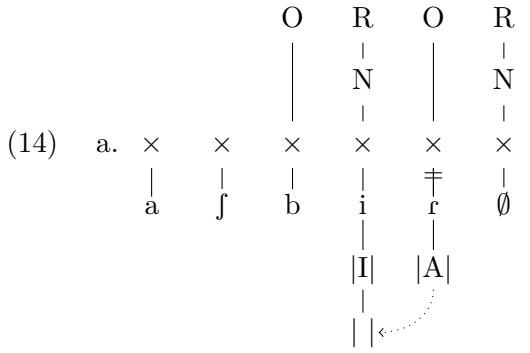
Underlying form	/aʃbir/	/ayur/	/mar/
Vowel lengthening	aʃbiːr	ayuːr	maːr
Vowel pharyngealization	–	–	–
R-deletion	aʃbiːr	ayuː	maːˈ
Surface form	aʃbe	ayo	mɑ
(Chtatou, 1982)			

This analysis encounters some problems however. Firstly, there is no phonological evidence that lengthening occurs in these forms. Secondly it is not transparent why it is the case that the vowels in these data change under the influence of rhotics. Chtatou (1982) states that elongated vowels are lowered before any consonant in a final position. If this were the case the derivation of (13) would still be incorrect and vowel quality should already be lowered before R-deletion takes place. Finally, if lowering happens before any final consonant, then it is incorrect to postulate {[e], [ɑ], [o], /ɑ̣/, /o̞/} as derivatives of Vr sequences. To further illustrate that vowels are indeed lowered before word-final consonants, Chtatou (1982) provides the following data.

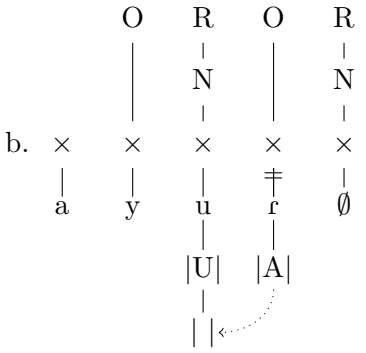
A more transparent explanation is achieved by employing Element Theory. If /r/ only contains |A|, the only step to obtain the surface forms in (13) is to construe that /r/ spreads its |A| element to the preceding vowel and is promptly delinked from the phonological structure. In the cases where there is additional morphological structure (such as [aʃbira]), /r/ needs to remain in the surface form to prevent a vowel clash and consequently does not spread |A|. The autosegmental derivations for [aʃbe] and [ayo] are exemplified in (14). in (14a) the phonological content of |I, A| yield [e] on the surface. Similarly |U, A| yields [o] in (14b). This approach is simpler compared to the SPE-type approach and is also more transparent. It follows directly that these lowered vowels are derived from Vr sequences if it is the case that /r/ contains the |A| element.[7]

[7]Syllabification is done in accordance to the analysis proposed by Harris and Gussmann (2002) unless there is reason to assume otherwise. For example, Germanic languages are assumed to allow word-final codas rather than word-final onsets.

(14) a.



b.



The diachronic changes presented in (10) can be analyzed in a similar manner. In all cases where there was originally a tap it seems that /r/ is reinterpreted as a vowel (/r/ becomes /a/) which, in Element Theory, does not require any change in the phonological content of this sound. In the cases with a historical trill, the |A| element is weakened to |A|, yielding a tap. Additionally, the |A| element is spread to the preceding vowel, lowering its spectral quality.

2.1.2 Swedish and Norwegian

Swedish and Norwegian (INDO-EUROPEAN) are both north-Germanic languages spoken in respectively Sweden and Norway. Germanic languages are known for their complex vowel systems and these two languages are no exception. Both languages also have a rhotic in their phonological inventories (Riad, 2014, Kristoffersen, 2000). The two languages are discussed together in this thesis, because they appear to have a very similar process in which vowels are affected by /r/ in a coda position. This is a process whereby vowel quality is lowered slightly if and only if the vowel occurs before an /r/ in a coda position. This process concerns the vowels [e] and [ø] which respectively become [æ] and [œ] before /r/ (Riad, 2014, Kristoffersen, 2000). The data for Swedish is presented in (15a) and for Norwegian in (15b).

(15) a.

ORTHOGRAPHY	UNDERLYING FORM	SURFACE FORM	TRANSLATION
'ära'	/erɑ/	[æːra]	*"honour"*
'öra'	/ørɑ/	[œːra]	*"ear"*
'bär'	/ber/	[bæːr]	*"carry.*PRES*"*
'för'	/før/	[fœːr]	*"lead.*PRES*"*

(Riad, 2014)

b.

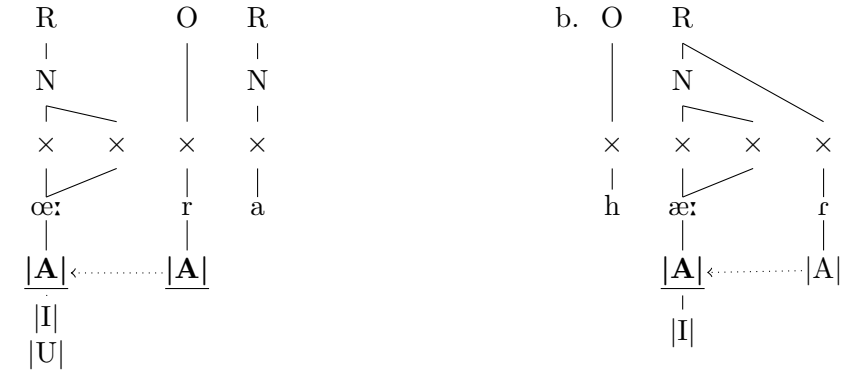
ORTHOGRAPHY	UNDERLYING FORM	SURFACE FORM	TRANSLATION
'hær'	/heːɾ/	[hæːɾ]	*"army"*
'mær'	/meɾ/	[mæɾ]	*"maiden"*
'stjele'	/stjeːɽə/	[stjæːɽə]	*"to steal"*
'hæl'	/heːɽ/	[hæːɽ]	*"heel"*
'humør'	/hymøːr/	[hymœːr]	*"humor"*

(Kristoffersen, 2000)

Both Riad (2014) for Swedish and Kristoffersen (2000) do not give a satisfactory explanation that encompasses these data. Kristoffersen (2000) goes as far as to say that all instances of [æ] on the surface must be analyzed as having /æ/ underlyingly in order to account for these data in a satisfying manner. However, given the knowledge that /r/ contains |A|, these data become much

easier to interpret. An Element Theory solution to account for this data would be as follows: |A| spreads to the preceding [e] or [ø] (which have (|A|, |I|) and (|A|, |I|, |U|) respectively). Resulting in a |A| in the surface form. The result of having headed |A| rather than just |A| is a realization that is phonetically closer to [a]. In this case this is [æ] and [œ]. An autosegmental representation for Swedish /ørɑ/ and Norwegian /heːɾ/ is given in (16).

