Liquid dissimilation with a special regard to Latin

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Abstract

Liquid dissimilation is a process whereby a liquid changes its category from lateral to rhotic or vice versa if another liquid of the same category is found in a nearby syllable within the same word. While many cases of liquid dissimilation seem to occur sporadically throughout the history of the Latin language, allomorphy of the *-ālis*/*-āris* suffix in Latin arose out of systematic dissimilation. A close examination of the corpus of adjectives and deadjectival nouns affected by liquid dissimilation suggests that linear distance between the liquids involved plays a significant role in the process. This paper seeks to study the preponderance of dissimilation in non-words with liquids in a language with a similar liquid system, Modern Greek. Results show that both the distance between liquids as well as the position of the liquid within the syllable structure have an effect on the occurrence of liquid dissimilation as well as on liquid assimilation.

1 Introduction

Liquids are those sounds which combine both consonantal and vocalic aspects in their articulation and acoustics. Languages often subdivide the liquid part of their sound inventory into types, the most common of which are laterals and rhotics. While laterals are defined by their being produced with lateral side channels through which air can flow freely, no defining common articulatory or acoustic feature of rhotics has been agreed on so far (see for instance Schiller 1999 for a discussion).

The fact that liquids have both consonantal and vocalic traits leads to their susceptibility to change toward one or the other domain. Thus, liquids may vocalise to a wide range of vowels and vocoids, depending on the particular phonetic circumstances present at the origin of the development, or else they may lose their vocalic components and become indistinguishable from ordinary fricatives and stops. Vocalisation of liquids occurred for instance in the evolution of Romance when Latin "caldum" ('hot') became French "chaud", whereas consonantisation is seen in the evolution of Latin "ālam" ('wing') which has become "ava" or "aga" in some Auvernhat Occitan dialects (Müller 2011: ch. 2). Sometimes, however, they maintain their distributional properties within the syllable structure, such as when an alveolar tap – a rhotic – develops into a uvular fricative and is thus more consonant-like, but continues to occur as a second element in syllable-initial consonant clusters, for instance in the French or German complex onset /gʁ/ as in French "gris" or German "grau" (both meaning 'grey').

Not only do liquids evolve into non-liquid sounds, they may also wander from one subtype to the next. Thus, rhotics may become laterals, and laterals can develop into rhotics. These phenomena, known as lambdacisation and rhoticisation, refer to the category switch[1] effected during perception by a listener of a language with these liquid categories, regardless of whether the category switch leaves a trace in the phonology of a language or whether it is a

[1] Note that the use of the word "switch" is not meant to imply that the sound in question will move in a single-step fashion from one category centre to the other. Rather, it may change all the way down through being perceived as a bad member of one category or the other before establishing itself firmly in the new category.

so-called 'mini sound change', i. e. a one-time error without further consequences (Ohala 1992). When these changes occur in the presence of another liquid, they are called dissimilation or assimilation, depending on the direction of the category change.

Long-distance dissimilations and assimilations of liquids (i.e., when the two sounds at hand are not immediately adjacent to one another) occur in a wide array of languages, but very often have a sporadic rather than a systematic character. Examples for this kind of change in Latin can be found in (1)-(2):

(1) Dissimilation:
**caeluleus* > *caeruleus* 'dark blue' (derivative of *caelum* 'sky')
**corcorio* > *curculio* 'grain weevil'
**Praetorius* > *Plaetorius* 'Roman family name (gentilicium)'
peregrinus > *pelegrinus* 'pilgrim'
terebra > *telebra* 'borer'
arteriae > *alteriae* 'arteries'
flagellum > *fragellum* 'scourge'
Belial > *Beliar* 'proper name: biblical character'
Albuelis > *Albueris* 'a species of grape wine'
infirmabatur > *infilmabatur* 'it weakened'

(2) Assimilation:
Alexander > *Alexandel* 'proper name'
simulacrum > *simullaclum* 'image'
Aurelia > *Aulelia* 'proper name'
ulciscimur > *ulciscimul* 'we avenge ourselves'
prolixius > *plolixius* 'more courteously'
cervical > *celvical* 'bolster'
celeberrimo > *cereberrimo* 'very frequently'
exploratione > *exproratione* 'examination'[2]

There are, however, a few known instances where liquid dissimilation took on a systematic character and became grammaticalised in allomorphy. One is, of course, the allomorphy of the suffix *-ālis*/*-āris* in Latin, to be presented in greater detail in section 2. The other two cases found in the literature come from Sundanese and Georgian. In Sundanese, an infix /ar/ signalling "PLURAL" has a lambdacised allomorph /al/ when the word stem contains a rhotic (Cohn 1992). In Georgian, the suffix /uri/ denoting "ETHNICITY" also has a lambdacised allomorph /uli/ when the word stem contains a rhotic (Fallon 1993). Note that in these two unrelated languages, dissimilation involves lambdacisation rather than rhoticisation as in Latin.

In what follows I look more closely at the allomorphy of the suffix *-ālis*/*-āris* in Latin (§ 2). In § 3, I present a short overview of the view of dissimilation as hypercorrection (Ohala 1992) and the problems liquid dissimilation poses to this approach. The remainder of this contribution is devoted to an experiment designed to eludicate the nature of liquid dissimilation, both with respect to the Latin grammaticalised suffix alternation as well as with

[2] All examples are taken from Schuchardt (1866: 136-139) and Bechtel (1876: 19-23), and most, but not all data are from the Late Latin period. Some of the above examples, take *pelegrinus* for instance, have been the basis for further development, while others, found perhaps in just one manuscript or two, have had no known lasting effects, such as the form *alteriae* for *arteriae*. Nonetheless all of them illustrate the occurrence of liquid dissimilation and assimilation.

respect to predictions derived from the view of dissimilation as hypercorrection. § 4 presents the experiment's design, § 5 details the statistical analyses of the data, and in § 6 I discuss the findings of the experiment. In drawing the conclusions in § 7, I relate the findings to the Latin *-ālis*/*-āris* alternation and assess whether it should be viewed as hypercorrection.

2 Systematic liquid dissimilation in the *-ālis*/*-āris* allomorphy in Latin

While liquid dissimilation in individual words only occurred sporadically throughout the history of the Latin language, it became incorporated into the grammar at the level of one particular morpheme, the derivativonal suffix *-ālis*/*-āris* which derives adjectives from nouns. The default allomorph of this suffix is *-ālis* (3), but when another lateral occurs within the stem of the word, the rhoticised allomorph *-āris* is used instead (4). In the case of an intervening /r/ in the stem between the stem-internal lateral and the derivational suffix, *-ālis* again is the form chosen in word formation (5).

(3) noun: *anima* 'breath' > adjective: *animālis* 'animate'
noun: *spīritus* 'breath' > adjective: *spīritālis* 'spiritual'
noun: *nātūra* 'essence' > adjective: *nātūrālis* 'natural'

(4) noun: *mīles* (gen. *mīlitis*) 'soldier' > adjective: *mīlitāris* 'military'
noun: *populus* 'people' > adjective: *populāris* 'popular'
noun: *cōnsul* 'consul' > adjective: *cōnsulāris* 'consular'

(5) noun: *lībra* 'pound' > adjective: *lībrālis* 'weighing one pound'
noun: *fulgur* 'lightning' > adjective: *fulgurālis* 'pertaining to lightning'
noun: *plūrēs* 'more people/things' > adjective: *plūrālis* 'plural'

Each of the three categories has, however, a number of exceptions. Taking into account the total number of adjectives and deadjectival nouns (n = 770) listed in the Lewis & Short (1879) Latin-English dictionary, the following distribution emerges (Table 1):

rule	number of forms obeying the rule	number of exceptions to the rule
stem + *-ālis* (3)	549	4
stem (/l/) + *-āris* (4)	161	33
stem (/l – r/) + *-ālis* (5)	21	2

Table 1. Distribution of the suffix *-ālis*/*-āris* in Latin.

While the first rule, (3), has only 0.7% exceptions, the number of non-compliant forms for rules (4) and (5) reach 17.0% and 8.7%, respectively, out of the total number of forms which are susceptible to fall under the rules. The question arises whether the exceptions to the use of the *-āris* allomorph in particular follow any specific pattern. A closer look at the set of the 194 adjectives falling under the scope of rule (4), which has the largest number of exceptions, reveals that the relative position of the stem-internal lateral (which should trigger the rhoticised suffix form) with respect to the suffix determines the likelihood of words to contain the *-āris* allomorph.[3]

[3] Cser (2010), in a descriptive account of the *-ālis/-āris*-alternation, claims that the exceptions to (4) arise from these adjectives having a labial, velar, or palatal consonant in between the two liquids. This is, however, only true for 21 out of the 33 exceptions (63.3%) in Table 1; among the adjectives complying with (4), 10.6% (17 out of 161) meet the condition which should have led to their retaining the *-ālis* suffix. In the present

Note that the rhoticised allomorph always appears when a stem ends in a lateral. In other words, a hypothetical sequence *-*lālis* never occurs and we always find -*āris* instead (cf. also Cser 2010: 38); see examples in (6). Conversely, when the last stem-internal lateral is in the preantepenultimate syllable of the stem, the rhoticised suffix allomorph -*āris* never occurs and we only find -*ālis*; see examples in (7). This state of affairs is shown in the mosaic plot in Figure 1 where zero observations are marked by a dashed horizontal line. That the use of the rhoticised or non-rhoticised allomorph of the -*ālis*/-*āris* suffix is indeed sensitive to the position of the last lateral in the stem, as suggested by Figure 1, is corroborated by Fisher's Exact Test for Count Data ($p = 0.000$). This leads to the hypothesis that liquid dissimilation needs to take place inside a given window of no more than four syllables. This idea is not new. It was proposed by Hurch (1991: 45-48) based on observations made over a large set of adjectives composed with the -*ālis*/-*āris* suffix. The idea of temporal distance playing a role in the occurrence of liquid dissimilation processes is also in line with the auditory trace decaying by about 400 ms (Remez 2003: 295), i.e. it decays within about three to four syllables.

(6) *agricolāris* 'agricultural'
angulāris 'angular'
aniculāris 'anile'

(7) *bibliothēcālis* 'belonging to a library'
multisonālis 'which resounds'
palmipedālis 'a foot and six inches long'
sōlstitiālis 'belonging to the solstice'