(16) a. b.



It is not the case however that these vowels only lower before rhotics. It has also been attested that vowels may lower before retroflex sounds (Riad, 2014, Kristoffersen, 2000). This may seem to be a counterpoint to the argument that rhotics have |A|, but this is not the case. It has been attested in Element Theory that retroflexes also have |A| (Backley, 2011). Additionally, many of the underlying forms of the words where vowels are lowered before retroflexes contain /r/. Given this information, it is possible to account for these data within the Element Theory analysis. In the derivation, /r/ spreads its |A| element to the adjacent coronal which becomes retroflex and also spreads its resonance element to the preceding vowel, lowering its quality.

(17) a.

ORTHOGRAPHY	UNDERLYING FORM	SURFACE FORM	TRANSLATION
'smärta'	/smɛrᵚt-ɑ/	[smæt̚ːa]	*"pain"*
'pärla'	/pɛrl-a/	[pæːl̪a]	*"pearl"*
'hörde'	/hør-de/	[hœːɖɛ]	*"hear.*PST *"*
'värna'	/vɛrn-ɑ/	[væːɳa]	*"protect"*

(Riad, 2014)

b.

ORTHOGRAPHY	UNDERLYING FORM	SURFACE FORM	TRANSLATION
'vert'	/vert/	[væːt̚]	*"host"*
'herse'	/herʂʂə/	[hæʂ̺ʂə]	*"to bully"*
'tørt'	/tør-t/	[tœt̚]	*"dry"*
'kjørsl'	/çør-sl/	[çœʂ̺l̪]	*"driver"*

(Kristoffersen, 2000)

What further illustrates that both /r/ and retroflexes contain |A| is that in these languages, /r/ may be a source of retroflex spreading (Riad, 2014). This is a process by which adjacent coronals become retroflex if the cluster is preceded by a source of retroflexion. In Swedish, this source may be either /r/ or /ʂ/. If the source is /ʂ/, the spreading may also be regressive rather than only progressive.

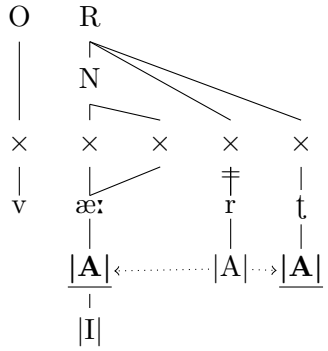
(18)

ORTHOGRAPHY	UNDERLYING FORM	SURFACE FORM	TRANSLATION
'kortnäst'	/kɔrt+nɛst/	[kɔʈːɳɛːst]	*"shortnosed"*
'horststrand'	/hɔrst+strɑnd/	[hɔʂːtʂtranːd]	*"horst beach"*
'lunch'	/lʉnʂ/	[lɔɳːʂ]	*"lunch"*

(Riad, 2014)

Both the data in (17) and the data in (18) can be explained by means of the analysis briefly discussed earlier. The rhotic spreads its |A| element to both the retroflex and the preceding vowel and is promptly delinked in the case of the data in (18). In the spreading data from (18), the rhotic spreads its |A| element to the adjacent coronal, which in turn spreads the |A| element further and so on until a blockade (such as a vowel) is encountered. In all cases observed, /r/ is delinked from the structure after it has spread its resonance element. The derivation is illustrated with the underlying form /vert/ in (19).

(19)



2.1.3 Dutch

Dutch has appeared earlier in this thesis to demonstrate the immense phonetic variation a rhotic may be subject to. Aside from a large amount of phonetic variation, Dutch vowels also interact interestingly with the rhotic. Sebregts (2015) mentions that in Dutch some vowels are altered in quality under the influence of /r/. More specifically, the presence of a rhotic or a lateral (like [ɬ] affects the vowels /e, ø, o/ such that they supposedly become [ɪ, ʏ, ɔ] in the surface forms (Botma, Sebregts and Smakman, 2012). This r-coloring effect is exemplified in (20).

(20)

ORTHOGRAPHY	UNDERLYING	SURFACE	TRANSLATION
'veel'	/vel/	[vɪɬ]	*'many'*
'beer'	/ber/	[bɪːɹ]	*'bear'*
'kleur'	/klør/	[klʏːɹ]	*'color'*
'geul'	/gøl/	[gʏɬ]	*'ditch'*
'stoor'	/stor/	[stɔːɹ]	*'disturb.1SG'*
'pool'	/pol/	[pɔɬ]	*'pole'*
'wierp'	/ʋirp/	[ʋiɹp]	*'threw'*
'pier'	/piːr/	[piːɹ]	*'pier'*

This may seem like a clear counterexamples to the lowering hypothesis that is the subject of this thesis, but, as Botma et al. (2012) note the vowels [ɪ, ʏ, ɔ] are phonetically not higher in quality than /e, ø, o/. The former vowels are just more back. The distinction between the former group

and the latter group has been identified as a distinction of laxness versus tenseness (Botma et al., 2012). Botma et al. (2012) have shown that in the cases of vowels occuring pre-/l/, the phenomenon is not phonological but rather phonetic. /l/ Exerts a retracting effect on both lax vowels and tense vowels.