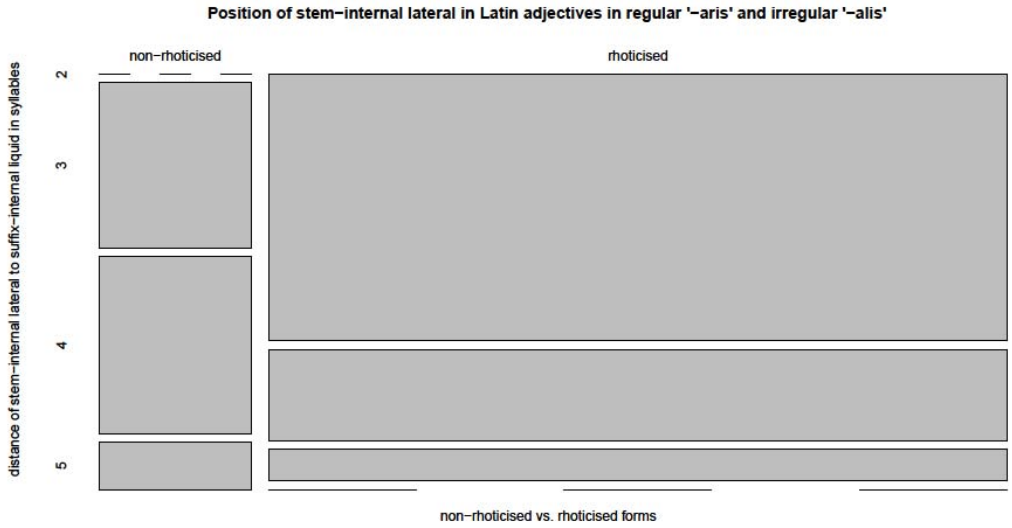

Figure 1. Mosaic plot depicting the distribution of Latin adjectives the stem of which contains a lateral as its last liquid before the suffix and which therefore ought to contain the rhoticised allomorph of the -*ālis*/-*āris* suffix (n = 194). Adjectives which follow this rule make up the righthand side of the plot, while adjectives which are an exception to the rule by having the non-rhoticised allomorph -*ālis* are shown on the left side of the plot. The y-axis shows the position of the last liquid in the word stem, from the penultimate syllable in the word (2) at the top to the fifth-to-last syllable in the word (5) at the bottom.

experiment, this tendency of non-coronal sounds to possibly interfere with the regular -*ālis/-āris*-alternation has not been tested.

3 Dissimilation in sound change theory

In John Ohala's view on sound change, dissimilation is seen as an instance of hypercorrection (e.g., Ohala 1993: 249). He calls dissimilatory sound changes 'unnatural' in the sense that they are not amenable to explanation on principles of coarticulation alone. Rather, they arise out of the listener-speaker's knowledge of long-distance acoustic effects of the relatively slow gestural movements of the lips or the tongue body. Dissimilation occurs in those cases where the listener erroneously thinks she detected an unintended acoustic effect where it was in fact intended. Phrased differently, dissimilation is correction applied where it shouldn't have been applied (Ohala 1993: 250).

Classic candidates for dissimilatory processes are the so-called secondary articulations such as nasalisation, velarisation, or labialisation.[4] These are essentially superimpositions of a gesture carried out by the slower articulators onto a gesture produced in many cases by the faster moving tongue tip.[5] As stated in the introduction, liquids have just such a slow component: the acoustic effects of tongue body movement can be detected as far as up to five syllables before they actually occur (Heid & Hawkins 2000). But what is subject to dissimilation in liquid dissimilation processes are the acoustic results of the fast tongue tip movement, not those of the slow-moving tongue body, as predicted by Ohala's account which states that slow transitions in the acoustic signal arising from slow-moving articulators are susceptible to give rise to dissimilation in perception.

John Ohala's (1993: 252-253) interpretation of what happens in the Latin dissimilation described in § 2 is as follows: Sounds which give rise to dissimilation in perception need to have long and slow transitions in the acoustic signal. Laterals do have such slow transitions in their formant structure, especially in the second and third formant. In historical sound change, they often vocalise, which means that these formants transitions may be a prominent cue to laterals. Furthermore, it has been found that the rhotic and the lateral of American English are distinguished solely by the height of F3. It is then this slow formant transition, he claims, which gives rise to the dissimilation in the case of the Latin *-ālis*/*-āris* alternation. But there are some points where Ohala's account should be challenged: First, dissimilation of the American English rhotic and lateral, although occurring on liquids, are better treated as retroflex dissimilation. It is well-known that the American English rhotic is retroflex (Stevens 1998), and that retroflexion is signalled by F3 movement (Hamann 2003). Moreover, the acoustic quality of the Latin intervocalic singleton lateral is not known (see Müller 2011: 189) and the singleton Latin rhotic was most certainly an alveolar tap or a trill, not a retroflex approximant as in contemporary American English.

Moreover, Ohala's account of dissimilation as hypercorrection would predict that it operates from left to right, i. e. the dissimilating sound would be the first liquid in the word while the dissimilation-triggering sound would be the second one. Of course, this is not true for the Latin *-ālis/-āris*-alternation, where the second liquid, the one in the suffix, undergoes dissimilation. It can be argued, however, that the morphological distinction between word stems and suffixes can somehow explain this mismatch between theory and data, perhaps in terms of frequency of occurrence, with suffixes occurring more often than individual word

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[4] The classic example for this type of sound change is the evolution of Latin *quīnque* 'five' to the Romance forms *cinque* (Italian), *cinc* (Catalan/Occitan), *cinq* (French), *cinco* (Spanish), where lip rounding on the first velar stop came to be erroneously factored out by listeners from the second labialised velar stop and was subsequently omitted in production (Ohala 1993: 250-251).

[5] Of course, secondary articulations can occur on vowels as well as on consonants, especially when the 'secondary' gesture is produced by structures other than the tongue body which is already involved in the production of the vowel.

stems and offering thus more occasions for change through misperception (cf. Bybee 2001: 11-12).

In this sense, one may ask whether liquid dissimilation is really dissimilation in Ohala's sense at all: in other words, whether the listener actually employs a hypercorrection strategy. An alternative hypothesis would be to suppose that what we see as liquid dissimilation really is the result of liquid confusion or hypocorrection. If confusion is involved, we would predict that sporadically-occurring category changes of liquids involve assimilatory outcomes as much as dissimilatory ones, and that these sporadic changes must also be at the beginning of dissimilation processes to be grammaticalised at a later point in a language's history.

4 Testing conditions for liquid dissimilation

The foregoing descriptive analysis of a large set of Latin adjectives and deadjectival nouns together with the discussion of Ohala's account for sound change leads to a number of research questions which we will attempt to answer through a perception experiment designed for this purpose.

First of all, the hypothesis of temporal distance playing a key role for the occurrence of the alternation process arises from observations based on the data discussed in § 2. Thus, distance between two liquids as measured in numbers of syllables will be an independent variable whose influence needs to be assessed.

Second, as dissimilations should involve a change of the first liquid in the word with the second one acting as dissimilation-trigger, i.e., changes of the type /l-l/ > /r-l/ and /r-r/ > /l-r/, it will be tested whether this alleged preference for the left-to-right direction will be reproduced by the subjects in this experiment. If the directionality of dissimilation (or assimilation, for that matter) turns out to be at chance level, this would not support Ohala's interpretation of the *-ālis/-āris*-alternation as dissimilation presented in § 3.

Third, if the subjects make hypocorrective errors in perception, i.e. if they miss some cue in the acoustic signal, we will expect to see a number of liquid assimilations. If assimilations and dissimilations are found with equal frequency, i.e. at chance level, the claim that two like liquids in a given word like to dissimilate is weakened.

In the following, I present the set-up of the experiment. Since the search for native speakers of Latin was hindered by unsurmountable difficulties, Modern Greek was used instead. Like Latin, Modern Greek has two liquids /l/ and /r/, as well as a five-vowel system. Moreover, the existence of a suffix /is/ «-ης», which can occur attached to word stem ending in /ar/ and /al/, respectively (e.g., «γιδάρης» /ʝiˈðaɾis/ 'goatherd', «χαμάλης» /xaˈmalis/ 'carrier'), can provide a testing ground for the phonetic – albeit not morphological – conditions on liquid dissimilation.

4.1 Stimuli

Natural clear-speech nonsense-word stimuli with the following characteristics were created (see Table 2):

1. Each stimulus is six syllables long and starts with an onsetless syllable, i.e. the unstressed vowel /a/.

2. The consonantal slots (C) are filled by a voiceless stop consonant (one of /p, t, k/) and the vocalic slots (V) by one of the vowels /a, i, o/. The order of the vowels is in all stimuli /a-a-a-o-a-i/. These choices were designed to make the nonsense words acceptable as possible

words to Greek listeners. Indeed, the Greek lexicon contains a number of words starting with the sound sequence /akata-/.[6] Also words ending in -ης /is/ are frequent in Greek.

3. Each stimulus contains two liquids (l-condition: l-l; r-condition: r-r; mixed condition I: r-l; mixed condition II: l-r).

4. The first liquid can occur in intervocalic, complex onset or coda position, while the position of the second liquid never varies: it is always intervocalic.

5. Segment duration in like stimuli was matched through manipulation in Praat (Boersma & Weenink 2012), so that duration could not serve as a cue to liquid identity.

6. All stimuli bear primary stress on the penultimate syllable.

7. All stimuli were preceded by the introductory phrase «*Γεια σας! Εμένα με λένε…*» ('Hello! My name is…').

8. The total number of stimuli amounted to 144 (12 templates × 4 conditions × 3 repetitions; see below in § 4.2).

9. The liquid in the word body is named hereafter "stem liquid" and the one in the word ending "suffix liquid", but it should be kept in mind that in the nonsense stimuli, no real stems and suffixes are involved.

template	**l-condition**	**r-condition**	**mixed condition I**	**mixed condition II**
VCVCVCVCLaLi	akatatoplali	akatatoprari	akatatoprali	akatatoplari
VCVCVCVLaLi	akatatolali	akatatorari	akatatorali	akatatolari
VCVCVCVLCaLi	akatatolpali	akatatorpari	akatatorpali	akatatolpari
VCVCVCLVCaLi	akataklopali	akatakropari	akatatropali	akataklopari
VCVCVLVCaLi	akatalopali	akataropari	akataropali	akatalopari
VCVCVLCVCaLi	akataltopali	akatartopari	akatartopali	akataltopari
VCVCLVCVCaLi	akaklatopali	akatratopari	akatratopali	akaklatopari
VCVLVCVCaLi	akalatopali	akaratopari	akaratopali	akalatopari
VCVLCVCVCaLi	akaltatopali	akartatopari	akartatopali	akaltatopari
VCLVCVCVCaLi	aklatatopali	akratatopari	akratatopali	aklatatopari
VLVCVCVCaLi	alatatopali	aratatopari	aratatopali	alatatopari
VLCVCVCVCaLi	alkatatopali	arkatatopari	arkatatopali	alkatatopari

Table 2. Stimuli templates and stimuli used in the perception experiment. See text for details.

4.2 Listeners and presentation method

A total of six listeners participated in the experiment. All of them are of Athenian origin, from a homogeneous socioeconomic background and speak Standard Greek with an Athenian accent.

Stimuli were embedded in pictures displaying an animal with text transcribing the introductory phrase (*Γεια σας! Εμένα με λένε…*) in a speech bubble so that the nonsense-word stimuli could be understood by listeners as being each animal's proper name. These are not real animals' names, but the word structure of the stimuli suggests a phonotactically acceptable noun in the accusative case. Listeners were instructed prior to the experiment that they would hear strange names which would all sound very much alike.

[6] The Babiniotis' 1998 dictionary lists 30 words beginning with /akata-/. Of these, 14 are five syllables long, 13 six syllables long, and 3 seven syllables long.

The entire set of stimuli was presented to listeners over headphones in three blocks ordered randomly within each block. There were thus three repetitions of each individual stimulus. The accompanying pictures, however, varied each time so that no animal could be associated with a particular stimulus through repetition. Each block took about 15 min to complete, depending on the listeners' individual handwriting speed. Between blocks listeners were presented with a short soothing piece of music.