The case for /r/ remains unsolved as this interactions appears to be more deeply rooted in the internal phonology of Dutch. First of all the phonetic realization does not seem to matter for the occurrence of r-coloring. Second of all, the syllabic position of the rhotic has no influence over whether this effect occurs or not. A multisyllabic word like [kʏːrɪχ] *'neat'* still seems to be subject to r-coloring despite the rhotic possibly no longer being in a coda position. As is visible in (20) and in (3), vowels are sometimes also realized as long as a result being in a preceding position to /r/. This is the case for both tense and lax vowels.

Ultimately there are some interesting observations to be taken from the data from Dutch. The pre-r-lengthening that takes place in some of these forms seems to always be present when the elongated vowel is a lowered one. If the vowel that precedes /r/ is not one of the vowels /e, ø, o/ (/i/ for example), the lengthening does not occur in every form. Pre-r-lengthening has been briefly described in Gussenhoven (1993) who ultimately decided that the pre-r-lengthening rule is lexical because the rule does not seem to interact with either stress patterns or feet structure in Dutch.

Because of the very close phonetic characteristics of underlying /e, ø, o/ and surface [ɪ, ʏ, ɔ], there is no longer reason to assume this process is some sort of lowering process under the influence of /r/. Rather, this interaction may be closely related to the distinction between tense and lax vowels in Dutch.[8] Which is a distinction that seems to be heavily influenced by suprasegmental domains such as the syllable and the foot (Botma et al., 2012). Because the case of the Dutch tense/lax distinction is a complex issue that strays relatively far from the aim of this thesis, the issue is left open.

A less opaque interaction with regards to r-coloring is visible in the The Hague dialect of Dutch. The dialect of The Hague is known for having monophotongized almost all of the Dutch diphthongs in addition to having a very distinct [ɑ] in some places where in standard Dutch [ə] is expected (Goeman, 1999). The distribution of this last phenomenon seems to be very relevant for this thesis. Namely, it seems to be the case that an [ɑ] on the surface is a result of /ər/ sequences. Additionally, the rhotic in other Vr may realized as an ɑ on its own.[9]

(21)

ORTHOGRAPHY	UNDERLYING	SURFACE	TRANSLATION
'lekker'	/lɛkəɹ/	[lɛkɑ]	*'pleasant'*
'fokker'	/fɔkəɹ/	[fɔkɑ]	*'breeder'*
'domper'	/dɔmpəɹ/	[dɔmpɑ]	*'pity'*
'kanker'	/kɑŋkəɹ/	[kɑŋkɑ]	*'cancer'*
'goor'	/χɔɹ/	[χɔɑ]	*'nasty'*
'alweer;	/ɑɬʋeɹ/	[ɑɬʋeɑ]	*'again'*
'bier'	/biːɹ/	[biːɑ]	*'beer'*

There are two observations that can be made after examining these data. Firstly, if the rhotic

[8]The tense/lax distinction is a distributional phenomenon in which tense vowels (usually more central than their lax counterparts) are prohibited from occurring in closed syllables. However the issue appears far more complex than merely a syllabic constraint and for the details of this distinction I refer the reader to Botma et al. (2012) and Gussenhoven (2009).

[9]Because of the limited research on the phonology of the dialect of The Hague, Standard Dutch will be assumed as the underlying form for the dialect of The Hague.

follows a schwa, this schwa is surfaced as the back vowel [ɑ]. Secondly, if the rhotic follows any other vowel, remains unaltered and instead the rhotic is surfaced as [ɑ].

In Element Theory this phenomenon is relatively straightforward to account for. A rhotic tries to spread its |A| element to a preceding vowel. A schwa in ET has no phonological content, therefore the rhotic is able to spread its element to the empty "slot" of the schwa. With any other vowel it is not the case that there is an obvious empty slot. In these cases the rhotic is unable to successfully spread and is realized as [ɑ] itself.

All of the interactions visible in (21) are word-final. It is not the case that this spreading phenomenon is unique to a word-final position. It need not be the case that the rhotic is the last segment in the word. This is attested by pluralizing nouns which in singular have Vr word-finally. It is also the case that in slow speech the rhotic (which is [χ] in this dialect) may not be deleted if it is not the last segment in the word.

(22) 'koffers' /kofərs/ [kɔfɑs] [kɔfɑχs] 'suitcases'

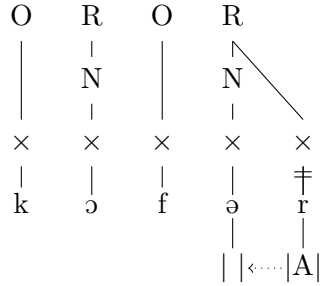
This does not entail the phenomenon is further unrestricted. This interaction does not seem to occur if the rhotic occurs in any position that is not in the ultimate syllable of the word. In these positions the rhotic is merely deleted on the surface without spreading to a neighbouring vowel. Even when the neighbouring vowel is a schwa it remains unaffected. This is demonstrated in (23).[10]

(23) 'verdrag' /vərdrɑχ/ [fədʁɑχ](*fɑdʁɑχ) 'treaty'
'verlaten' /vərlatə/ [fəlatə](*fɑlatə) 'to leave'

There are two observations that can help with understanding the distribution of this phenomenon. Firstly, both word-initial and word-final syllables containing schwa are rarely stressed. Word-final syllables containing schwa have even been analyzed as potentially being extrametrical in the Dutch stress-system (Kager & Zonneveld, 2002). Secondly, processes whereby contrast between segments is lost such as lenition (in this case either complete assimilation of /r/ and [ə] or /r/ becoming more similar to a vowel), tend to occur in weaker positions in syllabic structures. Word-final positions are regarded as generally fairly weak in contrast with word-initial positions (Botma and van 't Veer, 2014, Backley, 2011).

With these two observations in mind it becomes less difficult to account for the distribution of this phenomena. Word-inital syllables containing schwa are simply not weak enough to facilitate r-coloring in the dialect of the Hague. On the other hand word-final positions are weak enough and therefore are able to facilitate r-coloring. An example derivation of the word 'koffer' is given in (24).

(24)



[10]These words may seem multimorphemic, but note that the the seeming prefix 'ver' in Dutch is highly lexicalized. In any case the words in (23) are monolexemic.