Listeners were handed an answer sheet which displayed a small-scale version of each animal's picture. They were invited to transcribe the stimuli they heared – the animals' names – on the answer sheet using normal Greek script. Liquids in Greek script are straightforwardly identifiable with <λ> representing /l/ and <ρ> representing /ɾ/.

The aim of this procedure was to observe whether subjects could faithfully reproduce the stimuli they were presented with, and if this wasn't the case, what kind of errors they would make and where. The task was deliberately designed to be demanding but feasible, in order to produce a number of errors that would be large enough to be analysed statistically. The focus of attention for the present analysis lies, of course, on any liquid dissimilations or assimilations that occurred in the data.

4.3 Analysis

A GEE (Generalised Estimation Equation) model was used for data analysis.[7] Fixed-effect variables were the identity of the liquid in the suffix (lateral vs. rhotic), the identity of the liquid in the stem (lateral vs. rhotic), the position of the stem liquid within the syllable (intervocalic position vs. coda position vs. complex onset position), the distance of the stem liquid to the suffix (one to five syllables away), as well as whether the error was an assimilation or a dissimilation (subsumed under the header term 'confusion') and whether it affected the liquid in the word body or in the ending. The GEE model was chosen also for its ability to control for the fact that multiple observations from the same subject are correlated. It fits a marginal model and does not need a full specification of the joint distribution; it models population averages. Furthermore, it has no likelihood function, but rather uses estimates of quasi-likelihood equations as parameter estimates. The dependent variable – occurrence or not of an error – was assumed to be binomially distributed.

Occurrences of other types of errors (e.g. metathesis, presence of an additional liquid, elision of an entire syllable, and so on) were noted in the dataset, but not analysed in the present study.

The total number of elicited responses amounts to 864 (6 subjects × 144 stimuli). Altogether, 39 cases of dissimilation of a stem-internal liquid, 52 cases of dissimilation of a suffix liquid, 14 cases of assimilation of a stem-internal liquid, and 61 cases of assimilation of a suffix liquid were noted.

5 Results

Of all the fixed variables described in § 4.3 above, only the position of the liquid within the syllable structure (intervocalic vs. coda vs. complex onset) and the distance of the liquids to each other (by one to five syllables away) turned out to have a significant effect on the occurrence of assimilation or dissimilation.

Liquid identity did not reach significance (in the suffix, the difference in probability of occurrence for /r/ vs. /l/ was 0.032, $z = 0.793$, $p = 0.428$; in the stem, the difference in probability of occurrence for /r/ vs. /l/ was 0.012, $z = 1.244$, $p = 0.214$), nor was the liquid in

[7] The statistical analysis was conducted in R version 2.15.1 (R Core Team 2012), using the Package gee (Carey 2012).

the stem affected any more than the one in the suffix by listeners' mistakes (difference in probability of occurrence was 0.058, $z = 1.777$, $p = 0.076$). Furthermore, the analysis shows that there was no significant preference for dissimilation as opposed to assimilation in listeners' errors (difference in probability of occurrence: 0.015, $z = 1.319$, $p = 0.187$).

I shall now describe each significant effect in turn. In § 5.1, I shall present the probabilities for an error occurring on a liquid in the stem as a function of its distance to the liquid in the suffix, as well as the probabilities for an error occurring on the liquid in the suffix as a function of its distance to a stem-internal liquid. For reasons of space, I will illustrate this only for the intervocalic condition in the case of the stem-internal liquid. The suffix-internal liquid was, of course, always intervocalic. In § 5.2 I shall describe the probability of an error occurring on the stem-internal liquid as a function of its position within the syllable. It will be shown here that liquids in consonant clusters have a greater probability to give rise to errors than intervocalic ones do. Finally, these two significant effects will be discussed in § 6.

5.1 Distance of the liquids from each other

The probability that an assimilation or a dissimilation error occurs, that is, a confusion of the identity of a liquid (taking a rhotic for a lateral or vice versa), increases as the distance between the two liquids in the stimulus becomes greater. This is shown in Figures 2 and 3 for the stem-internal liquids and the suffix liquids, respectively.