2.1.4 Alyawarra

Alyawarra (PAMA-NYUNGAN) is a language spoken in central Australia which has two rhotics; /rr/ (realized as a trill or flap) and /r/ (realized as approximant) (Colin, 1977). There is an interesting phenomena present in this language that needs to be addressed. In Alyawarra, an /a/ is raised to [ɛ] before /rr/, but not before /r/. The raising only occurs between a palatal consonant and /rr/ or before /rr/ + /iy/. This seems like an interesting interaction, because in light of element theory it is unexpected that a vowel may raise in the neighbourhood of a rhotic. The process is demonstrated in (25).[11]

(25)

ORTHOGRAPHY	TRANSCRIPTION	TRANSLATION
ayarra	[ayɛra]	*'ant'*
iyltjarrima	[ijltjɛrima]	*'rest'*
anarriya	[anɛrija]	*'daughtes husband's sister'*

(Colin, 1977)

The vowel [ɛ] in the surface forms contains both |A| and |I| as its resonance elements. Therefore under an analysis utilizing Element Theory the vowel must have received an |I| element from elsewhere in the word. The neighbouring rhotic merely contains |A|. For this reason it is unlikely that /rr/ is the source of spreading some sort of |I| resonance to the vowel in question. What is visible in these data is that in all three cases, there is some classical |I| bearing consonant in the neighbourhood of the vowel, namely /y/ or /j/. I propose that it is more likely that these segments are the cause of vowel-raising in Alyawarra. It is correct that not all of these segments are situated in the adjacency of the vowel /a/, but this is not a requirement for processes like this one (which is very similar to that of vowel harmony showcased in (6).

This hypothesis is supported by a few examples where it is not the case that /y/ or /j/ is present in the same word as the /a/ + /rr/ structure and according to Colin (1977) raising does not occur here.

(26)

ORTHOGRAPHY	TRANSCRIPTION	TRANSLATION
arrangikinha	[araŋgikinha]	*'emu.POS'*
arranthinikanima	[aranthinikanima]	*'wild plum.dat'*

(Colin, 1977)

According to Colin (1977) this process is only active for the apical rhotic /rr/ and not for the approximant /r/. This may be explained by the slightly different phonological content by these two rhotics. This behaviour could be an argument for postulating the Alyawarra approximant as having headed |A̲| and the apical trill as having non-headed |A|. Postulating the segments as such implies that headed |A̲| is able to block the raising/harmony process when it is situated in the rhyme together with /a/ in the nucleus.

In order for this analysis to work it must be assumed that this process can work both progressively and regressively. This because there is on the one hand the form *ayarra* where /y/ precedes the targeted vowel and on the other and the form *anarriya* where /y/ follows the targeted vowel. Additionally, it is not believed that this type of vowel harmony occurs anywhere else in the language, at the very least it is not described in Colin (1977). This in itself is not a problem, for it is never necessarily the case that vowel harmony processes or the like must be observed in all facets

[11] Due to the dated and limited information about Alyawarra, the transcriptions in these examples are my own.

of speech. However, this type of interaction does raise the question of what the particular phonological/phonetic motivation could be. If this a-raising process is purely motivated by the presence of palatals or vowels that are |I|, then we expect the first [a] in *ayarra* to raise as well. However, this first vowel does not raise and it must thus be concluded that the presence of /r/ is required in order for this interaction to take place. For now, it will be postulated that vowel raising in Alywarra is some sort of disimmilation process increasing phonological contrast between adjacent sounds.

2.2 Diachronous Phenomena

2.2.1 German

As has been exemplified in section 1. German has historically undergone a vocalization of /r/ in certain positions. More specifically, the German rhotic has two allophones: [ʁ] and [ɐ]. The alterations are exemplified in (27).

(27)

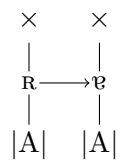
ORTHOGRAPHY	TRANSCRIPTION	TRANSLATION
Pferd	[pfeːɐt]	*'Horse'*
Vier	[fiːɐ]	*'Four'*
Wir	[ʋiɐ]	*'We'*
Brief	[bʁiːf]	*'Letter'*
Rad	[ʁaːt]	*'Letter'*
Fragen	[fʁaɡən]	*'to ask'*
Keller	[kɛlɐ]	*'Cellar'*
Kerl	[kɛʁl]	*'Fellow'*
Herr	[hɛʁ] or [hɛɐ]	*'Sir'*
Büro	[byʁo]	*'Desk'*

(Hall, 1993)

What becomes apparent from these data is that the German rhotic has remained uvular and consonantal in onset position, but has vocalized in a coda position. One possible explanation for this alteration involves the distinction between weak and strong syllable positions. Onsets (especially word-initially) are stronger than codas (Botma and van 't Veer, 2014, Backley (2011)). Additionally, codas are dominated by the same syllabic unit as nuclei (the rhyme). These two observations lead to the respective implications that onsets are less prone to change than codas and codas may interact more with nuclei than nuclei with onsets. These implications are reflected in the German data in (27). Rhotics in onset positions remain strong and consonantal while rhotics in coda positions are weaker and share syllabic structure with the nuclei, thus take on vowel-like qualities. What is particularly appealing about this analysis is that it is independent of the phonological content of preceding or following segments. After all, rhotics are supposed to have only the |A| resonance element. This analysis proposes that this diachronic change is just a reinterpretation of a phoneme in a coda position independent of its segmental neighbourhood.

The form that deviates from this analysis is [kɛʁl] (*'Fellow'*). It seems that ʁ is in a coda position but has not undergone vocalization. It is however the case that the following consonant [l] is notorious for being syllabic in certain environments in German (Hall, 1993). Because of the syllabic consonant following the rhotic, the position in the syllabic structure is obscured. It could be the case that ʁ in this word is actually an onset.

(28)



In conclusion, it would seem that German has two allophones for its rhotic phoneme. One of which vocalizes in coda-position. Because it is the case that the coda rhotic becomes phonetically more like its adjacent vowel, which shares syllabic structure with the coda rhotic, this process may be analyzed as a loss of contrast. In terms of elements, this means that the difference between a rhotic in an onset and a rhotic in a coda may be accounted for by proposing that the onset rhotic has the element |A̲| and this was weakened to just |A| in a coda position over time.