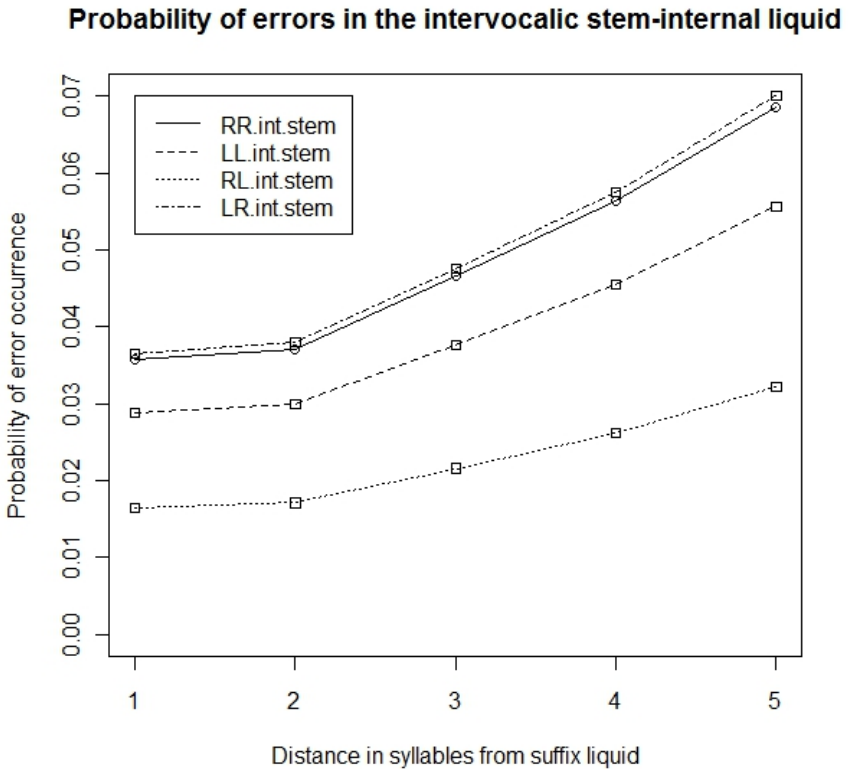

Figure 2. Probability of errors occurring in the stem-internal liquid, illustrated here for the intervocalic position. Laterals and rhotics are coded "R" and "L", respectively. The first letter refers to the identity of the stem-liquid, the second one to the suffix liquid. Thus "RR" stands for a stimulus where both liquids are rhotics. "int" is the abbreviation for "intervocalic". "stem" indicates that the liquid for which the error occurrence probability has been calculated is the stem-internal one. X-axis: 1 = the stem-internal liquid is in the syllable preceding the suffix, 5 = the stem-internal liquid is in the fifth syllable preceding the suffix; y-axis: probability of an error occurring when transcribing the stimulus.

In Table 3, the z-scores (the z-score indicates the distance of an observation to the mean where z = 0) for all differences between effects of syllable distances are shown. It can be seen that, regardless of position or liquid identity, only where the liquid in question is five syllables away from the suffix is there a significant difference compared to a liquid in syllables 1 or 2 before the suffix. The marked leap from the distance of two syllables to the distance of three syllables before the suffix, seen in Figures 2, 3, and 4, does not reach even marginal significance. Note that the z-scores illustrate how the differences gradually increase towards significance.

Distance in syllables	1	2	3	4	5
1		0.0907	0.7215	1.6260	**3.1018**
2	-0.0907		1.1079	1.4809	**2.3606**
3	-0.7215	-1.1080		1.4745	1.5497
4	-1.6260	-1.4809	-1.4745		1.0081
5	**-3.1018**	**-2.3606**	-1.5497	-1.0081	

Table 3. Difference of the effects of the distance of the stem-internal liquid to the suffix in syllables, as measured in z-scores. The z-score indicates the distance of an observation (here: the effect of the independent variable 'distance of the stem-internal liquid to the suffix in syllables') to the mean where z = 0. Significant z-scores ($p < 0.05$) are in bold face. 1 = syllable immediately adjacent to the suffix, 2 = two syllables away from the suffix, and so forth. For instance, the difference of the effect of the second syllable before the suffix when compared to that of the first syllable before the suffix has a z-score of 0.0907. There is thus a probability of 0.9278 that the two effects are actually the same and only differ by accident in the observations obtained experimentally.

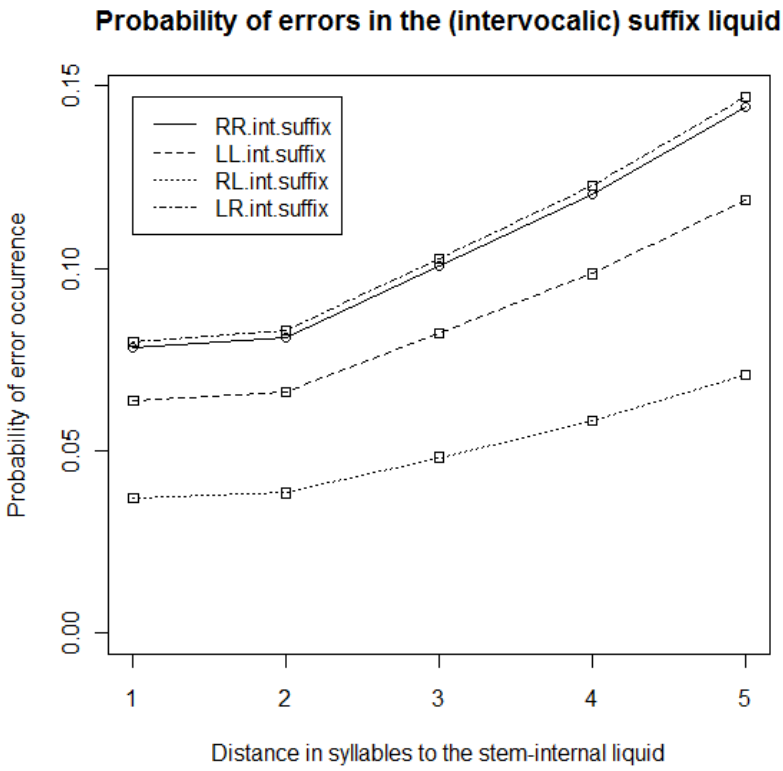

Figure 3. Probability of errors occurring in the suffix liquid, which is always in intervocalic position. Laterals and rhotics are coded "R" and "L", respectively. The first letter refers to the identity of the stem-liquid, the second one to the suffix liquid. Thus "RR" stands for a stimulus where both liquids are rhotics. "int" is the abbreviation for "intervocalic", which is redundant for the suffix liquids. "suffix" indicates that the liquid for which the error occurrence probability has been calculated is the one in the suffix. X-axis: 1 = the stem-internal liquid is in the syllable preceding the suffix, 5 = the stem-internal liquid is in the fifth syllable preceding the suffix; y-axis: probability of an error occurring when transcribing the stimulus.

5.2 Position of the liquid within the syllable structure

Assimilations and dissimilations of liquids occur at a significantly different rate when the stem-internal liquid is in intervocalic position as opposed to either coda position or complex onset position (coda – intervocalic: difference in probability of occurrence = 0.028, $z = 2.695$, $p = 0.007$; complex onset – intervocalic: difference in probability of occurrence = 0.021, $z = 2.289$, $p = 0.022$). The positions at the syllable margins, complex onset and coda, on the other hand, do not prove to differ significantly from each other (coda – complex onset: difference in probability of occurrence = 0.007, $z = 0.507$, $p = 0.612$). In Figure 4, this is illustrated for stimuli where both liquids (stem-internal and suffix) are rhotics, and thus an error on one of the liquids would constitute a case of dissimilation. It is shown there that the intervocalic position correlates with a lower probability of error occurrence. It cannot be said, however, whether it actually prevents dissimilation and assimilation errors, or whether conversely, the other two syllable positions heighten this probability.

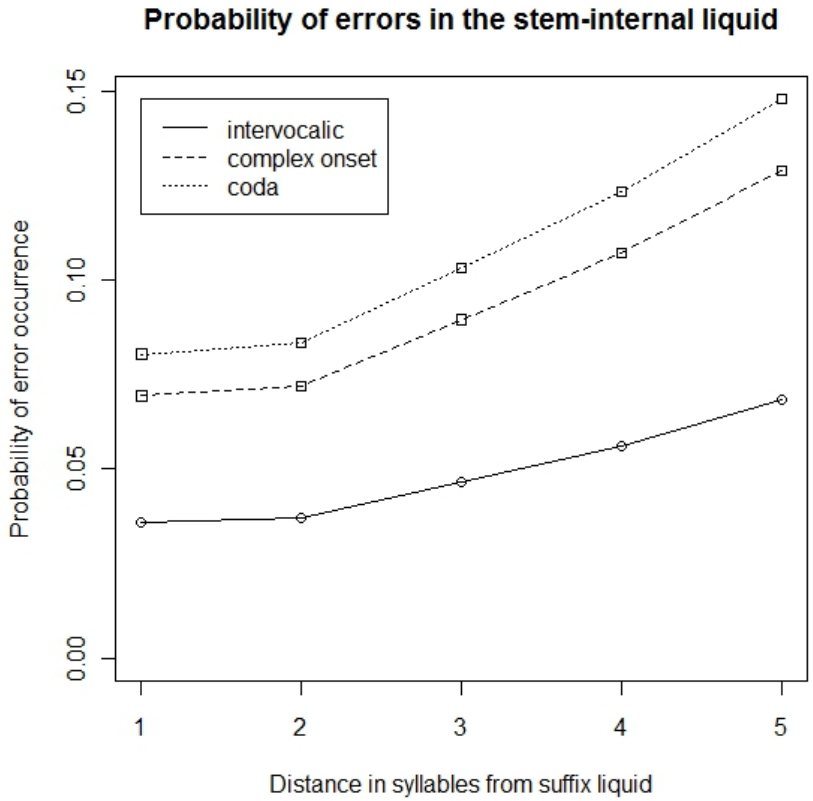

Figure 4. Probability of occurrence of an error in the identity of the stem-internal liquid in a stimulus where both liquids are rhotics according to the liquid's position within the syllable (intervocalic position, complex onset position, coda position followed by a consonant) and to the distance in syllables which separates that liquid from the one in the suffix. X-axis: 1 = the stem-internal liquid is in the syllable preceding the suffix, 5 = the stem-internal liquid is in the fifth syllable preceding the suffix; y-axis: probability of an error occurring when transcribing the stimulus.

6 Discussion

The results of the statistical analysis discussed above in § 5 indicate that two factors, the distance of a given liquid inside the stem and the position of the liquid within the syllable, have a significant effect on the correct retention and reproduction of words containing two liquids.

First, it was found that significantly less errors are likely to occur when the stem-internal liquid is only one or two syllables away from the suffix, as opposed to five syllables away. This finding would suggest that the memory trace of the first syllable heard, i.e. the trace of the syllable five syllables away from the suffix, had already begun to fade in the listener's memory and was therefore more difficult to retrieve when the entire word was to be written down.

One obvious objection to this conclusion can be made at this point: Given that of a five-syllable distance stimuli comprised only coda position, and that the likelihood of an error occurring on a liquid in coda position is greater than in intervocalic position (see § 5.2), the effect could be a by-product of syllable position. The results of a GEE model run only on coda condition, however, show that the difference of the fifth vis-à-vis the second syllable preceding the suffix is robust. Table 4 displays the z-scores associated with the differences of the effect of distance. Note that the distance of three syllables away from the suffix as

compared to two syllables away from the suffix almost reaches significance ($p = 0.0545$) when considering the coda condition only. This can also be seen in Figure 4 above.

Distance in syllables	2	3	4	5
2		1.9226	1.2007	**2.1100**
3	-1.9226		0.3441	1.0592
4	-1.2007	-0.3441		0.4301
5	**-2.1100**	-1.0592	-0.4301	

Table 4. Difference of the effects of the distance of the stem-internal liquid to the suffix in syllables, measured in z-scores. Significant z-scores ($p < 0.05$) are in bold face. 2 = two syllables away from the suffix, 3 = three syllables away from the suffix, and so forth. For instance, the difference of the effect of the fifth syllable before the suffix when compared to that of the second syllable before the suffix has a z-score of 2.1100, with a probability of 0.0349 that they are actually the same and only differed by accident in the observations tested.

Second, it was shown in § 5.2 that the likelihood of an error occurring on an intervocalic liquid is significantly lower than on a liquid in a consonant cluster, whether the liquid is preceded by a voiceless stop (complex onset condition) or followed by a voiceless stop (coda condition). The reason for this state of affairs seems fairly straightforward: a liquid in intervocalic condition has two transition phases, in and out of the liquid. When one of the adjacent sounds, however, is a voiceless stop, then one transition phase may be masked to some degree, and this may make recognition and mnemonic retention of the stimulus more difficult for the listener.