2.2.2 Armenian

the Agn dialect of Armenian (INDO-EUROPEAN) is especially interesting with regards to its rhotics as it has a three-way contrast within this class (namely {χ, ʁ, r}) (Vaux, 1998). Vaux (1998) notes that the vowels /i/ and /u/ in classical Armenian are lowered to respectively [ɛ] and [o] before any of the sounds in the class of rhotics in modern Agn Armenian.

(29)

CLASSICAL	AGN	TRANSLATION
ʃɑɾ̊viχ	ʃɑɾ̊vɛχ	*'Sprig'*
giʃiɾ̊kʰ	giʃɛɾ̊kʰ	*'Weight'*
gʰluχ	gʰəloχ	*'Head'*
gɑguʁ	gɑgoʁ	*'Soft'*
dʰuɾ̊n	dʰoɾ̊	*'Door'*

(Vaux, 1998)

These data seem to be very transparent in light of Element Theory and the analyses proposed for some other languages in this thesis. Namely, all of the sounds in the class of rhotics in Armenian possess the |A| element, which in turn spreads to the preceding vowel, lowering its quality.

However there are some apparent counterexamples that need to be discussed. These are presented in (30).

(30)

CLASSICAL	AGN	TRANSLATION
sirt	saɾ̊t	*'Heart'*
mɑrd	moɾ̊d	*'Man'*
gorts	gʲuɾ̊ts	*'Handiwork'*
ordn	yɾ̊nə	*'Worm'*
bɑrdz	bøɾ̊dz	*'Pillow'*
ɑrdʒ	oɾ̊dʒ	*'Bear'*

(Vaux, 1998)

In these data, the opposite of the initial expectation occurs. Namely, the vowels [e] [o] and [ɑ] raise in the neighbourhood of [r]. It is extremely unlikely that [r] is somehow exceptional in that it has historically caused vowels lower ([i] and [u]), but also to raise ([e], [o] and [ɑ]). Such an explanation would be clearly ad-hoc given the observation that [r] spreads its element to the preceding vowel.

However, there is a systematic observation to be made from these data. A vowel only raises before a /r/ in classical Armenian, but does not raise before a historical /ṙ/ in classical Armenian. Vaux (1998) notes that the difference between these two phones is grounded in the place of articulation. The former is articulated more on the alveolum and the latter more retroflex. Aside from this, classical Armenian /r/ is not the only phone that has diachronically caused vowels to lower on the surface forms of modern Agn. Vowel raising has also occurred under the influence of a number of other coronal phonemes. These data are presented in (31).

(31)

CLASSICAL	AGN	TRANSLATION
mɑz	mɔz	*'Heart'*
ʃɑt	ʃɔt	*'Very'*
tsits	tsaijts	*'Breast'*
mets	mits	*'Big'*

(Vaux, 1998)

These two observations can lead to the suggestion that /r/ is not the historical source for the raising of vowels, but rather any coronal in a post-vocalic position. Since /ṙ/ is retroflex according to Vaux, 1998, it makes sense that this phone does not trigger vowel raising. Additonally, /ṙ/can trigger vowel lowering and appears on the surface in modern Agn. From this it is possible to establish some chronology in the sound changes from classical Armenian to modern Agn. Namely, vowel raising before coronals has occurred before /r/ changed into /ṙ/, thus preventing the latter phone from lowering a preceding vowel. The only form in (30) that counteracts this analysis is *'sirt'* which changes into *saṙt*. It is possible that, because the classical Armenian form has an /i/ the raising before any coronal could not occur (/i/ is already as high as can be in the vocal tract). Since /i/ is not raised, it was able to be lowered into /ɑ/ in modern Agn under the influence of /ṙ/.

2.3 Loanword adaptations

2.3.1 Japanese

Japanese (JAPONIC) is a widely spoken language that is known for a number of things. Firstly for the vast amount of loanwords in its lexicon and secondly for its relatively rigid syllable structure (Crawford, 2009, Kubozono, 2015). One of the main donor languages of loanwords in Japanese is American English (Ichikawa, 1998). Given these observations the adaptation of loanwords in the Japanese language becomes a unique point of interest regarding the status of rhotics. Japanese does have a rhotic /ɾ/, but it is prohibited from occurring in a coda. This is contrast with American English which also has a rhotic /ɹ/ that is not restricted from occurring in a coda. Furthermore American English has the lateral /l/ in its phonemic inventory. Japanese by contrast does not have a contrast between liquids. It is also known that loanword adaptations rely not only on perception, but also account for both the phonology of the donor language and the patient language (Smith, 2004). For these reasons the adaptation of English words containing /ɹ/ becomes a phenomenon that could lead to further insights with regards to the status and phonological content of rhotics.

When adapting English words containing /l/ or /ɹ/ there are differences between onsets and codas. An /ɹ/ in an onset is analyzed as /ɾ/ in Japanese, if the rhotic appears in a coda position it is absent from the surface structure of the Japanese adaptation. An /l/ is analyzed as /ɾ/ in an onset, but as /ɾɯ/ in a coda. These pieces of information are especially interesting given that Japanese natively does not distuingish between /r/ and /l/. The data are showcased in (32)

(32)

ENGLISH	UNDERLYING	LATIN ORTHOGRAPHY	SURFACE
department store	/dəpɑɹtˀmənt/	depātō	[depaːtoː]
cheer girl	/chɪɹ + gəɹl/	chia gāru	[tɕia + gaːɾɯ]
service	/səɹvɪs/	sābisu	[saːbisɯ]
elevator	/ɛləve͡itəɹ/	erebētā	[eɾebeːtaː]
guard	/gɑɹd/	gādo	[gaːdo]
morning call	/mɔɹmɪŋ + cɒɬ/	mōningu kōru	[moːniŋgɯ + koːɾɯ]
orgy	/ɔɹdʒ͡i/	ōji	[oːd͡ʑi]

(Ichikawa, 1998)

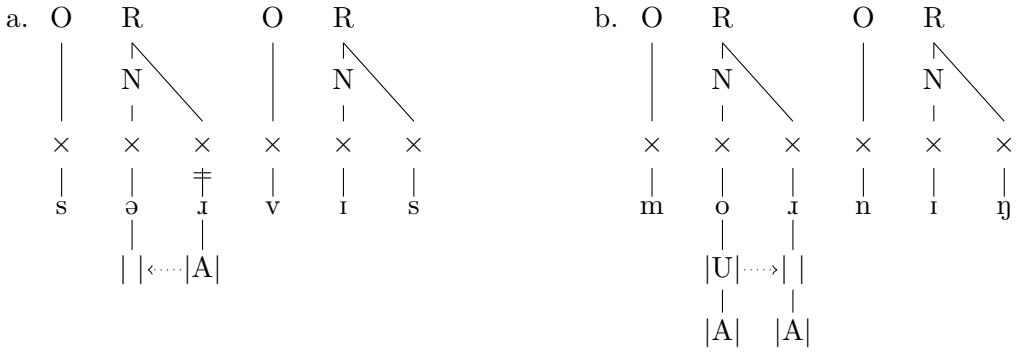
Both the adaptation from /ɹ/ to ∅ and /l/ to /ɾɯ/ seem to stem partly from the constraint that restricts codas from containing anything other than nasals (Kubozono, 2015), thus rendering either of these sounds illegal in that position. The way this problem is dealt with differs in both these sounds. In the case of /l/ an unrounded back vowel is appended to conform to the standard Japanese syllable structure, breaking up an illegal CVC syllable into CV or (CV)(CV). On the other hand an /r/ in a coda is simply deleted from the structure, resulting in a CV or CVV syllable. This discrepancy is possibly is caused by the different phonological content of /ɹ/ and /l/.

Backley (2011) mentions the difference between /ɹ/ and /l/ in terms of elements. Based on numerous phonetic and phonological observations it has been suggested that /l/ is a complex segment consisting of two resonance elements. The elemental make-up of /l/ can be either |A, I| or |A, U|. These different interpretation may be reflected respectively in a language that has both [l] and [ɬ]. By contrast, as has been noted numerous times in this thesis, rhotic segments only contain |A| in their elemental make-up. Given these suggestions it becomes possible to account for the behaviour of /ɹ/ in Japanese loanword phonology.

The behaviour of the adaptation of rhotics goes slightly further than just deletion of /ɹ/. It becomes clear from the data in (32) that the previous vowel is also elongated. This behaviour is consistent except when the previous vowel is /i/ or [ɪ]. The elongation is visible in forms such as 'gādo' but not in 'chia gāru'. In this last form it is also not the case that the rhotic is deleted, merely re-analyzed as [a]. By adopting a slightly altered version of the spreading analysis that is employed elsewhere in this thesis as well, it is possible to account for these data.

In the case of Japanese it seems that it is not the rhotic that spreads its |A| element to the preceding vowel in all cases, but rather the vowel spreading its elements to the empty positions of the rhotic. The result of this is a elongated vowel. For example, if the preceding vowel is /o/ (consisting of |U, A|) the |U| element is spread to the rhotic resulting in phonological content that can be reinterpreted as /o/. On the surface form this is realized as a long vowel. However this process is unable to occur if the preceding vowel is /i/ or /ə/ underlyingly. In the former case because there is no way in which spreading the |I| element can result in a long version of /i/ and in the latter case because /ə/ has no elements that are able to spread. These two environments are dealt with differently. If the preceding vowel is /i/, there is no spreading and the rhotic is forced to surface as a vowel ([a]) in order to avoid illegal syllable structure. If the preceding vowel is /ə/, the rhotic spreads its element to the empty element slot of schwa and the rhotic is then deleted. Example derivations of the words 'service' and 'morning' are given in (33).

(33)



The processes described in this section are different methods of achieving the same goal: preserving native syllabic structure. But more importantly, they are processes that seem to be made possible (and restrained) by the elemental make-up of the rhotic being |A|.

There are however some counterexamples that need to be discussed. First of all, English is not the only donor language of loanwords in Japanese. There are some words from languages such as French, German and Dutch (Crawford, 2009). Some of these loanwords seem to oppose the analysis employed earlier in this section. One such word is from French.

(34) concours /kõkuːʁ/ konkūru [konkɯɾɯ] 'competition'

In this case the word-final rhotic is not deleted, but is adapted in similar fashion to English /l/. One possible explanation could be that French is considered a language which has word-final onsets (Harris & Gussmann, 2002). Therefore this rhotic would be treated as if it were situated in an onset. However, there are some words loaned from Dutch and German which show similar behaviour despite being non-word-final-onset languages. Some data is presented in (34), here the first word is from Dutch and the other two words are loaned from German.

(35)	bier	/biːr/	biru	[biɾɯ](*bia/*biː)	'beer'
	arbeit	/ɑːb͡eit/	arubeto	[aɾɯbeto](*aːbeto)	'work'
	hormon	/hoʁmoːn/	horumon	[horɯmon](*hoːmon/*hoamon)	'hormone'

These forms all have rhotics that appear in a coda, but are adapted similarly to /l/ in English. Given the assumption that all rhotics contain |A| in their phonological content these forms oppose the explanation for the English loanwords presented earlier in this section.

However, internal phonology is not the only factor that determines the surface forms of loanwords in the receiving language. As noted before, perception of speech also plays a vital role in this process (Smith, 2004). The phonetic realizations of at least Dutch and French are different from the approximant realization of /ɹ/ in English. This difference could be the source for the difference in adaptation. However the German rhotic still makes this explanation somewhat undesirable. Recall that the German rhotic is often vocalized in a coda position. On phonetic grounds this observation implies the prediction that this type of rhotic should be treated similarly as the English approximant. However this is not the case and the German /ʁ/ is adapted to /ɾɯ/. It could be the case that these two words were subject to loanword adaptation into Japanese in a time where the rhotics in both Dutch and German were still apical and had not yet vocalized. Since the diachronic timeline of these words is uncertain, the issue of adaptation of rhotics into Japanese from languages that are not English is thus not fully analyzed and partially left open in this thesis.