7 Conclusion

The present study aimed at understanding the factors underlying long-distance dissimilation, and also long-distance assimilation of liquids. It was inspired by the systematic dissimilation that had been grammaticalised in the *-ālis*/*-āris* suffix morphology of Latin. In the close study of the set of Latin adjectives and deadjectival nouns containing the *-ālis*/*-āris* suffix in § 2 it was found that the temporal distance as measured in syllables had a significant effect on the occurrence of the rhoticised allomorph *-āris*. The experiment that followed was designed to test whether this effect could be reproduced in the laboratory. As native Latin listeners were unavailable, Modern Greek listeners were chosen. They were presented with nonsense words each containing two liquids where the position of the first liquid inside the syllable structure, the identity of the liquids, and the distance of the liquids to each other varied systematically. It was shown that temporal distance between two liquids had a significant effect on the error rate of the Greek listeners, and that, in addition, liquids in consonant clusters led to a greater probability of errors than in intervocalic position. On the other hand, there was no significant effect of liquid identity: the probability of any error occurring was not influenced by the liquids being laterals or rhotics. There also was no effect of the direction of dissimilation or assimilation when an error did occur: the dissimilated or assimilated liquid could be the one in the word body (‘stem’) or in the ending (‘suffix’). Finally, listeners did not make significantly more assimilations than dissimilations or vice versa.

Several important caveats have to be made, however: First, the nonsense stimuli used in the experiment do not contain morphological structure. Although I referred to ‘suffix liquids’ in the analysis of the experimental results for convenience, it is important to remember that they are not suffixes in the proper sense. There is no suffix *-ālis*/*-āris* in Greek, even though the corresponding sound sequences do occur frequently in word-final position. It is, however, not completely inconceivable that through exposure during the experiment to the nonsense stimuli where these sound sequences invariably occurred at the end of the word while the word ‘stem’ changed, the listeners attached some sort of suffix-like interpretation to these

sequences; such an approach could be modelled in a usage-based account (e.g. Bybee 2001). More errors occurred in 'suffix' liquids as opposed to 'stem' liquids (113 vs. 53 cases), but this difference was not significant (difference in probability of occurrence 0.058, $z = 1.777$, $p = 0.076$).

Second, the further away the stem-internal liquid was in the Latin words, the more likely were exceptions to the grammaticalised dissimilatory allomorphy described in § 2. So one could argue that the analysis of the Latin corpus of adjectives in *-ālis*/*-āris* was actually about the diffusion of dissimilation in the lexicon, whereas the experimental study looked at the origin of perceptual mistakes resulting in a change of category of one of the liquids, be it dissimilation or assimilation. On the other hand, on the basis of the Latin data, one would have expected listeners to make more dissimilations in adjacent syllables than when several syllables intervened between the two liquids, since the use of the dissimilated suffix is exceptionless when the word stem ends in a lateral and thus immediately precedes the suffix. In this sense, the results of the present experiment go in the opposite direction of the ones derived from the Latin corpus. Nevertheless, it has taken us a step further in the understanding of the interaction of liquids within a word's sound structure.

In spite of these caveats, this study has underscored again two well-known aspects in the perception of sound structures: the importance of linear sequence, measurable in temporal units, and the role of salience and redundancy of acoustic cues. Linear sequence has been underrated in accounts of dissimilation cast within the framework of generative phonology (see Cohn 1992 and Fallon 1993 for an approach to liquid dissimilation through linking and delinking features, and Hurch 1991 for a thorough critique of this approach in the case of the Latin *-ālis*/*-āris* dissimilation). Salient cues are better than masked cues, and more acoustic cues are better than less for identifying a given sound. This is the most likely reason why intervocalic liquids led to fewer errors in perception than liquids in consonant clusters.

Furthermore, in the observations collected in the present experiment, rhotics were as much error-prone as were laterals. Recall that in the other two languages with grammaticalised liquid dissimilation, Sundanese and Georgian (see § 1 above), the dissimilated allomorph came about through lambdacisation of a rhotic, not rhoticisation of a lateral. Whether a language grammaticalises one or the other, may be either a matter of chance or a matter of some intrinsic qualities of lateral and rhotic variants that may be hard (but not entirely impossible) to determine for sound changes which happened a long time ago.

Finally, it is necessary to address whether the findings of this experiment correlate with the predictions derived from Ohala's model of dissimilation as hypercorrection. In his account, dissimilation is largely anticipatory rather than perseverative (Ohala 1992: 28). No significant effect, however, was found of the direction of assimilation or dissimilation, i.e. whether the first or the second liquid in the word underwent the change. In other words, the kind of dissimilatory errors found in the present experiment does not seem to be hypercorrective dissimilation.

Could liquid dissimilation be hypocorrection or confusion? There was no significant difference between the likelihood with which errors of the dissimilatory kind versus the assimilatory kind were found to occur. Unless more contributing factors are unearthed in future research, it is quite possible that the occurrence of one or the other type of error is due to chance. Whatever gave rise to the Latin allomorphy in the first place might not have been only the presence of two laterals in adjacent syllables, but some additional conditions may have been needed as well. In conclusion, liquid dissimilation might only look like hypercorrective dissimilation. Its initial conditions, however, may rather belong to hypocorrection, i.e. mishearing and confusion.

Acknowledgments

I'd like to thank the editors of this volume, Fernando Sánchez Miret and Daniel Recasens, as well as three anonymous reviewers for their feedback on earliers drafts of this paper. Moreover, my colleague Mary Stevens has provided extensive and valuable feedback which has greatly helped to improve this paper. The statistical analysis was done in consultation with Karen Grace-Martin of The Analysis Factor. All remaining errors are, of course, mine.

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