3 Conclusion

The final section of this thesis will address some of the issues with the phonological account of rhotics in generative frameworks in light of Element Theory. More specifically the success of an element theoretical account of rhotic vowel interactions and the overall phonetic variation of rhotic is evaluated.

3.1 Phonetic variation in Element Theory

This thesis began by examining some of the peculiar properties of rhotic segments in languages of the world. Recall that rhotics display a relatively large amount of phonetic variation both cross-linguistically and language-internally (in the case of Dutch for example). This particular characteristic has been rather troublesome for traditional theories of generative phonology. Rhotics behave like a natural class on the one hand, but display such a phonetic variation that it is very difficult to encapsulate this natural class in articulatory or physiological features like the ones employed in SPE.

Phonetic evidence and observations are the basis for many of the primitives and their relation to phonetic segments in Element Theory (Backley, 2011). For example, the element |A| is supposedly present in pharyngeal segments because it is possible to observe a spectral pattern in these segments that is similar to /a/-like vowels. For rhotics however it is not really the case that the connection to the |A| element is grounded in phonetics. [12] Rather, the connection is supported by phonological observations similar if not identical to the ones presented and analyzed in this thesis. The inability to observe phonetic evidence for this connection is largely in part of the enormous variation. On the assumption that rhotics indeed carry the |A| resonance element, it is possible to generate the rhotic in languages that do not have contrasting rhotic segments. Because of the rather well-supported notion of headedness it also possible to generate the rhotics in languages with two rhotic phonemes (|A̲| and |A|). There are however languages that have more than two rhotic segments (Wiese, 2011). Warlpiri is a language spoken in Australia that presumably has three rhotic segments (/ɾ/, /ɹ and /ɽ/) (Wiese, 2011). In order to account for this three-way contrast under Element Theory it must be assumed that one of these segments contains more elements than just |A|. This can be postulated for /ɽ/ which is analyzed as a flap and thus is potentially a more lateral liquid similar to /l/. Laterals are complex segments and thus the three-way contrast can be accounted for under Element Theory. Languages with more than four rhotics are extremely rare and the status of some of these segments is under discussion (Wiese, 2011), therefore I will not go into them here.

The fact that the basis of Element Theory lies in perception thus gives it a clear advantage over articulatory theories like SPE. SPE is unable to group rhotics as a class without lumping in other unrelated sounds or ending with an ad-hoc denotation. Because ET is based on perceptive "targets" in a language, there is no need to consider every phonetic variant and detail of rhotics, at least not until there are multiple rhotic contrasts in a language. For this reason Element Theory is a theory more suited to dealing with the phonetic variety of rhotics.

[12] Backley (2011) does note that English /ə/ does bear a similar spectral pattern to the rhotic /ɹ/, but this observation is not shared between other rhotic-vowel pairs (such as /χ/ - /a/ for example).

3.2 Positional strength and weakening

It is definitely possible to observe a systematic mechanism in the derivation of r-coloring processes across the different languages discussed in this thesis. Most notably the positional arrangement of r-coloring. In the languages analyzed in this thesis it is never the case that rhotics in an onset can be the cause for any sort of r-coloring to happen. In almost every case the rhotic is situated in at least the coda of a syllable (aside from possible Alyawarra and the North-Germanic languages, to which I will return later). For some languages the process is only active word-finally. Such is seemingly the case in the Dutch dialect of The Hague. Not preferred positions for r-coloring are thus word-initial and onset positions.

The distinction between weak and strong positions has been touched upon in the analysis of numerous languages in this thesis. This distinction has a certain importance in the analysis of r-coloring effects. Namely, the spatial pattern of r-coloring effects aligns with the notion of positional strength in phonology. This notion dictates that onset positions are 'stronger' than coda positions, foot-initial positions are stronger than foot-internal positions and word-final positions are weaker than word-initial positions (Backley, 2011). The immediate prediction that follows from this proposal is that weak positions are more often targeted by weakening processes (i.e. loss of elements or loss of contrast between elements). Conversely, strong positions should be more often targeted by processes that add elements to a structure or strengthen the phonetic properties of a segments (for example, aspiration). This prediction seems to be borne out with regards to r-coloring. In every language that has been of interest in this thesis it is either the case that the rhotic is deleted from the structure (loss of elements) and/or the preceding vowel assimilates to the phonological structure of the rhotic in its adjacency (loss of contrast).

A good example of the former, loss of elemental structure, is visible in German. Recall that German has historically undergone some sort of lenition process whereby a rhotic in a coda position vocalizes to /ɐ/. This in contrast with a rhotic in an onset, which is realized as /ʀ/. It is very likely that that in a weak position like a coda the rhotic was more vulnerable to weakening processes which promptly caused the rhotic to vocalize in that position. In terms of element theory, something about the phonological content of the original rhotic had to be either removed or weakened. In this case it is likely that the original rhotic, which survives in onset positions, was made up of |A̲| and that it was consequently weakened to |A|, resulting in [ɐ] in the surface form.

A suitable example for the latter process, loss of contrast between segments, is visible in the historical changes in Berber. The processes in Berber also serve as a key example that evidences the |A| element's presence in the elemental structure of rhotics. A number of interesting historical vowel changes under the influence of rhotics have occurred in berber. These were presented in (10), which is repeated as (36).

(36)

∗ur	[oă]
∗ir	[eă]
∗ar, ər	[a]
∗urr	[oăɾ]
∗irr	[eăɾ]
∗ar, ərr	[aɾ]

(Kossmann, 2016)

Aside from the fact that the rhotic itself has vocalized, it is also the case that the adjacent vowel is affected by the elemental structure of the rhotic. Through the spreading mechanism that

has been described extensively throughout the analysis of r-coloring, some features of /r/ can be traced in the preceding vowels. For example, an /u/ is lowered to an /o/. This is precisely what the prediction that /r/ contains |A| dictates, as /u/ is a simplex element containing |U| and /o/ is a complex element containing |U|, |A|. The loss of contrast is that vowels become more like /a/ (they contain structure that is similar to /a/ and are lowered in quality) and thus the phonetic contrast between /r/ and the preceding vowel decreases.

Lastly, a language that transparently supports the notion of positional strength playing a role in r-coloring processes is the Dutch dialect of The Hague. Word-finally, /ər/ clusters are reduced to /ɑ. However, word initially vowels are not lowered and rhotics are merely deleted. This thus showcases that supposed strong positions are not targeted by weakening processes to the same extent as supposed weak positions.

3.3 Foot internal weakening

Not every language that has been discussed in this thesis exactly follows the predictions posed by the notion of positional strength and weakening. First of all there is Swedish and Norwegian. The r-coloring process seems to not obey the notion of positional strength in these languages as r-coloring occurs both word-initially and word-finally, some of the examples from (19) are repeated here to showcase this.

(37)	/stjeːɻə/	[stjæːɻə]	*"to steal"*
	/hymøːr/	[hymœːr]	*"humor"*
	(Kristoffersen, 2000)		

Additionally, some words in Swedish seem to undergo r-coloring with the source being a rhotic in an onset position.

(38)	/erɑ/	[æːra]	*"honour"*
	/øɾɑ/	[œːra]	*"ear"*
	(Riad, 2014)		

Given the notion of positional strength, these sort of processes can also be accounted for. In the Swedish and Norwegian data in (37) and (38) respectively the rhotic is in a foot-medial position. That is to say, the rhotic is located in the onset of the second syllable in the foot. The foot-medial position has been previously described as another weak position in the positional hierarchy (Backley, 2011, Harris (2000)). Therefore it is not out of the ordinary that a rhotic in foot-medial position can facilitate lowering of the preceding vowel. A similar interaction has been noted in the case of standard Dutch in section 2.1.3. The difference between the foot-medial interactions and the word-final or coda interactions is that the rhotic is not deleted in the former phenomenon. The reason for this is likely to prevent vowel clash between the nuclei of the two syllables in the foot.

A second language that was examined in this thesis and does not necessarily adhere to the notion of positional strength is Alyawarra. Here, it was observed that vowels undergo some sort of dissimilation/harmony that raises vowels under the influence of a /j/ or /y/ (a glide which is |I|) in the neighbourhood of /r/. This sort of process is certainly unexpected, but it does not serve as a counterexample to the prediction that /r/ is the source of lowering vowels as the source of raising is demonstrably an |I|-glide rather than a rhotic. It is however correct that the phonetic motivation for this type of process is unclear and begs the question as to why this would occur in a language.

For now, it has to be accepted that this process is some sort of dissimilation attempting to increase the contrast between rhotics and their preceding vowels.

Additionally, it is not the case that just because a certain process is more likely to happen in a certain position (in this case prosodically weak positions), the same process cannot occur elsewhere. The prediction is merely that processes occuring in dispreferred positions are less likely. It seems in Alyawarra it is the case that this r-coloring process takes a certain priority that superimposes the positional strength of the position of the rhotic. An analogy could be the more understood phenomenon of aspiration and ejectivity. Aspiration and ejectivity strengthen segments and are thus predicted to be more frequent in strong positions like onsets (Backley, 2011). This prediction seems to be correct as most aspiration and ejectivity is observed in word-initial or onset positions (consider English for example in the case of aspiration) (Backley, 2011). However, this does not mean that these two strengthening processes are not observed anywhere else. Georgian (KARTVELIAN), for example, has ejective segments in surface forms that occur in weak positions as well (Vicenik, 2002).[13]

3.4 Concluding remarks and further studies

It is also the case however that not all r-coloring phenomena discussed in this thesis have a satisfactory explanation within the framework of Element Theory. Most notably the case of standard Dutch where vowels are not lowered or raised, but potentially slightly backed under the influence of /r/. Another complicating factor in standard Dutch is that this happens not only if the rhotic is situated in a coda, but also intervocalically (i.e. as an onset). This process is possibly intertwined with the tense/lax distinction in Dutch vowels that was touched upon briefly. To gain more insight into this phenomenon requires further research.

Furthermore, Japanese loanword adaptation does not seem to be consistent for all rhotics in all languages. This is evident from the fact that a Dutch or German /r/ is treated differently than an English /ɹ/. Loanword adaptation is aside from phonology also strongly based in perception, therefore further research into both of these aspects is required to find the source of the discrepancy in the adaptation of loanwords into Japanese.

In conclusion it can be said that there are many processes which support the hypothesis that rhotic segments contain the |A| resonance element. The prediction that if a rhotic spreads its element to a preceding vowel, the vowel quality should be lowered on the surface seems to be borne out for the most part. Thus far there are no attested cases of a vowel raising under the direct influence of a rhotic. It is however the case that the distribution of these r-coloring effects is systematic and strongly dependant on the positional strength of the position of the rhotic and the preceding vowel in the prosodic structure of the string.

[13] Do note that even in Georgian, ejectives have slightly weaker phonetic values in weak prosodic positions than in strong prosodic positions (Vicenik, 2002).

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A Appendix

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A.1 List of relevant phenomena

Language	Process	Reference
Aramaic	vowels are lowered by rhotics and pharyngeals	Attestation unclear
Armenian	e,o,u,i are affected by r,χ,ʁ	Vaux (1998)
Beijing Mandarin	Numerous phonetic effects called "erhua"	W. S. Lee (2005)
Berber	non-cardinal vowels are the product of Vr-clusters	Chtatou (1982)
British English	some vowels are rhoticized before /ɹ/	Harris (1996)
Dutch (The Hague)	vowels are affected/vocalized by /r/	Sebregts (2015)
German	/r/ has diachronically vocalized to an a-like vowel	Hall (1993)
Japanese	rhotics are deleted in codas of English loanwords	Crawford (2009)
Korean	some rhotics in codas are deleted in loanwords	H. Lee (2013)
Kumiai	i becomes ɛ before /r/	Mielke (2018)
Louisiana Creole French	a becomes ɑ before glides/rhotics	Mielke (2018)
Michigan German	i,u become e,o respectively before /r/	Mielke (2018)
Ngiyambaa	i, u, a become more central before /r/	Mielke (2018)
Norwegian	ɛ,ø become æ, œ respectively before /r/	Kristoffersen (2000)
Swedish	ɛ,ø become æ, œ respectively before /r/	Riad (2014)